# Cooking Banana in Africa

JAICAF ジェイカフ

Japan Association for
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Cover page

Left: Bunch of Plantain "Boi" (Southeastern Cameroon)
Credit: K. Komatsu

Upper right: Trader transporting cooking bananas from villages (Central Uganda) Credit: Y. Sato

Lower right: Pygmy woman peeling bananas (Southeastern Cameroon)
Credit: K. Kitanishi

# Preface

Since most developing countries are situated in the Tropics or Subtropics and exposed to harsh conditions in terms of natural, social and economic environment, the level of productivity of crops is generally low and unstable. Under such circumstances the developing countries are endeavoring to increase food production, while struggling to cope with population issues and the poverty. In these efforts, because the technology developed in advanced countries situated in the temperate zone are often not applicable directly, it is necessary in the agricultural cooperation with developing countries to carry out in advance the surveys and studies on the technologies applicable to local environment by taking full account of the specific geographical and social conditions of a location. Actually we receive frequently the requests for carrying out such tasks of research.

Consequently our Association, in the framework of activities of survey and study, has been engaged for a long time in implementing projects of research on the technologies for tropical agriculture, the results of which have been summarized in the publication of the "Tropical Agriculture Series" (consisting of "Manuals of Tropical Agriculture" and "Manuals of Tropical Crops"). Since 2006 we are implementing the project of "Studies on subsistence crops", assisted by a subsidy program of the Ministry of Agriculture, Forestry and Fisheries, in order to collect and analyze the basic fact data and the useful information for improving production technologies on the crops grown principally for subsistence purposes, and at the same time to explore new potentials for the commodities. As principal food crops in Africa, there are root crops (cassava, yams, etc.) and cereals (maize, sorghum, millets), but this year we focused our studies on cooking bananas that occupy the fifth place in the rank of food crops of the largest consumption in Sub-Saharan Africa (data by FAOSTAT 2003).

In the creation of this report, in order to acquire accurate and up-to-date information, we have dispatched a field survey mission to the Republic of Uganda (hereafter Uganda) that produces the largest quantity of cooking bananas in Sub-Saharan Africa, and at the same time a study committee (chaired by C. Kaneda) was organized at home within the Association to review the research contents from the viewpoints of an advanced level of expertise.

This report reflects the efforts exerted by writers as well as by the committee members. We would like to take this opportunity for expressing our deep appreciation for them. Moreover, we acknowledge with high gratitude the collaborative favors extended for the implementation of the project by the officials of relevant authorities including Ministry of Agriculture, Forestry, and Fisheries, Ministry of Foreign Affairs, Japan International Cooperation Agency, the Government of Uganda, and various international organizations.

Incidentally, we have also compiled a monograph "Agriculture and forestry in Uganda" that describes and discusses the current state and the issues on development of the agriculture and forestry in Uganda, which we hope that you would also refer to at the same time.

We earnestly hope that this report shall serve as a useful reference for those who are engaged in actual activities in situ with the mission of international cooperation for the reduction of starved and undernourished population, the establishment of food security, and the poverty reduction in Africa.

March 2010

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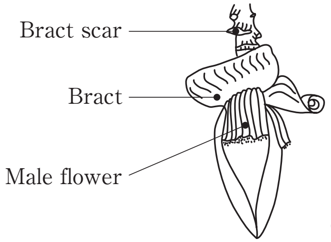
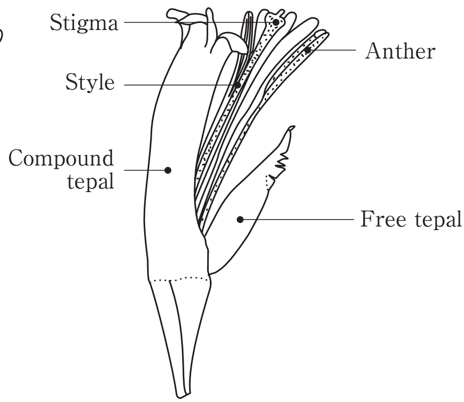
Note: Order of the alphabets
Chairperson indicated by *



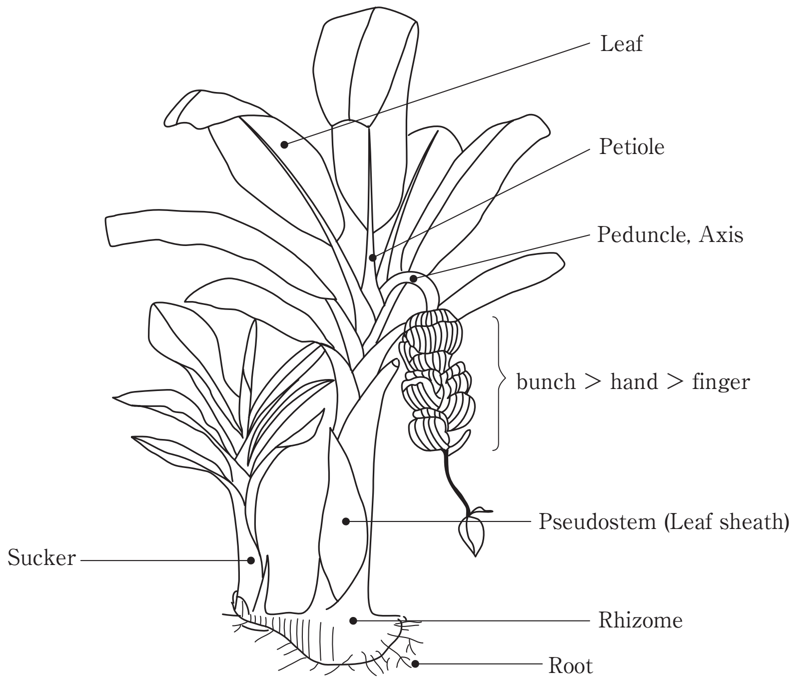




**Fig. 1 Organs of banana**
Original: IPGRI, INIBAP and CIRAD 1996, Descriptors for banana (*Musa* spp.).

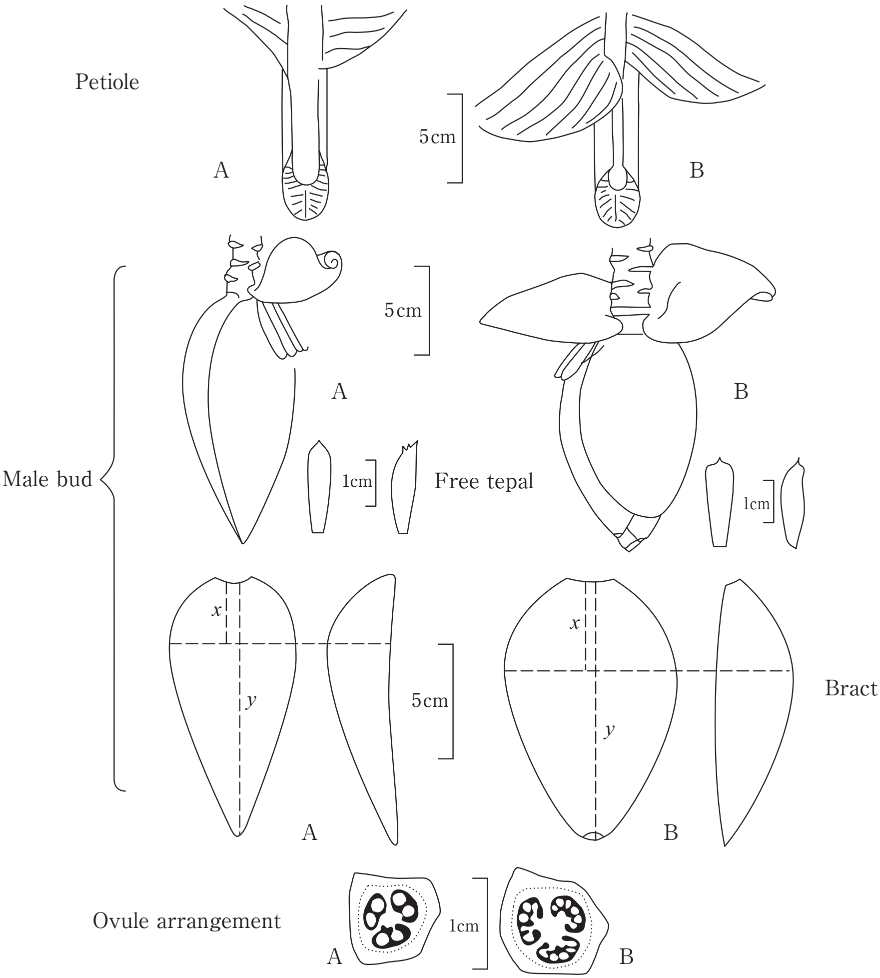



**Fig. 2 Some characters used in taxonomic scoring of banana cultivars to estimate the genome types**

Original: Stover, R.H. and N.W. Simmonds 1987, Bananas, 3rd ed., Longman, Essex.

# Table of Contents

# Chapter I. Taxonomy and genealogy of cooking bananas: diversity in genome types and cultivars

## 1. Diversity of banana and its origin

### 1) Taxonomy and genealogy

Banana is a vegetative and perennial herbaceous plant domesticated by selection from several wild species of the genus Musa of Musaceae family[1]. Among species of the genus Musa, most of banana plants grown as food crop are included in the section of Eumusa and descend either from one of two wild species of *Musa acuminata* Colla and *Musa balbisiana* Colla or from both of them (Phto 1-1). [2]

**Photo 1-1 Ancestral wild species of banana**

Left: *Musa acuminata* Right: *Musa balbisiana*

Credit: Left, Kaori Komatsu; Right, Koichi Kitanishi

[1] Ensete (*Ensete ventricosum* (Welw.) E.E. Cheesman) also belongs to Musaceae and is closely-related to *Musa* spp. In Africa it is cultivated in Ethiopia for the consumption of starch contained in vegetative parts as the staple food. Wild species of ensete grow in the zone stretching from Ethiopia to Central Africa.

[2] However, another group of domesticated banana called Fe'i is distributed in New Guinea and the Pacific islands. These bananas belong to Australimusa and are called Fe'i banana. Fe'i banana is characterized by the trait that fruit clusters stand vertically upward, while in those bananas of Eumusa section they grow horizontally or downward.

One of the most important characters of cultivated banana is that it fruits by parthenocarpy and therefore it is propagated by vegetative means instead of by seeds. The genome types of cultivated bananas of Eumusa section are denoted as AA, AB (diploids), AAA, AAB, or ABB (triploids), depending on the combinations between the genome type of *Musa acuminata* (AA) and that of *Musa balbisiana* (BB).

These genome types have been so far estimated based on characters. Fruits and vegetative parts are larger in triploids than in diploid, and those plants composed more of genes from Musa balbisiana are characterized by the presence of less remarkable blotches in pseudostem, lower bract shoulders, and rectangular fruit fingers. Simmonds has devised the procedures to estimate the genome type of individual plants based on differences of characters between *Musa acuminata* and *Musa balbisiana* by quantifying each trait by a score and accumulating it. Later on the score sheet that Simmonds and his colleagues have improved has been considered to be useful (Fig. 1-1). Currently, the genome identification by means of gene analysis is being developed by various research institutions.

<u>1. Pseudostem color</u>: score 1 2 3 4 5
Distinctive brown or black blotches／very slight or no blotches
<u>2.Petiolar canal</u>: score 1 2 3 4 5
Lower portion with scarious wing hairs, erect fringes not clasping pseudostem／clasping pseudostem
<u>3. Peduncle</u>: score 1 2 3 4 5
Normally downy or hairy／glabrous
<u>4. Pedicels</u>: score 1 2 3 4 5
Fruit finger base is short／long
<u>5. Ovules</u>: score 1 2 3 4 5
Each cluster with two regular rows／each cluster with four irregular rows

<u>6. Bract shoulder</u>: score 1 2 3 4 5 # x = cm, y = cm
Shoulder position usually high (x/y < 0.28)／usually low (x/y > 0.30)
<u>7. Bract curling</u>: score 1 2 3 4 5
Bract reflex and roll back after opening／bract present but not reflex

8. Bract shape: score 1 2 3 4 5

Spear head shaped or narrowly ovate and tapering beyond shoulder／broadly ovate, not tapering

9. Bract apex: score 1 2 3 4 5

Apex acute／obtuse

10. Bract color: score 1 2 3 4 5

red, dull purple or yellow outside, dull purple or yellow inside／distinctive brownish-purple outside; brown crimson inside

11.Bract color fading: score 1 2 3 4 5

Usually fades to yellow towards the base／inside bract color continuous to base

12. Bract scars: score 1 2 3 4 5

13. Free tepal of male flower: score 1 2 3 4 5

Lower part of apex variably corrugated／rarely corrugated

14. Male flower color: score 1 2 3 4 5

Creamy white／variably flushed with pink

15. Stigma color: score 1 2 3 4 5

Orange or rich yellow ／ cream or pale yellow/pale pink

・Criteria of Simmonds: 15 – 23 → Acuminata strain (AA, AAA, AAAA), 26 – 46 → AAB, around 49 →AB, 59 – 63 →ABB, around 67 →ABBB (Stover and Simmonds 1987)

・Examination of degree of agreement between the estimated genome types based on the evaluation list by Banana Researchers Network of Japan and those based on documented data and the identification by local banana scientists has revealed that the probability of agreement is higher when more than 10 morphological characters out of 15 in the list are evaluated. Moreover, since 10 characters out of the 15 concern those of male bud, it is needed to observe carefully the morphology of male bud, in order to improve the accuracy of estimation.

**Fig. I – 1 Criteria of classification by Simmonds**

Source: prepared by S. Maruo based on Simmonds and Shepherd 1955

In the zones stretching from India through Southeast Asia to New Guinea, wild banana species bearing fertile seeds are growing spontaneously. However, those banana species found in Africa, most parts of the Pacific and in South America are cultivated ones either without seeds or sometimes with seeds that are sterile and essentially no wild species of any kind grows there. Banana is a vegetative crop.

Suckers of banana are clones of an original plant, essentially inheriting the identical genes that the parent stock has. Diversification of cultivars occurs, except for that due to crossing of wild and/or cultivated plants that still have fertile seeds, only either through the human intervention of selection and conservation of variations in forms caused by mutations, or with respect to different areas, by the introduction of new cultivars from different areas.

**2) Origin and dissemination of banana**

Although the exact center of origin of domesticated banana has not been identified, it is generally assumed that it has originated from the area around the Malay Peninsula from the fact that the areas of distribution of wild species of *Musa acuminata* are found around the Peninsula [30)] [3].

Wild *Musa acuminata* grows mostly in the Malay Peninsula, Indonesia, the Philippines, while wild *Musa balbisiana* grows mostly in Northeastern India and the Philippines. It is assumed that wild *Musa acuminata* had by mutation evolved into a seedless strain with the trait of parthenocarpic fruit set to become the origin of diploid cultivars (AA). In the case of banana, the domestication signifies the processes in which humans first happened to find by chance an edible seedless banana and continued to cultivate and manage the same stock over the generations to establish a cropping system. Subsequently, presumably based on the autodiploids of *acuminata,* autotriploids, AAA, or hybrids between *Musa acuminata* and *Musa balbisiana,* AB, AAB and ABB, were generated by hybridization and somatic mutation.[4]

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[3] There are several arguments about the possibility of independent occurrences of the first domestication of banana in other areas, particularly the possibility of the first cultivation in New Guinea where the variation of existing varieties is great.[33)]

[4] Regarding the genesis of triploid bananas, there are different views. Some researchers advocate the following view: A tetraploid *Musa acuminata* (AAAA) was generated by an abnormal disjunction of the chromosome in a fertile diploid. Then, autotriploid AAA was generated by crossing the tetraploid (AAAA) and the diploid (AA). Hybrid triploid AAB is generated by mating tetraploid *Musa acuminata* (AAAA) with diploid *Musa balbisiana* (BB).

The center of origin and propagation routes of banana have not yet been completely identified, but Simmonds et al. have drawn up a diagram to illustrate the centers of origin and diversity of cultivars. It suggests the following hypotheses: the origin of *Musa acuminata* diploid AA is located around the Malay Peninsula; East African coastal areas and New Guinea together comprise the second center of diversity of cultivars; Malaysia is also a center of diversity of *Musa acuminata* autotriploid AAA, with East African highlands being the second center; hybrid AB is a small group that originated in India; AAB originated mostly in India, and one genealogy originated in eastern Malaysia, spread to the Pacific Islands and diversified there to derive numerous cultivars; ABB also possibly originated in India with some cultivars from eastern Malaysia [30) ].

Although Simmonds, for no apparent reason, undervalued the existence of triploid *Musa balbisiana* (BBB) in the Philippines, certain researchers appreciated the Philippines as the origin of hybrid genome types where many unique cultivars of the types of ABB and BBB are distributed and wild species of *Musa balbisiana* grow. [21)]

The results of past studies on the history of hybrid bananas can be summarized as follows: AAB and AB might have originated in India; ABB, in India and the Philippines; BBB, also in the Philippines. In other words, *Musa acuminata* (AA) was domesticated in the areas around the Malay Peninsula, then hybridized with *Musa balbisiana* (BB) in the Philippines and in India, and then spread westward toward Africa and eastward toward the New Guinea and the Pacific Islands, and to all the humid tropics and subtropics of the Old World before the "discovery" of the

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These researchers emphasize the essential role of tetraploid as the intermediary for derivation of various hybrid varieties. [21)] Alternatively, another view argues that the triploid genome type (AAA) was generated by abnormal meiosis in crossing of acuminata diploids (AA). This view has been adopted in many textbooks. [4) 7) 29)] It is based on the fact that the occurrence of wild tetraploids is very rare. The diploid BB is supposed to have been domesticated while maintaining fertility and ability of bearing seeds, from which BBB was generated in a manner similar to either one of the hypotheses proposed for triploid acuminata AAA.

New World.[5] Moreover, after the Age of Geographical Discovery, diverse cultivars were brought to South America principally from Central Africa and West Africa.

In addition to these bananas, Fe'i banana is grown in eastern Indonesia, New Guinea and the Pacific islands. There were certain areas in the Pacific islands where Fe'i banana played an important role.

Among bananas of the same genome type, diverse variations in characters are observed. As the term for a group of classification that is stable genetically and has established agronomic status, "cultivar" is employed, and the group of cultivars that has been classified by Simmonds et al., based on the similarity of characteristics, is denoted as "cultivar group (subgroup)". As well-known subgroups, there are Mysore (AAB) and Bluggoe (ABB), etc. as well as Cavendish and Gros Michel. Subgroups range from those recognized as having diverse variations to those with very few variations. When the distribution of banana on a global scale is considered, the distinction by individual cultivars as the unit of classification is too narrow and therefore genome types and subgroups make effective units for analysis. Table 1-1 shows subgroups currently recognized widely in the world.

In the meantime, people who have cultivated and utilized banana for a long time have distinguished different types of banana and given specific names (vernacular names) to them by recognizing delicate differences in morphology, taste and maturity period. In such a case, "cultivar" is used as the traditional classification unit that people involved directly with production and consumption have differentiated and named. Hence, "cultivars" reflect cultural characteristics of different cultures of banana cultivation.

Incidentally, the description of species, genome type, and cultivar family differs greatly for each paper and author. In this paper, we have used the description of species and genome type [6] reported by Simmonds et al. [29)] For the description of

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[5] A certain paper of recent publication argues that the center of origin is the zone covering New Guinea, Indonesia, and the Philippines. [15)]

[6] The hybrid strains are sometimes described as Musa x paradisiaca. [38).]

cultivars, we have adopted the nomenclature based on the conventional classification of local people.

### 3) Distribution

Regarding cultivar groups for export and table banana, Gros Michel among AAA dominated the international trade as a cultivar group for export in the early half of the 20$^{th}$ Century. However, the cultivar suffered from devastating damage due to the fungal Panama disease and was replaced by Cavendish that has continued to dominate the market since the latter half of the 20$^{th}$ Century

Meantime, with respect to bananas for self-sufficiency and local consumption, the distribution of cultivars and cultivar groups is rather complicated, and in certain cases so much so that the composition differs greatly even between two neighboring localities. According to the results of surveys conducted by the study group of "Banana Researchers Network of Japan", it has been revealed that in Asia the composition of cultivars by genome types varies within the same country or between two neighboring islands [13)] (Fig. I -2).

Rough description of the distribution of genome types of banana is as follows:

In the zone stretching from Southeast Asia to East African coast, cultivated bananas include a wide range of genome types, AA, AAA, AAB, AB, ABB, BBB, BB, etc. Instead, the number of cultivars or cultivar groups belonging to a specific genotype found in an area is small. On the contrary, in the interior of Africa, we are able to observe a completely different pattern of distribution of genotypes.

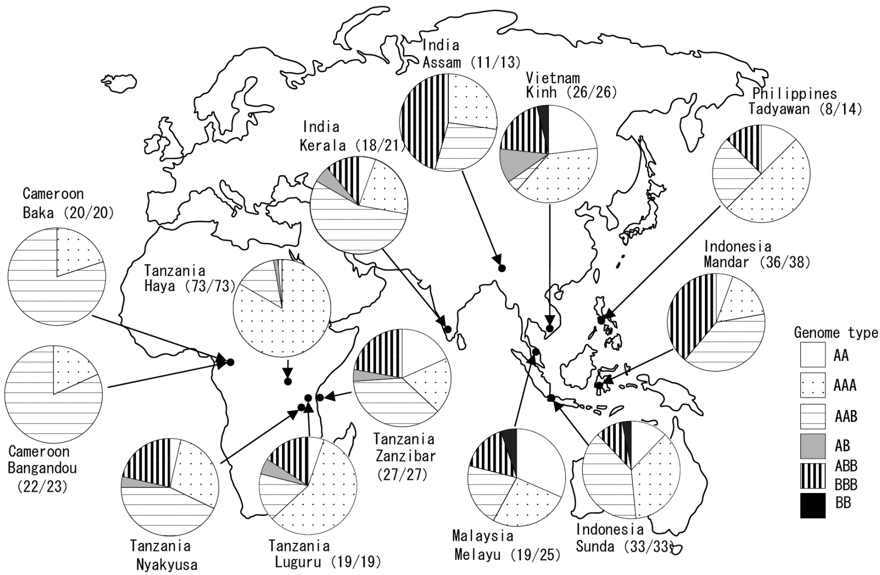
In the East African highlands, the cultivars of cooking type with the triploid *Musa acuminata* AAA genotype account for a high proportion. These cultivars of cooking banana are of a type specific to this area that cannot be found in other areas such as Asia, and called "East African Highland banana (AAA-EA)". This classification shall be described in more detail in the following section. In Central and Western Africa, cultivars are uniquely composed of those of plantain type of the AAB hybrid, with the presence of many plantain banana cultivars found only in this area. The cultivars of this subgroup are characterized by traits such as slender arched fruits and further regrouped into three secondary subgroups, namely, Horn plantain, False Horn plantain, French plantain[30], or into four secondary subgroups by adding French Horn type. For further details, please refer to Section 3 of the present chapter.

Incidentally, the term "plantain" as a unit of classification is used in dual senses. In the case of its usage as a general term, it is often employed to signify cooking bananas (as in the case of referring to a commodity group as "banana and plantain"). On the other hand, like in the preceding paragraph, it is sometimes used to represent the subgroup of banana species possessing the genome type of AAB.

**Table I-1 Well-known cultivar groups**

| AA | AAA | AAB | AB | ABB |
|---|---|---|---|---|
| Bande | Cavendish | Maja maoli | Ney Poovan | Bluggoe |
| Mjenga maua | Dwalf Cavendish | Mysore | | Pisang awa |
| Mhali hali | Giant Cavendish | Pisang kelat | | |
| Paka | -Grain nain | Pisang raja | | |
| Palembang | -Umalog | Plantain | | |
| Pisang jari buaya | -Pisang masak Hijau | -Horn Plantain | | |
| | -Robusta | -French Plantain | | |
| Pisang lilin | Gros michel | | | |
| Pukute | -Freehill | Pome | | |
| Sikuzani | -Glengoffe | Silk | | |
| Sucrier | -Highgate | | | |
| Tongat | -Pink Jamaica | | | |
| Zahala | -Plantain Jamaica | | | |
| | Red | | | |
| | Green red | | | |

Source: INBIAP information/internal document of document service




Designations below country names represent those of ethnic groups or localities.
In parentheses, right figures for total numbers of cultivars, left for numbers of cultivars excluding those of unknown genome types or with two candidate genomes.

**Fig. I-2 Proportion of numbers of cultivars by genome types in different areas in Asia and Africa**

Source: Komatsu et al. 2006

There are several arguments with regard to the history of banana's arrival in Africa. Many scholars agree on the view that it arrived there in waves at several separate occasions. The points of disagreement among them concern, firstly the question on route of arrival, namely, whether the point of entry was in Northern Africa like Ethiopia, along the Eastern African coast, or in Madagascar after arriving from Indonesia, and secondarily the question on the timing and manner of arrival, namely when and in what sequence the entry at those locations took place. Many scholars believe that banana first arrived in either East African coast or in Northeastern Africa such as Ethiopia and afterward spread to other areas, in which firstly plantain bananas with the genotype of AAB migrated from East Africa to

Central and West Africa, and later the ancestral races of East African Highland bananas arrived and spread.[7]

## 2. East African Highland banana

### 1) Classification

(1) Morphological classification

East African Highland bananas (AAA-EA) are classified as a subgroup of the autotriploid acuminata (AAA) and distributed over humid areas in East African highlands (Great Lakes Region of East Africa). This subgroup has been traditionally referred to as Lujugira-Mutika (subgroup). This has been because Shepherd placed these cultivars in two sets of the botanical taxonomy, i.e., Mutika in which a bunch hangs, has fingers relatively large and the apical part maintains bottleneck form at maturity, and Lujugira in which the fingers are short and the apex does not have bottleneck form. [26)] In this report it is denoted as AAA-EA hereafter.

Among cultivars in the subgroup of triploid AAA, other well-known cultivars include Cavendish, Gros Michel, and Green-Red, as presented in Table I-1 [4) 30)].
As characteristic differences in appearance of AAA-EA in comparison with these cultivars, the following 5 sets of morphological description can be cited:
① The surface of pseudostem is glossy and the basal part of petiole is covered with an extremely large number of blackish or brownish speckles due to pigment; ② the leaf blade is broad and colored in dark-green; ③ a large number of tears occurring along lateral veins are observed; ④ the bracts of male buds are colored in brownish purple; ⑤ anthers of stamen (pistil) are colored in pink. Incidentally, the fruit flesh is in a color between milky white and brown, smooth and sticky to touch, and turns to yellow when cooked. In the use as food, while other cultivars in the same subgroup are mostly consumed as table banana, AAA-EA banana is cooked and consumed as the staple food or processed into an beer or spirits (except in the Western Ethiopia where it is eaten fresh).

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[7] Rossel has reviewed and summarized systematically these hypotheses. [24)]

One of the principal factors to determine the distribution of this subgroup is altitude. All of major growing areas are located at an altitude of between 1,000 m and 2,000 m. It is distributed in vast areas lying across many borders, specifically: Eastern, Central and Western Uganda; Western and Central Kenya; in Tanzania, areas around Lake Victoria in the Northwest, around Lake Tanganyika – Lake Malawi in the South, and Mountains in the North; the almost whole of Rwanda and Burundi; Eastern Democratic Republic of the Congo; and Southwestern Ethiopia (Fig. I-3).

