

## AGRONOMIC PERFORMANCE OF INTRODUCED BANANA VARIETIES IN LOWLANDS OF RWANDA

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### ABSTRACT

Most of Rwandan banana cultivars are low-yielding and susceptible to pests and diseases. High yielding and pest/disease resistant varieties have been obtained in advanced breeding centers recently. Introduction, evaluation and adoption of such varieties by local producers may be one of the options to boost yields. The objective of this study was to evaluate the agronomic performance of FHIA hybrids in lowlands of Rwanda. Completely randomised design was used with 9 treatments (varieties) and 20 replicates. Data were recorded on plant growth and yield components, banana bunchy top virus and yellow Sigatoka incidence. All hybrids matured later than local cultivars except FHIA 18 which was the earliest maturing variety. FHIA 17 and FHIA 25 matured 1 and 3 month late compared to the average cycle of the 2 local checks. However, it was compensated by high bunch weight of 53.4 and 52.3 kg for FHIA 17 and FHIA 25, versus 26.9 and 19.5 kg for Poyo and Barabeshya, respectively. FHIA 17, FHIA 25 and FHIA 18 had the highest yield of 55.7, 52.6 and 46.5 t ha<sup>-1</sup> per year, respectively. Considering their resistance to fusarium wilt and yellow Sigatoka and superior agronomic performance, they may be released for Rwandan lowlands after conducting palatability tests.

*Key Words:* Agronomic performance, FHIA hybrids, hybrids, *Musa* spp.

### RÉSUMÉ

La plupart de cultivars de banane Rwandais sont faible production et susceptible aux pestes et aux maladies. Les variétés à haute production et résistantes à la peste/maladie ont été obtenues récemment dans les centres de pépinière. L'introduction, l'évaluation et l'adoption de telles variétés par les producteurs locaux peuvent être une des options pour hausser des rendements. L'objectif de cette étude était d'évaluer la performance agronomique de FHIA hybride dans des basses-terres du Rwanda. La conception complètement aléatoire a été utilisée avec 9 traitements (les variétés) et 20 copient. Les données ont été enregistrées sur la croissance de plante et les composants de rendement, bunchy de banane premier virus et l'incidence de Sigatoka jaune. Toutes les variétés hybride ont mûri plus tard que les cultivars locaux sauf FHIA 18 qui était la plus première variété à mûrir. FHIA 17 et FHIA 25 ont mûri 1 et 3 mois tard en comparant au cycle moyen des 2 contrôles locaux. Cependant, il a été compensé par le poids élevé de paquet de 53,4 et 52,3 kg pour FHIA 17 et FHIA 25, contre 26,9 et 19,5 kg pour Poyo et Barabeshya, respectivement. FHIA 17, FHIA 25 et FHIA 18 ont eu l' à haut rendement de 55,7, 52,6 et 46,5 t ha<sup>-1</sup> par an, respectivement. Considérer leur résistance au fusarium flanche et Sigatoka jaune et la performance d'agronomique supérieure, ils pourraient être relâchés pour rwandais des basses-terres après avoir dirigé les tests de saveur.

*Mots Clés:* L'exécution d'agronomic, FHIA hybride, hybride, *Musa* spp.

## INTRODUCTION

Globally, banana and plantain (*Musa spp.*) are ranked the fourth most important food crop in the world after rice (*Oryza sativa*), maize (*Zea mays*) and wheat (*Triticum spp.*) (Frison and Sharrock, 1999). In sub-Saharan Africa, it is estimated that over 30 million people subsist on bananas as the principal source of dietary carbohydrate (Karamura *et al.*, 1999). Rwanda is placed among the countries with the highest consumption of banana in the world (197 kg per *capita* per year) and annual production of 2.25 million metric tons (Frison and Sharrock, 1999). Nearly, one quarter of country's arable land is allocated to this crop (Mpyisi *et al.*, 2000). However, banana yields are low (about 8 t ha<sup>-1</sup> per year) (MINECOFIN, 2001), while production is compromised by pest and disease complex (Okech *et al.*, 2002).

