Author's post-print of the paper published in the Proceedings of the International ISHS-ProMusa Symposium on Global Perspectives on Asian Challenges, Acta Horticulturae 897, ISHS 2011. Available from www.musalit.org

Screening *Musa* genotypes for Banana Bunchy Top Disease Resistance in Burundi

C. Niyongere[1,2], E. Ateka[2], T. Losenge[2], G. Blomme[3] and P. Lepoint[4]

[1] Institut des Sciences Agronomiques du Burundi (ISABU), P.O. Box 795, Bujumbura, Burundi

[2] Department of Horticulture, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya

[3] Bioversity International, Uganda office, P.O. Box 24384, Kampala, Uganda

[4] Bioversity International, Burundi office, P.O. Box 795, Bujumbura, Burundi

Keywords: *Banana bunchy top virus*, disease incidence, latent infections, *Pentalonia nigronervosa*.

Abstract

Banana bunchy top disease (BBTD), caused by the *banana bunchy top virus* (BBTV), is reported as one of the most devastating diseases affecting banana and plantain cultivation worldwide. In order to identify putative sources of resistance, a cultivar screening trial comprising 40 *Musa* genotypes was established in March 2007 at the ISABU Mparambo research station in northwestern Burundi (893 masl). Dessert bananas (AAA group), East African highland bananas (AAA, EAHB), plantains (AAB), cooking bananas (ABB), a tetraploid hybrid and wild diploid bananas (*Musa acuminata* and *Musa balbisiana*) were assessed. Ten plants per genotype were planted in a completely randomised design with border rows consisting of BBTV-infected 'Yangambi Km 5' (AAA) plants. Colonies of *Pentalonia nigronervosa* collected in BBTV-infected fields were released in the plot to enhance disease spread. Twenty-eight months after trial establishment, 32 genotypes have shown typical banana bunchy top symptoms. The first symptoms appeared 80 days after trial establishment on 'Yangambi Km 5'. Twenty-eight months after trial establishment, only eight genotypes [*Musa balbisiana* type Tani (BB), 'Kayinja' (ABB), 'FHIA-03' (AABB), 'Prata' (AAB), 'Gisandugu' (ABB), 'Pisang Awak' (ABB), 'Saba' (ABB) and 'Highgate' (AAA, Gros Michel subgroup)] have not manifested typical disease symptoms on any of the ten plants per genotype. Plant samples taken from these visibly healthy cultivars and analysed at a molecular level [at the *Faculté Universitaire des Sciences Agronomiques de Gembloux* (FUSAGx) in Belgium] indicated the presence of the virus in 'Pisang Awak', 'Saba' and 'Highgate'. These genotypes can be considered as BBTD tolerant. They could potentially act as a reservoir for the virus. Further diagnostic tests will be carried out on the five BBTV-free genotypes to confirm the extent of latent infections. Preliminary results indicate that genotypes with one or two B genomes tend to be more tolerant to BBTD.

INTRODUCTION

Banana and plantain (*Musa* spp.) are cultivated in over 120 countries in tropical and subtropical regions worldwide (Hu et al., 2007; INIBAP, 2000). The annual per capita consumption of banana in Burundi, the Democratic Republic of Congo (DR Congo) and Rwanda is amongst the highest in the world representing 89, 69 and 197 kg,

respectively (Frison and Sharrock, 1998). Fungal, bacterial and viral diseases threaten banana production in Central Africa, as elsewhere. Banana bunchy top disease (BBTD), caused by the *Banana bunchy top virus* (BBTV), is the most serious and destructive viral disease of banana and plantain in Africa, Australia and South-East Asia (Dale, 1987). It has been reported in Central Africa since 1958 (Kavino et al., 2007; Wardlaw, 1961) and, so far, has spread to 11 countries within the African continent (www.bananadiseasesframework.org).