Variations among cultivars within the AAA-EA are great, and particularly a wide range of variation can be observed in inflorescences. For instance, the apical part of fingers varies from that with a bottleneck form to that with rounded shape, the fruit length from approximately 5 cm to 30 cm, and the bract color varies from red, yellow to one approaching green-yellow, while brownish purple prevails mostly[10]. Since no plant that possesses the same morphological characteristics as those in AAA-EA has yet been identified in other parts of the world, it is assumed that the existing variations have developed as a result of the early introduction of a limited number of original plants from other areas and the subsequent somaclonal mutations repeated over the years, and not by the initial introduction of a large number of different types of plants from other areas which have remained as they are in the inland highlands of East Africa. This is the very reason

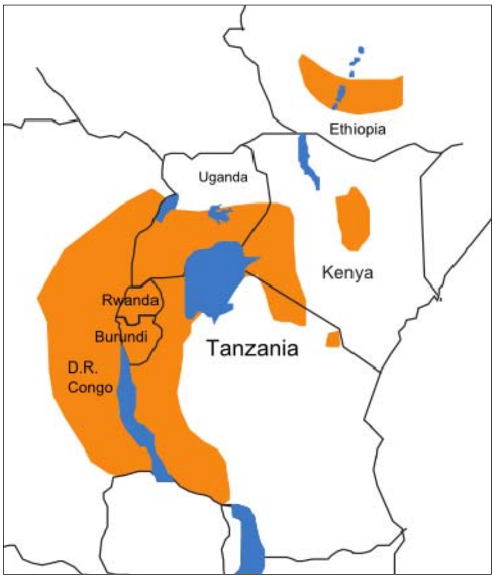



**Fig I-3 Distribution of AAA-EA**

Source: Modified by Y. Sato based on Karamura et al. 1998 why this area is called the second center of diversification of banana.[30)]

The subgroup AAA-EA is multiplying morphological variations in a complex manner, and the manifestation of those characteristics occurs often under the influence of natural environment. Moreover, in a multitude of languages, the variations are called by different local cultivar names. Consequently, it had been extremely difficult to identify “the identical cultivar with different names” and to distinguish between “different cultivars with the same name”, and hence the taxonomy for the subgroup of AAA-EA had remained an unresolved scientific subject for many years. However, as a result of the research efforts by Karamura in which she described morphological characteristics of 61 traits respectively for 238 strains of the subgroup preserved under cultivation by farmers and the National Agricultural Research Institute in Uganda, on which she conducted a multivariate analysis, it has been revealed that those strains can be classified into 84 clones and they apparently constitute 5 distinct sets. Karamura postulated an intermediate level between subgroup and cultivar and referred to it as “clone-set”. [10)] Namely, a taxonomic system comprising 4 classification levels, genome type (AAA), subgroup (AAA-EA), clone-set, and clone (cultivar), was proposed. In recent years, studies are being carried out, based on this proposed classification system, to clarify the characteristics of various cultivars in different countries in East Africa and to verify the appropriateness of the system.

Table I-2 lists the traits that were effective for differentiating clone-sets and cultivars, among those adopted by this analysis. The table shows that the useful traits for classification of clone-sets include 11 of those for describing female inflorescence, 5 for male inflorescence and 3 for other plant organs. Furthermore, for the classification of cultivars, i. e., lower level to clone-set, 7, 3, and 6 traits respectively for female inflorescence, male inflorescence, and other plant organs, are of practical value. Since most of these variations cannot be found in other parts of the world, measures have been taken to add 12 items as particular traits applied in the case of AAA-EA in the unified descriptive items for banana in the documents prepared by international research institutions.9) [8]

For the 5 clone-sets, the nomenclature using names of typical local cultivars in

**Table I-2 Traits and characteristics used in classification of clone-sets and varieties of AAA-EA**

| Traits | Characteristics | Useful for classification of clone-sets | Useful for classification of cultivars |
|---|---|---|---|
| Plant height / circumference length of pseudostem | — | | ○ |
| Sap color | Watery/milky | ○ | ○ |
| Sap dripping | drips/does not drip | ○ | ○ |
| petiole backround color | watery green/green/other | | ○ |
| Anthocyanin of petiole | throughout ventral side/ confined to margins/absent | | ○ |
| Petiole length/width | — | | ○ |
| Leaf tip twisted | Present/absent | ○ | |
| Bunch orientation | sub-horizontal/ oblique/other | ○ | |
| Bunch shape | Round/cylindrical//rectangular/truncated | ○ | |
| | | ○ | |
| Bunch compactness | Very compact/compact/lax | ○ | |
| Finger orientation in bunch | strongly recurved to touch rachis/ less strongly recurved/ perpendicular to rachis | | |
| Color of unripe pulp | White/cream/orange-brown | ○ | ○ |
| Color of ripe pulp | White/cream/orange-brown | ○ | |
| Brown sticky excretions in pulp | Present/absent | ○ | |
| Astringency/bitterness of pulp | Present/absent | ○ | |
| Finger apex shape | Round/round to bottle-necked /bottle-necked | ○ | ○ |
| style on finger apex | Present/absent | ○ | ○ |
| type of persistent style on finger apex | Fresh/dry/other | | ○ |
| persistence of stamen | Present/absent | | ○ |
| Cracks on fingers | Present/absent | | ○ |
| Finger shape | Round/rectangular/triangular/ gourd-shaped/slender | ○ | ○ |
| Male bud | Present/absent | ○ | |
| persistence of neuter flowers along rachis | Present/slightly present /absent/other | ○ | ○ |
| Shape of male bud | Elliptical/lanceolate/oblong/ cordate/ovate/other | ○ | ○ |
| waxiness of male bud | waxy/intermediate/non-waxy / other | | ○ |
| Apex of male bud | Pointed/ round | ○ | |
| Bract imbrication | Present/ absent/ other | ○ | |

Source: Created by Y. Sato based on Karamura 1999

[8] "Descriptors for banana (*Musa* spp.)" were first published in 1996, and this addition was made after that.

Ugandan vernacular ganda, has been adopted, i.e., Mbidde, Musakala, Nakabululu, Nakitembe and Nfuuka. Roughly described characteristics of different clone-sets are as follows. [36)]

① Mbidde clone-set

While this resembles other clone-sets in appearance, fruits taste astringent and bitter when ripe. People distinguish it from other clone-sets by the difference in its use, for it is used uniquely as raw material for processing alcoholic beverages and juice, while others are used for preparing the staple food. Examples of cultivars include Namadhi, Nalukira, Entanga Engambani, Engumba, Oruhuuna, and Katalibwambuzi.

② Musakala clone-set

A fruit bunch as a whole is large, and fingers are arranged sparsely in it. It is most preferred commercially. Examples of cultivars include Muvubo, Musakala, Mayovu, Mudwale, Muturit, Lumenyamagali.

③ Nakabululu clone-set

Fingers are short and arranged densely in a bunch. Bunches are small but mature early and fruits taste good. Examples of cultivars include Nakabululu, Kazirakwe, Butobe, Mukite, Bifusi.

④ Nakitembe clone-set

Fingers are medium in size and arranged densely in a bunch. It is preferred commercially. Fruits mature early and taste good.

Examples of cultivars include Nakitembe, Mbwazirume, Nakitembe Nakamaali, Nakitembe Nakawere, Nalwera, Waikova, Enjagata, Nasaala, Oruhuuna.

⑤ Nfuuka clone-set

Fruit fingers are arranged densely in a bunch and medium in size. Fruits mature late and the taste is not so good. Examples of cultivars include Entukura, Nassaba, Nzirabushera, Entazinduka, Nakinnyika, Enyeru, Lusunna Kasenene, Namakhumbu, Bukumu, Nambokho, Enyamakazi.

Table I-3 summarizes the characteristics of these clone-sets.

Moreover, in addition to the utility as criteria for describing appearance and taste, the effectiveness of the classification by clone-sets has been recognized for describing other traits. For example, the ability for bearing fertile seeds differs greatly from one clone-set to another. The results of a laboratory experiment in which Calcutta 4, cultivar of acuminata diploid (AA), was crossed with the cultivars of AAA-EA have revealed that the combination with Nakabululu and Nfuuka clone-sets produced seeds at a rate higher than 50 %, but in the crossing with other clone sets, it was difficult to obtain seeds and in the case of that with Nakitembe no seed was produced. [40] Thus it is expected that future studies will demonstrate that the classification based on morphological characteristics corresponds with that based on a multitude of other plant properties as well.

**Table I-3 Traits of clone-sets of AAA-EA**

| Clone-set | Finger | | Bunch | | Male bud | |
|---|---|---|---|---|---|---|
| | Astringency/bitterness of fruit flesh | Shape of apex | Orientation | Compactness | Persistence of bract | Orientation of floral axis |
| Mbidde | ○ | Round | Sub horizontal - pendulous | Lax - compact | (Unknown) | Sub horizontal - pendulous |
| Musakala | × | Bottlenecked | Pendulous | Lax | × | Pendulous |
| Nakabululu | × | Round | sub-horizontal | Very Compact | × | sub horizontal |
| Nakitembe | × | Intermediate | Oblique | Compact | ○ | Oblique |
| Nfuuka | × | Intermediate | Oblique | Very compact | × | Oblique, sigmoid |

Source: Created by Y. Sato based on Tushemereirwe et al. 2001

Katalibwambuzi （Mbidde clone-set）

Lumenyamagali （Musakala clone-set）

Bifusi （Nakabululu clone-set）

Mbwazirume （Nakitembe clone-set）

### (2) Molecular biological studies and taxonomy

Molecular biological studies on the taxonomy and lines of AAA-EA have been conducted since the 1990s. Studies have been carried out for the comparison between the morphological classification and that based on gene analyses by means of RAPD and/or AFLP methods.

Pillay et al. conducted a cluster analysis on 29 lines belonging to AAA-EA by applying RAPD (Random Amplified Polymorphic DNA) method, to evaluate its genetical diversity. The result demonstrated that the genetical diversity of the subgroup as a whole is low and that RAPD method can be applied for identifying differences among cultivars. Moreover, the result confirmed that the analyses were not able to establish clearly the genetical differences between cultivars used for brewing and those for the staple food, suggesting that there might have been genetical exchanges between the two cultivar groups.[23)]

Entamakazi (Nfuuka clone-set)

**Photo I-2 Five clone-sets of AAA-EA** Credit: Y. Sato

Tugume et al. applied AFLP method for the analyses on genetical diversity and classification of chloroplast of 115 lines preserved and managed by the National Research Institution of Uganda.[34)] Firstly, it was confirmed, as in the case of RAPD method, that the relationship between different lines is close genetically. Then they applied the results, from the viewpoint of genome composition, for evaluating each of the aforementioned five clone-sets identified by the classification based on analyses of morphological diversity. The study revealed the situation that, while the morphological classification and that based on genetical differences roughly overlap each other, they still lack complete correspondence to each other.

For example, while in morphological relationship Musakala clone-set is the most distant from Mbidde clone-set uniquely used for brewing purposes, the banana lines for brewing cannot be distinguished from those used as the staple food according to the analyses by AFLP method, both clone-sets not making up two distinguishable distinct sets. Moreover, AFLP analysis showed that the relationship between Musakala and Nakabululu was the most distant, suggesting that the analysis reflected more intensely such morphological traits as fruit finger length and density. The fact that the genetical analysis resulted in showing low diversity, in spite of the presence of high morphological diversity, provides many suggestions with respect to the origin of AAA-EA and the mechanism of its diversification. As a factor for variations, the existence of retrotransposon can be assumed.

Recently, molecular biological studies on a Tanzanian cultivar, Muraru, assumed to be close kin to AAA-EA, are underway by Onyango et al. [2] The progress of the research is hoped for from the viewpoints of contribution to the knowledge on the origin of AAA-EA as well as the potential for application to varietal improvement of AAA-EA.

**2) Distribution and diversity**

Although East African Highland bananas cover a wide area of distribution in inland regions, neither the cultivars of their origin, their characteristics, nor the routes of their transmission at an early stage have been identified. While in the case of plantains, there was a strong likelihood that historically there were "waves" of transmission at several occasions from Asia to Africa, in the case of AAA-EA, it was also likely that it arrived in Africa only once. In archeological terms, through methodology of historical linguistics, it is estimated that at least as early as the 10$^{th}$ century, banana was already being grown in the area lying from Uganda to Tanzania [25]. Moreover, through the analysis of phytolith (silicate bodies of glass components accumulated in cell tissues) found at archeological sites, it is being revealed lately that bananas already existed in Uganda in the ages before Christ.[19] However, theses methods do not allow the identification of genome types or specific subgroups. In order to advance the research in this area, it is necessary to purse a comprehensive approach integrating the research results in ethnobotany as well as those of comparative gene analyses of bananas cultivated currently in different regions.

The distribution of AAA-EA subgroup varies within the East African highlands and the number of cultivars differs from one area to another. For example, regarding Uganda, Tanzania and Rwanda the numbers of cultivars have been reported as follows:

① Uganda

With respect to AAA-EA, Uganda has the largest number of cultivars, along with Tanzania. In the initial analysis by Karamura, more than 200 lines were examined, but as a result of her team's subsequent investigation and observation based on field collection and interviews covering vast areas within the country, a total of 95 cultivars including 82 AAA- cultivars, in which an identical cultivar with different names was counted as one, have been identified. [6]

② Tanzania

According to the survey by Maruo, in the villages of ethnic group of Haya, 72 banana cultivars were confirmed in a village, out of which some 60 cultivars were of the AAA-EA type.[20] The result of a study conducted by the same procedures as those in Uganda, confirmed the existence of a total of 107 cultivars including 82 AAA-EA cultivars.[5]

③ Rwanda

According to Nsabimana, cultivars of bananas classifiable into genome types of AA, AB, AAA, AAB, and ABB are cultivated in Rwanda, and apparently they, except those of AB and AAA types, have been introduced there relatively recently. The breakdown by clone-set of AAA-EA lines collected and preserved by Institut des Sciences Agronomiques du Rwanda (ISAR) is as follows: 21 cultivars for Mbidde, 5 for Musakala, 8 for Nakabululu, 8 for Nakitembe, and 13 for Nfuuka[22].

Incidentally, the border line between the zone of cultivation mainly of AAB plantains and that mainly of AAA-EA bananas corresponds to the western fringe of the Great Rift Valley lying dozens of km away to the west from the border between Rwanda and the Democratic Republic of the Congo and that between Uganda and the latter.

## 3. Plantain subgroup

### 1) Classification

(1) Morphological classification

Plantain is a subgroup of hybrid triploid AAB bananas generated by hybridization between *Musa acuminata* and *Musa balbisiana*. Plantain is distributed widely over the world from Asia, Africa to Central and South America, constituting the largest cultivar group among AAB bananas.

The center of origin of plantain is presumed to be Southern India. The presumption is based on the fact that the area is the only zone in Asia where a great diversity of AAB bananas is observed (although the extent of diversity is very much smaller than that in Africa)[30]. In Kerala State in southern India, a French plantain cultivar called Nendraka is the most important one and used for preparation of a variety of dishes (the classification of plantain bananas shall be described later)[13].

The indicator characteristics that distinguish the plantain group from other AAB bananas are the conditions that the color of compound tepal, a part of male flower ranges from yellow to orange, the male axis is absent, or if present, it is covered with bracts or flowers (or their vestiges), fingers are slender and angulated, and that the fruit flesh, even when it is ripe, is starchy and inedible without cooking[30]. However, since these criteria are not absolute ones and there are cases of exception, they may have to be considered only as general characteristics. For example, there are certain cultivars in which the color of male bud disappears when they are grown at a high elevation, or those having fingers without slender appearance[24]. Nonetheless the majority of plantains has common characteristics in the elements constituting the cluster (male axis, flower, bract, finger, etc) and can be recognized at a glance.

Plantain group has a diversity of characteristics in the cluster structure and the morphology and size of fingers, and hence comprises a multitude of cultivars. Consequently, it is classified into a number of groups. The classification conventionally used and practiced still widely at the present time is that based on the extent of development (or degeneration) of male axis, flower and male bud. These parts may be the most impressive elements when one looks at plantains.

Simmonds in the beginning classified plantains largely into two groups[20]. They were French plantain and Horn plantain. The male axis in French plantain does not fall and is normally covered with the vestiges of male flowers and bracts. Meanwhile, Horn plantain lacks male axis at maturity or loses it at an early stage (naturally no male bud present either). Subsequently, it became known that those which had been assumed to belong to Horn type plantain group included different types, and the group of cultivars retaining only neutral flowers became to be called False Horn plantain. Later on, researchers have recognized a plantain group falling in an intermediate place between False Horn type and French Horn type, and nowadays it is classified as French Horn type [5]. These four groups currently constitute the general classification of bananas of plantain group. The differences of the four groups are summarized as follows[16][24].

① French type

At maturity, an inflorescence becomes complete. Compared with plants of other plantain groups, fingers are smaller and their number is larger. The inflorescence bears a multitude of neutral flowers and has a large and persistent male bud (consisting of male flowers and bracts).

② French Horn type

This type is characterized by the growth development in which the male bud dies off before maturity, and the entire inflorescence becomes incomplete. It bears fingers resembling those of French type but they are a bit less numerous and larger in size. Besides, it bears less numerous neutral flowers than French type.

③ False Horn type

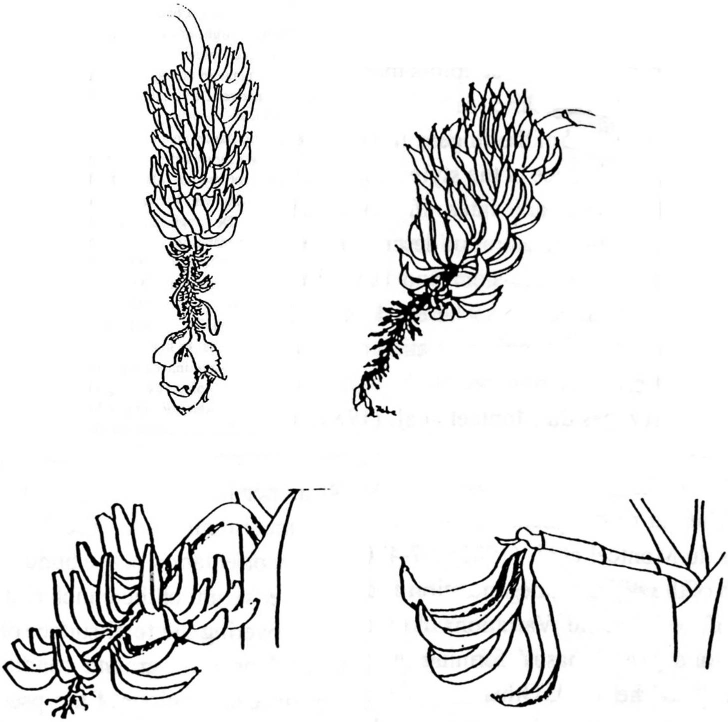
Like French Horn type, a part of male axis and male buds die off before maturity, the entire florescence becomes incomplete, but the number of fingers are smaller and their size is larger than in French Horn, and neutral flowers are less numerous than in French Horn..

④ Horn type

At maturity, male axes, male buds, neutral flowers disappear completely. Moreover, compared with other types of plantains, the plants bear less numerous but larger fingers.

To summarize succinctly, the inflorescence varies from complete one to incomplete one (reduction of male axes and flowers), and from one with numerous small fingers to one with few large fingers, in the order of types from French, French Horn, False Horn, to Horn. One is able to make with a certainty the differentiation between French type plantains having the complete inflorescence and Horn type plantains thoroughly lacking in male axes and flowers at maturity. But as for French Horn type plantains and False Horn type plantains, the trait of incomplete inflorescence is the matter of degrees and hence continuous. Fig. I-4 is a diagrammatical representation of these characteristics.

The author would like to show pictures of some of actual bananas (Photo I -3). These are: Mzuzu, French Plantain type cultivar in Zanzibar, Tanzania; Bai, False Horn type cultivar of East Region in Cameroon; Mkono wa tembo, a Horn type cultivar in Zanzibar.

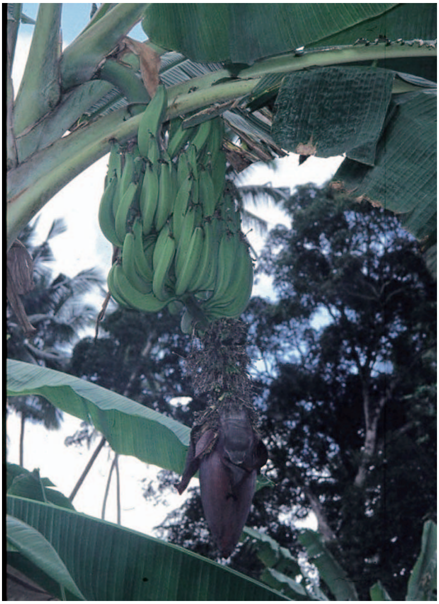


Upper left: French, Upper right: French Horn,

Lower left: False Horn, Lower right: Horn

**Fig. I-4 Fruit clusters for different types of plantain bananas**

Source: Tezenas du Montcel 1987



Mzuzu (French type, Zanzibar)

Bai (False Horn type, East Region, Cameroon)

Mkono wa tembo (Horn type, Zanzibar)

**Photo I-3 Clusters of different types of plantain**

Credit: K. Kitanishi

In the classification of plantains, the plant size is also an important criterion. Plant sizes are classifier into three groups, large, medium and small. However, it is difficult to apply this classification to actual field work conducted in rural areas, since the same cultivar expresses different sizes depending on the differences in growing environment. For example, Langhe et al., 2005, classify the height of pseudostem at flowering into three ranges: shorter than 320 cm; 320 cm to 370 cm; and taller than 370 cm. [16] On the other hand, De Langhe, 1964, adopted the ranges around 225 cm, 275, and 350 cm [14], and Tezenas du Motcel, 1979, used those, shorter than 400 cm, 400 cm to 500 cm (around 450 cm), and taller than 500 cm. [31] Although the classification based on actual height of pseudostem may be possible when different cultivars are planted on the experimental plot with identical conditions (this applies to the above-mentioned studies), it is difficult to apply the same criteria to studies conducted for actual fields with variable conditions in diverse geographical areas.

A practicable criterion likely to be applied to field work is the number of leaves developed by the stage of flowering which shows a high correlation with the plant height in experimental plots[16]. Moreover, the number of developed leaves is a trait relatively stable under variable environmental conditions [24]. While the criteria based on the size, i. e., large-medium-small, differ delicately depending on papers, they approximately correspond to those of the number of leaves as follows: more than 40 (or 42) ; 38 (or 40) to 32; and less than 30.

It is known that, for each of the above-described 4 types of fruit clusters, plantains of 3 different classes of plant size exist [16]. Other traits used for classification include the pseudostem colors, the shapes of finger apex, and the cluster orientation, etc.

(2) Molecular biological studies and classification

In recent years, studies on DNA of bananas have been started. It has been proved that the plantain bananas can be clearly distinguished from other groups of bananas by means of RAPD technique.[8] On the other hand, the above-described classification systems based on morphological characteristics (inflorescence and plant size) seemingly do not agree unequivocally with the classification based on genetical differences. The studies by Crouch et al have shown only very little correlation between the differences by cultivars of plantain and the morphological classification of them, suggesting the existence of great diversity in the domains of genes that affect scarcely the cluster type and the plant size.[3] Furthermore, the studies by Ude et al. has shown that the AFLP technique is more efficient than the RAPD as a method for identifying differences between plantain cultivars, and that the types of fruit clusters correlate slightly with the differences identified by the AFLP technique.[37] It is anticipated that the research in this area shall develop rapidly in the future.

(3) Hypotheses on the evolution of plantains

There is a commonly accepted theory concerning the evolution of plantains that have such a morphological diversity. According to the theory, it is believed that the original French type had undergone the changes in which the inflorescence progressively evolved by somaclonal mutation to become incomplete one to generate the types of French Horn, False Horn and Horn in that sequence. This is called inflorescence degeneration. The evolution processes postulated by De Langhe and Rossel can be summarized as follows:

It is assumed that the ancestors of plantains in Africa had been those which were similar to the existing French type having perfect inflorescences and that they undergo the process of evolution in which the inflorescences degenerate progressively, to French Horn, False Horn and Horn type. In ensuing phases, secondary changes take place (pseudostem colors, finger apex shapes, dwarfed finger apex, finger colors, etc.) [14, 24]. As a matter of fact, certain types of plantains in which the morphology of cluster is unstable are known. Although the case is very rare, a plantain plant may change from Horn type to False Horn, then to French type, and occasionally we find more than two types of cluster in a single plantain stock (Ngego of Nyakyusa to be described later) [24]. Hence it is believed that the domain of genes determining the morphology of cluster is such one as is very liable to cause variations [39].

The study of Crouch et al. on DNA by using RAPD technique shows the following three points. First, the genetical within the plantain subgroup is quite low. Second, the genetical variation within a group becomes larger in the ascending order from French, French Horn, False Horn to Horn type. From this we can guess that French type has passed a longer period of evolution since its origin than Horn type, in agreement with the hypothesis of degeneration of inflorescence. Third, the classification into three groups by plant sizes of plantains does not seem to be able to suggest the path of evolution, since the extent of variation within each group does not differ from one group to another.[3] From these three points, it is suggested that although the appearance of plantain subgroup plants, especially cluster structure seems to be various, they are comparatively uniform in genes except the domain of genes determining the morphology of cluster, that the present plantains are derived from a small number of clones through the process of the inflorescence degeneration, and that the groups of different size are likely to be diversified separately.

**2) Distribution and diversity**

Plantains are distributed widely in Africa from East Africa, Central Africa to West Africa, but the types and the number of their cultivars differ from one area to another. To describe briefly, the contrast between Central Africa characterized as the zone with multitudes of types each of which comprises numerous cultivars and East Africa with a limited number of types each of which comprises only a few cultivars. West Africa could be considered as a zone with a situation similar to that of Central Africa, but since documents with quantitative data were not available, the author does not speculate on it here.

(1) East Africa

In East Africa, except for a limited number of areas, no agriculture is practiced based on plantains as the main crop. Since the diversity of plantains is due to somatic mutations, the variations are likely to occur more frequently where bananas are grown abundantly, and the relative scarcity of cultivars in East Africa may be attributed to this fact. In East Africa the plantain of cluster type of French, medium type in size, and the pseudostem color in green is found most abundantly over the entire region and contains the largest number of cultivars, followed by the plantain with the type of Horn, medium and green. The type of False Horn is distributed only to a limited extent, and French Horn type is not found[24) 9].

Rossel has divided East Africa into three zones depending on the diversity of plantains. The zone ① includes coastal areas of Kenya, Tanzania (excluding Zanzibar and Pemba) and Somalia where only two plantain groups, French-medium-green type and Horn-medium-green type, are found. The northeastern Kenya and Somalia are generally arid and hence not suited for growing banana, but it is reportedly cultivated by exploiting riverside forests[24)].

Although Zanibar is included geographically in the zone ①, it is a peculiar area where False Horn type is found. Maruo and Kitanish have conducted a field survey there[13)]. The island belongs to the Indian Ocean complex zone according to the classification of De Langeh et al. [17)] where diverse genome types are distributed, and resembles Asia. In particular, several kinds of banana of genome types of AAB other than plantains are found. Bananas are grown in home gardens and permanent arable lands in mixture with other crops. However, the level of importance of banana is lower than rice and cassava. Among different types of bananas, plantains, in particular a cultivar of French type called Muzuzu (Photo I – 3), are cultivated fairly widely, but in spite of it, they do not necessarily exceed other genome types of bananas in importance.

Seven cultivars are found, comprising 3 of French type, 2 of False Horn type, and 2 of Horn type. Zanzibar has been since early the center of international communication and as a result of exchanges with people from various origins, False Horn Plantain bananas could have been imported. During our survey, we

[9] Rossel 1998, adopting the three traits, i. e., cluster structure, plant size, and pseudostem color as the principal criteria together with other subsidiary traits, classified plantains and analyzed their distribution and the numbers of cultivars.

happened to meet a person who had imported a new banana cultivar from Rwanda. Rossel has pointed out the historical fact that Britain had made banana collection in Zanzibar in the 1880s, and in Entebbe, capital of Uganda, in 1902, and the possibility of the introduction of False Horn type to Zanzibar as a consequence of the British activities of banana collection[24].

The zone ② extends from the center to the west of Tanzania and to Malawi. Here, in addition to French type and Horn type, the unstable Horn type (it sometimes mutates to False Horn type) is found[24].

The people of Nyakyusa in southwestern Tanzania practice the agriculture based principally on plantain bananas that is an exceptional case in this zone. According to Maruo who conducted a study on banana cultivation of Nyakyusa, banana is cultivated in mixture with other tree crops for earning cash income such as coffee in the permanent home gardens where a total of 28 banana cultivars including 12 plantain cultivars were observed. A French Plantain cultivar called Ittoki sege, is the one that was cultivated most frequently[13]. As far as the observation of photographs of fruit clusters taken by Maruo is concerned, eleven cultivars out of twelve are of French plantain type bananas, and one is of Horn plantain type (cultivar name is Ngego). However this Horn plantain type banana seems to include also unstable lines, since the photographs of fruit clusters show under an identical cultivar name the plantains of different types ranging from those of typical Horn type to those of False Horn or French type. Rossel also describes Ngego of Nyakyusa as a cultivar of unstable Horn type[24]. There plantains are consumed for cooking in general but used also for brewing. Bananas mainly of plantain cultivars are shipped out in large quantity to the regional capital of Mbeya[13].

