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DIVERSITY, DISTRIBUTION AND FARMER PREFERENCE OF *MUSA* CULTIVARS IN UGANDA

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SUMMARY

The East African highlands, home to more than 80 cultivated varieties of locally evolved bananas, constitute a secondary centre of banana diversity. Uganda is the leading producer and consumer of banana in the region and also enjoys the highest diversity of a group of bananas uniquely adapted to this region. These East African highland bananas comprise cooking and brewing types. The former is a staple for more than 7 million people and thus important for food security. Little is known about the distribution of the vast germplasm and this study was set up to help determine a distribution pattern and to understand the dynamics of cultivar change using farmers participatory appraisal methods. The study involved a guided interview with 120 farmers, at 24 sites throughout the banana-growing region of Uganda, to reveal cultivar diversity, proportions, distribution and preferences. Cultivar diversity ranged from 18 to 34 (mean = 26) cultivars per site, and from 4 to 22 (mean = 12.3), cultivars per individual farm. Such high diversity was attributed to a variety of end uses, better food security and the perception that each cultivar had a unique range of strengths and weaknesses. Highland banana (AAA-EA) represented 76% of total production while Kayinja ('Pisang Awak' subgroup) (ABB) contributed 8%; Ndiizi ('Ney Poovan' subgroup) (AB) 7%; Kisubi ('Ney Poovan' subgroup) (AB) 5%; Gros Michel ('Bogoya') (AAA) 2%; and plantain (AAB) 2%. Although 130 highland cultivars were recorded, only 10 constituted 50% of highland banana production while 45 cultivars were found at only 1 or 2 sites. A few cultivars showed more universal distribution and it is proposed that these may be the oldest and best performing local landraces.

INTRODUCTION

Bananas are a very important subsistence food crop in the East African Great Lakes region which includes, Uganda, Kenya, Tanzania, Rwanda, Burundi and Democratic Republic of Congo (formerly Zaire). Production is dominated by locally evolved (endemic) clones, which are referred to as East African highland

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bananas (EAHB, denoted *Musa* AAA-EA). This group includes cooking types ('Matooke') and brewing types ('Mbidde') (Karamura and Karamura, 1994).

Edible bananas originated in Southeast Asia and are believed to have entered this region through multiple introductions between the first and sixteenth centuries A.D. (Price, 1995; Karamura, 1998). The first phase of introductions consisted of plantains (AAB), which became predominant in Central and West Africa (De Langhe *et al.*, 1994), while a second phase consisted of the introduction of AAA cultivars into East Africa. West and East Africa then evolved as secondary centres of diversity for plantain and East African highland bananas (EAHB), respectively (Stover and Simmonds, 1987). A third phase consisted of the introduction of a complex of cultivars of variable genomic constitution (for example AA, AB, AAA, ABB). This last phase was relatively recent and contributed to by various colonial workers and religious missionaries, as shown by the introductions made at the Entebbe botanical gardens in Uganda from 1904 to 1931 (Rossel, 1990).

Uganda has the highest level of banana cultivar diversity in this region (Kyobe, 1981) with more than 80 distinctive EAHB clones present (Karamura, 1998). Based on morpho-taxonomic methods, these can be grouped into five major clone sets: Musakala, Nakabululu, Nakitembe, Nfuuka, and Mbidde (Karamura, 1998). Uganda is also the leading producer and consumer of bananas in the region and ranks second in the world after India (Lescot, 1998). Situated along the equator, Uganda has a tropical climate that is well suited to banana production.

Highland cooking banana is the most important staple food in Uganda and parts of Burundi, Democratic Republic of Congo, Kenya, Rwanda and Tanzania. An extended harvest period ensures a source of food and income throughout the year, making it a primary component of food security of the region. Broad banana growing areas, consumer preference, limited production of competing cereals and the high cost of imported grain has made cooking banana the leading urban staple in Uganda (Lynam, 2000). Rapid population growth in Kampala and other cities has driven continued market growth for cooking banana and opened commercial opportunities for growers in the high-yielding banana growing areas in southwestern Uganda (Gold *et al.*, 1999).

