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RAPID MASS PROPAGATION AND DIFFUSION OF NEW BANANA VARIETIES AMONG SMALL-SCALE FARMERS IN NORTH WESTERN TANZANIA

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ABSTRACT

Since the seventies, factors such as declining soil fertility and the emergence of pests and diseases have reduced banana (*Musa* spp.) yields from about 10 to 4 t ha^{-1} in the Kagera region, North Western Tanzania where banana is the most important staple food. Clean planting materials are required to solve the problem of pests and disease infection. To this effect, new banana varieties were introduced, multiplied locally and distributed to more than 0.5 million people since 1997. The target was set to have 1 million plants of superior varieties in the farmer's fields by March 2003 which accounts to about 1.5% of the total banana population in the region. A total of 21 varieties were introduced and evaluated for their palatability and field performance by the local communities. Fourteen varieties were multiplied *In vitro*. A total of 71,000 *In-vitro* plants were introduced in the region since 1997 and multiplied in 35 nurseries by field decapitation. These multiplication fields contain 84,000 stools and are spread over the entire region. To-date 340,000 suckers have been distributed by the project and 680,000 suckers from farmer to farmer, amounting to 1,020,000 suckers. The best performing varieties are FHIA-17, FHIA-23, SH3436-9 and Yangambi. Results of an impact assessment survey show that the superior varieties outyield the local varieties by an average of 40%.

Key Words: Clean planting material, impact assessment, *In-vitro*, *Musa* spp.

RÉSUMÉ

Depuis les années soixante-dix, des facteurs tells que la réduction des la fertilité de sols et l'émergence des pestes et maladies ont réduit le rendement de la banane (*Musa* spp.) de 10 a 4 t ha^{-1} dans la région de Kagera, au nord ouest de la Tanzanie où la banane est la nourriture de base. Par conséquent, du matériel sain est nécessaire pour résoudre le problème d'infection des pestes et des maladies. Pour ce faire, des variétés nouvelles étaient introduites, multipliées localement et distribuées a plus de 0.5 million des personnes depuis 1997. Il était ciblé d'atteindre 1 million de plantules de variétés supérieures dans les champs des fermiers vers Mars 2003 représentant 1,5% de la population bananière dans la région. Au total 21 variétés ont été introduites et évaluées pour leur goût et performance dans les champs par les communautés locales. Quarante variétés ont été multipliées in vitro. Au total 71,000 In-vitro plantes ont été introduites dans la région depuis 1997 et multipliées dans 35pépinière par découpage en champs. Un total de 84,000 coupures ont été réalisées par multiplications dans les champs et ont été disséminées dans toute la région. Aujourd'hui 340,000 rejetons ont été distribués par le projet et 680,000 rejetons d'un fermier a l'autre, pour un total de 1,020,000 rejetons. Les variétés les plus performantes sont le FHIA-17, FHIA-23, SH3436-9 et Yangambi. Les résultats de l'évaluation de l'impact ont montré que les variétés supérieures ont outré passées les variétés locales par une moyenne de 40%.

Mots Clés: Matériel de plantation sain, evaluation de l'impact, *In-vitro*, *Musa* spp.

INTRODUCTION

Several factors such as declining soil fertility, reduction in good management practices and the emergence of pests (nematodes and weevils) and diseases (Fusarium Wilt and Black Sigatoka) have reduced banana production in Tanzania and elsewhere in the Great Lakes region (Sebasigari and Stover, 1987; INIBAP, 1988; Swennen and De Langhe, 1989; Swennen and Vuylsteke, 2001). Due to their close genetic basis, all highland bananas have been severely affected (Vuylsteke and Swennen, 1988). As a result, yields have declined by 60% from 10 tons to about 3-4 t ha^{-1}.

To address this issue, several strategies have been envisaged in the Kagera region including organic/chemical fertiliser application, pesticides to control pests and diseases, and distribution of high yielding pest and disease resistant cultivars. Chemical fertilisers and pesticides are not an economically viable option in Tanzania because peasants are very poor. In contrast, farmyard manure and mulch have much to offer since animal husbandry is widespread and grasses are part of the natural fallow. This approach is sound as far as it concerns soil fertility, but its effect on pest and disease resistance is still questionable (Bosch *et al.*, 1995). Indeed, local cultivars are still succumbing especially to nematodes and weevils over the past 3 decades, despite the heavy dressings with farmyard manure and grass mulch. The provision of clean planting material has shown its merit (Speijer *et al.*, 2000; 2001) but its effect on local cultivars is not long lasting.