The zone ③ covers Uganda and the northwest of Tanzania where plantains of False Horn type as well as those of French and Horn types are found, and is also the area with the largest number of cultivars in East Africa. Among sub-zones, the western part of Uganda has the greatest diversity, and the cultivars found there show similarities to those in Central Africa, and hence the region can be considered as a part of Central Africa in terms of culture and ecology. The linkage with Central

Africa may be a factor to explain such diversity. On the other hand, in the southern part of Uganda, very few plantains are cultivated and the number of cultivars is small, although three types (French, False Horn and Horn) are found there[24]. As described in the preceding section, East African Highland bananas, AAA-EA, are grown abundantly in many parts of Uganda.

In the northwestern part of Tanzania also, East African Highland bananas are mainly grown, but plantains are also grown, although the cases of cultivation of the latter are less frequent compared with the former. According to the study conducted by Maruo on the cultivation of bananas by Haya people, although the number is much smaller than 61 in the case of cultivars of East African Highland bananas, they still cultivate 10 cultivars of plantain. The 6 cultivars that can be observed in photographs comprise 2 cultivars of French type, 1 of False Horn type, and 3 of Horn type. Plantains are used for light meals[13].

Thus, in the eastern part of East Africa plantains are not cultivated so much and their diversity is not great (except Zanzibar). In further west the diversity of plantains increases and reaches the highest degree in Uganda (particularly in the western Uganda neighboring on the Democratic Republic of the Congo). However, the people of Nyakyusa in the west of Tanzania grow plantains abundantly and there are numerous cultivars.

(2) Central Africa

Central Africa could be the zone where there are the most diverse plantains in the world. Besides, there are many areas where people take plantains as the staple food. Rossel has studied the number of plantain cultivars in each country of Central Africa (data on Democratic Republic of the Congo, Republic of the Congo, Gabon, Cameroon and Nigeria of West Africa, Table I-4). His work concerns the classification of plantain cultivars by morphological characteristics, which is based on his own observation and the reports on plantains preserved in research institutions in Nigeria and Cameroon and those described in a certain number of published papers[24].

Figures in Table I-4 indicate that there are a considerably larger number of plantain cultivars than in East Africa. The table gives an impression that the diversity in Cameroon is the highest and that in Nigeria is low, but the adequate evaluation of the difference is difficult. Rossel himself notes that the table gives only a rough comparison of diversity for different countries. It is likely that the data vary depending on the extent of investigation and on the criteria used by an individual for differentiation of morphological types. In general, the diversity of bananas vary little between these 5 countries and the order of importance for different types is uniformly the same to all the countries, namely, French type represents the most numerous cultivars, followed by False Horn, Horn, and French Horn.

From his own field survey in Cameroon, Rossel has concluded that the diversity is great in East Region of Cameroon. In East Region of Cameroon, however, the main cultivars differ between different areas, and for example, while the prevailing cultivars in Mbang are of green Horn type, in Abong Mbang those of medium-sized and green French type with rounded finger apexes are grown more frequently. Moreover, Rossel states that the greatest diversity is observed in Moloundou Sub-division (the south of Boumba-Ngoko Division of the East Region of Cameroon) [24], the area where Komatsu and Kitanish have conducted a study on the culture of banana cultivation [13].

**Table I -4 Number of plantain cultivars in different countries**

| | F | Fr H | Fa H | H | Total |
|---|---|---|---|---|---|
| Democratic Republic of. Congo | 29 | 1 | 12 | 8 | 50 |
| Repub. Congo | 21 | 1 | 16 | 5 | 43 |
| Gabon | 27 | 3 | 16 | 3 | 49 |
| Cameroon | 35 | 2 | 11 | 3 | 51 |
| Nigeria | 15 | 4 | 13 | 4 | 36 |

F＝Frenc, Fr H＝French Horn, Fa H＝False Horn, H＝Horn

Source: Rossel 1998

Komatsu conducted a study about the people of Bangandou in the Mbateka

Village of Moloundou Sub-division. People there practice a type of shifting cultivation system growing plantain as the principal crop (refer to Chapter 2 for details of the shifting cultivation in this region). Among the 22 banana cultivars grown in this region, 18 are plantains[13)]. The cultivar that is most abundantly grown in this village is one of Horn type called Boi that matures early and develops numerous suckers [27)]. Incidentally, Shikata has conducted a detailed study on plantain cultivation in Bangandou.

Kitanishi conducted a study on an ethnic group of hunter-gatherers (so-called Pygmies) in Ndongo Village in the same Moloundou Sub-division. They used to live originally mainly by hunting and gathering, but since around 1950s, their livelihood changed progressively to agriculture-based and sedentary life, and currently they lead life passing more than half of their yearly time in settlement villages, albeit temporarily leading life of hunting and gathering in the forest, and consume plantains as the staple food just like agricultural people around them [12)]. They also practice shifting cultivation like the villagers in Bangadou and grow plantains as the main crop.

The number of confirmed cultivars is 20 for all kinds of bananas out of which 15 are plantains. Numbers of cultivars for different types are: 6 for French; 1 for French Horn (also possibility to be False Horn); 5 for False Horn; 1 for Horn; and 2 for unknown types. The most frequently cultivated cultivar is Tetendo of French plantain type (medium in size), accounting for 60 % of harvested plantains. The strait distance between Mbateca Village and Ndongo Village is about 40 km. The observed difference between them may be due to the difference in ethnic group, but the difference in the composition of principal cultivars between two locations with such a short intervening distance is very interesting.

We present some of characteristic plantains observed in Ndongo Village (for clusters and vegetative parts, refer to Photos I -4). Libele is a cultivar having a small plant body and less numerous fruits, but bearing harvestable fruits earlier than other plantains (about a year, compared to one and a half year for others). This cultivar is cultivated extensively in Cameroon, Congo and Gabon, and called by similar cultivar names [24]. The general preference for it may be due to its early maturity. Mboko is a plantain cultivar of French type characterized by arched fingers. Mboko signifies a buffalo in the local language, and the cultivar is thus named because the arched shape of fingers resembles that of a horn of buffalo.


Libele


Mboko


Ndumu


Medo


Mobili

**Photo I – 4 Plantains in Ndongo Village in the southeastern Cameroon**

Credit: K. Kitanishi

Ndumu is a plantain cultivar of Horn type characterized by slender fingers curved in a long arch. While the cluster shown in the picture consists of three hands, there is a certain type that has only one hand with less numerous but thicker fingers. Medo is characterized by a red pseudostem. Since in general the pseudostems of plantains are green with black speckles, this is very noticeable. On the other hand, the pseudostem of Moboli is almost entirely green and moreover glossy. As these descriptions show, people in this region cultivate a multitude of cultivars of plantains that have diverse characteristics in respect to not only cluster's shape and size but also pseudostem.

Ankei conducted a study on the agricultural activities of Songola people inhabiting the area around Kindu of Kivu Province in the eastern part of the Democratic Republic of the Congo [1)]. People there practice shifting cultivation in which the principal crops are cassava and plantain. Ankei cites 29 plantain cultivars in Songola as a whole. However, the number of cultivars for each subgroup ranges from 12 to 18 and is more or less similar to the number identified in the study conducted for each village in the East Region of Cameroon, suggesting the presence of the same level of diversity.

### (3) Is it "From East to West" or "From West to East"?

Hereupon let's contemplate the manner of propagation of plantains in referring to the studies of Rossel [20)]. As described in the preceding sections, the numbers of plantain cultivars are larger in Central Africa (and West Africa) than East Africa. The number of cultivars is related to the incidence of somatic mutations. If the latter is correlated to the length of period of cultivation in a particular region, the statistics on cultivars' population signify that Central Africa has a longer history of plantain cultivation and that plantains have secondarily spread to East Africa from the region. However, considering the fact that bananas have spread from Asia, such a scenario is quite unlikely. Moreover, if plantains have spread by chance from Central Africa to East Africa, those of False Horn type commonly found in the former should have spread equally to East Africa, but they are found only in very limited places there.

This situation is quite contrasting to that in West Africa or in Americas. Rossel has reviewed the reports on the plantains in Ghana and concluded that there are five cultivars of French type plantain, one of French Horn type, three of False Horn, and one cultivar of Horn type plantain in Ghana. Moreover, in Venezuela in South America five cultivars of French type plantain and four cultivars of False Horn type are found. In Columbia cultivars of types of French, French Horn, False Horn, and Horn have been confirmed. In other words, the plantains in West Africa and American Continents are considered to have originated in Central Africa. However, it is also likely that the plantains in Americas have arrived there via West Africa [24].

In short, it is difficult to assume that plantains have migrated from West Africa to East Africa, since in East Africa the cultivars found in Central Africa do not exist, while in West Africa and in Americas they are found at random. Those plantains that had arrived in Central Africa via East Africa were cultivated abundantly over an extensive area, and have undergone frequent somatic mutations out of which people in Central Africa have selected desirable lines and developed the existing diversity of plantains found there.

In East Africa, people continued to grow the plantains that had arrived there from Asia, but since the number of plants cultivated was small, the frequency of occurrences of mutation might have been lower than in Central Africa (or it might have been due to the matter of selection by people). Besides, the diverse plantains developed in Central Africa have not come across with so many opportunities to be introduced to East Africa. The existence of the East African Highland bananas might be postulated as a factor.

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# Chapter II. Cultivation and utilization of cooking bananas in Africa

## 1. General situation

### 1) Systems of cropping and utilization

The production of cooking banana in Africa is essentially practiced by small farmers on a small scale. It is grown in either home gardens or agricultural lands away from residential quarters. In the case of cultivation in home gardens, it is grown in mixture with other tree crops and/or herbaceous crops and managed more elaborately than in remote agricultural lands. Because farmers apply wastes from living as nutrients or sometimes fertilizers there, it is possible to grow continuously the crops for dozens of years in the same plots. In the Great Lakes Region like Uganda, people carry out an intensive form of cultivation by such a system to feed a dense population. On the other hand, the remote agricultural lands are essentially utilized by shifting cultivation by slash-and-burn systems, but as a consequence of recent population growth and the demographic migration to urban and suburban areas, in certain localities the necessary fallow period in the shifting cycle cannot be secured and lands are being put to continuous cultivation. Mixed cropping is the general mode of farming and the cropping system incorporating tree crops such as cacao and coffee and other crops for the staple food, legumes and vegetables is observed throughout all the regions in Africa. In particular in those areas where cacao is grown, banana plays the roles of cover plant to shade seedlings of cacao and for the production of the staple food and the income source until cacao reaches the stage for harvesting. In small scale production, essentially chemical fertilizers are not used. It is because chemical fertilizers are relatively expensive in comparison with the selling prices of products. Organic fertilizers are provided by wastes of living in the case of home gardens and by the vegetation at the end of fallow period in the case of shifting cultivation. Lately in certain parts in suburban areas of cities in West Africa, agricultural lands under continuous cropping sustained by the application of chemical fertilizers are observed.

The variations of current banana growing culture in Africa can roughly be classified into three regional types depending on the historical processes through which banana cultivation as well as cultivar groups have been accepted. In the eastern coastal zone, there is an area where every type of banana of various genome types is cultivated evenly in a small scale, which De Langhe called “Indian Ocean complex” [5]. In the area genome types are diverse similarly as in Asia, and in dietary culture banana plays only a secondary role supplementing rice or cassava. Another area is located around the Great Lakes Region that is characterized by the abundant presence of cultivars of one particular type of AAA banana called “East African Highland Banana”, a type of banana for cooking and brewing that is not found in Asia (refer to Chapter I and Chapter III). People in this area depend heavily on banana for the staple food. Uganda which shall be described in detail from the next chapter is included in this area. Finally, there is an area stretching from Central Africa to West Africa where plantain subgroup (=a subgroup of ABB genome type in this chapter) is highly developed. In this area the majority of banana cultivars are plantains for cooking, and play an important role as the staple food. In the ensuing sections, the characteristics of cultivation and utilization are described for each zone from East Africa, except the zone of East African Highland AAA, to Central Africa and then to West Africa (Fig II-1 shows the zones described in the present chapter).

**2) Production and yield by zone**

Among the African countries the one which produces the largest quantity of cooking banana is Uganda. Even in comparison with the second largest country, Tanzania, Uganda’s production is more than twice as large as that of it (Table II -1).

The Great Lakes Region which includes Uganda has a very particular agricultural culture even from a global perspective. The people living there maintain a high population density based on the intensive cultivation of banana as their staple food that they grow on home gardens under a long term regime of continuous cropping. Further details about this region shall be given in the next chapter.

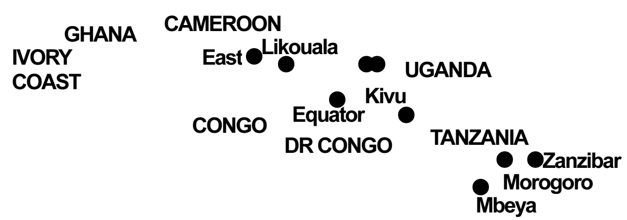


**Fig. II-1 Areas of banana cultivation described in Chapter II**

Source: created by K. Komatsu

Additionally in East Africa, in other parts of Tanzania, Kenya and Malawi outside the Great Lakes Region, a large volume of banana production is observed.

Bananas of plantain subgroup are grown in Central Africa, i.e., Democratic Republic of the Congo (hereafter referred to as DR Congo), Republic of the Congo (hereafter simply as Congo), Gabon, Equatorial Guinea, and in West Africa, in the humid areas of Nigeria, Ivory Coast, and Guinea. They are grown less intensively than in East Africa, mainly on agricultural lands under shifting cultivation regime, providing either the main staple food or a supplementary staple food.

Bananas are grown in almost all parts of humid areas, and the areas with statistics of large production include the southern part of Nigeria, Ghana, Ivory Coast, the southern part of Cameroon, and the northern part of DR Congo. In the areas as a whole where bananas are cultivated, the most important crop is cassava and it is cultivated in almost all areas except highlands.

**Table II-1 Ten leading countries of banana production in Africa in 2008**

| Country | Production (1000 ton) |
|---|---|
| Uganda | 9846 |
| Tanzania | 4100 |
| Nigeria | 2991 |
| Ghana | 2988 |
| Rwanda | 2600 |
| Cameroon | 2260 |
| Ivory Coast | 1870 |
| Kenya | 1791 |
| Burundi | 1600 |
| DR Congo | 1519 |

Source: FAOSTAT

Note: Since the definition of banana and plantain differs depending on countries, cited statistics represent the total of both categories of bananas. Excepting figures for Ivory Coast and DR Congo, values are from the estimation by FAO.

## 2. East Africa – Indian Ocean Complex

In East Africa, the areas where bananas are cultivated are roughly divided into two zones. The first zone comprises the areas where the cultivars of "East African Highland" bananas are cultivated, covering Uganda, Rwanda, Burundi and the western Tanzania. This zone shall be described in detail in the next chapter and those following it. The second zone comprises the areas, where people cultivate the group of cultivars of Indian Ocean Complex resembling those in Asia, covering the coastal areas of Tanzania and the coastal areas in the north of Madagascar, and those islands lying between the two areas including Zanzibar. Moreover, between "East African Highland" and "Indian Ocean Complex" diverse areas, each with a specific banana culture, are scattered about.

In colonial periods, bananas were produced as a commodity for self-sufficiency in Uganda, for export in Kenya, and for both export and self-sufficiency in Tanzania. In the 1940s, the banana producing countries in East Africa were reportedly Kenya, Uganda, and Tanganyika (present day Tanzania).

The following descriptions on the methods for production and utilization of cooking banana as the staple food in various parts in Tanzania are based on the reports of field surveys conducted by S. Maruo (the surveys in Zanzibar were conducted in collaboration with K. Kitanishi).[1]

① Zanzibar , Tanzania

Zanzibar has been since ancient times the entrance of trade between Arab world and Africa, where typical cultivars of "Indian Ocean Complex" are cultivated. Bananas are cultivated in home gardens and permanent agricultural lands in mixture with other crops. However, the importance of bananas in agricultural lands is lesser compared with rice, cassava or other cash crops. 27 cultivars are observed and the breakdown by genome types is as follows: AA (5), AAA (5), AAB (10), AB (1), and ABB (6).

It is remarkable that we are able to find the high proportion of hybrid lines, particularly of those bananas of AAB other than plantain subgroup that are rare in Africa and ABB types. The representative cultivars that are found in actual agricultural lands are Kijakazi (AAB), Mzuzu (AAB), Koroboi tungu (ABB), and Bukoba (ABB). The list does not agree with that based on their frequencies observed in the market of Stone Town, center of the island. Hybrid lines are often used for cooking, but the characteristic fact is that many of acuminata lines (AA, AAA) are also used for cooking, and that there are three cultivars of AAB type which are not plantains and consumed mainly as dessert bananas. Thus, as a whole, bananas are mainly consumed for cooking purposes. More often than not, rice constitutes the main ingredient of the staple food, but bananas are also consumed as such like the case of serving the boiled banana or the banana cooked in coconut milk for breakfast or light meals, or the case of preparation of a stew, one of much

[1] For banana cultivation culture in Tanzania and Bangandou people, refer to Komatsu et al. 2006 and the website of "Banana Researchers Network of Japan". (http://www.geocities.jp/banana_rnj/)

preferred regular meal items, in which boiled banana is added to stews of coconut milk, tomatoes and onions. Alcohol beverages are not brewed. Since coconut serves as raw materials for fabrication of articles for daily living, the utilization of banana leaves or pseudostems is not so frequent.

While some cultivars of dessert banana and the cultivars of cooking banana like plantains are shipped out to supply the Stone Town market, banana is generally grown for self-sufficiency purposes.

For planting banana, suckers of approximately 1 m in length are used. Recently the use of organic fertilizers such as fowl droppings has spread. Certain farmers believe that the fertilizer application can prevent diseases like Sigatoga and Panama.

**Photo II-1 Banana stew in coconut milk, Ndizi na nazi, Zanzibar**

Credit: S. Maruo

② Morogoro Region, Tanzania

Morogoro Region is located in the East of Tanzania, and Morogoro, the regional capital, lies about 200 km away to the west of Dar es Salaam, the national capital. Most residents are Luguru people. This area grows many cultivars of “Indian Ocean Complex” similarly as in Zanzibar. The bananas produced in this area are shipped out to supply the markets of Dar es Salaam, and hence farmers grow them more often for selling purposes rather than for family consumption. Bananas are grown in home gardens or on permanent agricultural lands either in mixed cropping with coconut or yautia (*Xanthosoma sagittifolium* (L.)) or as a single crop on the plot, and although the cases are infrequent, plots with a single cultivar only are sometimes observed. Suckers are generally thinned out but those of cultivars of AAB type are not thinned out. On sloped lands, one can observe plant populations which are not thinned out for the purpose of preventing soil erosion. Male inflorescences in most cultivars are not removed because farmers believe that they supply the nutrients to fruits. When a banana stump emerges above ground, the stump is replaced. The frequency of renovation is about once every three years in plantains, 10 to 20 years in AAA, and in some of the AAB type reportedly once every 50 to 100 years. While the incidence of Sigatoga disease and Panama disease is increasing, no measure against pests and diseases has been taken.

19 cultivars have been observed and the breakdown by genome types is as follows: AA (1), AAA (11), AAB (3), AB (1), and ABB (3). Among them, those which have been established since early times are said to be 9 cultivars including the principal 6 cultivars of AAA genome type. The representative cultivars are Mwanza (AAA), Mtwike (AAA), and Mzuzu, (AAB). Many of autotriploid lines of acuminata are grown as cultivars of dual usage for cooking as well as for eating fresh. The staple foods for the Luguru people are essentially rice and maize, and hence the position of banana as an item of the staple foodnot so important. Nonetheless banana is consumed as a supplementary staple food and for light meals in such dishes as fried banana or banana stew mingled with beef or beef entrails. Alcoholic beverages are brewed from banana by the Chaga people, a minority ethnic group in this region. As a luxury grocery item, there is an improved

Left: Stew of banana and beef, Ndizi na nyama
Right: Banana bread, Mkate wa ndizi

**Photo II-2 Banana dishes in Morogoro Region**

Credit: S. Maruo

chewing tobacco prepared by mixing cooking liquid of dried fruit peels of Mzuzu, a kind of plantain subgroup. The bananas produced in the studied area are purchased through periodical markets and transported to the regional capital Morogoro and the national capital Dar es Salaam. In the market, about 7 major cultivars are traded and these are bought at preferential prices 10 times as high as those for other minor cultivars.

③ Mbeya Region, Tanzania

Mbeya Region is located in the south of Tanzania and to the north of Lake Malawi, where the population density is very high. People of various ethnic groups live there among which Nyakyusa people cultivate banana as the most important crop for the staple food, only in the area at the elevation between 700 m and 1000 m. The Nyakyusa grow banana cultivars of mainly plantain types, and it is almost the only case in East Africa.

Banana is cultivated in home gardens in mixture with other tree crops for earning cash income such as coffee. It is tended elaborately by various measures of management care including mulching and the application of ashes, the removal of dried leaves and male inflorescences, etc.

28 cultivars are observed and the breakdown by genome types is as follows: AA (1), AAA (8), AAB (12), AB (1), ABB (6). Among them, those of East African Highland banana of AAA lines and plantain subgroup of AAB lines are said to have been in presence since early times. The banana with the overwhelmingly highest frequency of observation is a plantain cultivar (AAB) called itooki sege followed by kambani (AB) and gulutu (ABB). With regard to the method of utilization, while many of the plantain cultivars of AAB and ABB types are cooking varieties, many of the cultivars of AAA type are for dual usage of cooking and dessert, and, in general, the distinction of usage between cooking and dessert is not so clearly made among varieties. Until the 19$^{th}$ century, a main dish consisting of ball of sun-dried banana flour was generally served. However, the custom of consuming ball of banana flour is observed normally in West and Central Africa and very rarely in East

Africa. From the latter half of the 20th century, stews of plantain and common beans became the general custom. This manner of consumption represents the cooking technique in East Africa. In luncheonettes, fried plantain and deep-fried pork without breading are standard items.

All the cultivars of AAB and AB genotypes are also used for brewing. The utilization of banana in this locality is characterized by various kinds of floor mats woven by using fibers of petioles, for which the cultivars of ABB and AB types are utilized. Moreover, in oral tradition, banana enters not only as an item of food culture but also as the symbol of social prosperity. Large quantities of bananas mainly composed of plantains produced in the studied village are shipped out to the regional capital city Mbeya.

### 3. Central and West Africa – Plantain

Common features in the banana cultivation culture in Central and West Africa are as follows:

Cooking bananas are essentially those of plantain type;

Land utilization system is essentially that of slash-and –burn shifting cultivation;

Crop management is less intensive than that in the Great Lakes Region;

Ball-shaped staple dish processed by various ways.

Agricultural culture in Central and West Africa has essentially inherited two types of agricultural culture that had evolved uniquely in Africa, i.e., the Sudan agriculture complex of savanna type and the Guinea agriculture complex of tropical rainforest type. Having started from the cultivation of crop plants indigenous to Africa such as yams and miscellaneous minor cereals, the two types of agricultural culture later received bananas, yams and taro originating from Southeast Asia around the beginning of the Christian era, and cassava, yautea and maize from Central and South America after the 16th century to establish the existing crop complex. In parts of humid areas in West Africa, a type of agricultural culture based on the rice indigenous to Africa has developed, and also in the east of DR Congo the rice cropping culture was introduced by Arab traders after the latter half of the 19th century, and hence in these parts of Central and West Africa, there are certain areas where rice predominates in agriculture. Consequently, the current banana farming culture exists in equilibrium with these crop species that differ from one area to another.

In these areas, we can recognize three patterns for banana cultivation. The most important one is the mixed cropping system incorporating multitudes of crop species on a small plot of less than one hectare under the slash-and-burn shifting cultivation. In high population density zones including the coastal areas in West Africa, a part of the east of DR Congo and urban areas, field under shifting cultivation are being turned to those under permanent cultivation. However, where there are abundant land resources, the shifting cultivation with a fallow period of a few years to dozens of years is practiced. In any of these areas, farmers believe that banana should be grown, in spite of the actual practice, in primary forest, or at least in old secondary forest. People have cropped bananas intercropping with rice, cassava, coffee or cacao in each area, but lately the mixture with other new crops like soybean and melons with edible seeds is being promoted. The combination of mixed crops varies depending on such factors as the necessity for cash income, the liability to theft of products, and preferences. As to the burning of vegetation, there are two modes, i.e., one in which the cover is burnt before planting banana and the other in which it is treated after planting. Reports on the banana yield in different areas quote following figures: 5 t/h and 6 t/ha in DR Congo; 10 t/ha in Ghana; 15 t/ha in Central African Republic; 26 t/ha in volcanic ash soil at the foot of Mount Cameroon in the eastern part of Nigeria1[1)].

The second pattern concerns the cultivation on residential plots or in backyards of urban houses. Residential plots in this part of Africa contain home gardens where the vegetation is composed of stratified populations of tree crops, plantain bananas, and low-stature herbal crops, and the soil fertility is high thanks to application of wastes of living, enabling the continuous cultivation of bananas for more than 20 years. This type of agricultural land has the advantages of good access and low liability to theft. Urban homes keep backyard gardens where bananas including plantains are cultivated with the crop composition similar to that in rural home gardens but excluding tree crops.

The third pattern concerns the monoculture of bananas in the areas surrounding cities and along the main routes. The monoculture of banana crops is practiced by the class of people trained with advanced education, as side businesses of public servants and entrepreneurs and as activities of unemployed highly-educated persons. Chemical fertilizers and herbicides are applied and bananas are planted in strait rows. Bananas are generally gown for selling in urban markets, but recently some of them are produced for exporting to international markets.

In this zone, the commonest preparation methods for plantain banana are boiling or steaming and the further processing by pounding thus cooked banana into ball-shaped, which are accompanied with side dishes and consumed as the staple food. The latter preparation is called fufu in West Africa. Bananas are either cooked after peeling or cooked before peeling. Mainly in Nigeria, banana ball is sometimes prepared from kneaded plantain flour. Sometimes stew is prepared by using palm oil that is a particular condiment in this zone. The customary menus of light meals consisting of charcoal-grilled plantain, deep-fried plantain, banana chips, etc. are similar to those encountered at many localities in other parts of Africa and in Asia.

In the following sections, the information on cultivation and utilization of plantains is described for each area going from the East to the West.

① Democratic Republic of the Congo

In Eastern part of Kivu Provinces and East Province of the eastern end of the DR Congo, bananas had been cultivated as the principal crop since early times, to which later cassava was added and in the late 19th century upland rice was added, and the mixed cultivation of these three crops constitutes the agriculture.

The Songola people of Kivu Province living in tropical rainforest cultivate these three crops and maize, of which Y. Ankei has reported the existence of 29 cultivars of cooking bananas. Different cultivars can be identified by the shape and size of fingers. He reports even the existence of a cultivar in which the thickness of fingers reaches the size of human ankle, which suggests that the cultivar may be a Horn type plantain. The field is prepared by lightly burning vegetation residues while leaving trees with hard wood standing. The banana sucker is prepared by cutting the top portion of a sucker of about 60 cm in length to make it to 30 to 40 cm, and planted with the root covered with soil to a depth of about 10 cm. It was reported that in the late 1970s young people would be no more attached to bananas so much as aged persons. On average the planting density is 4.6 plants per 100 $m^2$ (0.01 ha); a few examples of yield per plant have quoted 10.6 kg, 13.2 kg, 22.6 kg, and 25 kg for each of different cultivars; and Ankei estimates land productivity at 4.9 to 11.5 t/ha [2)].

Kum people who lives to the east of the Songola also practices a type of agriculture of mixed cultivation of cassava, rice, banana, and maize, which is similar to the Songola agriculture. In the same province of Kivu, the people of Lega, living to the south of the Kum and to the southeast of the Songola, cultivate the lowland tropical forest to grow cassava, maize, and bananas with the importance attached in that order. In addition to the plots where they grow banana in mixture with cassava and maize, they maintain separate plots that are devoted exclusively to growing bananas for eating fresh, cooking, and brewing. The Tembo people, living on the western slope of the escarpment of the Great Rift Valley to the east of residential zone of the Lega, practice agriculture based mainly on cassava in the highland at an elevation of 1380 m, and cultivate bananas planted in rows on the south side of fields for growing mainly cassava. In low-elevation villages farmers grow upland rice as the principal crop in mixture with bananas, maize, and cassava. Dishes prepared by stewing for many hours banana and common bean with palm oil are preferred as the staple food. Bananas are also used for brewing alcoholic beverages[13)].