Most EAHB production is on small plots of <0.5 ha which maintain high cultivar diversity. In addition to EAHB cultivars, farmers also grow a range of 'exotic' (relatively recently introduced) genotypes. Due to declining production in the traditional production areas of central Uganda, there has been a gradual replacement of cooking banana with exotic beer banana cultivars (AB and ABB) and other annual crops even though cooking banana remains the preferred staple food crop (Gold *et al.,* 1999). At the same time, banana production has expanded in southwestern Uganda in response to urban market demand. Nevertheless, cultivar diversity has remained high in both situations.

Little is known about banana cultivar diversity, distribution and the rationale for maintaining so many cultivars in Uganda. The objective of the present study was to obtain an understanding of cultivar diversity, distribution and importance in the banana-growing region of Uganda through the use of farmer interviews.

Table 1. Study sites for Ugandan diagnostic survey on banana-based cropping systems, 1993–1994.

Site	District	Village	Elevation (m)	Length of rainy season[†]	Population density[‡]
1	Kabale	Bukinda	1760–1830	Supplementary	
2	Bushenyi	Mitooma	1510–1670	*	**
3	Bushenyi	Ryeru	1340–1420	*	**
4	Mbarara	Rukiri	1430–1460	*	*
5	Mbarara	Bubare	1360–1410	*	*
6	Mbarara	Rugaga	1430–1470	*	*
7	Kabarole	Buhesi	1520–1560	Supplementary	
8	Rakai	Kagamba	1190–1330	*	**
9	Masaka	Matete	1200–1270	*	**
10	Masaka	Ntusi	1260–1290	*	*
11	Mpigi	Kabulasoke	1160–1200	**	**
12	Mpigi	Buwama	1180–1260	**	**
13	Mubende	Kitenga	1200–1215	**	*
14	Mubende	Bulera	1250–1310	*	**
15	Mubende	Madudu	1210–1280	**	*
16	Kibale	Nkooko	1080–1180	***	*
17	Kibale	Matale	1180–1240	***	*
18	Kiboga	Bukomero	1160–1200	***	*
19	Luwero	Nyimbwa	1230–1280	**	**
20	Luwero	Butuntumula	1130–1180	**	**
21	Mukono	Kayunga	1050–1070	**	**
22	Iganga	Bulongo	1070–1120	**	**
23	Mbale	Butiru	1250–1270	***	**
24	Kapchorwa	Kaseren	1820–1870	Supplementary	

[†] Rainy months: * 3–5 months; ** 6–8 months; *** > 8 months.
[‡] Population density: * < 50 km^{-2}; ** > 50 km^{-2}.

METHODOLOGY

Site and farm selection

The study was conducted on five farms at each of the 24 sites used in a countrywide diagnostic survey on banana production constraints (Gold *et al.*, 1994). Sites were selected using a Geographical Information Systems (GIS) package developed by the International Institute of Tropical Agriculture's (IITA) agro-climatology unit and digitized demographic, topographic and climatic data bases of the United Nations Environment Program (UNEP) and Centro Internacional de Agricultura Tropical (CIAT) (Jagtap, 1993). Uganda's banana growing regions were classified on the basis of human population density, elevation and rainfall. Twenty-one sites were selected from the resulting grid (8-km square) map using a stratified random sample. Three supplementary sites, showing features of particular interest (for example, high elevation) were also selected (Table 1, Fig. 1). Local district agricultural officers were consulted to identify important banana growing areas within selected zones. The banana-producing village nearest to the centre of the selected grid cell was selected for