The distribution and cultivation of pest and disease resistant bananas is therefore a better, sustainable and cheaper option. Already in 1987 the breeding of Highland bananas was considered a high priority (Persley and De Langhe, 1987) but until today, because of their high sterility, no suitable hybrids are available from the Highland banana genepool. However pest and disease resistant banana hybrids from other gene pools (from the AAA, AAB and ABB group) have been successfully developed in the breeding programmes of FHIA (Fundacion Hondurena de Investigacion Agricola) and IITA (International Institute of Tropical Agriculture). These hybrids and landraces have undergone intensive testing either by different breeding programmes alone or/ and are part of the worldwide IMTP (International *Musa* Testing Programme) (Orjeda, 1998; Orjeda *et al.*, 1999). In Burundi for example, several of these hybrids and landraces have been tested for several years and are now cultivated in several villages. Such an approach has also shown its merit in other regions of the world like Costa Rica, Nicaragua and Nigeria, where hybrids and landraces differing from the local *Musa* pool were introduced, tested, multiplied, distributed and successfully cultivated by smallholders (Jarret *et al.*, 1985; Dens *et al.*, 2002; Hahn *et al.*, 1990; Tshiunza *et al.*, 2001).

This paper gives an account on the strategy followed during the introduction and distribution of about 1 million banana plants to smallholders in northwestern Tanzania and provides preliminary information on the performance of these new cultivars and potential impact at the farmer's level.

MATERIALS AND METHODS

Study area. The study was carried out in the Kagera region of northwestern Tanzania as part of the Tanzania/Belgium funded Kagera Community Development Programme (KCDP). The Kagera region is situated south of Uganda, west of Lake Victoria and east of Rwanda and Burundi. Nearly half of the national banana production is harvested (1.26 million mt per year) in this region, which is situated between 1,135 m (Lake Victoria level) to 1,800 m above sea level. An estimated 1.2 million people from the region depend on this crop for their daily food intake (Mgenzi and Mbwana, 1999). In this region, the most important banana types are "matoke" (cooking) that represents 85% of the total banana production. These bananas are steamed and eventually mixed with beans, meat or fish. Ripe fruits are also used for preparing juice and banana beer. Brewing bananas represents 5% of the total production in the region and is an important source of income. Sweet bananas represent also 5% of the production. There are exotic varieties as Gros Michel, Cavendish and Pisang Awak. The remaining 5% are plantain. This type is not very common but is also considered as an important source of income.

The Kagera region consists of the districts

Bukoba, Muleba, and Karagwe in the north and the districts Ngara and Biharamulo in the south. In the 3 northern districts, 50 % of the daily calorie intake comes from banana but in Ngara bananas contribute about 30 % of the energy intake. In the Biharamulo district banana contribute approximately 5% of the energy intake. There are an estimated 150 million banana plants grown in the Kagera region.

Local cultivars. Local cultivars include highland bananas which have been cultivated for centuries in the Kagera and the so-called "exotic" cultivars that were introduced some decades ago either from neighboring countries (Uganda for Gros-Michel and Pisang Awak) or from other regions of Tanzania (Kilimanjaro and Arusha Regions for Mshale and Mtwishe, respectively).

The highland banana cultivars are called locally matoke or ebitoke (cooking) type and are generally susceptible to weevils and nematodes. Most of the "exotic" banana cultivars in the north eastern part of the Bukoba district may be wiped out very soon because of their susceptibility to Panama (Mgenzi and Mbwana, 1999), except the Mtwishe (Cavendish) cultivar which is resistant to Panama but sensitive to drought.

Introduction of new bananas cultivars. The whole activity involved 21 cultivars but started only with a few at the beginning. Among these, the hybrids FHIA-01, FHIA-03, FHIA-17, FHIA-23, Pelipita, Yangambi KM 5 and SH 3436-9 have so far been most widely distributed (Fig. 1) because of high acceptance by farmers. Many of these cultivars had been tested in other countries (Hahn *et al.*, 1990) or were part of the worldwide IMTP programme coordinated by INIBAP which tests landraces and hybrids in more than 30 sites in the world (Orjeda, 1998; Orjeda *et al.*, 1999). The cultivars were obtained from the INIBAP Transit Center and multiplied *In vitro* at the Laboratory of Tropical Improvement (K.U.Leuven) (Vuylsteke *et al.*, 1990; Van den houwe and Swennen, 1998; Van den houwe, 1999).