Locally grown banana varieties are susceptible to fusarium wilt, nematodes and weevil borers (Gaidashova *et al.*, 2004; Okech *et al.*, 2005). Productive varieties, which are resistant to pests and diseases, may be highly suitable for improving yields and increase productivity. Banana improvement research has made some advances in 1980s and early 1990s and banana breeders have released varieties originated from conventional breeding, somaclonal or field selection, which had desirable pest- or disease resistance traits (Hwang and Tang, 1996; Rowe and Rosales, 1996a; 1996b; Singh and Uma, 1996; Tomekpe *et al.*, 1996; De Beer *et al.*, 2004; de Oliveira e Sylva *et al.*, 2004; Kumar *et al.*, 2004). FHIA hybrids originated from Honduras and are known for their superior yield characteristics, resistance to fusarium wilt and leaf spot diseases and desirable adaptability traits (Rowe and Rosales, 1996a; 1996b; Orjeda, 1999). Some FHIA hybrids (AAAA, AAAB, AABB) were introduced and evaluated in many countries in Africa and world-wide in early and mid-1990s (Vigheri, 1997; Eckstein *et al.*, 1998; Rwezaula *et al.*, 1998; Hartman *et al.*, 2000; Nowakunda *et al.*, 2000). However, such evaluation has not been conducted in Rwanda. The objective of this study was to evaluate the agronomic performance of the new introduced banana cultivars in lowland environment of Rwanda.

## MATERIAL AND METHODS

An on-station trial was carried out from January 2002 to December 2005 at Bugarama research site of the Institute of Agricultural Sciences of Rwanda (ISAR). Bugarama plain is situated in south-west of Rwanda, at 980 meters above sea level (masl) and it receives a mean annual rainfall of 1000 mm. Rains are bi-modally distributed with long rain season from March to May and short rain season from mid-September to November. The soil type is volcanic alluvial soil, while dominant crops are rice and banana.

Seven hybrids bred by FHIA (Fondation Hondureña des Investigaciones Agrícola) were introduced by ISAR, National Banana Research Programme in January 2002 and compared with two local cultivars (Poyo and Barabeshya) for yield characteristics over two successive crop cycles. The experimental material consisted of nine varieties: FHIA 17, FHIA 18, FHIA 21, FHIA 23, FHIA25, SH 3640 and SH 3436-9 obtained from Bioversity International *via* Du Roi tissue culture laboratory, South Africa; Poyo (Cavendish sub-group, dessert variety) from ISAR Rubona Research Station and Barabeshya (Lujugira-Mutika sub-group, a cooking variety), taken from farmers fields locally. FHIA varieties were introduced in form of tissue culture plantlets, while Poyo and Barabeshya were conventional suckers. The selection of FHIA varieties for this trial was based on their superior yield and adaptability characteristics (Rwesaula *et al.*, 1998; Oreda, 1999; Nowakunda *et al.*, 2000), while Poyo and Barabeshya were local checks.

A completely randomised design was used with 9 treatments consisting of varieties, where each variety was replicated 20 times (one replicate was a single plant) with spacing of 3 by 3 meters. Experimental field was located in plain having flat surface and uniform soil type (deep volcanic alluvial soil). This design was selected as recommended for banana field experiments by Orjeda (1998).

Cow manure was applied at rate of 20 kg per hole at planting. This rate corresponds to the quantity of manure recommended by ISAR for banana plantation establishment (ISAR, 2002). No mineral fertilisers were used in this trial. All plots were mulched with rice pad (about 5cm

thickness) before the beginning of dry season (in June and January). Rice pad was available locally and used by Bugarama farmers as mulching material. Mulch thickness of 5 cm was reported to be efficient for soil moisture conservation (Van Asten *et al.*, 2007). Three plants were maintained within each banana mat. De-suckering and weeding were done regularly each 1-3 months depending on necessity.

Data were recorded on plant growth and yield components, banana bunchy top virus disease (BBTV) and black Sigatoka incidence during two successive crop cycles. Plant height and girth at one meter level were recorded at flowering. Bunch weight, number of hands, number of fruits of the second hand and total fruit number were recorded at harvest. Date of flowering and harvest were recorded. Flowering time was recorded at emergence of the flag leaf and number of days from planting to flowering was counted. Maturation period was recorded as number of days from flowering to harvest. Harvest was done when the fruits' ridges were rounded. Average annual productivity was calculated from the following formula (De Beer, pers. comm.)

Yield (t ha<sup>-1</sup> per year) = Average bunch weight (tonnes) x Number of harvests/ year x Plant density ha<sup>-1</sup>

where the number of harvests per year is derived from the ratio: number of days in year/average period between two harvests (days). BBTV incidence was estimated as percentage of plants affected by the disease during two production cycles. Youngest leaf spotted was recorded at flowering to estimate yellow Sigatoka incidence.

Data were analysed using Genstat Release 4.3 software. One and two-way analyses of variance (ANOVA) were performed. Least significant difference (LSD) test was done for variables with significant difference of means.