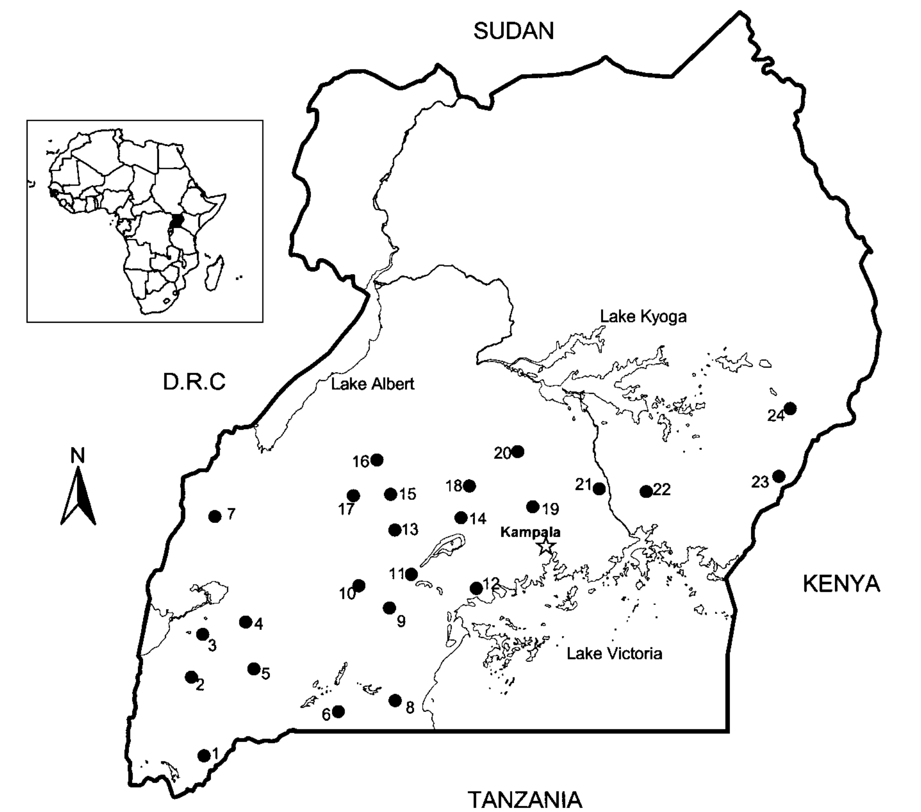

Fig. 1. Sites used in the study.

Table 2. Regional breakdown of study sites for Ugandan diagnostic survey on banana-based cropping systems; 1993–1994.

Region	Name	Elevation (m)		Sites	Districts
1	Southwest	High	1340–1830	1, 2, 3, 4 ,5 ,6, 7	Kabale, Mbarara, Bushenyi and Kabarde
2	Central-South	Low	1160–1330	8, 9, 10, 11, 12	Rakai, Masaka, Mubende and Mpig
3	Central-North	Low	1080–1310	13, 14, 15, 16, 17, 18	Mubende, Kibale, Mpigi and Kiboga
4	Central	Low	1050–1280	19, 20, 21, 22	Luwero, Mukono and Iganga
5	East	High	1250–1870	23, 24	Mbale, Kapchorwa

study. Five farms, containing 100 or more banana mats that were at least two years old, were randomly selected from those within the village. Sites were then grouped into five production zones based on geographical and cultural similarities for regional comparisons (Table 2).

Farmer interviews

Interviews were conducted with the head of the household or the person responsible for maintenance of the banana plantation. After realizing that the women did most of the banana cultivation, the authors preferred to talk to women but always encouraged men to make contributions. Each farmer first named all of the banana cultivars on his/her plantation. These were listed on a large Manila sheet and petri dishes were placed against each cultivar name. The farmer was then asked to divide a pile of approximately 200 beans among the petri dishes to reflect the relative proportions of the different cultivars currently being grown. In this and other exercises, the farmer was asked to review his distribution of beans and allowed to make adjustments before the beans were counted and scores recorded. The farmers were then asked to allocate beans to reflect their cultivar preferences (that is, the proportions of cultivars s/he would like to be growing in the next five years). This provided insight into which cultivars were being phased in or out. Discrepancies between cultivar attributes and proportions that appeared obvious during the time of interview were addressed through follow-up questions.

Treatment of data

All known synonyms were replaced with standard names, using the provisional checklist of banana cultivars in Uganda (Karamura and Karamura, 1994). Data on cultivar proportions and preferences were converted to percentiles by farm, and means were computed for sites, regions and the whole country. To standardize cultivar number across sites, all cultivars were registered at all farms, but scored as zero where they were not physically present. Shannon–Weaver's diversity index (H') (Southwood, 1978) was then computed for all sites using the function:

$$H' = -\sum_{i=1}^{S_t}(P_i)(\log_e P_i)$$

where P_i is the proportion of plants in the ith cultivar and S_t the total number of cultivars. The diversity index takes into consideration the number and proportion of species (i.e. cultivars in this study) as well as diversity of the species localities. Witcombe *et al.* (1996) reported that agricultural diversity is a function of both the total number of cultivars and the number or extent of agro-ecosystems they occupy.

RESULTS

In this study, 240 cultivar names were recorded, but this number was reduced to 130 names after known synonyms were replaced with standard names (c.f. Karamura and Karamura, 1994). Cultivar number per site ranged from 18 to 34 (mean = 26), while the number of cultivars on individual farms ranged from 4 to 22 (mean = 12.3).