In the eastern parts of DR Congo farmers practice the banana cultivation of the Central Africa type based on the slash-and-burn shifting cultivation system. In further east however, one comes across with the banana-related culture similar to that in East Africa, with such elements as the establishment of banana specialized fields, the staple food consisting of the stew of banana cut in round slices and common bean, and the use of banana for brewing alcoholic beverages.

On the other hand, in the Equatorial Province which lies at the center of DR Congo on the south of the bend of Congo River, cassava was disseminated as the food for slaves in the age of slavery, making this area the zone that depends heavily on cassava cultivation among areas in Central Africa. There are certain areas with sandy soils that are not suited for banana cultivation.

The Boyela people who live in Equatorial Province cultivate cassava as the main crop along with maize, banana, yam, etc. Cassava and banana are consumed in the same manner of preparation, namely, firstly they are cooked by boiling or steaming, then pounded and made into ball[11].

The Ngandou people who live to the north of the Boyela also cultivate cassava as the main crop but grow banana as well. Bananas are roasted by exposing them to a charcoal fire or flames and consumed for light meals. Bananas are also used as a material for distilling spirit[13].

This zone used to be one of those where cassava was introduced early and consequently there the importance of bananas is relatively low. Although in certain areas like the Ngandou bananas are consumed only as light meals, because they are still prepared to make ball and served together with other side dishes as the general case in Central Africa, DR Congo could be considered as the zone where the earlier tradition of banana cultivation has deteriorated in the course of history.

② Republic of the Congo (Congo)

Although in Congo as a whole cassava is the crop with the largest volume of production, in certain areas there are farmers who cultivate bananas as the main crop. The Bobanda people living in the marshlands along the Motaba River in Likouala Department in the northeastern part of the country also cultivate bananas as the main crop. Bananas are planted on the plots under a slash-and-burn regime together with other crops of about 20 different species. In certain cases, a staple food crop is planted in a cacao field. As a matter of fact, cacao was not planted in the 1990s because of the instability of the market for it, but before the decade it was likely that cacao might have been planted to the field of a staple food crop to convert the plot to a cacao orchard after harvesting the food crop. The infestation of weeds surpasses the efforts for eliminating them, and hence after the harvest of cassava, farmers collect the fruits of bananas that are able to renovate themselves spontaneously even in the bush. Cultural management operations such as the tending of suckers and the elimination of male inflorescences are not practiced. All cultivars of cooking banana are plantains and 57 of them have been reported[6]. People serve for supper the dishes of banana as the staple food without fail, which are either the ball prepared by beating steamed bananas hundreds of times or the mashes prepared by beating steamed bananas lightly a few times. Bananas are often given as a gift among intimate friends, in particular playing an important role in maintaining social relationship of women. Moreover, around the Bobanda community there are other ethnic groups of people living on the cultivation of cassava as the main crop, and hence the banana cultivation constitutes an element of the ethnic identity of the Bobanda.

**PhotoII-3 Planting of banana (Congo)**

Credit: K. Komatsu

③ Cameroon

In all parts of Cameroon, bananas are cultivated in mixture with cash crops such as cacao and coffee and with other self-reliance crops such as cassava and maize. The types of banana cultivation in Cameroon are classified into those of three zones[4].

South Region, the southern part of East Region, and the southern part of Centre Region are located in low-altitude areas with the annual rainfall of 1500 mm – 2000 mm and with a low population density. In this zone, following cassava and maize, plantain bananas come as the next important crop. The agriculture in this zone is characterized by the slash-and-burn fields leaving selectively certain tree species and the mixed intercropping of the self-reliance crops such as plantain bananas, yautea, melons, groundnut and maize, with the cash crops such as cacao and coffee. In Centre Region lying close to the state capital there are fields for mixed cropping of bananas for shipping to the capital markets, where yautea is integrated in the mixture because it is also marketable. Banana can be either processed into ball by boiling or steaming followed by pounding or consumed as it is after simply boiling or steaming[4)].

The Bangandou people living in the tropical rainforest in East Region grow plantain bananas in mixture with other staple food crops or cacao through the cyclic use of the secondary forest generated by fallowing for dozens of years. Among 22 cultivars of banana observed in this zone, the number of those of AAA type is 4 and that of the plantains of AAB type is 18[9)] . Above all, the cultivars of Horn plantains that grow fast and produce numerous suckers are cultivated abundantly. Except for weeding of a few times, banana crop receives little care after planting, and the operations of selection of suckers and elimination of male inflorescence are not observed. Once or twice a year, a farmer opens a new plantain plot to plant several cultivars of different maturity. Since the farmer continues to harvest bananas for several years after finishing the harvest of other crops from plots that have almost reverted to bushes, he is able to raise a stable income out of several pieces of land. In certain villages, 51 % of ingredients for the staple food are composed of plantain bananas, and the annual consumption per capita of plantain bananas amounts to 382 kg on the edible part basis, a daily equivalent of 1.1 kg. The standard staple food consists of the ball prepared by pounding steamed bananas, in addition to which steamed or grilled bananas are consumed as light meals[12)]. The Baka people who live in the close vicinity of the Bangandou and used to engage in hunting-gathering in the tropical rainforest nowadays pursue the agricultural activities in mixed cropping with banana as the main crop in the fields under shifting cultivation. It is conceivable that the type of banana cultivation in this zone in which, except for the labor for opening land and for planting, little additional effort is required has been an agricultural system that is easily acceptable for the hunter-gatherers [8].

Upper left, upper right: Process of slash-and-burn  Middle left: A mixed intercropping field  Middle right: Harvesting banana  Lower: ball-shaped banana dish

**Photo II-4  Cultivation and utilization of bananas in East of Cameroon**

Credit  K. Kitanishi for upper left, K. Komatsu for the others

The zone comprising the western part of Cameroon, the coastal area of the Gulf of Guinea, and the foot of Mount Cameroon is that with the annual rainfall of 2,000 – 4,000 mm, and with a medium population density. In colonial era, plantation farms including those for growing dessert bananas were developed. Currently, in almost all farm fields of subsistence crops either cacao or coffee is planted or both are planted in mixture. As a staple food crop banana plays an important role following yautea, taro, and cassava. Regarding the cooking method, it is cut in round slices and stewed with palm oil, or often simply boiled and steamed for consumption as it is[4].

Southwest Province and West Province in the southwestern inland part are situated in highlands at an altitude of 1,200 m – 2,700 m, having the annual rainfall of more than 2,000 mm. The population density is very high and the agricultural land is fragmented. Banana is planted in mixture with subsistence crops or with coffee. As staple food crops, maize, yautea, taro, potato, and banana are important in that order. Regarding cooking methods, banana is often stewed together with meat, common bean, or vegetables to make a food with a consistency of putty, which is different from the staple food in the form of ball that the general method of banana cooking in Central Africa produces. Banana may sometimes be consumed as it is after simply boiling or steaming[4].

④ Ghana and Ivory Coast

In Ghana plantain banana is the second most important ingredient after cassava for preparing the staple food and people consume on average 83 kg of plantain banana per capita and spend 3 % of the total expenditure for food to buy it[3]. The production of plantain banana by a small-scale farmer is carried out on a field plot of 0.2 – 0.8 ha under shifting cultivation. The shifting cultivation used to be carried out by using the primary forest or the secondary forest of more than 30 years of regeneration period, but as a consequence of the expansion of cacao fields and the population growth, the fallow periods have been reduced to 3 – 9 years. Plantains are often grown in mixture with oil palm that is native to West Africa. In order to compensate for the reduction of fallow period, the agroforestry technique is increasingly practiced. Neither fertilizers nor agricultural chemicals are utilized.

The observable manner of cultivation of plantain bananas varies and includes: the cultivation in mixture with root crops such as cassava and yam; the transition to plantain banana by following cocoyams growing spontaneously and the association with other tree crops such as lemon, palm oil, cacao, or coffee. The monoculture of plantain banana is sometimes encountered, although the case is rare.

There 14 – 15 cultivars of plantain banana, and those of Horn type and False Horn type that can be harvested in 15 – 18 months, and those of French Horn type that can be harvested in 18 – 24 months are grown.

The variations of cooking or processing method include: *fufu* prepared by pounding boiled or steamed immature plantains of Horn type; *ambesi* prepared by boiling or steaming of plantains of French type; and the flour processed by grinding deep-fried or dried chips of sliced bananas. Recently the demand for the *fufu* flour is growing.

Moreover, there are handicrafts for fabrication of ropes and doormats from the fibers of pseudostems.

In Ivory Coast yams and rice constitute the important staple food crops but plantain bananas are also important as ingredients for preparing the staple food[10). Frequently observed cropping systems for growing plantain bananas include: the association with other tree crops such as cacao, coffee, palm oil, rubber, or cola; the mixed cultivation with yams, maize, groundnut, taro, cassava, or other vegetables; and the association with both tree crops and food crops. There are certain cases of the monoculture of plantain banana as a cash crop, or the intensive cultivation of it in a small scale in the vicinity of urban areas where living wastes are applied as manure. Cultivars of Horn type plantains and some cultivars of French type plantains have been recognized as landraces, and recently the different cultivars of False Horn type plantains and French type plantains have been imported. The food preparation procedures are similar to those in Ghana. Cavendish banana is also cultivated for exports.

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# Chapter III. Cultivation and utilization of cooking bananas in Uganda

Republic of Uganda situated in the Great Lakes Region in East African inland is a country where the activities associated with the production, distribution, and consumption of bananas are very much flourishing. Bananas are influencing not only the livelihood economy in rural areas but also vegetation and many other sectors including culture, politics and national economy. The banana cultivation includes the domain of agricultural production and can also be perceived as an entity existing in a much wider context, i.e., "livelihood system based on bananas" [17),19)]. This perception would explain the reason why Uganda is also called "Country of Banana" in the sense that is different from the aspect that the national economy depends on the production and the export of primary products under external initiatives such as those of multinational enterprises.

## 1. Production and distribution

### 1) Production

While published figures of production volume of bananas differ depending on the methods of estimation, it is a sure fact that Uganda outstands among other banana producing countries in Africa and the entire world. According to the statistics of FAO the value for 2008 is reported to be 9,986,000 tons which exceeds that for the Philippines, 8,687,624 tons, and is the second largest after that for India, 23,204,800 tons. The value comprises 9,371,000 tons for cooking bananas (presented as plantains), accounting for the largest portion, and 615,000 tons for dessert banana (presented as banana). It is not known into which category the bananas used for brewing alcoholic beverages are classified.

In Uganda most of bananas are grown in Regions other than the North (East, Central, West). At the beginning of the 20$^{th}$ century, bananas were cultivated abundantly as the primary staple food for ethnic groups of the Bantu people, particularly the Ganda and the Soga who dwelled in the vicinities of the Lake

Victoria. Moreover, the production increased in the Southwest by the 1960s. For example, the total area of banana fields was 45,000 acres (about 18,000 ha), but it expanded 12-fold to 561,000 acres (about 227,000 ha) by 1965, and the majority of the increase reportedly took place in the areas inhabited by the Ankole people[4)]. The evolution of the national production since the 1960s is shown in Fig. III -1. It is indicated as a general trend that Uganda experienced rapid expansion from the latter half of the 1960s to the 1970s, and an abrupt fall from 1979 to 1981 due to the war with Tanzania. Subsequently after the intense internal conflict in the 1980s, Museveni took the power in 1986, and the banana production continued to increase until around 2000. Since 2000 the rate of increase seems to be stagnating.

A close examination of the situation of different zones within the country shows that the production differs greatly among zones and the major cultivation zones moved during the period from 1970 to 1990. During this period, the production in the Central Region, traditional zone of production, decreased due to shortages of labor, insufficient management capacity, increase of pests and diseases, and depletion of soil nutrients. At the same time, the banana production in the Southwest

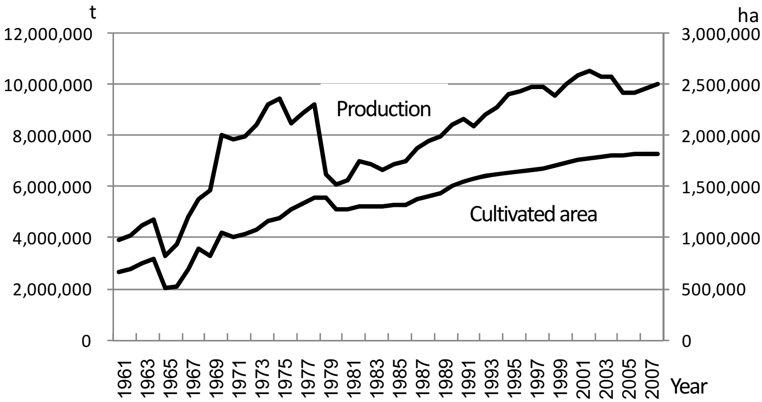


**Fig. III-1 Evolution of production and cultivated area of bananas in Uganda**

Source: FAOSTAT

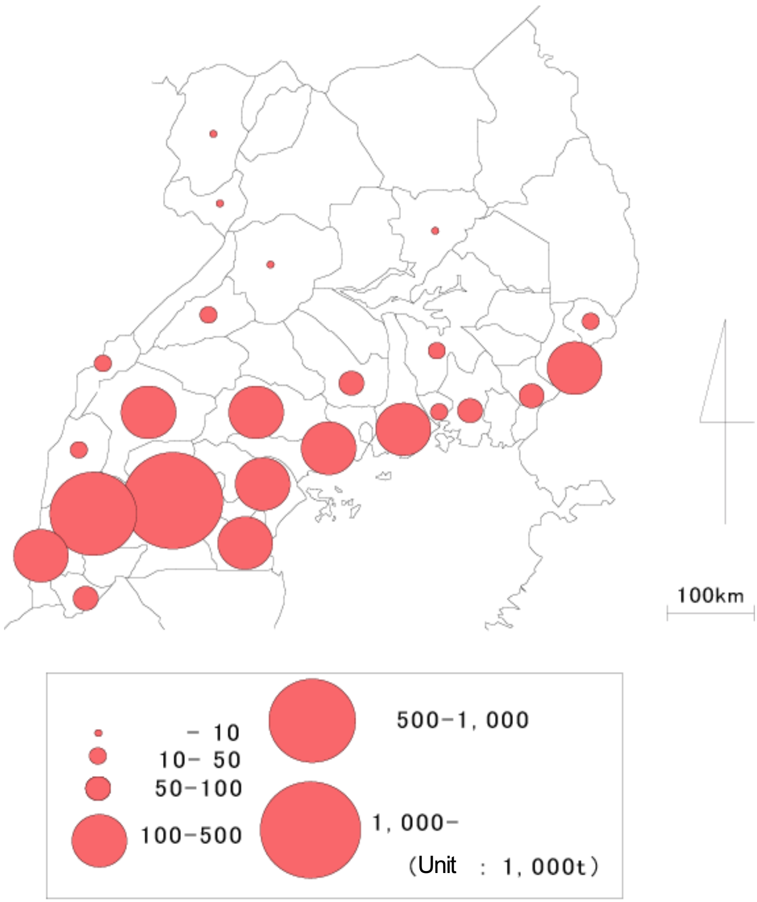


**Fig. III-2 Banana production by district (Apr. 1990 – Mar. 1991)**

Source: Prepared by Y. Sato from data of Ministry of Agriculture, Animal Industry and Fisheries, Uganda 1992

**2) Distribution**

Bananas in Uganda are mostly distributed and consumed within the country. A tiny fraction of cooking bananas are exported by air cargo to Europe and put on shelves of grocery stores in cities like London. About the feasibility of transport by sea through the port of Mombassa has been studied but at the moment the routes of marketing are still being explored. As the market for dessert bananas, Middle East has a potential, but the substantial overseas demand for cooking bananas has not yet been identified.

Regarding the domestic banana distribution, Ngambeki[13)] and Yoshida[20)] have conducted detailed studies.

In Uganda the distribution of food including bananas until now has been mostly carried out in the framework of free market economy. The system of building reserves of cereals that had been institutionalized in East Africa under British rule during the World War II had dealt with mainly maize, wheat and finger millet, had little impact on Uganda and was abolished in 1952. Afterward, the Produce Marketing Board established in the form of public corporation in 1962 also managed only a fraction of the total volume of distribution, and the structure of board was abolished in the 1990s, under the government economic policy of market liberalization[20)].

With respect to banana distribution, in harmony with the expansion of production in the Southwest in responding to the growth of the capital since the 1970s, there occurred the progressive development of a unique intraregional distribution system through the intermediary of a series of actors, which enabled fresh bananas to reach as far as urban retail stores without losing freshness. Nowadays a share of about 70 % of banana supply to Kampala markets is taken by the Southwest and 20 % by the East[13)].

Thus far the marketing system of bananas has historically evolved through undergoing several phases. Firstly during the period from 1960 to 1979 a cooperative movement was promoted to control the market but it failed in the 1980s. Later a strong group of middlemen gained power to monopolize the market information and to take a share of 30 to 60 % of consumer prices. The current banana distribution system is constituted by numerous actors including farmers, several types of wholesalers, middlemen, haulers, urban wholesalers, and retailers. As a result of the improvement of farmers' accessibility to market information, their position has been so elevated that nowadays they are able to receive a share of up to about 60 % of consumer prices[13]. In the districts of Mbarara and Bushenyi in Western Region, the cases in which farmers' cooperatives intervene between producers and trucking operators are observed but such cases are only few[4].

The routes of banana distribution are shown in Fig. III-3. Producers, traders, retailers participate in it and up to about 6 persons intervene until the product reaches the end-consumer. In the processes of distribution chain, the product is traded based on various units (kg, fruit finger, fruit hand, bunch, pile) and the price is determined by the size of finger, hand and bunch, by the number of hands per bunch, by cultivar, season, place, etc.

As a particular type of actors in the distribution chain, we can cite the traders on bicycle who visit individual small farmers one by one to purchase bananas and transport the products to local merchants. Because they purchase products directly from farmers, they are also called village buyers[20]. These are not professional merchants but young persons from farming households who voluntarily visit farmers, negotiate prices, buy, and transport the agricultural products to markets or depots located along principal roads. In certain cases where producers and traders are on friendly terms, traders directly select the merchandise out of bunches still hanging in the fields. By the existence of such a type of buyers, the ubiquitous networks of distribution are always functioning and enable many rural producers to be connected to urban markets without the need for going out.

Another important category of actors includes those who purchase the collected products and haul them a long distance to urban markets and sell the merchandise to other wholesalers or retailers. They are called "transporter/wholesaler" and well versed in the situation of both production areas and the demand in urban markets. They are not the employees of other organizations like large companies who are simply executing the job of hauling the merchandise, but they are the independent entrepreneurs operating their own business, and they are not composed of people of a particular ethnic group either. The trucks they use are mostly rented vehicles[18].

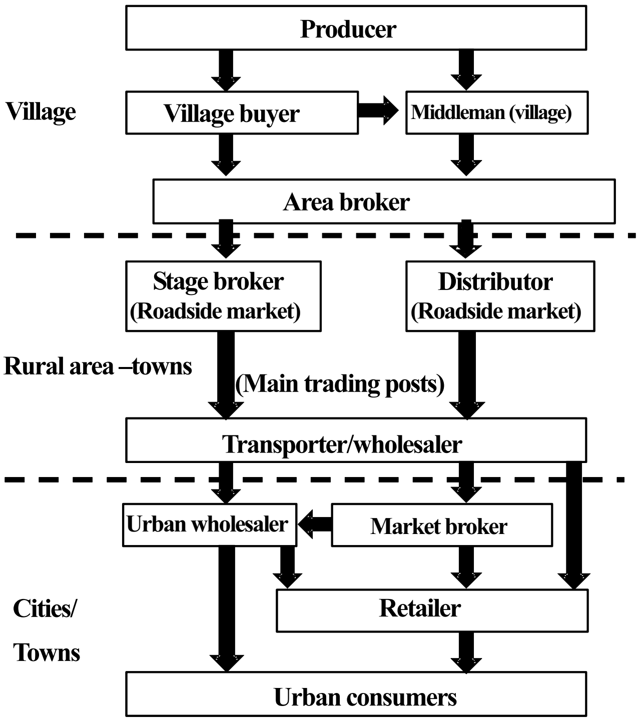


**Fig. III-3 Routes of banana distribution from production sites to urban markets in Uganda**

Source: Ngambeki 2006, Yoshida 2006

**Photo III-1 Trader on bicycle purchasing bananas in villages (village buyer)** Credit: Y. Sato

On a single bicycle made in China, a trader is able to carry up to 6 clusters of about 30 kg each simultaneously.

**Photo III-2 Truck loaded with bananas (transporter/wholesaler)**

Credit: Y. Sato

Each banana bunch is protected by leaf sheaths. The truck makes many roundtrips on the trunk routes connecting rural areas with the capital.

## 2. Cropping system

### 1) Home garden system

The banana cropping systems in East and South Africa as a whole are classified into the following three categories[8]:

① Backyard systems providing an auxiliary function for the livelihood

② Banana subsistence systems playing the principal role in the livelihood

③ Plantation systems

Most of the banana cultivation systems in the Great Lakes Region (inland highlands) including Uganda correspond to the category ②. This system is notably characterized by the agriculture that is predominantly autonomous and practiced on the basis of dispersed as well as sedentary residences, and on banana fields constituting large home gardens tended by the labor available in households consisting of married couples and their children.

Bananas are mostly grown as a single crop in the fields established around the residences and make up a “pure forest” but can also be planted in mixture with various other crops. Bananas are treated as perennial crops and stocks are renewed in situ, and the continuous cropping for long duration is practiced[10),18]. The banana field possesses complexity comprising elements in terms of many factors including component cultivars, soils, topography, pests and diseases, management techniques, utilization methods, etc.

Concerning this type of agriculture, scholars have pointed out the fact that people with a situation of limited land and capital resources still have managed to achieve the self-sufficiency within a local community by trying to cultivate diverse cultivars based on mixed cropping and complex agriculture, and that people are not disposed to introduce readily modern technology such as mechanization[8]. In short this can be considered as the indigenous agriculture aiming at both the plant resource diversity and the livelihood stability.

Fig III-4 shows the map of house and home garden of a certain faming household found in Central Region of Uganda. In the ground close to the house the soil is bare and hardened by treading, and the banana field extends around it and is carefully watched and cared continuously all year round. Beside the house a "detached house" accompanies it and there every meal is prepared. The premise includes all other facilities: bathing area, arbor where tree barks are processed to make cloth, W. C., and graves. Pigs and fowls also are often reared inside the banana field. Bananas for

**Photo III-3 Distant view of a rural community in the vicinity of the Lake Victoria** Credit: Y. Sato
Light green patches on hillside are banana fields and dark green spots are trees.

**Photo III-4 Banana field adjoining a house (home garden)**
Credit: Y. Sato

the staple food, brewing, and dessert are planted in the banana field which is divided into different sections according to their use, since often those for the staple food are planted near the house, and those for brewing and dessert are raised in remote sections away from the house or areas bordering on neighboring farms. Besides, the boundary between the home garden and outlying areas is distinct. On the periphery of banana field, trees of a species of Moraceae *Ficus natalensis,* or a eucalyptus are often planted, or sometimes fences are built by using cassava stalks. The principal objective of erecting fences is to prevent the invasion by neighbors' animals such as dogs, cattle, goats, and pigs. The disposition of banana fields with respect to the house varies among different ethnic groups, but often they are arranged in a compact manner that allows people to spend most of daily life in moving about only the area enclosing home garden and house.

**2) Cultivation methods**

When one takes notice of the crop species in mixed cropping, two types of farming systems can be cited as the representative ones which incorporate bananas as the main crop[12),15)]. One is the banana-coffee system. This system is present over a wide zone centering on the coastal areas of the Lake Victoria and extending to Eastern, Central and Western Regions where the soils are fertile and the dry season is short. In this system, a home garden is plated with cooking bananas as the primary crop for family consumption, to which trees of Robusta coffee (*Coffea canephora*)

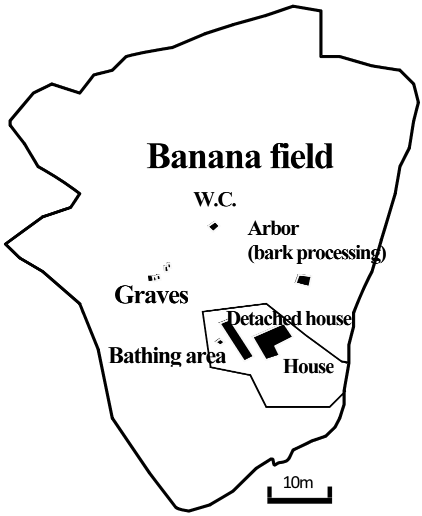


**Fig. III-4 Example of home garden found in Ganda, Central Region of Uganda**

Source: Created by Y. Sato

are added as a component of mixed cropping. The system has an advantage that banana plants serve as shading trees for coffee trees. It helps households earn livelihood by the combination of banana as crop for subsistence and coffee as cash crop, although recently cooking bananas have also become an actively traded commodity, as a result of the development of distribution system as mentioned previously.

Another cropping system is that of “banana-finger millet-cotton”. It is present in the zone where the rainy season and the dry season are clearly distinguished and the rainfall is relatively low. The zone lies slightly further north of the Central Region where the former system extends. In addition to finger millet, other crops such as cassava and sweet potato are also cultivated, and particularly in recent years it seems that maize cultivation is replacing that of cotton. The banana cultivation is not as active as in the “banana-coffee system”.

In the “banana-coffee system”, the tree species that are considered to be compatible with bananas are recognized and often planted in fields (Table III-1). This system consists of three strata of tall trees, banana and coffee or two of banana and coffee.

Each process of farming operations involved in banana cultivation differs in frequency and timing. They are classified into three classes, namely, those for starting the cultivation in fields, daily routine, and those carried out several times a year. Compared to the operations involved in the cereal cultivation, those for banana are more flexible in terms of seasonal labor allocation. For instance, the sowing of maize that has to be done at the beginning of the rainy season is prioritized in comparison with the work associated with banana and the latter is often carried out after the former has been finished. The following paragraphs explain the eleven different steps of farming work.

**Table III-1 Examples of plant species that farmers consider as compatible with banana in growth behavior**

| Term in Ganda language | Family name | Species name |
|---|---|---|
| Mukunyu | Moraceae | *Ficus mucuso* |
| Mutuba | Moraceae | *Ficus natalensis* |
| Muvule | Moraceae | *Milicia excels* |
| Mugavu | Leguminosae | *Albizia coriaria* |
| Musizi | Rhamnaceae | *Maesopsis eminii* |
| Musambya | Bignoniaceae | *Markhamia lutea* |
| Ennimu | Rutaceae | *Citrus limon* |
| Muccungwa | Rutaceae | *Citrus sinensis* |

Source: Created by Y. Sato

① Reclamation, land preparation, digging hole

Plots of land selected for banana fields are mainly those that are fertile and flat in topography. The upper and middle parts of gently-sloping hills or the flat bottom parts of steep hills are selected. In the Central Region of Uganda around the Lake Victoria the former case predominates and the latter case is also found often in the Western Region.

As the location for opening a new field, the bushes formed after long fallow periods are preferred. New fields are often opened in the late part of the dry season or early part of the rainy season. In the first place, branches of small trees are cut off with a matchet and grasses are mowed with a sickle. The cut vegetation materials are either piled on field borders or burnt. Sometimes the entire surface of the plot for opening the field is burnt.

After removing the vegetation, holes for planting banana seedlings are dug with a hoe one by one at intervals of 3 – 4 m. A hole is in a shape of pot with the diameter of about 100 cm and the depth of about 50 cm. The operation of digging hole takes place either at the time of planting or in advance of planting. The work is easier to carry out after the onset of the rainy season because the soil is softer.