## RESULTS

**Agronomic performance.** Varieties showed highly significant differences ( $P < 0.001$ ) for all variables in agronomic performance (Table 1). FHIA 18 was the first variety to reach flowering stage (255 days), followed by Poyo (291 day),

TABLE 1. Performance characteristics of the nine varieties at Bugarama trial (average from two production cycles)

Variety	Days planting to flowering	Maturation period (flowering to harvest), days	Days planting to harvest	Girth at flowering at 1 m (cm)	Height at flowering (cm)	Bunch weight (kg)	Number of hands	Number of fruits of the 2 <sup>nd</sup> hand	Total fruit number	Yield (t ha <sup>-1</sup> per year)
FHIA 17	313	152	462	80.6	308	53.4	14.2	21.6	266	55.7
FHIA 18	255	151	403	66.1	270	25.3	11.1	20.7	172	46.5
FHIA 21	359	138	496	69.4	337	24.3	8.8	16.9	134	26.1
FHIA 23	436	137	572	81.6	301	24.4	13.3	24.6	214	24.3
FHIA 25	355	159	518	87.2	294	52.3	14.7	21.7	268	52.6
SH 3640	350	145	465	73.5	284	22.5	10.0	16.5	153	27.0
SH 3436-9	484	134	564	79.6	306	21.7	9.6	24.3	185	20.2
Poyo	291	149	446	57.4	268	26.9	9.8	20.9	171	32
Barabeshya	331	100	426	57.7	328	19.5	8.1	18.3	134	27.8
LSD ( $P < 0.05$ )	45.3	7.7	46.1	5.9	26.5	4.2	1.1	2.2	26.3	8.4

Barabeshya (313 days) and FHIA 17 (331 day). SH 3436-9 and FHIA 23 were the latest to flower with 484 and 436 days, respectively.

Local check Barabeshya had the shortest fruit maturation time of 100 days only; at least one month earlier than the fruit maturation time of other varieties (Table 1). SH 3436-9, FHIA 23 and FHIA 21 took 134, 137 and 138 days, respectively. FHIA 25 had the longest fruit maturation time of 159 days. FHIA 18 and FHIA 17 had relatively long time to maturation with 151 and 152 days, respectively.

FHIA 18 and local check Barabeshya had the shortest cycle with 403 and 426 days from planting to harvest, respectively (Table 1). FHIA 23 and SH 3436-9 had the longest cycle with 572 and 564 days to harvest, respectively. Other varieties were in intermediate positions.

Girths of pseudo-stem at one meter level of FHIA 25, FHIA 23 and FHIA 17 were the most robust with 87.2, 81.6 and 80.6 cm, respectively. Local checks Poyo and Barabeshya were the least robust with 57.4 and 57.7 cm, respectively.

FHIA 21 and Barabeshya were the tallest varieties with 337 and 328 cm, respectively. Poyo and FHIA 18 were the shortest varieties with average height of 268 and 270 cm, respectively.

FHIA 17 and FHIA 25 yielded the heaviest bunches of 53.4 and 52.3 kg, respectively (Table 1). They also had the highest number of hands (14 and 15) and fruits per bunch (266 and 268, respectively). Varieties FHIA 18, FHIA 21, FHIA 23 and SH 3640 had bunch weight similar to that of Poyo (about 25.5 kg). FHIA 23 and SH 3436-9 had smaller fruits, but higher number of fruits of the second hand (24.6 and 24.3, respectively).

FHIA 17, FHIA 25 and FHIA 18 had the highest annual yield (55.7, 52.6 and 46.5 t ha<sup>-1</sup>, respectively). They were twice more productive than Poyo and Barabeshya, both having bunch weight, close to that of FHIA 18 (Table 1). SH 3436-9, FHIA 23 and FHIA 21 had lowest yields (20.2, 24.3 and 26.1 t ha<sup>-1</sup> per year, respectively). These were lower than the yield of the two local checks.

Cycle affected all measured growth and yield parameters, except the number of days from flowering to maturity. A significant ( $P < 0.001$ ) increase in girth, height, bunch weight, number of hands and fruits was observed in second

production cycle for some varieties (Table 2). An increase of 20% in bunch weight was recorded in the second production cycle. However, the varieties were not uniform in bunch weight increase in the second cycle. The varieties FHIA 17, FHIA 18, FHIA 25, Poyo and SH 3640 had a significant increase in bunch weight of 21.6, 14.9, 13.8, 11.2 and 10.6 kg per bunch, respectively. Barabeshya, SH 3436-9 and FHIA 23 had a bunch weight increase of about 1 kg in the second cycle.

## VARIETY RESPONSE TO DISEASES

**BBTV incidence.** The incidence of BBTV in the trial was 10.5%. Out of 180 plants of the trial, 19 plants were affected by BBTV during two cycles, with 84.2% of the infection occurring in the first cycle. The proportion of affected plants per variety is presented in Table 3. FHIA 21 and SH 3640 had the highest proportion of affected plants (25 and 20%, respectively). Poyo variety was not affected by the disease during the two cycles of the trial.