BBTD is spread with infected planting materials and is transmitted by an aphid vector, *Pentalonia nigronervosa* (Hu et al., 2007; Allen, 1987; Magee, 1940). Disease symptoms include dark green streaks of variable length on the leaf midribs and petioles, progressive dwarfing of leaves and development of marginal chlorosis, upright and bunched-up leaves at the apex of the plant, hence the name of the disease. In addition, a plant may not produce any fruit if the infection occurs at an early stage of growth (Su et al., 2003; Dale, 1987). The incubation period is approximately 4 weeks (Drew et al., 1988; Allen, 1978), with symptom development being a function of external temperature (Dale et al., 2000; Sun, 1961). Occurrence of symptomless infections on certain genotypes complicates disease management and increases the risk of pathogen spread since symptomless plants may act as reservoirs for the virus (Drew et al., 1988; Allen, 1978).

Although no *Musa* genotype is known to be resistant to BBTV to date, numerous studies report differences in susceptibility. Cultivars in the AA and AAA genomic groups are highly susceptible with the exception of 'Gros Michel', whereas cultivars containing the B genome are regarded as less susceptible if not tolerant (Ariyaratne and Liyanage, 2002). The deployment of resistant cultivars may be one of the best-bet options for the integrated management of BBTD. The present study evaluated 40 genotypes, belonging to a wide range of *Musa* groups, for their reaction to BBTV.

MATERIALS AND METHODS

A BBTV screening trial with 40 genotypes was established in March 2007 at the Mparambo research station of the *Institut des Sciences Agronomiques du Burundi* (ISABU). Mparambo is located at 893 masl in the province of Cibitoke in North-Western Burundi, bordering Rwanda and the Democratic Republic of Congo (S 2°50'220, E 29°04'375). According to climatic data collected at Mparambo station from June 2006 to September 2007, the average daily temperature was 32°C (min 14°C, max 36°C), while the average relative humidity was 73% (min 27%, max 97 %).

Thirty-five of the genotypes screened were established using lateral shoots (i.e., suckers) obtained from the *Institut de Recherche Agronomique et Zootechnique* (IRAZ) located in Gitega, Burundi (1700 masl). The remaining five genotypes ('FHIA-03', 'Isha', 'Nakitembe', 'Poyo' and 'Yangambi Km 5') were planted using tissue-culture plantlets obtained from Agrobiotech, a private tissue-culture laboratory based in Bujumbura, Burundi. One hundred *in vitro* plantlets of 'Yangambi Km 5' (AAA) commonly cultivated in the region and highly susceptible to BBTV were used as a control and planted at random amongst the 39 test genotypes which belong to a wide range of *Musa* groups (Table 1). The experimental layout was a completely randomised design with ten plants per genotype. Plants were established at a spacing of 3 by 2 meters. The plot was located 1 km from the closest BBTV-infected field and had previously not been cultivated with banana. Five kg of decomposed farmyard manure was applied in each planting hole prior to planting. No mineral fertiliser was applied. Desuckering and manual weeding

were carried out when necessary, and three to four suckers were maintained within each mat. Old and dead leaves were pruned at 2-weekly intervals and used as automulch.

The inoculum source for the trial consisted of BBTD-symptomatic 'Yangambi Km 5' plants obtained from farmers' fields in Cibitoke where the presence of BBTV had been previously confirmed using TAS-ELISA. Each row of test genotypes was planted adjacent to a row of diseased 'Yangambi Km 5' plants which contained aphid (*P. nigronervosa*) populations. Four months after trial establishment, source plants that had reached their final stage (i.e. death of the plant) were replaced with infected 'Yangambi Km 5' suckers. Simultaneously, aphids collected in nearby farmers' fields were released on the diseased 'Yangambi Km 5' border row plants to enhance disease spread.

The aphid population was monitored using yellow water traps in order to better understand seasonal fluctuations. Occurrence of aphids on trial plants was also assessed using a scale ranging from 0 to 5 (0 - no aphids; 1 - a single simple colony; 2 - several simple colonies; 3 - a large colony with one or more winged individuals; 4 - several colonies with one or more winged individuals, and 5 - generalised colonies at the level of the leaves and the pseudostem). BBTD symptoms were recorded on mother plants and lateral shoots at 2-week intervals, and incidence per cultivar was calculated as the percentage of infected plants over the total number of plants for a given cultivar in the trial. In addition, time from trial establishment to first BBTD symptom appearance was recorded for each mat. Incidence of Fusarium wilt (*Fusarium oxysporum* f. sp. *cubense*) and black leaf streak (*Mycosphaerella fijiensis*) was also recorded.