Performance evaluation of the introduced banana cultivars. The *In vitro* plants were imported through the Tanzanian Quarantine Services (Fig. 2) and were weaned in a nursery in the Kagera under high humidity and low light conditions. The nursery soil was sterilised and sieved to obtain high quality soil. After about 2-3 months in the nursery, *In vitro* plants were

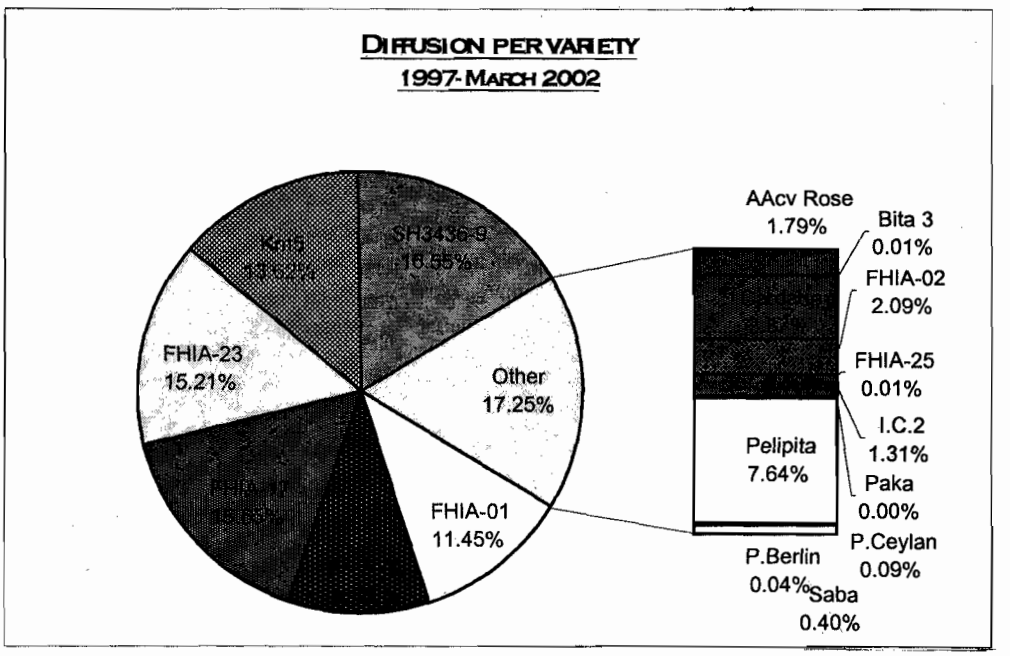

Figure 1. Distribution per variety.