**Yellow Sigatoka incidence.** All varieties expressed highly significant ( $P < 0.001$ ) differences in their response to yellow Sigatoka (considering youngest leaf spotted records). FHIA 18, FHIA 25, FHIA 21, FHIA 17 and FHIA 23 had good leaf health with YLS of 14.3, 10.9, 10.2, 9.5 and 9.4, respectively. SH 3640 was less resistant with a YLS score of 7.5. Local checks, Poyo and Barabeshya, and SH 3436-9 were susceptible to yellow Sigatoka with YLS of 6.3, 5.6 and 4.6, respectively.

## DISCUSSION

Some of the varieties performed better compared to the local checks, in terms of bunch weight and cycle duration. This resulted in higher productivity per unit of land and per year. The overall gain in annual yields was due to big bunches, as in case of the two varieties, FHIA 17 and FHIA 25, which had the highest productivity per unit of land and per year. FHIA 18, having bunch weight similar to that of Poyo, produced about 30% more per *annum* due to shorter time to flowering (255 days only) from planting to harvest) compared to Poyo which was harvested

TABLE 2. Effect of crop cycle on selected growth and productivity characteristics of nine banana varieties at Bugarama trial

Variety	Girth at 1 m leve (cm)		Height (cm)		Maturation period (flowering to harvest), days		Bunch weight (kg)		Number of hands		Total number of fruits	
	I	II	I	II	I	II	I	II	I	II	I	II
Crop cycle												
FHIA 17	72.2	89.0	276	339	148	156	42.4	64.0	12.5	15.7	215	312
FHIA 18	57.6	74.5	220	319	149	154	19.4	34.3	10.1	12.1	139	207
FHIA 21	64.6	74.5	326	348	137	140	23.6	26.7	8.9	8.6	123	152
FHIA 23	76.7	88.8	291	315	143	130	24.3	25.3	12.5	15.3	201	248
FHIA 25	79.7	94.7	282	306	162	156	46.5	60.3	13.1	16.4	227	309
SH 3640	62.4	86.1	254	318	145	145	17.5	28.1	8.4	12.0	117	208
SH 3436-9	72.2	89.4	291	327	130	137	22.5	21.7	9.1	10.4	164	215
Poyo	49.3	64.3	217	312	152	147	19.5	30.7	8.7	10.5	141	194
Barabeshya	53.0	62.4	292	364	97	104	19.9	20.4	8.0	8.4	129	144
LSD for cycle effect (P<0.05)	1.5		7.28		NS		1.5		0.33		6.9	
LSD for cycle*variety effect (P<0.05)	5.6		27.0		10.8		5.5		1.24		25.7	

TABLE 3. Rate of BBTV infection and yellow Sigatoka incidence of nine varieties at Bugarama trial

Variety	Affected by BBTV plants (%) (during two cycles)	Youngest leaf spotted (average of 20 plants)
FHIA 18	5.5	14.3
FHIA 25	10	10.9
FHIA 21	25	10.2
FHIA 17	15	9.5
FHIA 23	12.5	9.4
SH 3640	20	7.5
Poyo	0	6.3
Barabeshya	15	5.6
SH 3436-9	15	4.6
LSD (P<0.05)	-	1.8

33 and 68 days later in the first and second cycle, respectively (data not shown).

FHIA 23 and SH 3436-9 had the lowest annual yields due to longer periods from planting to flowering (436 and 484 days, respectively), which makes them non-desirable for small holder banana production systems.

All varieties except Poyo were affected by the BBTV during the trial period. However, any conclusion about its resistance to BBTV seems to be premature. Some varieties (FHIA 21 and SH 36 40) were recorded to have higher incidence of BBTV than the others.

Most of the introduced varieties were resistant to black Sigatoka (with 8<sup>th</sup> to 14<sup>th</sup> youngest leaf spotted) compared to local checks (YLS = 5 to 6), except SH 3436-9 which was susceptible to the disease (YLS = 4 to 5).

High bunch weight, short maturation time and resistance to diseases were important cultivar selection criteria highlighted by the Rwandan banana farmers (Gaidashova *et al.*, 2005). In this regard, FHIA 17, FHIA 18 and FHIA 25, which are resistant to black Sigatoka and fusarium wilt (Orjeda, 1999), may be suitable in small holder banana systems of Rwandan lowlands with strong growth characteristics, higher yields and slightly longer (FHIA 17 and FHIA 25 only) production cycle comparing to local farmers' varieties.

## CONCLUSION

Compared with Poyo and Barabeshya, FHIA 17, FHIA 18 and FHIA 25 performed better. Further evaluation of these varieties should be conducted on farm, after what they could be released for large dissemination in Rwanda. So far no tolerant or resistant varieties to BBTV were identified. Further observations on their behavior versus BBTV should be continued.

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