Plant height and pseudostem circumference at 20 cm above the soil level were measured at flower emergence. Additionally, data on average number of healthy bunches produced during the 28 months after trial establishment and average bunch weight during healthy crop cycles were collected.

Using the PhytoPass sampling system, plant samples were collected from all the symptomless trial cultivars for PCR analysis at the *Faculté Universitaire des Sciences Agronomiques de Gembloux* (FUSAGx) in Belgium.

ANOVA was carried out using the Statistical Cohort software (www.CoHort.com).

RESULTS AND DISCUSSION

BBTV incidence across the 40 genotypes ranged from 0 to 87% (Table 1). The highest disease incidence was observed on 'Poyo' (AAA). Eight genotypes did not show any visible disease symptoms 28 months after trial establishment. Seven out of these eight genotypes contain one or two B genomes [(*Musa balbisiana* type 'Tani' (BB), 'Gisandugu' (ABB), 'Pisang Awak' (ABB), 'Saba' (ABB), Kayinja (ABB), 'FHIA-03' (AABB) and 'Prata' (AAB)], while 'Highgate' (AAA) is the only genotype with a strictly-A genome. dela Cruz et al. (2008) reported that 'Cachaco' (ABB), Cardaba (ABB), 'Saba' (ABB), 'Pisang Ceylan' (AAB, Mysore) and the tetraploids 'FHIA-01' (AAAB) and 'CRBP 39' (AAAB) – all containing the B genome – show high levels of tolerance to BBTV. An additional sixteen genotypes distinguished themselves from the control cultivar 'Yangambi Km 5' by a lower (< 23%) disease incidence.

Symptoms of Fusarium wilt were observed on ten genotypes (Table 1), each containing at least one B genome. Black leaf streak lesions were mainly observed on cultivars 'Highgate' and 'Nakitembe' (AAA).

Pentalonia nigronervosa, the only known vector of BBTV (Young and Wright, 2005), was observed on all of the mats in the trial. Aphid populations fluctuate naturally

throughout the year (Tahira et al.1999). In the present trial, large colonies were mostly observed on plantain genotypes such as 'Mumbulu' (Table 1) confirming Kumar and Hanna's (2008) observations in West Africa. Robson et al. (2006) have suggested aphid preference for the base of plantlets and possibly for plantains due to the clear colour of their pseudostem. In field conditions, no direct correlation can be made between recorded aphid numbers and disease incidence. The fact that plantains contain one B genome may provide them a higher tolerance level to the disease despite the importance of aphid colonies observed on plants.

The first visible disease symptoms appeared on the control genotype 'Yangambi Km 5' 80 days after trial establishment (Table 1). Subsequently, symptoms appeared on the genotype 'Isha' (AAA, EAHB) 6 months after trial establishment. In contrast, the genotypes 'Kamaramasenge' (AAB), 'Ingaju' (AAA, EAHB) and 'Fougamou' (ABB) only showed symptoms 25 months after trial establishment. The number of cropping cycles (i.e. first crop = first cycle; first ratoon = second cycle; second ratoon = third cycle, etc…) that can be achieved before first disease appearance is presented in Table 1. Given the fact that BBTD is reported to reduce yields, plant growth traits during the first cycle, the average number of bunches produced before disease appearance and the average bunch weight during healthy cycles are indicated in Table 2. The tolerant cultivars were the largest cultivars in terms of height and pseudostem circumference at flower emergence, especially the robust ABB cooking bananas and 'Prata' (AAB). This could confirm the hypothesis that structural and physiological status might contribute to tolerance, as was suggested for 'Gros Michel' (Magee, 1948).

The virus was detected by PCR in 'Pisang Awak', 'Saba' and 'Highgate' genotype samples 19 months after trial establishment using the BBT1/BBT2 primer pair designed to amplify a 349-bp fragment of the putative replicase gene of BBTV (Dietsgen et al, 1999). Results suggest that these genotypes could be considered as tolerant to BBTV. However, they could potentially act as virus reservoirs.