② Transplanting

The optimum time of transplanting is the early to middle part of the rainy season. First of all it is needed to locate the suckers for transplanting. The ministry of agriculture of Uganda recommends the planting of a small seedling that is prepared by cutting off the most part of pseudostem born on the upper portion of a rhizome. The reason to remove the organs other than the minimum part that is essential for growth is to prevent the expansion of diseases and insects that may have infected certain parts of rhizomes for seedlings. However, many farmers transplant large suckers in which the length reaches that of human waist to human height, because of the fact that plants grow and mature faster with such seedlings.

All the seedlings needed on a farm are sometimes supplied from the existing banana fields on the same farm alone, but many households find it difficult to acquire on their own the numbers of seedlings needed for the planting season. In such cases, it sometimes happens that farmers acquire the needed seedlings by bargaining with other households. When a farmer wishes to plant a new cultivar, he has to obtain it from other farmers, too. In some villages, households cultivate a specific cultivar and sell its suckers for 500 Uganda shillings per plant (about 30

Carrying of suckers

Planting of suckers

**Photo III-5 Transplanting bananas** Credit: Y. Sato

Japanese yens, equivalent to the price of a bottle of Coca Cola of about 300 ml in Uganda).

Suckers are divided with a hoe from the parent stock. First of all, the soil around the parent stock is removed to make a hole, and the rhizome parts are separated from the parent plant, suckers are taken out, and the soil is replaced to fill the hole. The process of division of the stock requires a strong force for drawing out the plant because the hoe edge is lodged firmly in rhizome. In the past farmers used to make use of a spear-shaped tool specifically designed for this operation that can still be found in limited houses. Lifted suckers are processed by peeling old sheaf sheaths and cutting off all leaf blades and petioles. Some farmers remove also all the roots present. However, in small seedlings, leaf blades are kept as they are. Once suckers are taken out, they are planted to new places on the same day or the next day. They are put in the hole to stand upright and the basal portion is covered with soil all round and compacted lightly by treading.

③ Pruning of leaves and leaf sheaths

Pruning is carried out to remove dead leaf blades and excess leaves which are so many that they are hampering the plant growth itself. In order to carry out this operation, farmers use a special half-moon-shaped knife exclusively designed for pruning banana leaves or an ordinary-shaped knife mounted on a long wooden pole. It is believed that the operation to cut off with the knife the leaf blade beyond the base of petiole improves the plant appearance or enhances the plant growth. This operation is carried out throughout the year.

To prune dead leaf sheaths, a knife is employed. Dead leaf sheaths that are about to peel off are cut off to expose fresh leaf sheaths. It is believed that this operation enables the prevention of the inhabitation by insects between dead coverings and the fresh leaf sheath on the pseudostem. This operation has no specific season for execution.

④ Removal of male inflorescence

A little bit later than the emergence of the hand, the male inflorescence is cut off. The objective of this operation is to enlarge the bunch. This operation is normally carried out for cultivars used for the staple food, namely, clone sets other than Mbidde among AAA-EA bananas (see Chapter I). More often than not the male inflorescence is not removed in cultivars of Mbidde clone-set of AAA-EA and in those of banana groups other than AAA-EA.

⑤ Thinning of suckers

Depending on the characteristics of cultivar, banana plants generate many suckers and they are thinned out to reduce the number. It is generally believed that the presence of about two suckers per parent stock is desirable, in which one is to be reserved for transplant. In thinning operation, the portion above ground of a sucker is supposed to be cut off. The season of thinning is not defined.

⑥ Propping

When a bunch gets larger, it is feared that a pseudostem becomes unable to stand upright under its own weight and falls down. Hence, farmers often go around banana fields to watch out for the plants that bear large bunch and are feared to fall down, so that they are able to prop up such plants timely by placing poles of 2 - 3 m in length (Y-shaped wooden posts are often used) under the upper parts of pseudostems.

⑦ Mulching

Dead leaves, dead leaf sheaths, and residues of aerial parts after harvest are left lying on the ground as they are. Sometimes those materials are spread uniformly over the ground surface to prevent the exposure of the soil. By such a practice, the infestation of weeds can be retarded and the soil erosion due to rainfall can be prevented. However, certain households, on the contrary, gather with hoes fallen leaves and fragments of leaf sheaths and lay them around the base of a banana plant.

This practice is based on the concept that instead of benefiting from the advantage of mulching, it enables the concentration of soil nutrients around the plant.

**Photo III - 6 Mulching of banana field** Credit: Y. Sato

⑧ Weeding

Weeding is an important farming operation directly affecting the banana growth. In concrete terms, weeds are dug up with a hoe and set aside. It is a labor consuming operation like the digging and crushing of stumps after harvest. This operation is considered to be the one which requires the longest hour of continuous work among the total hours of banana cultivation labor. Weeding is often carried out once every 2 to 3 months for each plot. The state of field management is evaluated by people of other households from the appearance of the field which indicates whether weeding is properly executed or not.

⑨ Fertilization

Only a small minority of households practice fertilization (chemical, or cattle manure). Nevertheless, those households which rear large numbers of cattle often set up the banana fields on the spots where they had kept their cattle at night in the preceding year. In some banana fields, the earth around banana plants is thickly covered with ground coffee shells.

⑩ Harvest

Bananas can be harvested all year round. However, since the plant grows and matures better in the rainy season, the most productive season corresponds to the period from late part of the great rainy season to early part of the dry season. The least productive season falls on the early part of the rainy season succeeding the great dry season.

Bananas are harvested by the unit of a bunch without fail and never by the unit of hand or finger. Banana fruits mature, after having attained the maximum size, by starting from the fingers nearest to the pseudostem, and peel color turns to yellow. If they are to be consumed as the staple food, the optimum harvesting time is when the fruits attain the maximum size but are not yet ripe. Harvesting is carried out by making several cuts with a hatchet in the same plane into the pseudostem at a height of about 1 m above ground, then felling the upper part slowly. After that the bunch is cut off and carried away.

The duration from planting to harvesting lasts about 1 to 2 years. In the succeeding phase after the first harvesting from the new planting, the cycle time required for the growth before maturity becomes shorter, because the sucker of the next generation has already been established.

⑪ Treatment of plant body after harvesting

After harvesting, the felled pseudostem (with fruit axis) is cut up into several pieces and left on the ground. A field management procedure is widely practiced, in which in order to control insect pests and diseases including weevils, fragments of leaf sheaths are placed on the cross section of stump to attract weevils and later on the fragments are discarded together with weevils.

## 3. Maintenance of banana diversity

### 1) Cultivars and utilization methods

In Uganda bananas of diverse genome types including AAA-EA are cultivated, and they are all different in characteristics with respect to growth and utilization. Table III-2 presents the relationship between the genome type/cultivar and the preparation method of principal bananas in Uganda.

**Table III -2 Relationship between banana types/cultivars and different preparation methods in Uganda**

| Genome type and cultivar | | Steaming | | Boiling | Roasting | Making Juice/ brewing | Frying for cakes | Eating raw |
|---|---|---|---|---|---|---|---|---|
| | | Pee ⇒ steam | Steam ⇒peel | | | | | |
| AAA-EA | Mbidde clone-set | △ | △ | △ | | ○ | | |
| AAA-EA | Clone-sets other than Mbidde | ○ | ○ | ○ | | | | |
| AAA Bogoya (Gros Michel) | | △ | △ | △ | | ○ | | ○ |
| ABB Sukali Ndiizi | | | | | | ○ | ○ | ○ |
| AAB Gonja (Plantain) | | | | △ | ○ | | | |
| ABB Kivuvu | | | ○ | | | ○ | | |
| ABB Musa | | | | | | ○ | | |
| ABB Kayinja | | | | | | ○ | | |
| AB Kisubi | | | | | | ○ | | |
| AAAA , AAAB, AABB FHIA | | ○ | ○ | | ○ | ○ | | ○ |

○: Practiced　　△: Rarely practiced or practiced in very limited households

Sources: Sato 2004, Edmeades and Karamura 2007

AAA-EA type bananas include dozens of cultivars and they account for the major part of the total number of banana cultivars. Bananas of AAA-EA other than Mbidde clone-set are specialized for the consumption as the staple food by either steaming or boiling, except for the case in which they are eaten raw by children for nibbling. On the other hand, in bananas other than AAA-EA group, there are no cultivars which can be used as the staple food. ABB cultivar called Kivuvu is steamed with peel on but this is just for light meals. As an exceptional case, AAA Bogaya is cooked and served as the staple food in Kalangala Island in the Lake Victoria.

As materials for making juices and alcoholic beverages, the flesh of not only cultivars of Mbidde clone-set of AAA-EA, but also that of cultivars of diverse genotypes is used. Among them, the cultivar that can be propagated relatively easily is the cultivar called Kayinja the flesh of which is mixed with that of other cultivars and processed into juices and alcoholic beverages.

**2) Selection of cultivars**

As mentioned in Chapter I, in Uganda many cultivars of AAA-EA banana are cultivated and maintained by each of farming households. The mechanism by which the diversity is maintained involves many complex factors including the knowledge and behavior of farmers, social relationships, the morphological diversity of plants, etc. Since the 1990s until now, studies form various viewpoints have been conducted.

Selection criteria of cultivars by farmers are as follows: ① availability of seedlings, ② duration before harvest, ③ sustainability of the stock for many generations (longevity), ④～⑥ tolerances to low fertility of soil, droughts and insect pests, ⑦ taste, ⑧ marketing factors (bunch size and salability) [6)7)] . However, since people behave based on various manners of thinking in response to changing circumstances, the composition of cultivars in the actual field does not necessarily reflect the fixed criteria (taste and strategy).[16)]

Some studies try to identify the social and spatial units that enable the cultivar preservation, by integrating the information acquired through surveys conducted on micro elements such as individual fields and households. First of all, it has been reported that the cultivar diversity is maintained not on the level of village but on the level of much smaller unit, i.e., that of field[3)]. Moreover, it has been pointed out that the number of years of utilization of field is correlated with the number of cultivars[14)]. Thus, from now on it would become necessary to develop studies and promote measures of in situ conservation of the cultivars, by taking account of the differences existing within a local community between the households (fields) having many cultivars and those having few.

## 4. Utilization

In Uganda bananas are used for diverse purposes. Fig. III-5 presents principal uses for each part. They not only are used for food but also infiltrate deeply into daily material culture. Moreover, the plant parts that are most frequently used are flesh, leaf and leaf sheath.

**1) Use for food**

(1) Staple food

Meals for cultivators in Africa generally consist of a dish containing a starchy ingredient without seasoning suited for mass consumption (staple food) and another dish of strongly seasoned sauce to dip the former for eating (side dish) [9]. In agricultural areas in Uganda as well, meals are essentially composed of the set of staple food and side dish, and the daily interest of people concerns how to enrich this combination, what kinds of food to acquire, and how to prepare them. Among them banana is one of many ingredients for the staple food, and in many localities it is placed at a particularly high position in the social value system. The frequency of appearance of bananas varies greatly depending on households. According to a survey in the 1990s covering the whole country, in the areas where bananas were consumed as the staple food, the weekly frequency varied from 1.6 times to 12.4 times (7.8 times on average). Other items for the staple food include, sweet potato, yams, cassava, cocoyam, maize, finger millet, pumpkin, and rice.

As seen in the following sections, in Uganda there are numerous ways of preparation for banana food. Presentation is made to explain mainly the preparation methods in Ganda in the Central Region of Uganda where the most complex utilization system is practiced.

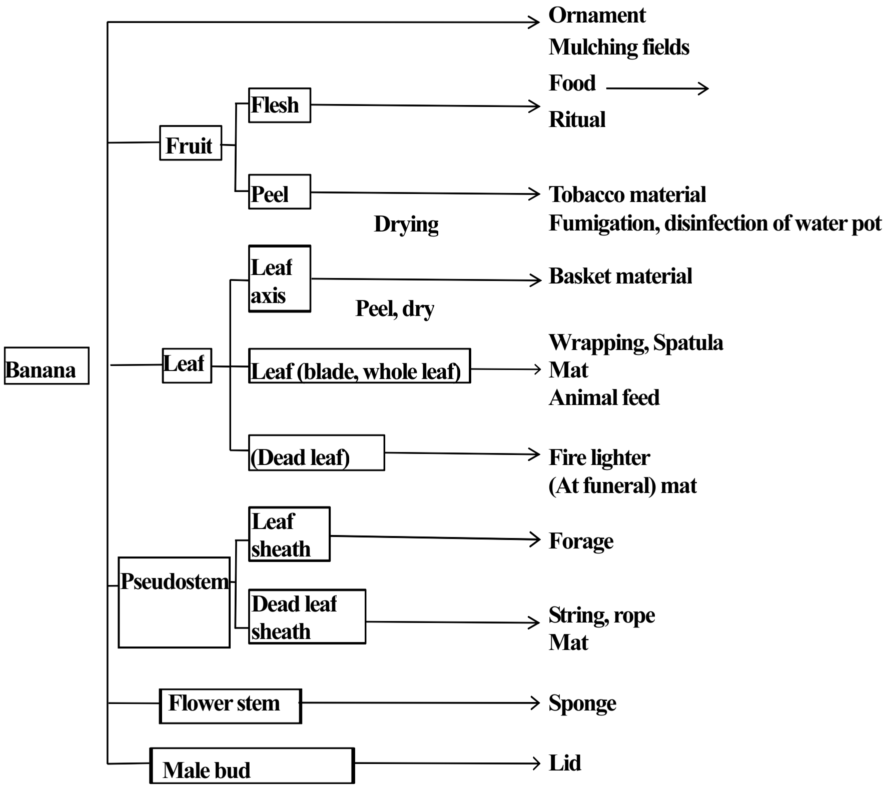


**Fig III-5　Different parts of banana and their main use**

Source: Created by Y. Sato

① Matooke

In language of the Ganda people, both the banana dish served as the staple food and the banana itself that is used as the ingredient for preparing the staple food are called "*matooke*". The word applies equally to the singular and the plural. The word is accepted widely not only in rural areas but also even in the urban areas of Kampala, irrespective of the difference in languages spoken. Matooke as a prepared dish is one which is made by cooking peeled unripe banana flesh by adding water. Cooked banana is either mashed to transform the texture or left as it is. In cooking, "boiling" method is used in many areas including Ankole in the southwestern part of Uganda and Haya in the northwestern part of Tanzania (Photo III-7).

The Ganda people besides regularly employ other refined methods undergoing the process of "steaming". They classify matooke dishes into three categories, according to the differences in procedures, i.e., boiling or steaming for cooking, and mashing or no mashing after cooking (after steaming, banana is always mashed). In addition to matooke, there is also a dish called "*katogo*" which is prepared by mixing other ingredients.

(a) Boiling only without mashing (Photo III - 8)

A dish in which bananas are peeled with a knife and put into a pot and boiled with water until the water gets low and the cooked bananas are not mashed. Normally stir-fried tomato or onion is added together with condiments but sometimes nothing else is added. This dish is made in order to prepare the food quickly or to add a variation to routine meals.

**Photo III - 7 Dish of boiled bananas in Haya of the northwestern Tanzania**

Credit: S. Maruo

Dish of unripe bananas boiled together with common bean. It is taken along with chili, sour milk, and/or soup.

**Photo III - 8 Matooke (boiled banana)**

Credit: Y. Sato (ditto for the following)

(b) Boiling and mashing

A dish in which bananas are cooked by the procedure similar to (a) and then covered with banana leaves and mashed. This dish is not so popular in Ganda but in Ankole, banana dishes are prepared mainly by this procedure.

(c) Steaming and mashing

Among the three categories of preparation, this method is the most complex one and the dish is considered to be the most authentic matooke. It is prepared not only for holiday lunches and festivities but also often for meals on ordinary days. It takes much time and labor and it is needed to spend about three hours from peeling bananas to completion, and to watch the fire at a close distance during the cooking process. This method is specific to the Central Region and deeply linked to the cultural value as seen in the custom in which the method is considered to be one of those manners that women are supposed to master before getting married.

Normally the flesh of unripe bananas is used, but sometimes ripe bananas with sweetness are used for children. However, in that case the latter are separated from the process for the unripe bananas. The following is the preparation procedure for (c) :

Utensils and materials for preparation: pot, knife, (A) – (D), plenty of banana leaves.

(A) Fingers (green unripe) of AAA-EA bananas other than Mbidde clone-set (refer to Chap. I Sec. 2)

(B) Fresh banana leaves from which main nervures have been chipped off, and bands made from split dead leaf sheaths

(C) Leaf axis and fruit axis cut and bent to fit to the pot bottom

(D) Leaves used for the previous cooking to cover the food during steaming

The procedure is as follows. The method to peel fingers with a knife is the same with that of the processes of (a) and (b).

１． Peeling bananas and making a pouch

At first cover the interior of the basket by laying leaves. Pick fruit hands from the bunch, fingers from the hand, peel fingers one by one, and put peeled fingers on the laid leaves to pile them up. When the pile is completed, mount leaves to close the pouch of leaves and bind it with bands. By this process the pouch containing the banana flesh is completed.

**Photo III-9 Peeling of bananas with a knife**

**Photo III- 10 Making of a pouch for steaming**

<u>2. Steaming</u>

Place (C) on the pot bottom to make a room above it. Pour water up to the upper level of leaf axis and fruit axis. Put the pouch prepared by step 1 on the axes to keep it above the water on the bottom so that the pouch may not get immersed, then place several fresh leaves and pieces of (D) on top of and around the pouch to enclose it. Sometimes, in order to improve the airtightness, the entire setup is covered with another pot turned upside down. Then heat the pot with a strong fire for more than 1 hour while watching the quantity of water on the bottom.

<u>3. Mashing and serving</u>

Remove the pot from the fire. Press hard the pouch from outside with both hands to crush bananas until the form of bananas disappears and the mass turns into paste. Place on the floor one leaf that has been used in cooking and put the prepared food on it. People surround the food thus served. People make spatula from banana leaf, use it for taking each one's portion, and eat with fingers. The author actually measured the amount of food intake and found out that on average an adult man consumed about 1.1 kg per meal.

**Photo III-11 Preparing of pouch for steaming**

To enhance airtightness, the pouch is covered with leaves used in the previous cooking.

**Photo III-12 Scene of meal with matooke**

② Katogo

The term applies to dishes mixing the staple food with other materials and specifically the dish of the cooked staple food with common bean. In urban areas, often the preparation of entrails is mixed. There are various recipes including the frequent cases of mixture of cassava with common bean, that of cassava with banana and common bean, and that of sweet potato with common bean. Recipes of katogo in rural areas often combine

**Photo III -13 Katogo served in an urban restaurant**

In addition to banana, it also contains entrails of cattle.

cassava with common bean, etc.

③ Empogola

This is a dish in which bananas are steamed without peeling. Bananas are often steamed simultaneously with matooke, namely, by placing them on the top of flesh pouch. The cultivars used for this cooking method are those of AAA-EA and an ABB cultivar called Kivuvu. In the case of Kivuvu, ripe bananas are cooked for serving as a light meal, but the Empogola of AAA-EA has more of significance as a ritual element.

(2) Light meals

① Kabalagala

This is a cake processed from ingredients consisting of the flesh of cultivars of dessert banana and cassava flour. At first, banana flesh is crushed and mixed well with cassava flour to make paste. Then it is molded into a disk shape and fried with oil on a strong fire until the surface turns golden for finishing.

As ingredient banana, an ABB cultivar called Sukali Ndiizi (also referred to as “apple banana”) is normally used. Alternatively the AAA cultivar of dessert banana, Gros Michel, can also be used but the kabalagala made from ABB bananas tastes better. The name of this food derives from a word of the Ganda people “oku-balagala (hot)”. It is said that red pepper also used to be added until the 1970s. Since the 1980s, people ceased to use red pepper, and it seems that ever since children have become able to consume this cake. From the field observation of the present author, 3.1 kg of bananas (73 fingers) and 1.5 kg of cassava flour could make about 125 disk-shaped cakes of 6 cm in diameter and 1 cm in thickness.

② Gonja

Gonja signifies bananas of AAB plantain subgroup and their cooked products. To cook gonja, generally peeled bananas are grilled until the surface get burnt a little. They are consumed for light meals. The banana flesh can be unripe as well as ripe according to the taste of consumer. The production volume of gonja is very small in Uganda and it is rarely taken in rural areas. In urban areas however, it is often sold on the roadside mainly in the hours from early evening to night and peddlers also trade actively at the rest areas for long-distance busses located along the trunk roads connecting towns.

**Photo III – 14 Gonja**

In Kampala recently one comes across more frequently burnt bananas (not sweet) accompanying fowl dishes. These are not gonja but matooke bananas grilled on a charcoal fire.

(3) Beverages

Beverages made from banana include juice, brewed liquors, and distilled spirits. Juice is more often made for family consumption but brewed liquors and distilled spirits are often processed by farmers for selling purposes. The transport of distilled spirits between districts is prohibited by the government.

① Juice（Omubisi）

This is a fruit juice made from the flesh taken out of well force-ripened bananas. It is also an intermediate product in the course of brewing alcoholic beverages.

② Brewed liquors (Tonto)

This is an alcoholic beverage brewed from the juice extracted from the flesh of force-ripened bananas. First of all, harvested bananas are force-ripened. The method varies depending on different places. In the area around the capital Kampala, bunches are split along the axes into two portions, placed on wooden shelves, covered with dead banana leaves, and heated with a fire built below them on which a banana pseudostem is placed to generate water vapor. The required duration for force-ripening is about a week. In areas around Masaka in the west of the Lake

Victoria, people dig a hole, cover the bottom with banana leaves, put fingers there and cover them with leaves.

Then the juice is fermented in a container. Containers and the additives (starters) for fermentation used in Uganda are presented in Table III – 3.

**Table III – 3 Containers and additives (starters) for fermentation used in Uganda**

| Container | Additive (starter) |
|---|---|
| Wooden boat (banana boat) | Roasted and ground sorghum |
| Earthenware | Finger millet grains and roasted and ground sorghum that were used in the previous fermentation |
| Gourd | Finger millet grains and roasted and ground sorghum that were used in the previous fermentation |
| Hole lined with plastic film | Sorghum used in the previous fermentation |

Source: Aked 1993

Among methods using these containers, the preparation using wooden boat is carried out as follows: first of all, the juice is squeezed out by treading slowly the mixture of grasses and the flesh of force-ripened bananas and drained into a pot; then the juice is poured onto a horizontally long wooden receptacle called "banana boat" and water is added; the juice can sometimes be squeezed by treading the flesh in the banana boat (Photo III – 15); the top of the banana boat is covered with banana leaves and the contents are let stand for a few days for finishing the process. Roasted and roughly ground maize grains are added into the banana boat. Since non-germinated seeds are used, the maize is considered to be added not as a fermentation starter but simply as a substance to control the taste.

**Photo III - 15 Preparation of brewed liquors**

③ Distilled alcoholic beverage (Waragi)

Waragi is strong sprituous liquor that is distilled abundantly in rural areas in the Western and the Central Regions. The fermented liquid is poured into an exclusive drum (normally of 200 liters) equipped with a tube and boiled on a strong open fire built below it. The generated vapor is let pass through the tube and distilled and collected to complete the process. A large quantity of waragi is produced in rural areas in the Western and the Central Regions. In many areas it is made by distilling brewed liquor but in Kasese District in the Western Region it is made by distilling the fermented product that is prepared by mixing the flesh of ripened bananas with water in a bag of plastic film or in a drum and letting the mixture stand for several days to soften the flesh [1)].

The residues of distillation in a color of grey to black are also used as an agent for bonding bricks in construction work.

**2) Other uses**

Aside from the use as food, banana plants are utilized for diverse purposes focusing on material culture. The organs utilized particularly often are leaves and pseudostems.

① Luwombo (pl. Mpombo)

Besides the use of flesh as the staple food, leaves also are used efficiently for food preparation. Luwombo is an accompanying dish that is prepared by simultaneous steaming and boiling of meat, vegetables and water enclosed in leaf pouches, which is often made for the occasions of family festivities and Christmas. Contrary to the case of matooke where the flesh contained in a pouch is steamed, in that of luwombo, water also is added to the contents of small envelopes, and hence the ingredients are boiled while envelopes are steamed. The following is the cooking procedure.

1. Acquire young and soft banana leaves with few fissures.
2. With a knife, cut off petioles, chip off the protrusion of main nervure, and cut

off both ends. Burn lightly the entire area of both faces of a leaf, fold it into two and further put another leaf so that the water leakage may be prevented. Make envelopes with the prepared material. Fill the envelopes with meat pieces, a bit of salt, water, cooked onion and tomato, red pepper, curry powder, etc., and close the envelopes.

3. Make an elevated level on the pot bottom for filling with water, pour water, place leaves, put envelopes on them and heat the pot on a fire for 1 to 2 hours to complete the process.

The main ingredient of the dish can be not only meat but also some other materials such as rice, groundnut source, etc. and it is consumed as an accompaniment to the staple food. Normally one person consumes one envelope.

② Basket（Ekibbo, pl. Ebibbo）

The Ganda people fabricate and utilize baskets from leaf axes of banana and Enjuru, Ganda name of Yoruba soft cane, a plant species of Marantaceae family, *Marantochloa purpurea*. Every household possesses and uses their own baskets when people prepare foods and place them. In the process of fabrication, leaf axes of Enjuru are fastened spirally around the main nervures of banana.

**Photo III - 16　Basket making**

③ Cushion (Enkata) and carpet (Ekirago, pl. Ebirago)

In Uganda various goods are transported frequently by carrying them on human head. On that occasion, a cushion is often made from banana leaves and kept between the burden and the head. In fabrication processes, the main nervure is bent roundly progressively and the leaf portion is inserted into inner side. Carpets (mats) are made by assembling dead banana leaf sheaths and tying many pieces of

them to fine strings made from leaf sheaths.
When bathing, banana leaves are laid on the ground and they are specifically called Oluleeba (pl. Endeeba).

④ Wrappings (Ettu, pl. Amatu)

For wrapping goods, banana leaves are frequently used. When a leaf is rolled up in a form of triangular cone to hold objects such as salt, it is called Olusogo.

⑤ Flavoring

Banana peels are used for flavoring. At present, a minority of rural households use earthenware pots to store drinking water, and they perform fumigation of them for disinfection about once a month. For that purpose, banana peels are used. First of all banana peels are dried by sunlight to make them black in color. Pieces of them and burning charcoal are put into the empty pot and the top is closed with a wooden plate. A period of about 30 minutes to 1 hour is allowed to pass for fumigation. After that the pot is rinsed lightly with water.

⑥ Use for animals

The peels produced in the food preparation are not only returned to fields as residues but also fed to goats and cattle. In urban areas there are banana peel traders who acquire free of charge the peels produced in markets or other establishments and sell them to animal husbandry operators[1).

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# Chapter IV Issues in banana cultivation technologies in Uganda

## 1. Pests in bananas and their control

The pests that pose the highest level of threats on bananas are nematodes attacking roots and weevils invading and damaging mainly the basal parts of pseudostem. In certain areas, coccids transmitting virus diseases are also considered to cause problems, but they do not attract so much attention.

### 1) Nematodes

Nematodes are imposing very serious constraints on the global banana production, and those which have been recognized so far include sweet potato root-knot nematode (*Meloidogyne incognita* Kofoid et White), Java root-knot nematode (*M. javanica* Treub.), pseudo-root-lesion nematode (*Aphelenchus avenae* Bastian), southern root-lesion nematode (*Pratylenchus coffee* Zimmermann), lance nematode (*Hoplolaimus* spp.), and Ryukyu stunt nematode (*Paratrophurus* spp.). The occurrences of nematodes in Uganda have been causing the reduction of banana productivity and reported since the 1980s, along with those of banana corm (root) borer weevils[15) 46)]. In the regions of Masaka and Rakai, a drastic reduction in banana production occurred over a wide area as a results of the weakening of banana plants and the toppling of pseudostems, which presents a very important problem still now[36)] .

(1) Species of nematodes in Uganda

The nematodes inflicting damage on bananas in Uganda are not those of a single species, but several species have been identified. All species cause the drastic reduction in yield and profitability by attacking and damaging roots, and consequently by weakening the plant body and reducing the cluster weight, and furthermore not only by retarding the maturity but also by accelerating the toppling of pseudostems because roots are injured and loose vitality.

However, Ugandan farmers cannot recognize adequately the damage due to nematodes because they are difficult to see with the naked eye, and hence they misunderstand that the injuries are due to some diseases or banana weevils, and consequently fail to apply correct measures to control the damage[14].