Shannon–Weaver's diversity index, H, ranged from 0.77 to 1.31 per site

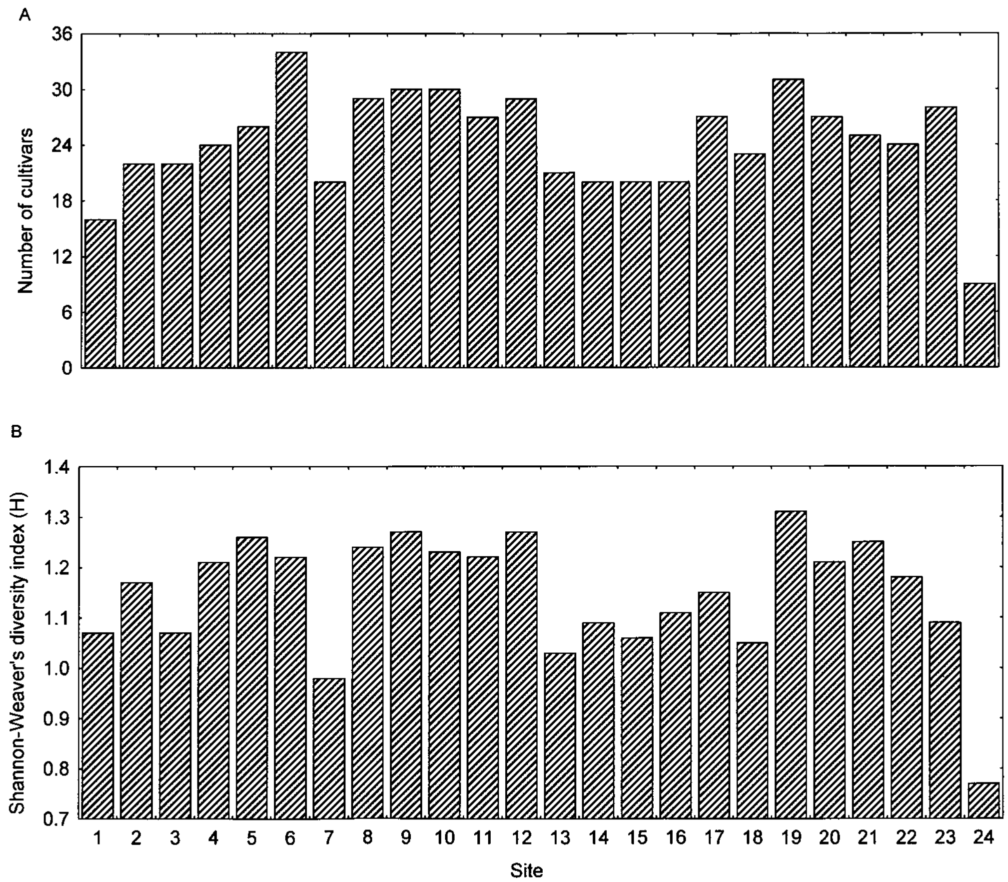

Fig. 2. Number of cultivars and diversity indices at study sites.

(Fig. 2). Diversity indices were highly correlated with cultivar number at each site ($r = 0.85$). In general, cultivar diversity was lowest ($H' < 1.15$) at sites greater than 1500 m above sea level or those growing high proportions of brewing cultivars. Similar observations were made in an earlier study by Karamura *et al.* (2000). In most key commercial growing areas (for example, Bushenyi, Masaka, Mbarara and Mpigi districts), diversity indices exceeded 1.17 although one Bushenyi site had a diversity index of only 1.07. Surprisingly, cultivar diversity was also high (1.18–1.31) in central Uganda where cooking banana has been under decline. High cultivar diversity in a region may indicate extended periods of banana cultivation and a more subsistence form of production. In some cases, poorly producing cultivars continue to be maintained for special traditional or religious uses. Similar results have been found in the case of rice in Asia (Witcombe *et al.*, 1996).

EAHB was found on all study farms and dominated production (> 70%) in all but the central-north region where exotic brewing types dominate production at many sites (Table 3; Fig. 3). The exotic cultivars, Ndiizi ('Ney Poovan' subgroup),

Table 3. Banana cultivar distribution at Uganda diagnostic survey sites, 1993–1994 (24 sites, 5 farms per site).