In line with previous reports (Magee, 1948) on the low susceptibility of 'Highgate' (subgroup Gros Michel) to BBTV, no visible disease symptoms were observed on this cultivar 28 months after trial establishment. Magee (1948) also mentioned the high susceptibility of Cavendish genotypes, corroborating our observations of rapid symptom expression on 'Poyo'.

CONCLUSIONS

Only 8 out of 40 genotypes screened were BBTD symptom free 28 months after trial establishment. However, BBTV was detected by PCR in 3 out of the 8 symptomless genotypes. Further ELISA and PCR testing is underway on symptomless individuals in order to determine whether they are latently infected with the virus (symptomless host) or are resistant genotypes. Moreover, preliminary results indicate that genotypes with one or two B genomes are less susceptible to BBTD but more susceptible to Fusarium wilt. Out of the 8 BBTD symptomless genotypes, five cultivars ('FHIA-03', 'Highgate', 'Pisang Awak', 'Prata' and 'Saba') and the wild banana *Musa balbisiana* type 'Tani' were not affected by Fusarium wilt.

ACKNOWLEDGEMENTS

The authors would like to thank the Directorate General for Development Cooperation (DGDC, Belgium) for funding this work through the CIALCA project.

Literature cited

Allen, R.N. 1978. Epidemiological factors influencing the success of rouging for the control of bunchy top disease of bananas in New South Wales. Australian Journal of Agricultural Research 29:535-544.

Allen, R.N. 1987. Further studies on epidemiological factors influencing control of banana bunchy top disease and evaluation of control measures by computer simulation. Aus. J. Agric. Res. 38:373-382.

Ariyaratne, I. and Liyanage, T. 2002. Survey on incidences and severity of virus diseases of banana in Sri Lanka. Annals of the Sri Lanka Department of Agriculture 4:245-254.

Dale, J.L. 1987. Banana bunchy top: an economically important tropical plant virus disease. Advances in Virus Research 33:301-325.

Dale, J.L., Horser, C.L., Karan, M. and Harding, R.M. 2000. Additional *Rep*-encoding DNAs associated with banana bunchy top virus. Arch. Virol. 146:71-86.

dela Cruz, F.S. Jr., Gueco, L.S., Damasco, O.P., Huelgas, V.C., dela Cueva, F.M., Dizon, T.O., Sison, M.L.J., Banasihan, I.G., Sinohin, V.O. and Molina, A.B. Jr. 2008. Farmers' Handbook on Introduced and Local Banana Cultivars in the Philippines. Bioversity International.

Dietsgen, R.G., Thomas, J.E, Smith, G.R. and Maclaen, D.L. 1999. PCR-based detection of viruses in banana and sugarcane. Curr. Top. Virol. 1:105-118.

Drew, R.A., Moisander, J.A. and Smith, M.K. 1988. The transmission of Banana bunchy top virus in micropropagated bananas. Plant cell, tissue and organ culture 16:187-193.

Frison, E. and Sharrock, S. 1998. The economic, social and nutritional importance of banana in the world. p.21-35. In: C. Picq, E. Fouré and E.A. Frison (eds.), Bananas and Food Security. International symposium, Douala, Cameroon, 10-14 November 1998. INIBAP, Montpellier, France.

Hu, J.M., Fu, H.C., Lin, C.H., Su, H.J. and Yeh, H.H. 2007. Reassortment and concerted evolution in banana bunchy top virus genomes. J. Virol. 81:1746-1761.

INIBAP. 2000. Banana: Food for the Poor. INIBAP, Montpellier, France.

Kavino, M., Harish, S., Kumar, N., Saravanakumar, D., Damodaranc, T., Soorianathasundaram, K. and Samiyappan, R. 2007. Rhizosphere and endophytic bacteria for induction of systemic resistance of banana plantlets against bunchy top virus. Soil Biology & Biochemistry 39:1087-1098.