As mentioned previously, as nematodes that attack banana roots and inflict damage in Uganda, several species have been identified. From the investigation carried out in the western, southwestern, central, and eastern regions, namely the center of banana production in Uganda, as the nematodes that have been found in banana plants and confirmed as those causing damage, 8 species shown in Table IV – 1 have been identified[20].

Three species, *P. goodeyi*, *H. multicinctus and R. similis* are spread over the most extensive production area in Uganda and treated as the species calling for particular attention. The survey results have reported that the yield of banana is reduced by about 7 % due to toppling, the principal symptom of nematode damage[46]. However, considering that nematodes cause not only the direct damage by toppling but also other troubles such as the loss of cluster weight and the insufficient storage of fruit substances, the overall magnitude of problems is much greater. Certain investigations reported that when both *R. similis* and *H. multicinctus* are present, a yield loss of 51 % occurred[56].

**Table IV-1 Species of nematodes in Uganda** [56]

| Scientific name | Popular name |
|---|---|
| *Radopholus similis* (Cobb) Thorne | |
| *Pratylenchus goodeyi* Sher & Allen | |
| *P. coffeae* (Zimmermann) Filipjev, Schuurmans & Stekhoven | Coffee root-lesion nematode,<br>Minami (southern) root-lesion nematode |
| *P. zeae* Graham | |
| *Helicotylenchus multicinctus* (Cobb) Golden | |
| *H. dihystera* Colbran | Cobb spiral nematode,<br>Minami spiral nematode |
| *H. pseudorobusts* Golden | |
| *Meloidogyne* spp | |

(2) Ecology and life cycle of nematodes

All of three species, *R. similis*, *P. goodeyi*, *H. multicinctus*, parasitize the cortex of roots to complete the life cycle. In general they invade roots from soil but in the case of *R. similis*, it is said that they sometimes invade also rhizomes. They feed on the parenchyma cells of root and destroy the tissue. The infestation causes the formation of cavities in roots or rhizomes, retarding growth and creating troubles such as toppling [6) 15)].

The life cycles of these nematode species do not vary so much from one to another. The eggs are laid in roots and hatch in 8 – 10 days. In the case of *R. similis*, the juvenile stage at the temperature range of 24 – 32 °C lasts 10 – 13 days and the total life cycle is completed in 20 – 25 days. So far the life cycle of *P. goodeyi* has not been investigated so thoroughly, but it is likely that it is completed in 45 -65 days and hence lasts longer than in the cases of the other two species [1)]. In general, the duration of life cycle of nematodes is influenced by environmental conditions. However, the details of life cycle under the conditions of banana cultivation and ecological factors in Uganda have not yet been well identified.

(3) Symptoms of damage

Since nematodes feed on tissues, tunnels are formed in the root cortices, and necroses are generated in surrounding tissues, which aggravates the damage. Wounds turn reddish purple, and the necrosed damaged parts expand progressively. Moreover, since the injuries caused by nematodes provide also invasion entries for pathogens, necrosed parts displaying purplish to reddish colors are generated, and ultimately the roots die and rot off completely [6) 47)]. The necrosis of root causes the necroses of young roots and the tissue destruction, leading to disturbances in the absorption of nutrients and water. The decline of plant growth and vitality retards the enlargement of cluster and prolongs the duration needed for reaching maturity. Furthermore, the damage leads to the degradation of nutrition of the plant as a whole including the yellowing of pseudostem and leaves [34) 15)].

Severe destruction of roots will lead to the toppling of pseudostem, but it is difficult

**Photo IV-1 Lower sample shows a root damaged by nematodes**
Credit: K. Suzuki (ditto for the following)

**Photo IV-2 Young plant damaged by nematodes (lower sample)**

to distinguish it from the toppling caused by banana weevils.

The selection of cultivars has to be made based on the analysis of investigations conducted on the root injuries (the extent of necrosis and the rate of dead roots) and the toppling caused by them as well as on the toppling of banana plants resulting from other causes. Cultivars of ABB type like Kayinija are more vulnerable to severe necroses of roots than those of AAA type, namely East African Highland bananas. However, the latter cultivars tend to be more liable to topple than the former. In general, cultivars of East African Highland bananas, for example, Mbwazirume and Nakitembe, are more vulnerable to nematode injuries than cultivars like Kyinja and Bogoya (AAA). The toppling tends to take place in areas at a higher altitude (1400 – 1900 m) than those at a lower altitude (1000 - 1350 m) [46].

(4) Distribution of nematodes

Among the 8 nematode species distributed in the investigated areas in Uganda, *P. goodeyi* and *H. Multicinctus* have been identified respectively at 96 % and 83 % of the investigated locations, and species of *R. similis* and *Meloidogyne* have been found at 53 % of them. Other 4 species are distributed in limited localities and found only seldom [20].

*P. goodeyi* that causes disturbances in banana is the most widespread species in

Uganda and East African Highlands. This species has become one of the principal pests also in Canary Islands, Cameroon, and Ethiopia. It occurs also in Uganda and is found in both the lowlands and the highlands (1400 m – 1800 m) but more frequently in the former than in the latter. In Uganda spiral nematodes, *H. multicinctus,* occur generally in the areas at a lower elevation and the damage is also very significant. Those species found in the tropics and the subtropics are also found in Uganda where and when *R. similis* is found. The nematode boring holes in roots, *R. similes,* was first found in Fiji, but it has recently been observed universally in other countries as well where bananas are grown such as Canary Islands, Egypt, and Taiwan. The reason for such a widespread distribution could be attributed to the dispersion through the potting compost when seedlings are exported.

The altitude influences greatly the nematode distribution and the principal factor for it is considered to be the temperature. According to a survey in Uganda in 1993, *R. similis* and species of *Meloidogyne* are found in the areas below the altitude of 1400 m, and only P. *goodeyi* is found in the highlands at an elevation above 1600 m. *H. multicinctus* is observed at an elevation of up to 1600 m. However, the majority of species are found more often in areas at an elevation of 1200 – 1300 m. The factors that influence the occurrence and the distribution of nematodes are considered to be the population size of nematodes, cultivation systems, and characteristics of banana cultivars [20].

(5) Strategies to control nematodes

When endoparasitic nematodes occur in a banana plant that is a perennial crop, it becomes difficult to control them. Although various methods for the treatment of nematodes have been tried, their effectiveness is influenced by different environmental conditions and the fundamental state of plant, and hence varies among different spots within a farm and among different farms.

① Control through cultural practices

The following sections describe some of the control methods through cultural practices that have been tried and proved to be effective. They are being practiced on an experimental basis in Uganda.

a) Rotational cropping system

A rotational cropping system is considered to be able to starve nematodes by cultivating temporarily other crop species that the nematodes cannot parasitize. The subsequent banana cultivation can be started with the presence of few parasitic nematodes. This method is the approach that is adopted often in replanting banana plants. For example, when banana productivity has declined and the elimination of banana plants from a field becomes necessary, farmers in Central Uganda implement the practice in which they dig out completely the roots of plants in the field and newly plant the seedlings of other crop species free from the infestation of nematodes. The populations of nematodes causing damage to banana were reduced in the successive phase of cropping after the root crops such as sweet potato and cassava were cultivated as the plants free from the infestation of nematodes. Concerning the approach through this principle, trials are being carried out for the determination of the duration of rotational cropping under different field conditions. Moreover, the search for applicable crop species other than cassava and sweet potato is going on, and it has been ascertained that this method enables the reduction of parasitic nematodes.

b) Introduction of uninfected plants

The expansion of nematode distribution from one area to another occurs also through the movement of plants infected with nematodes. This mode of dissemination can be prevented by the use of uninfected plants (nematode-free plants) that have been raised from the initial plants produced in the fields where no

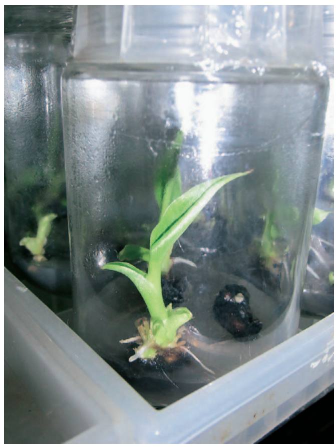

**Photo IV-3**
**Nematode-free plant derived by meristem culture**

nematode damage is observed, or by the use of plants derived through the technique of tissue culture, an application of biotechnology. As a feasible method on the farmers' level, the control procedures in which suckers are exposed to sunlight or treated with chemicals can reduce the incidence of nematode damage.

c) Soil amelioration and utilization of nematode repellent plants

It is known that the length of productive period is longer in those banana plants growing in the horticultural lands that are managed with care by weeding and applying fertilizers, or in the home gardens where the soil is improved by applying domestic wastes. This fact has been verified by the cultivation that has endured for long years with the Highland bananas in Uganda and with the bananas in West Africa. It is generally believed that the amelioration of soil reduces the injurious effect of nematodes, enhances the banana growth, and leads to the production of large and heavy fruit clusters.

Although the effect may vary depending on nematode species, a certain number of plants are known to repel nematodes. As representative species of such plants, there are crotalarias (rattlepods, *Crotalaria* spp.), marigolds (*Tagetes* spp.), and shrub sunflower or tree marigold (*Tithonia diversifolia* A. Gray). It is also important to reduce the nematode population by utilizing these plants, by growing them among banana


**Photo IV-4 Example of nematode repellent plant, Crotalaria**


**Photo IV-5 Example of nematode repellent plant, Marigold**

plants as mulching materials or growing them as antecedent crops before opening a new banana orchard.

**Tale IV-2 Examples of nematode repellent plants**

| Scientific name | Japanese name | Popular name |
|---|---|---|
| *Crotalaria* spp. | Tanuki-mame | Crotalaria, rattle pods |
| *Tagetes* spp. | Manju-giku | African marigold |
| *Tithonia diversifolia* A.GRAY | Nitobe-giku | Shrub sunflower, Tree marigold |

d) Use of resistant varieties

Studies on the nematode resistance are being conducted for cultivars of East African Highland bananas. At the moment no variety has been identified as having resistance to nematode. However, in the clone of a diploid of Pisang Jari Buaya, the resistance to *R. similis* has been reported. The nematode resistant clone material is being applied in the plant breeding program to develop resistant varieties against *P. goodeyi* and *H. Multicinctus*. The development of banana varieties resistant or tolerant to pests is also one of the objectives of the banana propagation project in Uganda.

② Chemical control

It is important to select nematocidal agents that show rapid and efficient effect against nematodes. The effect of nematocides for the yield increase was recognized when they were applied to heavily infested fields. However, the treatment with nematocides on the field where the banana cultivation is actually going on is not appropriate. Requirements for chemical substances and for the treatment of them differ depending on the type of farming management, and they are generally not feasible economically unless the farming management in question is that of a large scale commercial cultivation. Furthermore, the nematocides present hazards to humans and environment and are also likely to inflict harmful effects on many beneficial organisms serving as natural enemies. Consequently, at present non-chemical cultural management methods are being promoted as the measures to control nematodes, in order to benefit poor farmers with few opportunities for earning income, and to enable them to practice the type of agriculture that is sustainable and friendly to environment.

**2) Banana weevils**

(1) Banana weevil and its damage

A beetle that feeds on banana, the banana corm (root) borer weevil, *Cosmopolites sordidus* Germar (Curculionidae), (hereafter referred to as banana weevil) is the most destructive pest in bananas. In Uganda also the banana weevils was known since early and it was mentioned also in some countries that imported banana varieties in the 1900s. By the late 1950s, it was distributed all over the country except for Fort Portal and the surrounding areas of West Nile [29) 61) 11) 27) 16) 13)].

However, although in general it is not considered as an important pest in the large scale farms growing Cavendish banana, it has a very important economic significance for large scale farms growing East African Highland bananas. In a study conducted in Kawanda to evaluate the extent of damage due to the pest on Atwalira, an East African Highland banana cultivar, it was revealed that the damage increased from 10 % to 48 % [33)]. In much older orchards, the banana plants sustained a much higher level of damage due to the weevil, and pseudostems broke, which caused serious losses (50 % to 100 %) and shortened the longevity of orchards [35) 14)].

The cultivars of East African Highland banana (AAA) and cooking banana (AAB) are more liable to severe attacks of the banana weevil than the cultivars for brewing beer such as Kisubi (AB) and Kayinja (ABB). However, it is evident that Bogoya and Gros Michel (AAA) are less liable to the attack and the weevil cannot easily invade into their rhizomes. The gravity of the weevil damage causes a very heavy impact on the management of banana farms. For Ugandan farmers with few economic resource plants, the occurrence of the banana weevil is a serious problem.

(2) Ecology and lifecycle

According to a study by Traore et al. (1993) [51], females of the weevil lay eggs at the basal part of rhizome or in the cavities bored in pseudostems. Larvae hatch in 5 to 8 days, bore tunnels in the parenchyma of rhizome, feed on surrounding tissues and grow. The development of growing stages varies depending on the climate of the region and the season. Larvae spend 5 – 10 days in banana tissues, and another period of more than 4 – 7 days in the tissues until the pupation turns their skin almost black and hardened. It has been identified that the complete life cycle in Uganda takes about 53 – 72 days [3]. In most of other parts of the world cases of shorter duration of life cycle have been recorded and it takes 30 – 50 days. Moreover, the cases of longer lifecycle lasting 200 – 220 days also have been reported [12].

**Photo IV-6 Larva of banana weevil**

**Photo IV-7 Rhizome damaged by weevils**

Adult Weevils crawl out to the ground surface and spend there the rest of their life. The size of an adult weevil is about 12.5 mm long and 4mm wide in a larger one. Their life habit is nocturnal and they are most active in darkness. They particularly prefer to live in high humidity environment, and it is known that the adult weevils can survive for a long period without feeding. In a case identified in banana orchards in Uganda, it is known that they have survived as long as 4 years. Adult weevils are very sensitive to soil humidity and when the dry state is maintained, they inevitably die very quickly.

(3) Symptoms of attack and damage

According to Gowen (1995) [16], the damage due to the banana weevil results essentially from feeding activities of larvae that bore tunnels in rhizomes and pseudostems and feed on surrounding tissues. Grown-up larvae bore holes of about 15 mm in diameter, and feed on tissues to extend the holes upward for a distance of as far as 60 – 100 cm. As a consequence of this, the absorption and the translocation of nutrients and water by banana plants are disturbed, the nutrition is degraded, and the growth is weakened. Furthermore infested banana plants become susceptible to the attacks of pathogenic microorganisms, fungi and bacteria, which grow in the tunnels bored by the weevils. Particularly the invasion of the weevils in young banana seedlings not only interrupt the plant growth and retard fruiting, but also sometimes cause the death of the plants. Generally such a situation arises in the case where the weevil eggs have already been laid in suckers prepared for transplanting or the suckers have been already contaminated with larvae having invaded them or in the case where uninfected suckers are planted in contaminated fields. Severely damaged banana plants produce small fruit clusters and suffer from the lowered capacity for resisting droughts and strong winds. Sometimes the plants bearing large fruit clusters break spontaneously.

(4) Temperature and distribution

The place of origin of the banana weevil is supposed to be Asia, but the insect has already spread to major banana producing countries in the world. According to a recent survey conducted in Uganda, the insect is observed in all areas at an altitude below 1700 m. However, it has not been found in Kabele (1760 m) and Kapchorwa (1830 m). The absence of the insect in regions of higher altitude can be attributed to the factor that the insect cannot live in such areas because the temperature is not high enough to allow the growth of larvae and the survival of adult weevils. However, the annual mean temperature in Kabele is 17.7℃ and exceeds the lower value of threshold temperature of 12℃ that has been established by Traore *et al.*(1993) as the lower limit of the temperature range for the weevil survival. The absence of the weevil in Kabele could be explained by the possible situation in which the lowest temperature occurring in a certain season may be inhibiting the development of eggs and the egg laying of the weevil [51)].

(5) Control techniques

Currently no resistant variety immune to damage has been identified. Hence it is difficult for Ugandan farmers to choose cultivars as a means to suppress the damage.

Since the chemical control entails the problem of risks to humans and environment, it can not readily be recommended to farmers. Under these circumstances, it is known that cultural approaches and biological control are important as well as effective.

① Control through cultural practices

As methods for controlling banana weevils through cultural practices, various traditional practices described in the following are applied.

a) Introduction of pest-free plants

By planting healthy plants, it is possible to prevent the spread of weevils to new areas through the intermediary of plants. The plants obtained from the field without occurrences of weevils are more often healthy ones. In the case of plants that were collected from the field where the occurrences of weevils have been observed, it is needed to control the weevils by treating them: the surfaces of rhizomes are scraped off to remove eggs and larvae living there and immersed in the solution of a recommended insecticide to kill larvae embedded in subsurface tissues. Since plants propagated by tissue culture are generally free from weevils, such materials should be used, if they are available. Some farmers practice the immersion of rhizome in water for 24 – 48 hours, irrespective of the presence or absence of insecticide. But the effectiveness of this practice has not been determined. It has been recognized that the treatment with heated water also is not an effective control measure when larvae have penetrated deeply into the rhizome. In general, by using healthy rhizomes, the incidence of weevil infestation in earlier phases after transplanting can be reduced, but this method cannot be the measure to control the invasion and the attack coming from neighboring fields. However, since this method can prolong the period required for the growth of weevil population, it serves for the prolongation of the period allowing the cultivation.

b) Disposal of residues after harvesting

It is possible to reduce the habitats and the breeding environment of weevils by shredding and dispersing pseudostems and rhizomes after the harvest of fruits, because the treatment will accelerate the process of drying. Moreover, the treatment leads to the exposure of eggs and larvae of the weevils to aridity to kill them. Farmers conventionally believe that the treatment to cover remaining stumps with soil deprives the weevils of their living environment. However, because the weevils can reportedly bore an underground hole with a depth of up to 60 cm to lay eggs, the method cannot be said to be an appropriate measure. Nevertheless, while these conventional procedures can be considered as cost-effective control methods, detailed studies on them have not yet been conducted.

**Photo IV-8 Residues are shredded and spread**

**Photo IV-9 Residues are untreated**

c) Trapping and kill adult weevils

The capture of adult weevils by traps is one of the oldest methods for controlling weevils. Two types of traps are used: one using pseudostems and the other using discs of stump. The trap of pseudostems is made by cutting longitudinally a piece of pseudostem into two halves which are placed on the ground with the section facing the ground. On the other hand, the trap of stump discs is made by cutting transversely a stump to prepare a piece of 15-25 cm in length, which is placed on top of the stump and covered with leaf sheaths and leaves. Later the weevils that have flocked to these traps are collected and killed.

d) Appropriate environment management

It is important to take various measures to maintain the appropriate environmental conditions for the growth of banana, such as weeding, elimination of surplus suckers, removal of dead leaves, fertilizer application, and mulching. These measures contribute to the removal of habitats of adult weevils and the growth of banana plants tolerant to weevils. It has been noted that in the orchards under poor management care, weevils vigorously invade banana plants and cause damage, but in those under good management care and hence with good banana growth, the level of insect damage is low [33) ].

② Chemical control

Until the 1970s, organochlorine compounds such as dieldrin, DDT, and Aldrin were permitted as applicable insecticides. However, after that organophosphorus pesticides and carbamate pesticides with less residue-prone properties have been in use. Currently the most economically used chemicals include carbofuran (Furadan), primiphosthyl (Primicide), dursban, etc. Normally, liquid or granular forms of pesticides are applied to the basal part of plants by using simple apparatus. The application on the traps made from pseudostems or stump disks is also effective for killing weevils that have been attracted to the traps. Those farmers who can afford to use these chemicals are limited in number, because of the scarcity of supply and expensive prices and also the problem of possible hazards to health and environment. The guidance for the farmers who use pesticides is also essential. The utilization of pesticides is beneficial if the methods that are effective and cause no negative impact on environment can be identified. It can be also counted on as an effective method to integrate chemical control into other control measures or biological control.

③ Biological control

In an attempt to control weevils, a species of predatory insect in the date palm cultivation was introduced in 1934. Histerid beetle（*Plaesius javanus* Erichs） was imported from Java and released in Kibibi on the Lake Victoria, etc. From the surveys in 1937 and 1945, it was confirmed that the natural enemy had settle d in Uganda. It is likely that the exploration in banana growing areas within the country will enable the finding of more appropriate natural enemies.

Studies on pathogenic filamentous fungi attacking banana weevils, *Beauveria bassiana* (Balsamo) Vuillemin and *Metarhizium anisolpliae*（Metchnikoff）Sorokin, were started in 1991. *B. bassiana* is more promising between the two, and there is a possibility that it can be used in combination with other methods for controlling the weevil. Since it was confirmed that in the fields inoculated with *B. bassiana* the occurrence of the weevil was remarkably reduced, studies on these fungi in farmers' fields are ongoing [26].

**3) Other pests**

It has been identified that several insect species including *Poecilocarda* (*Tettigoniella*) *mitrata* Gerst, *Latoia viridissima* Holl (L. *satura* Karsch), *Temnoschoita nigroplagiata*, *T. erudita*, *T. basipennis*, etc, inflict damage on bananas. However, in Uganda these

**Table IV-3 Other pests [56]**

| Scientific name |
|---|
| *Poecilocarda (Tettigoniella) mitrata* Gerst |
| *Latoia Viridissima* Holl |
| *Temnoschoita nigroplagiata* Qued |
| *T. erudita* Duviv |
| *T. basipennis* Duviv |

insect species are not recognized as posing problems of economic significance. *Temnoschoita*, a beetle, lives generally in rotten tissues. It has been ascertained that the pests that are important in economic significance in Uganda are nematodes and weevils. It is pointed out that the damage and the yield reduction caused by these two types of pests are possible to increase seriously to the extent that the banana field shall be practically destroyed. Under these circumstances, the realization of effective and definite control has been recognized in the orchards where farmers practiced the strategy of the integrated pest management (IPM) that recommends to plant pest-free plants to pest-free fields.

## 2. Diseases of banana

Some of the diseases occurring to dessert bananas and cooking bananas in Uganda are caused by a number of important pathogenic microorganisms including fungi, viruses, and bacteria, etc. The diseases are classified into a couple of groups of symptoms including that of the occurrence of spots on leaves which includes "Black sigatoka", "Yellow sigatoka" and "Mottle leaf", and that of the occurrence of wilting and withering of the total plant which includes "Panama disease" (Fusarium wilt), "Matoke wilt" and Banana bacteria wilt (BBW) caused by a bacterial pathogen. Moreover, as a virus disease which inflicts heavy damage, there is "Banana streak virus"[52].

**Table IV-4 Diseases of bananas in Uganda**[56]

| Scientific name | English name |
|---|---|
| *Mycosphaerella fijensis* Morelet | Black sigatoka |
| *M. musicola* Leach | Yellow sigatoka |
| *Periconiella sapientumicol*a Siboe | Leaf speckle |
| *Fusarium oxysporum* Schlect. f.sp.*cubense* (E.F. Smith) Snyd. and Hans | Fusarium wilt, Maloke wilt, Panama wilt |
| *Fusarium oxysporum* f.sp. *cubense* (indeterminate) | Matoke wilt |
| *Xanthomonas campestris* pv. *musaceareum* | BBW: Banana bacteria Wiltshire |
| | Banana streak virus (BSV) |

**1) Diseases causing leaf spots on banana**

In general leaf spots in banana occur in the mixed presence of different pathogens causing black sigatoka *(Mycosphaerella fijensis* Morelet), yellow sigatoka (*M. musicola* Leach), leaf speckle *(Periconiella sapientumicol*a Siboe), etc. The two sigatoka diseases, black and yellow, are distinctly different from the leaf speckle disease, but the difference between black sigatoka and yellow sigatoka is sometimes difficult to distinguish in the field. These three diseases sometimes occur on the same leaf, but the temperature (altitude) is one of the limiting factors for the black sigatoka's occurrence. In Uganda the black sigatoka was reported first in 1989, but on the global level the disease has become one of the major constraints in the banana production [54]. On the other hand, yellow sigatoka and leaf speckle that were identified in Uganda first in 1938 were supposed to be of minor importance, but it was likely that they were underestimated at that time. Complex leaf spot diseases occurring on the same leaf that is infected with the black sigatoka are economically important. The result of investigation conducted on a cultivar of Highland banana, Mbwazimme, in Kwanda revealed that the yield was reduced by 37 % due to the diseases causing leaf spots. The loss resulted mainly from the insufficient filling of fruits due to disturbances in leaves occurring before the completion of fruit ripening [55].

(1) Symptoms and distribution of black sigatoka and yellow sigatoka

The black sigatoka disease is characterized by the appearance of necrotic infected parts in the form of oblong ellipse along leaf veins. The symptom develops in the following steps. At first fine yellow-greenish spots are visible, and then the spots become brown continuous streaks on the obverse side of a leaf which further develop to yellowish green ones as a whole. Moreover the continuous streaks expand to become spots with poorly defined margins in color of brown or rust-like red. After that the spots develop in the central portion the flecks with distinct contours which look like haloes in a color ranging from brown to yellowish tinge, and the central portion turns to the state inundated with water and becomes colored in a darker brown. Finally depressed central portion turns gray, with surrounding areas turning dark brown or with yellow surrounding areas enclosed by a black borderline and surrounded by the healthy green portion of the leaf, of which, if the disease develop intensely, the necrotic tissues get united rapidly and expand to occupy a wider area [48].

The symptom of yellow sigatoka also develops in the manner similar to the case of black sigatoka. The chief difference between the two sigatoka diseases concerns the color of streaks of infected parts at an earlier phase of symptom development, namely, in contrast to the case of black sigatoka with black streaks of spots, in the yellow sigatoka the color is yellow. However, as the tissues necrotize progressively, it becomes difficult to distinguish two diseases only by the symptoms.

(2) Distribution of diseases causing leaf spots in Uganda

According to the results of surveys conducted in 1993 at 24 localities growing bananas in Uganda, the black sigatoka was not found at localities where the altitude exceeded 1450 m and the mean minimum temperature was lower than 15 °C. However, the incidence of 100 % of the black sigatoka was observed in Highland cultivars growing in the same localities.

Meanwhile, regarding the incidence of yellow sigatoka, although it was low at a rate of 5 – 10 % at an altitude higher than 1450 m, the disease was observed at all the investigated localities. Careful studies revealed that the incidence of yellow sigatoka at a rate of 5 – 10 % was observed at 5 localities where the Highland cultivars, Entundu, Mbwazirume, and Nakitembe, were cultivated. The incidence of yellow sigatoka infection is said to be higher with Kayinja (72 %) and Bogoya (19%) than with Highland bananas. However, while at a higher altitude the rate of infection was lower with Bogoya and Highland bananas, a higher rate was observed there with Kabale and Kayinja. The occurrence of leaf spots with Highland bananas was observed at the rate of 100 % at all the investigated localities, and cooking bananas also expressed the symptoms in a similar manner. However other introduced cultivars demonstrated the resistance against the disease [52].

(3) Symptoms of leaf speckle

The disease becomes visible 3 – 4 weeks after a leaf expands with a symptom of slender bronze spots like traces drawn with a pencil. The spots further enlarge and the leaf turns blackish green. As the growth of leaf advances the spots turns from orange to yellow, and then brown, and ultimately necrotize. The necrosis starts from marginal parts of old leaves.

(4) Control methods

① Cultural control

Studies on appropriate cultivation in the context of cultural control are ongoing. It has been recognized that the improvement of nutritional status of banana plants enables reduction of the impact due to diseases causing leaf spots. It is important to promote the generation of well developed leaf tissues capable of enhancing photosynthesis [52]. The utilization of fungicides is an effective method but cannot be said to be an appropriate solution for small holders who constitute the core of banana production in Uganda.

② Utilization of resistant varieties

In general the least costly and the most effective means to control plant diseases is the cultivation of resistant varieties. Resistant Highland bananas are immune to diseases. Meanwhile resistant cultivars imported from abroad also are being cultivated. It is highly likely that some of those imported cultivars (for example, FHIA01, FHIA17, and FHIA23) can be used as cooking bananas.

**2) Fusarium wilt (Panama disease)**

It was reported first in 1952 that Panama disease (Fusarium wilt) was caused by *Fusarium oxysporum* Schlect. f.sp.*cubense* (E.F.Smith) Snyd. and Hans (FOC) in the actual fields of banana cultivation in Uganda [23]. The symptoms of wilt were reported for Highland bananas and dessert banana cultivars imported from abroad in 1955, and the similar symptoms were also observed in the survey conducted in1995 in the southwestern part of Uganda at an altitude of 1300 m [53]. Recent studies have revealed that the Fusarium expresses pathogenicity in 4 dessert banana cultivars grown in Uganda, namely, Gros Michel, Snkari-Ndizi, Kisubi, and Kayinja, but does not infect Highland bananas. Regarding the pathogen causing Matoke wilt, it has not yet been identified and the search is ongoing.