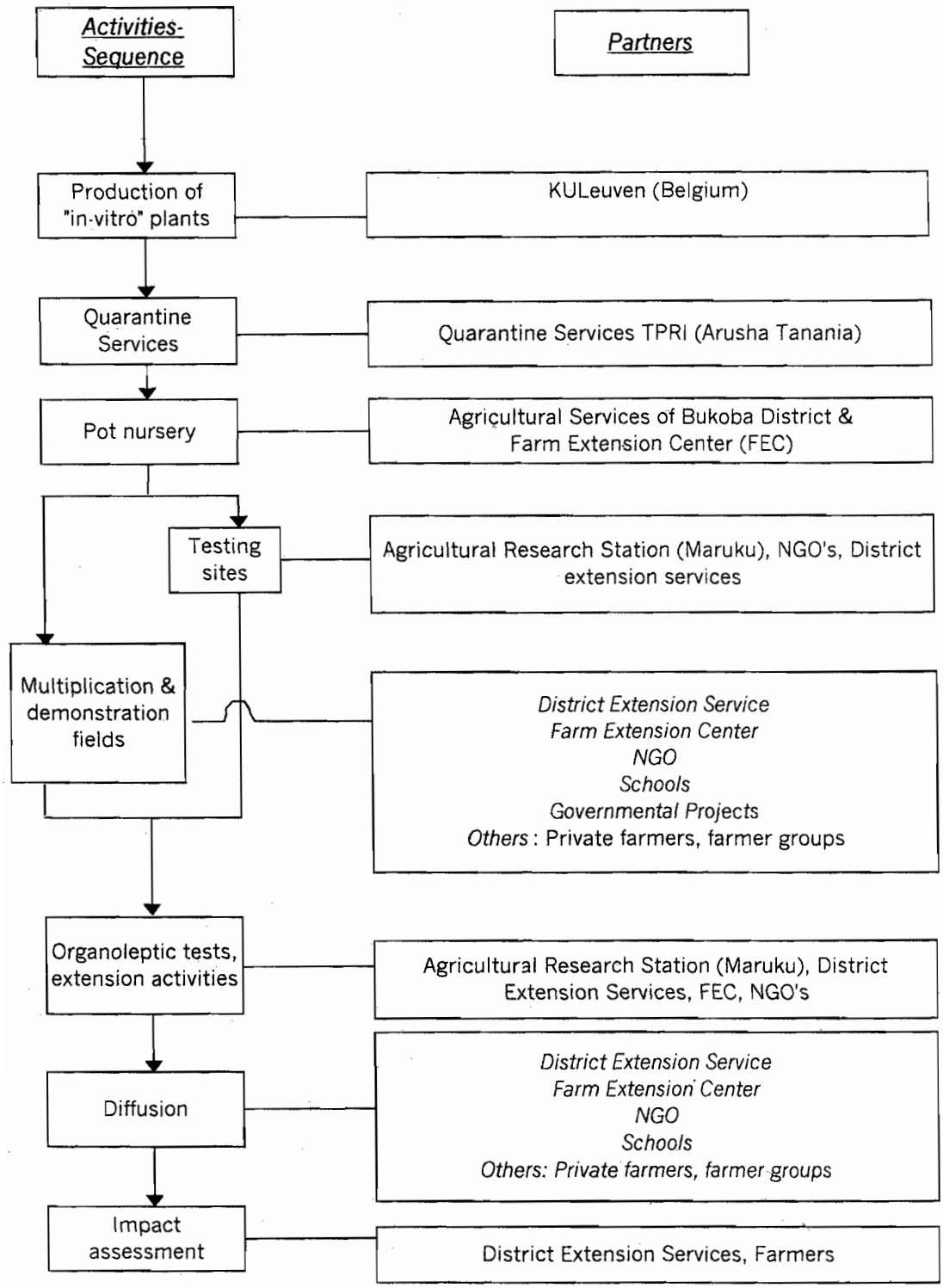

Figure 2. Partners involved and flow of new varieties from laboratory until the farmer.

transplanted in a plant hole of about 1.5m x 1.5m x 1.5m filled with 3 buckets of cow manure. At 6 months growth, plants were decapitated (De Langhe, 1961; Swennen, 1990b) to stimulate suckers production. Later on suckers were taken, peeled and used to establish demonstration and multiplication fields over the entire Kagera region. Demonstration fields were allowed to produce fruits for palatability tests. Plants in multiplication fields were at least once per year decapitated to produce suckers for distribution. Demonstration and multiplication fields had been set up in partnership with government extension centers, Tanzanian and foreign NGO's, private farmers and farmers organizations, primary and secondary schools, churches, etc. Data were collected about the number of suckers supplied to the farmers from multiplication fields. This was called direct distribution.

To evaluate the performance of newly introduced cultivars, a survey was conducted in three villages of the Bukoba district and in one village of the Biharamulo district. Farmers were asked to record yield parameters of all their varieties (highland bananas, exotic landraces and newly introduced varieties) which are grown together and mixed in association with other crops such as beans *(Phaseolus vulgaris)*, maize (*Zea mays* L.), potato *(Solanum tuberosum)*, sweet potato, cassava *(Manihot esculentum)*, coffee (*Coffea* spp.), etc. All these banana cultivars were fertilised either with cow manure and/or grass mulch.

Impact of the new banana cultivars at the farmer's level. Information was also gathered about the number of suckers distributed from farmer to farmer and the yield of the new varieties grown under farmer's conditions. This so-called indirect distribution provided an idea about farmer's perception about the value of the newly introduced cultivars.

RESULTS AND DISCUSSION

Current status of the distribution of new banana cultivars. Fourty demonstration and 35 multiplication fields were established all over Kagera region (Table 1). The multiplication ratio of plants distributed to farmers was estimated to be 1:2 on an annual basis, which means that a farmer obtains 1 plant or 2 plants after 1 year but without decapitation.