A. County-wide

Group	Type	No. of sites	No. of farms	Proportion (%)
AAA-EA	Highland cooking	24	120	76
AAA	Gros Michel	24	75	2
AAB	Plantain	20	51	2
AB	Ndiizi, Kisubi	24	110	12
ABB	Kayinja, Bluggoe	22	80	8

B. Regions (proportions %)

	Regions				
Group	1	2	3	4	5
AAA-EA	73	75	59	70	90
AAA	5	4	3	5	4
AAB	1	3	4	3	0
AB	14	10	16	13	4
ABB	7	8	18	9	2

Table 4. *Musa* cultivar distribution at Uganda diagnostic survey sites (24 sites, 5 farms per site).

Cultivar	Genome	No. of farms	Country-wide	Region				
				1	2	3	4	5
Kayinja (Pisang Awak)	ABB	75	8.1	6	6	18	6	0
Nakabululu	AAA-EA	70	7.0	7	5	3	6	24
Ndiizi	AB	102	6.8	10	6	6	8	1
Enyeru	AAA-EA	47	5.5	11	8	1	2	1
Nakitembe	AAA-EA	59	4.9	2	9	2	6	9
Kisubi (Ney Poovan)	AB	48	4.8	1	5	11	5	0
Mbwazirume	AAA-EA	60	4.5	6	4	1	5	9
Nakyetengu	AAA-EA	36	3.3	5	1	4	2	0
Kibuzi	AAA-EA	33	3.2	3	6	3	2	0
Nfuuka	AAA-EA	27	2.9	0	3	7	4	0
Musakala	AAA-EA	50	2.9	0	6	2	3	4
Gros Michel	AAA	72	2.4	4	2	2	3	1
Nandigobe	AAA-EA	40	2.3	5	2	0	1	0
Kisansa	AAA-EA	26	2.2	1	2	2	4	0
Kafuba	AAA-EA	27	2.0	2	4	1	1	6
Nassaba	AAA-EA	15	1.9	0	0	7	0	0
Salalugazi	AAA-EA	22	1.8	0	1	6	0	0
Enzirabahima	AAA-EA	30	1.8	1	2	1	6	0
Ndiibwabalangira	AAA-EA	35	1.8	1	2	1	6	0
Gonja	AAB	51	1.7	0	2	3	2	0
Enyamaizi	AAA-EA	38	1.6	3	2	0	1	0
Siira	AAA-EA	37	1.5	0	1	4	2	0
Muvubo	AAA-EA	41	1.4	2	4	1	2	0
Namwezi	AAA-EA	19	1.3	0	0	2	4	0
Ituntu	AAA-EA	19	1.1	3	0	0	0	0
Ntika	AAA-EA	12	1.0	0	0	0	2	0