(1) Symptoms and distribution of Fusarium wilt

Fusarium wilt known as Panama disease is the most destructive disease for introduced banana cultivars in Uganda [7]. The pathogen lives in soil and can survive without the presence of host tissues such as those of banana, making it difficult to control the disease through rotational cropping. The characteristic of the pathogen is the fact that it does not express the disease in other plants than species of *Musa* and *Heliconia* in the same family of Musaceae. This disease spreads also by the intermediary of contaminated soil stuck on infected banana young plants, farming tools, shoes, etc. Pathogens invade through injured lateral roots and are absorbed and translocated upward along with the current of evapotranspiration [4].

The translocation of spores through a vascular bundle is obstructed due to the generation of tylose and gel within tissues. However, in tissues of susceptible banana plants, the pathogen can pass through this defense line by the production of hydrolytic enzymes and substances inhibiting the generation of substances for obstructing the translocation. This situation further makes the banana plant susceptible to invasion and turns it yellow and wilted. The most remarkable external symptom of wilt is the expression of drooping of leaves. However the most definite symptoms of the Fusarium are the appearance of purplish brown color in the cross sections of rhizome and pseudostem, and the fading of color of vascular bundles.

Three strains of pathogens (Strains 1, 2, and 4) are known to infect dessert bananas. While Strain 4 is found mainly in the cooler subtropics, and Strains 1 and 2 are found widespread in all areas where bananas are cultivated, the latter 2 strains occur in a different way from one another. In Uganda, both of Strains 1 and 2 are observed in areas where Gros Michel and Bluggoe are grown, and Gros Michel is found infected with Strain 1 while Bluggoe is not infected with Strain 1. It has been ascertained that Strain 1 of FOC infects 4 cultivars in Uganda, i.e., Kayinja (Pisang awak-ABB), Bogoya (Gros Michel - AAA), Kisubi and Sukari-Ndizi (AB). The prevalence of Strain 1 has been confirmed in all regions of Uganda particularly in recently introduced cultivars that are mainly those used for juice production and the dessert banana varieties grown for export purposes.

(2) Control techniques

① Introduction of resistant varieties

The cultivation of resistant varieties is the most cost-effective method for controlling diseases. Those bananas and cultivars such as Highland bananas, plantains, Cavendish, FHIA01, FHIA17, and FHIA23 that have been identified as resistant varieties in a comparative investigation conducted on an identical location can be used as cultivars to replace the highly susceptible varieties of dessert banana such as Bogoya and Sukari-Ndizi.

② Introduction of uninfected young plants to disease-free fields

In the case of susceptible cultivar like Sukari-Ndizi, it is important to cultivate uninfected plants in an unpolluted field. Pathogen-free plants are already available because the tissue culture has enabled the mass production of such plants, and hence this strategy of planting them to unpolluted fields is practicable currently. So far no remedial method to cure the infected plants has been known.

**3) Matoke wilt**

(1) Symptoms and distribution of matoke wilt

In highlands at an altitude higher than 1300 m in the southwestern Uganda, it has been ascertained that Highland bananas wither due to another wilt disease, i.e., matoke wilt. The wilt was identified first in 1995 and attributed to the infection by *Fusarium oxysporum* f.s *cubense.* However, recent studies reportedly indicate that this Fusarium species is possibly not the pathogen of the wilt. The occurrence of matoke wilt is limited to the banana plants grown in home gardens and around dumps and fenced plots for animals. Even in the case where a rhizome obtained from an infected plant is transplanted to an unpolluted field, it is said that healthy fruit clusters and healthy suckers are produced. In the banana plants infected with matoke wilt the cluster yield is reduced by 78 %. Such a loss creates a problem when farmers expect to achieve high productivity in the fields nearer to the houses with a high content of organic matter. It can be assumed that the disease affects all cultivars universally[30)].

(2) Control measures

In order to restrain the impact on uninfected plants, certain farmers adopt measures to try to maintain the cleanliness, remove infected plants, and putrefy well the household wastes before applying them to fields.

**4) Banana streak virus, BSV**

In Uganda, while other virus diseases of banana are not important, the banana streak virus has become an important disease. The virus causing the banana streak virus disease was isolated first in 1986. Since then it has been reported also in India, Morocco, Nigeria, Latin America, Rwanda, Jordan, Tanzania, China, Mauritius, South Africa, Madagascar, Ecuador, and Uganda[18) 55)]. BSV presents an orderly bacilliform shape. It belongs to the group of badnavirus containing DNA in the form of round double helix. The badnavirus tends to cause a high incidence of mutation during the multiplication phase. Banana streak virus disease not only is liable to mutate biologically, serologically, and genetically, but also develops a wide range of symptoms and causes damage that could range from a light loss to sometimes a very heavy loss.

(1) Symptoms of BSV

The symptoms of an early phase of BSV that are visible on leaves resemble closely those of CMV (cucumber mosaic virus). First they are visible as yellow linear mosaic spots. The linear necroses on leaves that appear afterward differ from those of CMV. In the infected plants the growth slows down and the plant vigor is lost. Moreover, it becomes difficult to develop flowers, fruit clusters become smaller, and fingers get lean and distorted. The blighting of top portion due to necroses of internal parts of pseudostem resembles closely to the symptoms of BSV that are observed also in Rwanda. Periodical appearances of symptoms are the characteristics of banana plants infected with BSV. The symptoms do not necessarily appear continuously on all the leaves that emerge, but sometimes no symptom appears on a new leaf once in a few months, or a leaf emerges that expresses only a light symptom. Consequently, at the stage of quarantine, it is necessary to retain seedlings for at least 9 months for surveillance. If that procedure is omitted, the apparent resemblance to the symptoms of CMV may cause a case of misjudgment, due to the periodical appearance of symptoms of BSV [18].

(2) Transmission of BSV

BSV spread mainly through vegetative propagation. It has been ascertained that all the suckers collected from an infected parent plant develop BSV without fail. The phenomenon in which, while two plants were planted separately and one had been healthy before planting, the symptoms appeared in both of them also explains why this disease is said to be able to spread possibly through airborne infection. Meanwhile, it is conceivable that BSV can spread by the intermediary of mealy bugs of citruses (*Planococcus citri*), sugarcane (*Saccharicoccus sacchari*), and, though indefinite, mealy bugs of banana. The transmission through the manipulation of tools for pruning suckers and leaves or through soil is not thinkable.

(3) Control of BSV

An important measure to suppress the spread of BSV and other virus diseases consists of the practice to eliminate infected plants and not to use them. It is possible to control the virus by means of digging up all the plants infected with BSV and drying them. This means is effective because it enables not only the reduction of the incidence of disease but also the elimination of intermediate hosts and vectors at the same time. It is said that certain farmers who own farm fields infected with BSV are often reluctant to remove banana plants, in spite of the fact that the infection leads to the total loss of production [55].

As another measure, it is important to use only ascertained uninfected seedlings. To start with, it is needed to plant a new field with suckers and rhizomes obtained from the fields that have not been infected with BSV. Meanwhile, nowadays the uninfected seedlings generated through tissue culture techniques are available commercially and can be used as materials for establishing banana orchards. By adopting these effective measures, long term continuous banana production is assured unless the field is infected again.

In the context of acquisition of uninfected seedling, in the case of virus diseases such as BSV, it is important to establish an effective verification system by quarantine, isolation and inspection, and to exclude the pathogens from production areas by making full use of the technologies supporting the system. Moreover, as regards the control of virus diseases, it is essential to establish the guidelines for the quarantine to be applied to cases of international shipping or introduction of cultured cells, after thorough inspection of clone materials.

### 5) Banana bacterial wilt

This disease is said to be caused by the pathogens of banana bacterial wilt (BBW, *Xanthomonas campestris* pv. *musaceareum*) and is currently supposed to be one of the most important diseases in banana. The strong measures are being promoted at the level of farmers, and the extension centers in banana growing areas display posters urging producers to take control measures against the BBW. It is known that the BBW is caused by the same pathogen that causes a disease in ensete banana cultivated in Ethiopia.

This disease was detected at Mukono near Kampala in 2001 and afterward found widely in other areas as well. At first leaves turn yellow, and petioles break and droop. The cross section of leaf sheath reveals blocked vascular bundles and bacterial secretions exude from the section in 5 – 10 minutes after cutting. It is also likely that male flowers born on the tip of a mature and withered cluster bloom, and the bacteria are transmitted by activities of insects visiting them.

Since the transmission of diseases takes place most likely through the infected plants, it is important to practice various measures as follows: never use the suckers obtained from infected orchards; eliminate and dispose of male inflorescences, because it possibly happens that insects like honey bees transmit the disease from bloomed male flowers; and at the same time disinfect the tools like knife and hoe that have been used in the treatment of plants by an appropriate means such as by exposing them to an open fire. Moreover, farmers are recommended to observe the practices such as the elimination of infected plants by cutting and digging them up together with rhizomes, and piling them up to accelerate the putrefaction.

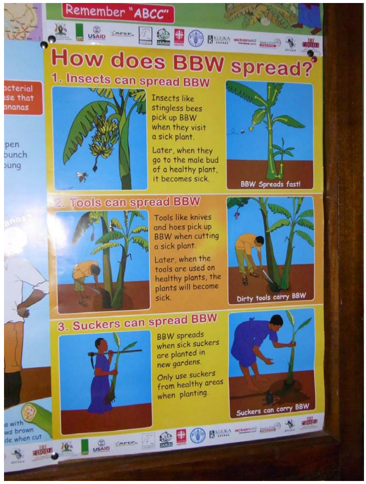


**Photo IV-10 Placard showing transmission paths of BBW**

### 6) Other diseases

As regards banana diseases occurring in Uganda, it has been reported that two pathogens, *Marasmius semiustus* Berk & Curt and *Armillaria mellea* (Vahl ex Fr.) Kununer, cause rot in the basal part of pseudostem and in rhizomes. Moreover, fruit fingers sustain disturbances caused by those pathogens including *Verticillium theobromae* (Turc) Mason & Hughes, *Colletotrichum musae* (Berk. & Curt.) Von Arx (anthracnose of bananas), *Fusarium monihforme* Sheldon, *Deightoniella torulosa* (Sny) Ellis (Leakey 1970). The pathogens causing the expression of symptoms on leaves include *Periconiella sapientumicolla* Siboe (Cladosporium leaf speckle), *Drechslera* spp. (eye spot), *Cordana musae* (Zimm) Hohn (Cordana leaf spot), *D. torulosa*, *Septoria* spp. and *Chloridium musae* Stahel. These pathogens cause disturbances on Highland bananas, but the symptoms are considered to be not serious.

**Table IV-5 Other diseases occurring on banana plants** [56)]

| Scientific name | English name |
|---|---|
| *Marasmius semiustus* Berk & Curt | |
| *Armillaria mellea*(Vahl ex Fr.)Kununer | |
| *Verticillium theobromae* (Turc) Mason & Hughes | |
| *Colletotrichum musae* (Berk. & Curt.)Von Arx | Anthracnose of bananas |
| *Fusarium monihforme* Sheldon | |
| *Deightoniella torulosa* (Sny) Ellis | |
| *Periconiella sapientumicolla* Siboe | Cladosporium leaf speckle |
| *Drechslera* spp. | Eye spot |
| *D. torulosa* | |
| *Cordana musae* (Zimm) Hohn | Cordana leaf spot |
| *Septoria* spp. | |
| *Chloridium musae* Stahel | |

## 3. Soil fertility management

### 1) Suitable soil conditions for banana cultivation

Banana grows well on the soil with good drainage and rich in humus, and the cultivation on the soil with poor drainage is not appropriate. Otherwise banana is characteristically able to adapt itself to a wide range of soil conditions. With respect to soil pH, strongly acidic soil is not suitable for banana growth. And banana can maintain yield levels on the soil rich in various mineral compounds. The most suitable soil conditions for banana cultivation can be defined as those with pH ranging from 5.6 to 7.5 and content level of salts at less than 500 mg/kg [49)]. Besides, it is needed to apply appropriate doses of potassium (K), magnesium (Mg), calcium (Ca), and phosphorus (P).

### 2) Management of soil fertility and fertilization

Banana plants absorb lots of nutrients from soil. In order to harvest 40 tons of bananas from 1 hectare of land, it is said that on average 250 kg of N, 26 kg of P, 830 kg of K, 105 kg of Mg, and 15 kg of S are absorbed from soil. According to Twyford and Walmsley (1974), some reports indicate that for every 40 tons of harvested bananas, 2000 kg of K are to be absorbed from soil [21) 57)]. Potassium is an essential element for the growth of banana and supposed to have the effects for enhancing the differentiation of floral buds, accelerating the ripening of fruits, and augmenting the size and weight of clusters and fingers and the number of fingers [22) 17)]. A study on banana conducted in 1968 determined the quantities of three essential nutrients, N, P and K, and demonstrated that the range of content of three elements present in leaves required for the growth of banana was 3.2 – 3.4 % in which potassium accounted for 2.77 % on average. According to the results of diagnosis in 1993, potassium was identified as one of the limiting factors in banana production.

Subsequent studies conducted in 1968-70 ascertained the necessary conditions for banana nutrition. A study on the farm of the University of Makerere found out that the banana yield of the cultivar, Nakyetengu, increased from 20 tons to 40 tons by application of 111 kg/ha of N and 36 kg/ha of P in the field mulched with a heap of elephant grass of 15 cm in depth. Based on the study result, tests are going on in Kawanda and Makerere to determine the nutritional requirements in banana plants [56)].

### 3) Farmers' practices of soil management

Farmers have been practicing the fertilization management of banana crop by combining organic manure and chemical fertilizers. Furthermore, as the resources of organic manure, they use not only mulch but also organic matter produced in households, crop residues, and organic wastes produced on farms. Consequently the rate of application of organic materials differs depending on

**Photo IV-11 Mulching treatment after planting of young plants**

individual farm households. However, the well cured manure applied at a rate of one wheelbarrow load per plant amounts to about 20 tons per hectare (Banana Programrne 1998). A recent survey indicates that in spite of economic difficulties for using fertilizers, the quantity of application to banana is increasing.

The report of Bekunda and Woomer (1996) [5] has demonstrated that 4 % of banana farmers in the central and the western regions of Uganda are using fertilizers. In those areas where fertilizers are used, it is desirable to apply them in a circular belt about 1 m apart from the pseudostem. If the ground is mulched, fertilizers have to be applied beneath the mulch.

Large scale commercial production of banana is increasing. With cultural practices including the planting of uninfected seedlings and the application of a larger amount of fertilizers under improved field management techniques, such a type of farming will possibly be able to contribute to the increase of banana production in Uganda.

## 4. Breeding techniques

### 1) Hybridization breeding

Banana plants that are currently used for production are generally parthenocarpic and unfilled seeds are generated in fruits, and those seeds are mostly incapable of germination. However, the efforts for breeding new varieties are being made based on the expectation that by chance some germinable seeds might be produced among them. First, selection is made about the parental plants of varieties having objective characteristics, one used as maternal plant and the other as pollinator parent. Before flowering starts on emerged inflorescences they are enclosed in bags to block the visit of insects. At the moment when the maternal plant's female flowers and the pollinating parent plant's male flowers bloom, bags are removed, the male flowers are taken out, the pistils of female flowers are rubbed with the anthers of male flowers, and the bags are closed again to wait for the maturity of fruits.

The matured fruit clusters are stored, seeds are extracted, and embryo culture is carried out on the seeds including undeveloped ones by applying the technique of tissue culture, in order to raise plants with novel characteristics.

The history of breeding new banana varieties started first in the early 1920s in Trinidad and Jamaica [8) 44) 39) 40)]. Since then, various programs of banana breeding were started in different countries, for example, Latin America [31) 32)], France [2) 58) 59)], Brazil [41) 42) 43)], India and Nigeria [28)]. All these programs were started with the objective of breeding varieties tolerant to the diseases that had been threatening bananas grown for commercial purposes.

The breeding programs of Honduras have produced so far the largest number of successful results. Among the varieties developed by breeding programs of the research institution of Honduras, Fundacion Hondurena de Investigacion Agricola (FHIA) (FHIA, 1997), those which have been imported to Uganda include FHIA01, FHIA02, FHIA03, FHIA17, FHIA21, FHIA23, and FHIA25. FHIA01 is a variety that is inferior to the traditional Highland bananas in terms of quality, but it has been accepted by Ugandan farmers as a cooking banana. Moreover, FHIA03 has been adopted as a better banana variety

**Photo IV-12 Rubbing bloomed female flowers with anthers of maleflowers**

**Photo IV-13 Derived seeds**

**Photo IV-14 Embryo culture is applied because not all seeds are viable.**

for brewing purposes. The banana breeding program in Uganda (by collaboration between the National Agricultural Research Organization and the International Institute of Tropical Agriculture) was started in 1944 with the objective of the improvement of agricultural characteristics of Highland bananas and the development of varieties resistant to the black sigatoka disease [28]. This program was implemented by the crossbreeding between the cross-fertile female Highland banana clones that are susceptible to the disease and the diploid male plants that have been developed through other breeding programs [1)32)60)] and are highly resistant to the black sigatoka disease.

Provision of a crop species with resistance is one of the important criteria in the control of diseases and pests for realizing ecologically sustainable cultivation. Consequently, the efforts to solve the problems of diseases and pests in Highland bananas through variety development have been recognized as the most appropriate strategy. A recent survey conducted on producers has confirmed the fact that they consider the recommended cultural control practices require of them lots of labor and expense [14]. Chemical control option is also available, but it is difficult to adopt in view of the small scale subsistence farmers with low profitability in Uganda. Moreover, the chemical control entails problems that not only it is likely to affect non-targeted organisms (example: worms, natural enemies, etc.), but also it involves chemicals that are often poisonous to humans and animals.

Crossbreeding strategy is not feasible unless the seed production is possible by the manipulation of sexual crossing as the first step of hybridization between different clones. However, most of edible banana plants show a high sterility and do not develop seeds. As the causes of sterility, there are several conceivable factors including disturbances in pollination or fertilization, and impediments to the development of ovules or zygotes [9) 10) 38) 44)]. The capacity of female flowers for fertilization can be expressed in a quantified term of the average number of seeds produced in a fruit cluster. The combination of clones that produced the most numerous seeds was that of Nfuuka and Nakabululu.

The rate of seed generation differs greatly depending on the combination of clones, and ranges from 0 to 20 per fruit cluster.

It has been demonstrated that the clones that were capable of producing the most numerous seeds by the combination with Nfunka clone were Entukura (Enairabahima), Nante, Kabucuragye, Tereza, and Enyeru. Kazirakwe (Nakayonga) and Mnkite (Nakasabira) were capable of producing the most numerous seeds by the combination with Nakabululu clone. As observed in the case of Entukura, for example, in which the number of seeds produced in each fruit cluster varies from zero to 227, the capacity of seed production varies greatly within an identical clone. The fact that viable seeds were obtained from some of these clones [50)] indicates that the genetical improvement of East African Highland bananas by means of crossbreeding is feasible. Meanwhile, the factors responsible for the low rate of seed production are also being studied.

As described above, in the past, the information on characteristics about clones of Highland bananas was not well clarified. However, based on the classification presented by Karamura (1998), the information on suitable combination has been clarified, and hence steady progress of research can be now expected to be achieved, although it may take some time.

A study was made about the introduction and utilization of banana plants of improved cultivars of good quality, although they were not cooking bananas. So far, several excellent varieties have been introduced, and the introduction of a larger number of strains is looked forward to. As a possible action in future, it is required to introduce, in response to the demand of consumers, the types and strains of bananas that they want to have. In this manner, the research efforts for the variety improvement by crossbreeding would contribute to the development of novel varieties to enable the amelioration of production of East African Highland bananas. Current variety development projects aim at the generation of resistance against the black sigatoka disease as well as at the yield increase. Furthermore, researches are ongoing also on the development of strains characterized by high levels of resistance against weevils and nematodes. Judging from these circumstances, it is assumed that there are great prospects for the successful control of diseases and pests of Highland bananas.

**2) Breeding by cell culture**

It is relatively easy to cause mutations in the callus cells generated from plants. In addition to mutations in somatic systems due to natural sports that are likely to occur in individual cells, other effective techniques for generating mutations are being tried and studied under in vitro environment including: systems to treat the calluses formed for breeding purposes and the liquids suspending cells; regeneration of seeds that are hard to germinate under normal environment; anther and pollen culture for obtaining haploid plants; isolation and fusion of protoplasts of plant species or interspecific crossing materials; and gene recombination.

**Photo IV-15 Interior of the isolation greenhouse**

Currently there are three research institutions in Uganda mainly devoted to the plant tissue culture and implementing projects on these subjects. One is a laboratory in Makerere University Agricultural Research Institute Kabanyolo (MUARIK) that deals with diverse plant species including cassava, yams,tree crops and others. Materials are multiplied mainly for the purposes of research and education, but they are also utilized for the benefit of farmers and extension programs. The other two institutions belong to NARO, with one unit working mainly on potato and sweet potato and located at Namulonge Agricultural & Animal Research Institute (NAARI), and another unit of large-scale facilities for research on tissue culture, charged with the production of seedlings, and currently focusing the efforts on coffee and banana, which is stationed at Kawanda Agricultural Research Institute (KARI).

## 5. Raising young nursery plants

The raising of banana young plants is essentially carried out most easily and generally by the procedure in which suckers growing from rhizomes of parent plants are separated and planted anew in pots or in a nursery plot. But the procedure has a drawback that it is difficult to prevent the spread of diseases and pests with this means of propagation. Local farmers are taking certain measures to prevent the migration of pathogens and pests through new young plants, by trying as much as possible to remove pathogens and pests from suckers used as young plants, in which they collect suckers as young as possible, scrape off roots and outer layers of rhizomes, and trim also the leaf sheaths to make them short. However, recently the shoot apex culture, i. e., a fast procedure for raising a large number of young plants free from diseases and pests, is practiced and being promoted.

### 1) Raising young plants by biotechnology

Currently in Uganda, the technique of tissue culture is being promoted and the young plants that have been produced by the culture of the uninfected or uninfested meristem of suckers are commercially available. In particular, against those diseases and pests which are difficult to control, such as virus diseases and various diseases and nematodes, the cell culture techniques to multiply rapidly tissue cells extracted from a meristem tissue have been established. The actual application of the techniques is carried out principally by Mbarara University and the three research

**Photo IV-16 Extraction of meristem from suckers**


**Photo IV-17 Scene of meristem culture**

institutions mentioned in the section on breeding. Furthermore, recently a certain private enterprise also has participated in the business applying freely the techniques, and is promoting actively the supply of the young plants freefrom diseases and insects.

**2) Planting of young plants raised by division of suckers**

For the propagation of banana plants, even now when the fast mass production of young plants by means of tissue culture has come into actual operation, the traditional method of using suckers produced in banana fields is still practiced. Suckers are cut off from the parent plant. In order to remove the traces of nematodes and weevils, the pseudostem of sucker is cut off, and the superficial tissues on peripheral parts damaged by nematodes and weevils are scraped off as elaborately as possible. Thus prepared suckers are either planted in pots or transplanted into a nursery plot or newly cleared fields.

The final transplanting of banana young plants has to be done at the beginning of the rainy season, so that they may take root by the end of the rainy season. As a young plant suitable for planting, a sword-shaped sucker of 30-60 cm in length that is as young as possible and with slender leaves branching off at a narrow angle is used. It should be avoided to use a soft and waterish sucker longer than 60 cm that bears broad and juvenescent leaves.

As suitable young plants, it is needed to select suckers free from damage due to diseases and pests and clean them by removing outer leaf sheaths. Then cut off all the roots and peel off outer skin layers of rhizome to remove manually diseases and pests. It should be avoided to plant the young plants in which outer skins have not been removed and the parts discolored with the damage due to nematodes and weevils have not been eliminated either.

In order to ascertain that a young plant is not infested with nematodes, it is necessary to immerse in heated water the sucker of which outer skin layers have been removed. In the case where a young plant has been transported for a long distance, the upper portion of the sucker has to be cut off at the level of 15 cm above the transitional zone between corm and pseudostem. Young plants produced by the process of tissue culture are available from Kawanda Agricultural Research Institute and Makerere University. These young plants are free from diseases and pests and possess uniform characters. Young plants by tissue culture are very much suited for the cases requiring a large number of uniform young plants.

When a newly prepared field is planted with banana young plants, the appropriate distances between neighboring plants are said to be 3 m x 3 m. The dimension of planting hole has to be 45 cm in both breadth and depth. The planting hole has to be filled with a mixture of soil and well cured manure, or with the dug up soil mixed with 10 –20 liters of well cured manure. The young plant is placed at the center and buried with the remnant soil. Young plants should not be buried too deep, and the covering with soil of about 5 cm in depth is appropriate.

**Photo IV-18 Well-built young plants with open leaves branching off at narrow angles**

**Photo IV-19 Young plants with broad leaves branching off at wide angles are soft and feeble ones.**

Photo IV-20 Scrape off peripheral parts of sucker to remove pests

Photo IV-21 Then cut off upper portion of pseudostem and plant the young plants

**3) Culture and distribution of young plants by private sector**

There is a private enterprise producing banana young plants by means of tissue culture. The company is called Agro-Genetic Technologies Ltd. (AGT). Although general observation of the state of tissue culture was not allowed for the reason of business secret, Dr. Erostus W. N. Nsubuga, president, guided a tour of the process of transfer from the culture laboratory to the nursery pots of 6 cm in a plastic greenhouse as well as a visit of the plastic greenhouse nursery to raise young plants for sale.

According to the story of Dr. Nsubuga, although, after finishing university course, he originally worked in business trying to disseminate cellular phones of Nokia, he intended to launch a business involved in Ugandan agriculture, aiming at contributing to the supply of high quality young plants by means of tissue culture using meristems that were free from pathogens. He said that he started his work first in the home kitchen. The tissue culture uses sterile media for multiplication, and at the stage of planting young plants outdoors, it is needed to use the soil which is almost sterile as much as possible. While in advanced countries young plant suppliers may often use the sterile soil that has been treated in autoclaves, Dr. Nsubuga's company is making use of a type of homemade steaming device. The specially built device consists of a square steel box about 2 m on a side in which concrete blocks are placed to support a steel grid. After pouring in water, bags containing culture soil are piled up on the grid, and the box is heated with a fire built under it to boil the water and sterilize the soil.

The president said that the young plant materials were cultured in a sterile room for 3 months and raised for 7 months in a plastic greenhouse, thus making it possible to ship them out as commercial products in 10 months after the beginning of culture. Immediately after the transfer to plastic pots in the nursery, young plants were simply covered with plastic sheets in the plastic greenhouse and thus no particular high technology was applied, but young plants of uniform quality were being produced.

Each young plant is shipped out in a plastic pot of about 15 cm. Young plants are about 50-60 cm tall. Reportedly, few of them are sold to ordinary farmers, and most of them are purchased by government institutions. The president says that

**Photo IV-22 Work scene of transplanting young plants of meristem culture to pots in a greenhouse.**



**Photo IV-23 Carrying by truck of young plants raised by biotechnology.**

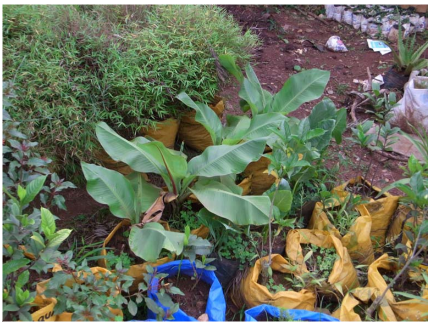

**Photo IV-24 Young plants for sale in a roadside young plant shop. Whether they are infected with diseases and pests is not known.**

he wants to sell them to ordinary farmers in the future. Since the demand for banana young plants is dependent on the rainy season, arising only twice a year in the two rainy seasons coming every year, and no demand exists during the dry seasons, creating problems in the context of business management, the president expresses his intention to expand the business to include also the production of young plants of ornamental orchids for which year-round demand could be expected. As a proof of his intention to launch particularly the orchid business, he proudly showed to the author a trial product of Phalaenopsis orchid.