Farmers either replanted the collected suckers or distributed them to other farmers. Over the 5 years period farmers distributed as such more than 680,000 suckers (indirect distribution) while the multiplication fields supplied in total about 340,000 suckers (direct distribution) (Table 2). The cost per sucker has continuously dropped from more than 10 Euro in 1996 up to less than 1.5 Euro in 2002.

The distribution of new cultivars started very slow in 1997-1999 but then accelerated during 2000 (Table 2). This was due to the small starting stock of *"In vitro"* plants together with the initiation phase whereby much attention was paid in setting up new fields with newly produced suckers. In addition the early involvement of many partners was a bonus since they assisted with the selection of the desired cultivars and the distribution of on-farm produced suckers through their own channels. This strategy was so successful that farmers produced and distributed more suckers

TABLE 1. Overview of multiplication and demonstration fields in the 5 districts of the Kagera region (March 2002)

District	Multiplication fields		Demonstration fields		Total	
	Fields	Stools	Fields	Stools	Fields	Stools
Biharamulo	2	7,136	3	902	3	8,038
Bukoba	18	53,050	17	1,557	23	54,607
Karagwe	2	3,145	2	130	2	3,275
Muleba	1	3,434	0	0	1	3,434
Ngara	3	12,349	3	445	3	12,794
Total	26	79,114	25	3,034	32	82,148

to other farmers than the project fields as from the year 2001. This situation will contribute to a sustainable distribution of the desired cultivars.

Performance of local and newly introduced cultivars. In the three surveyed villages in the Bukoba district (Byamutemba, Kabirizi and Kiilima) and the one in the Biharamulo district (Bisibo), 44 highland banana and 6 "exotic" landraces are cultivated. Among the landraces highland bananas represent about 80% of the banana plant population but the roasting type or "gonja" (plantain) and sweet bananas (sukari ndizi) represent together less than 5%. Average yields were 14.5 kg bunch^{-1} and 15.7 kg bunch^{-1} for highland banana and for "exotic" cultivars, respectively. The situation varied from village to village (Tables 3 and 4). The standard deviation shows great yield differences within and between villages. This could be explained by variations in soil fertility, climate and more generally by different management conditions.

Highland banana cultivars. The best yield has been recorded in the Byamutemba village, Bukoba district because of its relatively good environment. There, the kibanjas were situated on piedmont plains from undifferentiated rocks of the Karagwe-Ankolean System and are at the border of an Alluvial System (Tourber and Kanani, 1994). Despite the low rainfall and a dry season of about 5 months, the relatively good water holding capacity of the silty clay soils results in an average yield of 17.2 kg bunch^{-1} (maximum: 45 kg bunch^{-1}). The Kabirizi village has the same climatic characteristics but shows lower yields because of a more exhausted soil and depleted water holding capacity. The villages of Byamutemba and Kabirizi have a relatively high highland banana production as compared to the eastern and northern parts of the Bukoba district where the lowest yield is found in the Kiilima village (10.4 kg bunch^{-1}) because of poor fertility due to highly leached soils derived from the Bukoban Sandstone formation (Tourber and Kanani, 1994).

The average bunch weight for highland banana cultivars in Bukoba district is 14.1 kg, which is close to other reports (12 kg, Lorkeers and Bajukia 1996; 15 kg, Tibaijukia, 1984). In Biharamulo district, the yields of the Bisibo village are higher (16.0 kg bunch^{-1}) than in the Kiilima village (10.4 kg bunch^{-1}) despite the same soil type derived from Bukoban Sandstone. This is explained by a better natural fertility due to the presence of loamy soils with a thick and dark topsoil (presence of dolerite intrusions), good water holding capacity (Oosterom *et al.*, 1999) and a less aggressive climate.