Regions: 1 Southwest; 2 Central-south; 3 Central-north; 4 Central; 5 East

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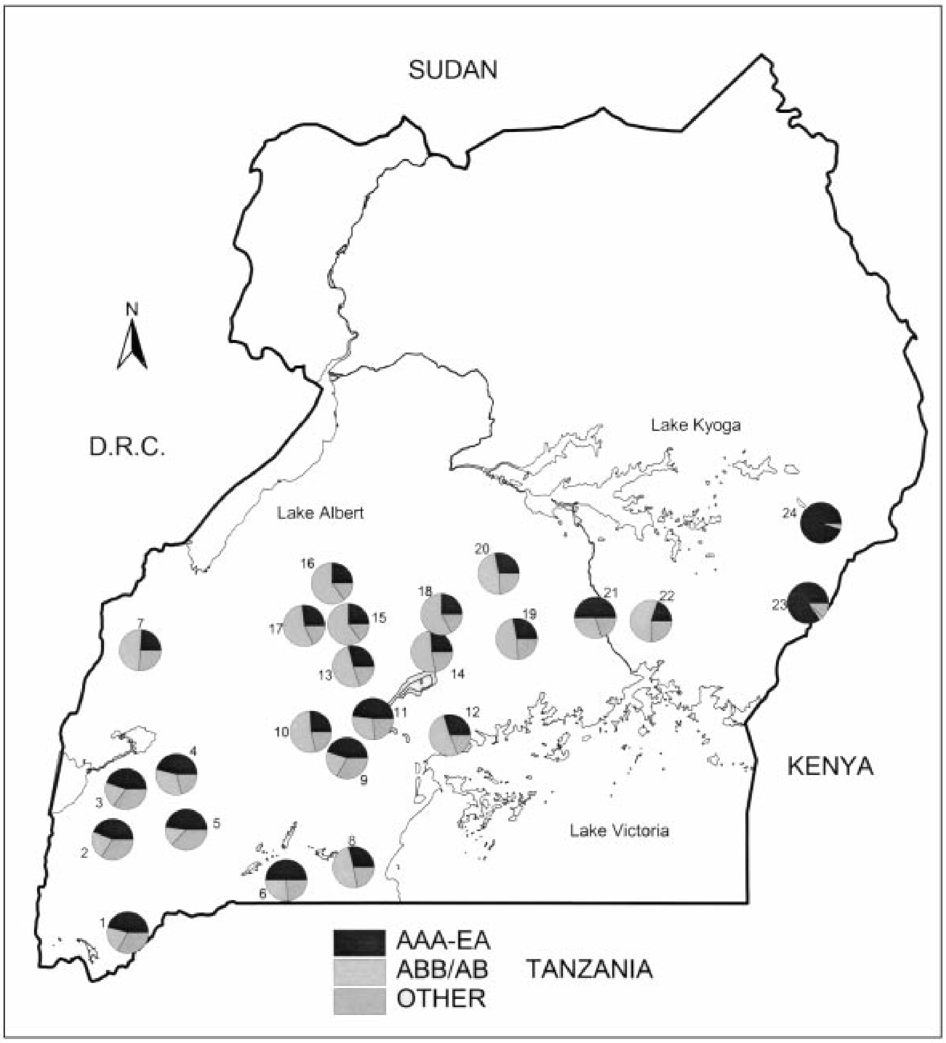

Fig. 3. Distribution of East African Highland bananas (AAA-EA), exotic brewing bananas (AAB/AB) and other types such as desserts and plantains (AAA/AAB).

Kayinja ('Pisang Awak' subgroup) and Kisubi ('Ney Poovan' subgroup) were also widespread and important in all but the eastern zone. Ndiizi was the most ubiquitous cultivar, being found at all 24 sites and on 102 farms, while Kayinja was grown at 22 sites and on 75 farms. Gros Michel (24 sites, 72 farms) and plantain (20 sites, 51 farms) were also widely grown but did not account for more than 5% of production in any one zone (Table 4).

Of the 130 cultivars, encountered, 10 comprised 50% of highland banana and 38% of total *Musa* production in Uganda (Table 4). A few cultivars (for example Nakabululu, Nakitembe) were important in all regions. Other cultivars (Kibuzi, Musakala) were widespread but absent from one region. Some cultivars (Nandigobe, Nassaba, and Nakeytengu) had narrow distributions and were of importance in only one region. Cultivar preferences also varied among neighbouring villages. In Mpigi district, for example, Enyeru constituted 16% of production in Kabulasoke but only 2% in Buwama. Finally, 45 cultivars were found on only one or two of the 120 survey farms. This may be due to unknown synonyms or to the development of new variants through high somatic mutations characteristic of banana (Vuylsteke *et al.*, 1991; Israeli *et al.*, 1995; Crouch *et al.*, 1998). These new variants are usually given new names that are very localized.

Among the cooking cultivars, Nakabululu, Mbwazirume, Nakitembe and Enyeru were the most frequently grown across the 24 sites (Table 4). This suggests that these may be the most ancestral, having been grown over a very long period and therefore having gained a wide distribution. Wide distribution may also indicate best adaptability and tolerance to diverse environments. The four widely cultivated clones are generally quick-maturing, produce soft-textured and tasty food making them preferred by farmers. Again Nakabululu and Nakitembe are mentioned to be some of the oldest clones in the region and their wide distribution supports this.

Ndiizi, the most widely distributed cultivar, was reported to be gaining importance in both local and export markets. This banana is characterized by a small compact bunch, short fingers with a very sweet apple flavoured fruit when ripe. Farmers in Kabale reported high market demand for Ndiizi. It was sold to schoolchildren and to local markets. Farmers in Mbale and Kapchorwa (Sites 23 and 24 respectively) reported that they sell both Ndiizi and Gros Michel across the border with Kenya. In more remote sites such as Kabarole, Ndiizi is increasingly becoming an important brewing cultivar since it produces excellent juice that may be used in the production of *Waragi* a local gin, made by distilling banana wine. The wine is produced by fermenting banana juice with sorghum.