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# Chapter V. Developments in banana processing and utilisation of the East African highland cooking cultivars

## 1. Introduction

According to botanical classification, bananas are members of the family Musaceae and of the order Zingiberales. The family Musaceae has two genera: *Musa* and *Ensete*. Genus *Musa* contains all the edible cultivars and it consists of four major sections: *eumusa, australimusa*, *rhodochlamys* and *callimusa.* The two latter functionally serve ornamental interest while the two former ones find popular use as cooked vegetables. The majority of the edible bananas, however, derive from species of *Musa*: *Musa acuminata* and *Musa balbisiana*[14]. Detailed classification of genus *Musa* was first outlined by Stover and Simmonds[19] and later by Coronel and Rivera[1]. The distinction between bananas in Uganda, however, is better understood along their functional properties rather than genotypes. Bananas with similar genotypes are sometimes classified under different functional groups. The key functional groups are:

(1) Cooking bananas (AAA-EA, Matooke)
(2) Juice/beer bananas (AB, ABB and AAA-EA)
(3) Dessert bananas (AB, AAA, eaten ripe)
(4) Roasting bananas (AAB, plantain group)

The rank of their economic significance also follows the above order; subsequently the cooking bananas have an unparalleled significance to the country. In a recent effort to classify and organise Uganda banana germplasm it was further confirmed that the East African highland bananas (AAA-EA) formed five distinct clusters based on female and male inflorescence characteristics[5].

The cooking banana locally known as Matooke only constitutes the AAA-EA (but not including juice types or Mbidde). They are further classified into soft and hard types. The latter have marginal market potential. They are harvested between three-quarters to full maturity, peeled and boiled or steamed in banana leaves during which the colour changes from a creamy white to an almost golden yellow depending on original maturity of the bunch. The extent of tenderness and yield to mash is, however, varietal dependant and it is a key consumer attribute[18]. The cooked dough, popularly known as "Emere" literally meaning "the food" is virtually free from astringency[17) 18]. The hard varieties are sometimes boiled with their peels in which case they are not mashed. These varieties blossom from leafy green into a bright yellow fruit on ripening and become quite succulent at maximum ripeness when left to ripen.

Matooke is predominantly eaten in Uganda and the Great Lakes regions. It is cultivated by up to 75% of the farmers and constitutes the chief dietary component for more than 60% of the Uganda's urban population[16]. Matooke has been further documented as constituting the highest contribution to the calorie requirement of the people in Uganda[8] and the most common weaning food for children in banana growing regions in Uganda[6].

Evidence from recent history of research on banana production in Uganda shows that the above statistics notwithstanding its contribution to food security was characterized by seasonal instability and bottlenecks in the food distribution chain. It subsequently brought in very marginal returns overall but especially to the grassroots stakeholders, the farmers, due to the banana bulk in fresh form and the fact that the real banana markets are far from the point of production. The latter results in excessive transport costs and damage, leading to high post harvest losses notwithstanding the fact that farm losses were already estimated at 20%. This is compounded by the fact that there was no value added to bananas prior to marketing. Indeed, until the commissioning of the Presidential Initiative on Banana Industrial Development (PIBID) Project in Uganda, the research on production issues was not matched by research on post harvest handling and utilisation.

## 2. Post harvest research

A baseline survey under the Uganda National Banana Research Programme revealed that juice and Tonto (beer) were the main products of banana at the grassroots level[13]. There was otherwise no record of any meaningful postharvest activities with respect to Matooke in Uganda. The Uganda National Banana Research Programme (UNBRP) subsequently prioritised the inclusion of post harvest aspects in all subsequent research programmes on banana, so as to support the characterisation of the physicochemical properties of the key banana cultivars in Uganda in order to: (1) stimulate the addition of value to bananas' post-harvest, (2) stimulate the alternative utilisation of banana through processing, and (3) inform the breeding programmes so as to support the sustainability of banana production.

On this background research was undertaken at Makerere University under the title *Composition and Physicochemical Characteristics of Starches of Different Banana Varieties.* The study was designed to compare four cooking banana cultivars (Matooke) of the triploid acuminata East Africa highland cultivars (AAA-EA) with a range of hybrid cultivars including Bogoya (Cavendish relative, AAA), Sukali Ndizi (AB), Gonja a plantain (AAB) and three juice cultivars namely Mbidde (AAA-EA), Musa Kayinja (ABB) and Kivuvu (ABB). The above research and subsequent research have served to address the following issues:

(1) Lend understanding of what constitutes Matooke as a food

(2) The characterisation of the key components of Matooke

(3) Processing of Matooke by applying technology that has been successfully applied to the development of a new generation of novel products including: weaning foods, snacks, and bakery and confectionery products

(4) Promotion of the Matooke based products for market uptake on both local and international trade foray

The Muranga study[9] which has served as a backbone to these studies specifically focused on generating the following outputs. 5.2.1 is some of the highlights of the above researches.

(1) To establish for all study samples the significant physiological and biochemical indices at maximum green maturity

(2) To test response of banana flour to a number of processing techniques and subsequently the potential to yield second generation products

(3) To establish the granular and molecular characteristics of the native starches

(4) To evaluate paste characteristics of native starches with or without ingredients and rheological characteristics of cold and hot pastes

(5) To evaluate effect of hydrothermal treatment on both granular and pasting characteristics of some representative samples

**1) Characterisation of physicochemical properties of Matooke raw material**

Table V-1 shows the chemical composition on dry basis for 5 common Matooke cultivars at maximum green maturity[9]. They were analysed for moisture content, starch, dietary protein, fat, crude fibre, ash, calcium, potassium, magnesium and tannin content. The moisture content ranged between 8-10% (dB). Nandigobe cultivar had a higher moisture content (9.6%) which could explain its soft texture when cooked compared to other cultivars. Similarly, Bukumu which had the lowest moisture content (8.1%) has a harder texture when cooked. The starch levels were high and ranged between 81-85%. The variations in starch content are attributed to cultivar age differences at their maximum green maturity. The starch content also has a positive correlation to age at maturity (r = +8.7).

The protein levels of Matooke were generally low and varied from 4.0 to 5.5%. These values were in agreement with other studies those of Watt and Merill[21] and Kayisu[3]. Muranga further reported a high negative regression coefficient between protein and starch content in Matooke. The fat content of Matooke was low, less than 1% on dry basis. The low fat is a critical positive attribute in the development of shelf stable Tooke flours and generic products due to reduced risk to oxidation. The crude fibre was low, ranging between 0.8 to 1.4 %.

The ash content was high and it varied between 3.5-4.4%. Potassium is an abundant macro mineral in Matooke whose composition varies from 1.7 to 1.9%.

The high content of potassium is attributable to the thriving of Matooke in only potash rich soils[9]. The other macro minerals analysed include magnesium and calcium whose composition is less than 0.1 and 0.01% respectively. The levels of tannins in Matooke are very low and vary from 0.1 to 0.2%. The low level of tannins could explain the minimal astringency and increased palatability of Matooke.

**Table V-1 Chemical composition of Matooke (dB) at maximum green maturity**

| Cultivar | Genotype | Compositions (%) | | | | | | | | | Tannin Abs at 500nm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Moisture content | Starch | Protein | Fat | C.fibre | Ash | Ca | K | Mg | |
| Bukumu | AAA-EA | 8.1 | 82.5 | 5.1 | ND | ND | 3.58 | 0.0044 | 1.82 | 0.09 | 0.181 |
| Embururu | AAA-EA | 8.8 | 82.9 | 4.01 | 0.56 | 1.33 | 4.1 | 0.0052 | 1.84 | 0.01 | 0.012 |
| Nakhaki | AAA-EA | 9.2 | 83.9 | 3.99 | TR | 1.1 | 4.09 | 0.0053 | 1.71 | 0.09 | 0.193 |
| Nandigobe | AAA-EA | 9.6 | 81.8 | 4.71 | 0.87 | 1.25 | 4.34 | 0.058 | 1.9 | 0.09 | 0.111 |
| Nalukira | AAA-EA | ND | 81.3 | 5.21 | ND | 0.81 | ND | 0.0051 | 1.63 | 0.12 | ND |

ND: Not determined.
Source: Muranga, 1998

Clearly there are four definite advantages in its composition that could also favour its processing/marketing: (1) the high levels of potassium content; which is important nutritionally as an anti-dote to high blood pressure, (2) the virtual absence of fat and sugar; which is critical for keeping quality of flours i.e. long shelf-life, (3) the very low levels of amylose content; which minimise cooking loss in pregelatinisation process, and (4) the very low levels of intensity of condensed tannins; which render the cooked Matooke free from bitterness/astringency.

Highlights of the study also revealed that the East African Highland cultivars (Matooke) mature fastest. On average, it reached full blown maturity within 15 weeks. On the contrary, most hybrid cultivars mature well beyond 20 weeks. The latter differences were further underlined by the fact that the Matooke cultivar peel/pulp ratio appreciated fastest during development. The mature green Matooke from the different cultivars on dry basis displayed some critical factors about the composition of Matooke namely that on average at harvest maturity the Matooke contained between 80-85% starch on dry basis, which is far above any of the local staples including cereals.

The native starch studies yielded the following highlights, which could be critical to the industrialisation process:

(1) The starch had a very high level of purity (97-100%) with virtually no fat.

(2) The starch granules were particularly resistant to swelling with high gelatinisation temperatures (>70°C).

**2) The processing characteristics of Matooke**

Technologies that have been exploited for processing of other starchy staples could be successfully applied for adding value to Matooke. A scheme adapted from Ogazi has been adapted and modified for purposes of testing operations on Matooke processing[9]. The most successful so far however, are the Raw and Instant Tooke flours as shown below in Photo V-1 and Photo V-2 respectively. Flours from Matooke have been successfully branded as Tooke by PIBID.

Tooke flours prepared from raw Matooke have been tested in a range of bakery products with tremendous success. This is because as already pointed out Matooke flour contains between 80-85% starch. Further, starch granule particle size of Matooke is quite close to that of the big wheat starch granule. The Raw Tooke Flours (RTF) have been substituted in bread, cakes, biscuits and pastries successfully.


**Photo V- 2 Branded Raw Tooke Flour** in its attractive package
Source: PIBID


**Photo V-1 Branded Instant Tooke Flour** in its attractive package
Source: PIBID

(1) Raw Tooke Flours (RTF) and their applications

RTF's for their unique starch properties cited above have been used successfully, to substitute up to 30% for wheat flour in bread (Photo V-3). The RTF particularly produced bread of almost comparable quality to pure wheat with respect to most common bread attributes except for the slight loss of bread volume.

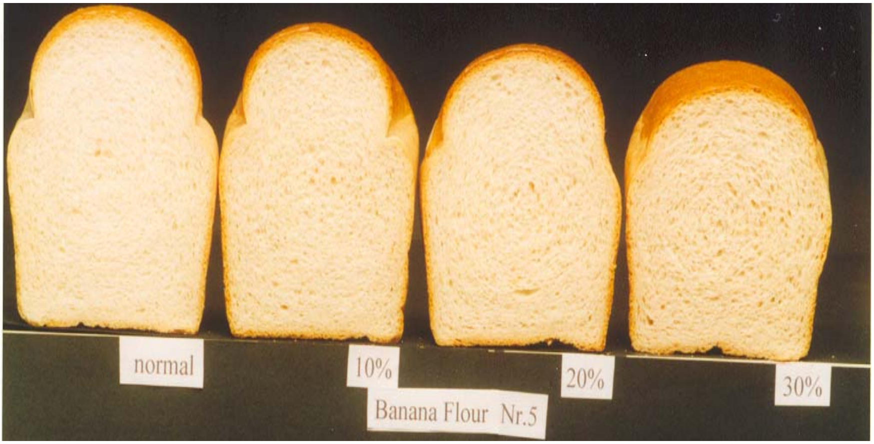


**Photo V-3 Bread incorporating Raw Tooke flour (L-R) Normal white bread, 10%, 20% and 30% Raw Tooke flour incorporation in bread.**
Source: Muranga, 1998

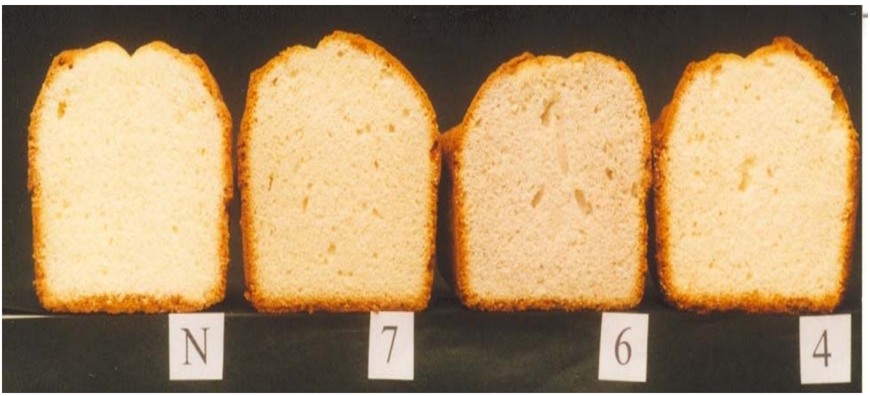


**Photo V-4 Cross section of cakes incorporating 30% RTF (7) and two other banana flour (6 and 4) in contrast to wheat and cornstarch (N)**
Source: Muranga, 1998

Photo V-4 above shows a cross section of three sand cakes incorporating 30% RTF in contrast to the standard from wheat/cornstarch. Cakes made with up to 30% RTF had very good consumer attributes. Those from RTF were closest in appearance to those from pure wheat flours. The latter can be explained by the fact that Tooke flours have very high content of starch on dry basis and in conventional sand cake recipes one third of the wheat flours is always substituted for by starch.

**Photo V-5 Wheat/Matooke biscuit**

Source: PIBID

Substitution of Raw Tooke flour for wheat flour (up to 45%) for the making of biscuits extremely increased the overall acceptability of biscuits. i.e. the higher the level of substitution with Tooke flour the better the sensory characteristics particularly with respect to texture and colour.

(2) Ready to eat (Pregelatinised) Tooke flours

Three types of Instant Tooke flours (ITF) have been prepared from Matooke applying extrusion cooking, drum drying as well as a technique filed for patenting as UG/P/04/00010. All these flours can be applied in a range of products including soups and porridges and enjoy excellent shelf-life. The ITF have been subjected to consumer profiling of strategic groups in the country with relative success including the following study that was funded by African Institute of Capacity Development (AICAD).

(3) Fortified Tooke flours and their potential as children's weaning foods

Following on to the fact that Matooke contains high levels of starch on dry basis, an award was obtained from the Rockefeller Foundation to look at the potential of Tooke flour obtained applying the above technologies as a carbohydrate resource for weaning foods. Soy and Sesame were applied for fortification and the following products have been obtained after an optimisation process:

(1) Tooke soy/sesame fortified products (soup & porridge) from raw, extruded and precooked Tooke flours

(2) Tooke/soy fortified products (soup & porridge) from raw, instant and extruded Tooke flours

Thereafter this author obtained a grant from AICAD which enabled her to establish the potential of Instant Tooke as a vehicle food for malnutrition intervention as outlined in the abstract below.

The aim of this study was to establish the potential of Instant Tooke flour (ITF) as a vehicle food for malnutrition intervention. 100 malnourished children admitted at Mwanamugimu Nutrition Unit Mulago hospital, Kampala, Uganda, were randomly allocated to either the test or control groups. The test group was fed on ITF developed under part I of this study, while the control group was fed on the Mwanamugimu dietary regime. Growth rate and food intake were measured daily, while blood samples were taken during recruitment and before discharge for testing serum albumin, ferritin and retinol levels. The means of the two groups were compared using univariate ANOVA of GLM of the SPSS version 11.0 statistical package. The protein and energy intake for the test group was significantly ($P<0.05$) higher in the porridge, while protein intake for the control group was significantly ($P<0.05$) higher in the kitoobero. The protein and energy intake were comparable between the two groups in high energy milk (HEM). The weight gain in the test group was significantly ($P<0.05$) higher than the control group, but there was no significant difference in serum albumin, ferritin and retinol values between the test and control groups. The study proved that ITF adequately met the protein and energy requirements of the malnourished children on rehabilitation, thereby justifying its use as a vehicle food for malnutrition intervention.

The above results have empowered us to test ITF as a vehicle food for school feeding programme. This programme is also running on partial funding from AICAD.

The above volume of research led to the Government of the Republic of Uganda's Investments in the Development of a fully fledged banana Industry.

## 3. The Presidential Initiative on Banana Industrial Development (PIBID)

### 1) Background

(1) Development strategy of Uganda Government

The Government of the Republic of Uganda in 1997 developed the Poverty Eradication Action Plan (PEAP) as Uganda's comprehensive Development Framework. The PEAP in its revised version (2004/5-2007/8) provides an over-arching framework to guide public action to eradicate poverty. For the transformation of the agricultural sector two pillars are particularly significant, as follows:

① The economic management pillar, which is designed to target, modernisation/commercialisation of agriculture with emphasis on value addition; removal of bureaucratic barriers to investment; actions to enhance rural access to finance & strengthen SME development and actions to enhance environmental Sustainability.

② A pillar for enhancement of production, competitiveness and incomes, which targets increasing the ability of firms to innovate & adapt to new technologies, thereby increasing the ability of the private sector to profitably increase market share.

Inline with the PEAP, Government developed the Plan for Modernization of Agriculture (PMA), which is a holistic strategic framework for eradicating poverty through multi-sectoral interventions, which empower the people to improve their livelihoods in a sustainable manner. PMA stipulates that faster growth of agriculture will drive growth in other part of the rural economy. Accordingly PMA's main goal is to accelerate agricultural growth in Uganda by introducing profound technological change throughout the sector as a strategy for raising incomes of the poor, who are predominantly rural based women.

(2) Research of Banana Processing

Currently, Uganda is the world's largest consumer of bananas, with average per capita consumption of 243 kg (FAO) per year to 300 kg[4]. Uganda ranks only second to India in the world's production, regrettably Uganda does not specifically feature in the world's banana production statistics simply because it has no position in the vibrant banana market, since its main banana crop is Matooke, a non-dessert banana cultivar. Fortunately, developments in Matooke research have led to the dehydration & physicochemical characterisation of bananas to yield patentable forms of *Tooke flour* (Patent No. AP/P/2005/003308) both in the raw and instant forms as well as one generic flour from the Raw Tooke flour in extruded (soluble) form[9].

The study of the Raw Tooke flour has revealed that the flour from Matooke is unique in contrast to that from other banana flours[9], particularly with respect to starch, potassium and phenolic contents, which together, have evolved as the prime indicators of Tooke flour quality with respect to consumer and end use profiling. The flour's unique properties include among others, the following: 80% starch (db) with 8% only amylose content, negligible levels of condensed tannin, high levels of potassium, which is very good for health, virtual lack of sugar and fat, which ensures extensive shelf-life free from caking or rancidity; and virtual lack of gluten, which makes it appropriate for celiac patients. The Instant Tooke flour on the other hand, is further characterised by high content of soluble fibre and mineral content[15] which has opened for it a niche market as a potential starch base in a range of pregel-based formulations, including porridges, soups, sauces and instant doughs for both healthy, and compromised groups. The extruded Tooke flour is particularly characterised by its exceptionally high water solubility index which has endowed it with phenomenal potency in the rehabilitation of severely malnourished children[10].

**2) The framework of PIBID**

On the above background, in 2005 H. E the President of the Republic of Uganda established the Presidential Initiative on Banana Industrial Development (PIBID) in order to kick-start the value addition to Matooke through a smart-Public-Private Partnership. In the PIBID institutional framework, Government's objective is to harness research faculty innovations through an R&D framework for rural enterprise development, operating on the principle of Technology Business Incubator (TBI). The focal point of the project is a designated Field Research Station in Bushenyi District, South-western Uganda with five main functions: (1) Value Addition & Quality Control, (2) Food Product Development, (3) Research & Training, (4) Commercialisation of Production and (5) Business Development & Marketing.

The "Value Addition & Quality Control" function is designed to develop through three consecutive levels; primary, secondary and tertiary. The primary level comprises the initial phase of the product process development and product quality assurance and safety for both the raw and instant Tooke flours; preparation of raw and instant Matooke chips, quality assurance of dried Matooke chips packaging & storage of Matooke chips. The secondary level will constitute the second phase in product process development and product quality assurance and safety and will include: milling operations for raw and cooked Matooke chips; quality assurance of Tooke flour, including test-baking, packaging and storage of Tooke flour, shelf-life determination and basic product development aspects. The tertiary level phase will involve process/product technology transfer and commercialization, which will include new product development and manufacture testing, as well as incubation of the scaling up of the Matooke flour enterprise, by small to medium sized enterprises (SME). This is consistent with the priority actions under Government's marketing and agro-processing strategy (MAPS), which empowers Government to intervene so as to promote increases in Uganda's export competitiveness through strategic exports development, value addition/new product development; promotion of products in domestic, regional and international markets; and set-up industrial parks. However, if the Matooke flour is to gain an entry point into the global market chains, it has to link into specified end-use quality profiles as well as product quality. There is therefore, need to optimise quality assurance and quality control protocols for flour and generic products, in order to assure standardization and branding.

PIBID is set to cause the transformation of the Matooke marketing map through export promotion where the majority will be the key stakeholders of the process as summarised in Fig. V-1, following the processed value chain. Through PIBID the Government of Uganda tasked herself with the challenging task of transforming a low value status commodity to an industrial raw material through a strong public-private-partnership.

**Fig. V- 1 Projection of the transformed Matooke value chain**

Source: Muranga, 2009

PIBID has made some preliminary projection right from the onset of the project to help illustrate potential benefits to the majority using conservative benchmarks. Taking the worst case scenario where farmers were failing to market their Matooke and were therefore giving it away at a laughable cost of 300 UGX /= (0.15 USD) we were able to show that the farmers would make significant profit on both the local and export markets if they were to be mainstreamed in the value chain. As per Table V-2 below.

**Table V-2 Projected income for farmers, 2006**

| | 20 kg bunch @ 0.15 USD | 20 kg bunch @ 0.5 USD | 20 kg bunch @ 1.5 USD | Tooke flour (3kg) @ 1 USD/kg (local) | Tooke flour (3kg) @ 2 Euros*/kg or 3 USD/kg (Export) |
|---|---|---|---|---|---|
| Income (USD) | 0.15 | 0.5 | 1.5 | 3 | 12 |

20 kg bunch approximately yields 3 kg flour
Matooke flour estimates were lab estimates
Matooke export source quoted by the pioneer buyer /distributor for Europe
Source: Kizza et al., 2004

The Matooke value addition route was projected to offer the long term potential for transformation of the existing cheap Matooke industry. The changing lifestyle of housewives was bound to dictate increased demand for processed Matooke based products, including flours and generic products from flours such as confectioneries, pasta macaroni equivalent i.e. Matooroni etc. The Matooke industry development, however, is peculiar to Uganda due to the exclusive growth of Matooke in the Great Lakes region. Subsequently a strategic planning and development process to guide the industry was proposed which would ensure minimization of risks to the private sector, and prioritisation of the most viable products. The latter process consists of three key stages: (1) a joint effort by the public and private sectors to confirm the market attractiveness of the sector, (2) establishment of the competitive strength of the interested parties in the private sector, and (3) confirmation of consumer satisfaction and therefore market success of the identified products by the private sector. Because there was no viable flour production in the country at the time, this writer recommended a pilot banana processing through a Technology Business Incubator (TBI) system for the development of primary value-addition stage of the banana industry, and an Industrial Technology Park (ITP) for the expansion stage or secondary value-addition.

**3) Strategy for streamlining of the PIBID value chain**

PIBID's goal is to kick-start a pilot industry in banana value addition, yielding products with both market strength and competitiveness, through a state-of- the-art banana-based sustainable processing enterprises, nurtured under a TBI and an ITP infrastructure framework, enshrined into University academic & technical research and manned by rural farmers and entrepreneurs. Its mission is to offer rural farmers technical/scientific services, outreach and Research & Development (R&D) opportunities in: (1) sustainable Matooke production; (2) sustainable and competitive value addition to Matooke; (3) business and product process development; (4) product quality assurance & safety; (5) Process/product technology transfer and commercialization so as to ensure the birth of a state-of-the art banana processing industry run by peasants in banana cropping systems. Namely the following four factors needed to be addressed if the rural farmers were to maintain their strategic stake in the Matooke value chain.

(1) Access to tested technologies in order to optimize their production capacity

PIBID has positioned herself to address the need of the majority to access tested technologies by harnessing knowledge from a critical mass of professionals in production, value addition through the TBI, where research infrastructure is availed to enable them concentrate on demand-driven research through the incubation process. The TBI will namely supply three functions: Commercialised agricultural production, value addition and quality control and business and marketing training.

The objective of the production function will be largely to ensure sustainable supply of the right quantity and physiologically ascertained quality of raw Matooke necessary for sustaining value addition operations and food security. Thereby subsequently transform the majority from peasantry agriculture to commercial production by training them to adopt high input strategy, best soil management practices, and high tech water- soil nutrient management practices such as coupling irrigation to biomass by-products as well as sustainable environmental management. At the current production levels, processing of the Tooke flour would have been inevitably only viable during the peak season, which would render the capital investment unnecessarily expensive besides the negative impact on the export market due to inconsistency in product availability. Besides, our cash projections at the time of starting of the project showed that at the current yield of 7 tonnes per/ha/year the farmer operated at a net total loss of 573 USD per year even at a constant farm gate price of 0.75 USD per bunch (0.0375 USD/kg)[15].

(2) Access to improved community based infrastructure that can support competitive value addition

Fig. V-2 represents the conceptual framework of the community processing centre through which the value addition and quality control function objective is to empower farmers' access to technology, through communal infrastructure offering opportunity for product technology transfer and commercialization and product quality assurance and safety for both the Raw and Instant Tooke flours.

The capacity building process through which stakeholders under the TBI will have to graduate through a transparent capacity peer review mechanism. First, graduating as a model farmer and then qualifying to join a processing unit or association. The members within the community who will graduate to join the Community processing centres will then be facilitated to develop a value addition centre similar in function.

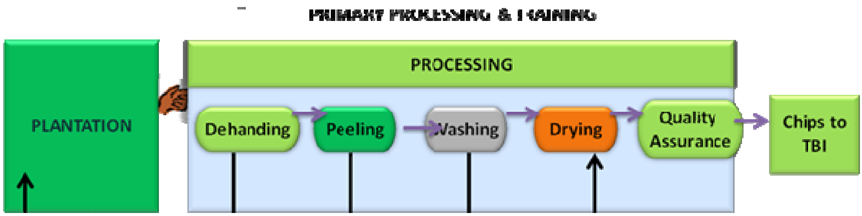


**Fig. V-2 Conceptual framework of community processing centre**

Source: UEPB, 2009.

There is a close interdependent relationship between the community and the scientist prior to the knowledge transfer process that cascades the farmer through a series of graduation to ultimately arrive at the level of a strong entrepreneur emerging out of the ITP. Naturally not everyone reaches the ITP but each one once empowered will position themselves strategically at their point of comparative advantage in the value chain.

(3) Access to accurate knowledge and information

It will be met through PIBID's research & development/training function which will serve to address demand-driven capacity building and research needs for all farmers/processors. Professionals are being harnessed to generate relevant and tailor designed training materials. The farmers will receive training in value addition and quality control, commercialised production best practices and business and marketing. Under value addition farmer entrepreneurs will graduate to different levels of value addition through a transparent peer review and performance assessment mechanism. Besides PIBID has established a framework for business and product process development with the Commodity Trading Centre (CTC) as the hub. The activities at the CTC include identifying market opportunities and creating market entry strategies (branding, logos etc.), collaborating with Uganda National Bureau of Standards (UNBS) to create a standard for banana flours by PIBID, and testing end-user responses to new product formulations/recipes.

(4) Empowerment in their bargaining power through the formation of strong marketing associations

The pilot plant at the TBI will be furnished with bulking facilities which will empower the Community Processing Association (CPA) members to hold their produce against price fluctuation. The strengthening of the community association is being done right from the grassroots through formation of viable farmers and processing association by: facilitating & promoting linkages among farmers, processing associations, processors, consumers & service providers; establishing a network of market information centres linking farmers, traders and community processor organisations.

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