"Exotic" cultivars. The yield of the "exotic" cultivars is especially high in the Kiilima village. This is due to the introduction of the "Mtwishe" cultivar (Cavendish), which is resistant to Panama disease and well adapted to the environmental conditions on the Victoria Lake Shore with an annual rainfall above 1,500 mm. This cultivar accounts for 71% of the "exotic" banana plants in this village and contributes to 81% of the production of the "exotic" cultivars. Unfortunately, Mtwishe is not tolerant to drought and is not suitable for the other 2 villages with a rainfall lower than 1,000 mm. Table 5 indicates that the percentage of "exotic" types among "local" cultivars is inversely proportional to the yield

TABLE 2. Direct (from project field to farmer) and indirect distribution (from farmer to farmer) of introduced cultivars over 5 years (period 1997 – 2002)

Time frame	Direct distribution	Indirect distribution	Total year^{-1}
1997	1,342	0	1,342
1998	2,330	2,684	5,014
1999	20,285	12,712	32,997
2000	101,380	78,706	180,086
2001	150,257	438,878	589,135
1st quarter 2002	62,082	149,394	211,476
Grand Total	337,676	682,374	1,020,050

TABLE 3. Average weight, standard deviation, number of harvested bunches and rainfall per village

District	Village	Varieties									Rainfall (mm)
		Highland banana			"Exotic"			Newly introduced			
		Kg	St.	#	Kg	St.	#	Kg	St.	#	
Bukoba	Byamutemba	17.2	8.6	654	15.0	8.7	95	17.5	8.8	96	750-1000
	Kabirizi	13.6	8.3	2,182	10.8	6.5	612	13.6	6.5	146	750-1000
	Kiilima	10.4	5.0	292	18.1	9.9	1,309	22.6	12.2	729	1500-2100
Biharamulo	Bisibo	16.0	8.2	1,008	16.0	7.1	15	22.0	10.5	103	750-1000
For the 4 villages		14.5	8.3	4,136	15.7	9.5	2,031	21.1	11.5	1,074	

Kg: Bunch weight in Kilogram St.: Standard Deviation #: Number of Harvested Bunches

performance of the highland bananas. In other words, farmers facing declining production and/or with a smaller kibanja are more open to new cultivars than farmers who are better off (bigger kibanja and/or better soil fertility).

New cultivars. Highest yield increases were noted in the Kiilima village where constraints due to pests, diseases and low soil fertility are the most severe. The yield increased from 10.4 for highland banana to 22.6 kg bunch^{-1}, in the case of the new cultivars. Some farmers even stopped buying bunches for home consumption and became net sellers after years of declining production. For Byamutemba village, the difference is not significant, the main reason being the low performance of Yangambi Km 5 (12.8 kg bunch^{-1}) under these drier conditions and accounting for 28% of the recorded bunches. In contrast to the Kiilima village, the average bunch weight is 23.1 kg for Yangambi Km5. Data for Kabirizi village do not show yield difference; in this case, the kibanja size is reasonable and provides enough bunches for home consumption, the pressure being not as high as in the Kiilima village.

The general trend was an increase in production (Fig. 3), taking into consideration the great fluctuation in bunch weight because of the seasons. Such a case of improvement was not isolated in an area where local banana varieties have been severely affected and almost wiped out by pests and diseases.

In Biharamulo district, the yield in the Bisibo village increased with 37 % (from 16.0 to 22.0 kg bunch^{-1}) and the potential gain due to the introduction of new cultivars is estimated at 39% for the 4 studied villages in Bukoba and Biharamulo districts. These yield figures reflected parameters such as the general soil fertility status, the size of the kibanja and the degree of management performed by the farmers as well as the introduced genotypes.

Comparing the data for the 4 different villages (Tables 3 and 4), highest bunch weight increases due to the introduction of new varieties were noted in the Kiilima village where constraints due to pests, diseases and low soil fertility are the most severe. The bunch weight increased by 117% - from 10.4 to 22.6 kg bunch^{-1} - as compared to the

highland cultivars (Fig. 4). This increase clearly indicates the gain due to the introduction of new banana plants. However, the yields of the local landraces had less variability than the yields of the introduced cultivars.

For the whole Kagera region, the newly introduced cultivars have been grouped according to their most important use:

Cooking and dessert - FHIA hybrids
Roastings and cooking - Cardaba, Peripita, Saba, Bita 3
Multipurpose - Yangambi Km 5, Cultivar Rose

CONCLUSIONS

The declining banana production in the Kagera region has been mostly addressed by advising farmers to apply farmyard manure, if available. This approach resulted in higher soil fertility but its effect on pest and disease resistance in banana was not clear (Bosch *et al.*, 1995). In fact, the decline in yield of the local banana over the last 3 decades has not been arrested by farmyard manure application, resulting in emigration of people.