A number of cultivars were reported to have disappeared or been phased out due to a cultural strategy whereby all new clones are first planted near the homesteads for initial testing. These plants receive mulch and other household refuse, which provides regular nourishment. Often, farmers will replace older clones with new selections or concentrate management on newer clones, abandoning the older clones to die out from neglect.

At the national level, Kayinja was the most abundant cultivar and represented 8% of total production. In many areas of central Uganda, where production of cooking bananas declined over the last 20 years, farmers are replacing cooking bananas with Kayinja. Kayinja is used for brewing and is grown mainly in single-cultivar stands that often are large and separated from the home garden. Farmer preferences at some sites shifted to Kayinja, which is believed to be more drought tolerant than the local brewing clones and which can earn them a ready income through the marketing of value-added products such as banana wine and Waragi. Nakabululu was the most widely grown cooking variety and Enyamaizi (also called Kabula) was the most widely grown EAHB beer variety).

DISCUSSION

Traditionally, banana stands were very long-lived and farmers often inherited existing cultivar mixtures from preceding generations. The experience of generations taught many farmers that their plantations performed better and survived longer with higher levels of crop diversity. High levels of diversity afforded a variety of outputs and minimized risk through multiple cropping. In Uganda, cultivar diversity reflects a broad range of banana types (genome groups) as well as the cultivation of a multitude of EAHB cultivars.

That farmers maintain high cultivar diversity is due, in part, to their perception of the different strengths and weaknesses for the cultivars they grew (Gold *et al.*, 2002). In Kabulasoke, for example, one farmer perceived Mutangendo as producing the largest bunches but susceptible to drought and not very hardy; Nakabululu as having the best taste and being quick-maturing but prone to pests; Nakyetengu as most pest resistant but susceptible to drought; Nakitembe as the fastest grower but susceptible to pests and toppling; and Nabusa as being most hardy and durable but slow maturing and only fair tasting. Cultivar diversity also reflected a variety of end uses (market, home consumption, beverage production) and differential performance against a multitude of production criteria and stresses. Cooking, roasting, dessert and brewing bananas contribute to a diversified diet. This scenario points to the importance of cultivar diversity for food security in subsistence cropping systems.

Certain traditional practices (for example religious or ceremonial rituals) also lead farmers to maintain small quantities of uncommon cultivars that may not produce well. Some farmers also liked to maintain diversity out of pride or for aesthetic reasons. One farmer in Rugaga, in the Mbarara district, for example, reported having obtained new cultivars from other parts of Uganda and from Tanzania. These he grew because of their unique appearance; for example, varieties with variegated leaves, with red leaves, or a yellow male bud.

Widely distributed cultivars, such as Nakabululu, Nakitembe and Mbwazirume, have probably been cultivated for long periods during which farmers developed a preference for those with the most favourable attributes. In contrast, many cultivars were found at only one or two sites. Somatic mutations are most likely responsible for the evolution of the large number of local cultivars. Some cultivars may present superficial expressions of morphological traits that are often not stable but may be seen as distinct by farmers and given local names. Additionally, some EAHB cultivars show different phenotypic expressions under different ecological conditions (Karamura and Karamura, 1994; Karamura, 1998).

Some very localized cultivars may ultimately prove to be synonymous with more widely spread cultivars; different names may reflect regional differences in tribal groups and languages. Further studies incorporating DNA analysis may be needed to confirm the nomenclature and the real extent of genetic diversity.

Since the beginning of the 1990s, development of a stronger national banana research programme and extension system, plus the improvement in infrastructure (especially roads), has led to greater exposure of farmers to exotic cultivars, hybrids and EAHB cultivars used in other regions. For example, the national banana research programme has an on-going programme of multi-locational testing of banana cultivars from other regions and offers germplasm to farmers for testing. It remains to be seen how this will affect future banana cultivar distribution and diversity levels within Uganda.

An understanding of cultivar distribution and selection criteria will assist future germplasm conservation to ensure continued food security. Farmer participatory methods are key to providing original information with insights into factors affecting the dynamics of crop production.

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