Banana breeding and collaborative research resulted in the breeding of high yielding pest/disease resistant cultivars as well as the identification of pest/disease resistant landraces as part of a global testing program. Through improved exchange of data and *In vitro* techniques, interesting cultivars could be quickly multiplied and tested by the people in the Kagera. Selected cultivars were then multiplied and distributed in partnership with different farmer organizations, NGO's, schools, churches, etc.

The result of this concerted effort is the cultivation of more than one million new banana cultivars fully integrated in the local farming system. It is expected that by the end of the project (March 2003) about 2 million plants of pest/disease resistant cultivars will be grown by the banana smallholders in the Kagera region. If achieved this number will be beyond the project target, but still small in comparison with the

TABLE 4. Mean differences between villages

Varieties	Byamutemba - Kabirizi	Byamutemba - Kiilima	Byamutemba - Bisibo	Kabirizi - Kiilima	Kabirizi - Bisibo	Kiilima - Bisibo
Highland	3.6 ***	6.8 ***	1.2 ***	3.20 ***	-2.4 ***	-5.6 ***
Exotic	3.9 ***	-3.4 ***	-0.6	-7.3 ***	-4.5 **	2.8
Newly introduced	3.9 ***	-5.1 ***	-4.5 ***	-9.0 ***	-9.0 ***	0.6
All	4.1 ***	-1.3 ***	0.4	-5.4 ***	-3.7 ***	1.7 ***

*, **, ***: Significant at 5, 1 and 0.1 % respectively, based on t-test

TABLE 5. Relationship between "exotic" and highland banana cultivars in Bukoba district

Village	Average yield (kg bunch^{-1}) highland banana cultivars	Percentage of "exotic" varieties among highlands banana cultivars	"Kibanja" size per household (ha)	Natural soil fertility
Byamutemba	17.2	12.7	0.9	Medium-good
Kabirizi	13.6	21.9	0.9	Medium
Kiilima	10.4	81.8	0.5	Low-very low

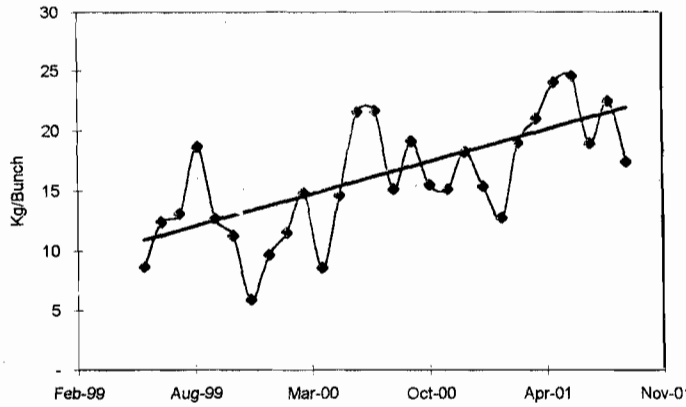

Figure 3. Monthly harvest at farm level.

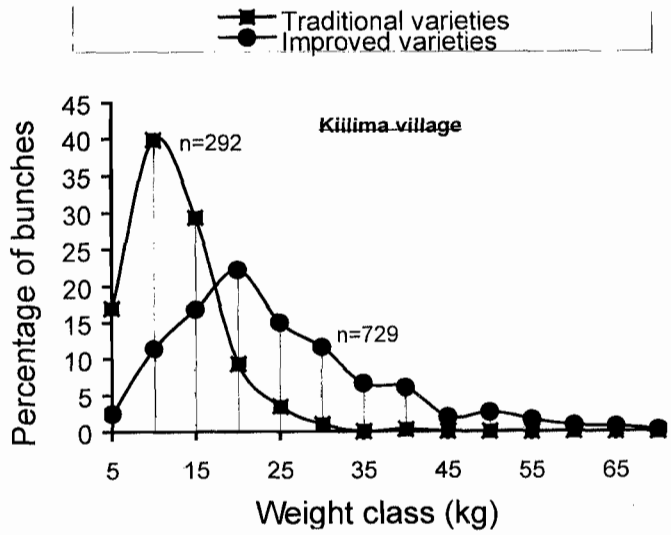

Figure 4. Percentage of bunches against weight classes.

estimated 150 million pest and disease infected highland bananas which are predominantly cultivated in the Kagera region.

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