Lava Kumar, P. and Hanna, R. 2008. Banana bunchy top virus in sub-Saharan Africa: established or emerging problem? p.95-96. In: Banana and Plantain in Africa: Harnessing International Partnerships to Increase Research Impact. Program and book of abstracts. Leisure Lodge Resort Mombasa, Kenya, 5-9 October 2008.

Magee, C.J.P. 1940. Transmission studies on the banana bunchy top virus. J. Austr. Inst. Agric. Sci. 6:109-110.

Magee, C.J.P. 1948. Transmission of bunchy top to banana varieties. J. Aust. Inst. Agric. Sci. 14:18-24.

Robson, J.D., Wright, M.G. and Almeida, R.P.P. 2006. Within-plant distribution and binomial sampling of *Pentalonia nigronervosa* (Hemiptera: Aphididae) on banana. J. Econ. Entomol. 99(6):2185-2190.

Su, H.J., Tsao, L.Y., Wu, M.L. and Hung, T.H. 2003. Biological and molecular categorisation of strains of Banana bunchy top virus. Journal of Phytopathology 151:290-296.

Sun, S.K. 1961. Studies on the bunchy top disease of bananas. Spec. Publ. Coll. Agric. Taiwan Univ. 10:82-109.

Tahira, Y., Ehsan-Ul-Haq, Khalid, S. and Malik, S.A. 1999. Some studies on biology of *Pentalonia nigronervosa* Conquarrel - The vector of Banana bunchy top virus. Pakistan Journal of Biological Sciences 2(4):1398-1400.

Wardlaw, C.W. 1961. The Virus Diseases: Bunchy Top. Chapter four. p.68-115. Banana Diseases including Plantains and Abaca. Department of Botany, University of Manchester. Longmans, Green and Co Ltd., T&A Constable Ltd., Edinburgh, UK.

Young, C.L. and Wright, M.G. 2005. Seasonal and spatial distribution of banana aphid, *Pentalonia nigronervosa* (Hemiptera: Aphididae) in banana plantations on Oahu. Proc. Hawaiian Entomol. Soc. 37:73-80.

Tables

Table 1. List of *Musa* genotypes screened for resistance to BBTD with incidence of the disease 28 months after trial establishment, aphid occurrence, time to BBTD expression and associated cropping cycle number and Fusarium wilt incidence.

Genotype	Genome group / Subgroup	Type	BBTD incidence		Scoring of aphid occurrence (scale 0-5)	Months to first disease symptoms	Cycle number[1] at time of first disease symptoms	Fusarium wilt incidence (%)
			Infected mats / total plants established	(%)				
Akondro Mainty	AA	beer	1/10	10	2.6 bcd	15	1	0
Figue Sucrée	AA	dessert	6/10	60	2.7 bcd	13.33	1.66	0
Musa balbisiana 10852	BB	wild	2/10	20	2.2 cde	8	1	0
Musa balbisiana type Butuhan	BB	wild	1/10	10	2.5 bcd	11	2	0
Musa balbisiana type Tani	BB	wild	0/10	0	1.7 de	NA[#]	NA	0
Kingala	AB	dessert	5/10	50	2.2 cde	14.5	3	20
Kisubi	AB	beer	1/10	10	2.5 bcd	18	4	60
Ney Poovan	AB	beer	4/10	40	2.4 bcd	12.5	3	50
Americani	AAA/Cavendish	dessert	6/10	60	2.5 bcd	16.83	3.83	0
Barabeshya	AAA/EAHB	cooking	3/10	30	2.9 bcd	10	1	0
Chibulangombe	AAA/EAHB	beer	6/10	60	2.1 cde	13.2	4.2	0
Gisahira Uganda	AAA/EAHB	cooking	4/10	40	2.5 bcd	17	4.5	0
Guineo Negro	AAA/EAHB	cooking	3/10	30	2.3 cde	14.66	2.33	0
Highgate	AAA/Gros Michel	dessert	0/9 [α]	0	2.4 bcd	NA	NA	0
Ingaju	AAA/EAHB	cooking	2/9 [α]	22	2.8 bcd	25	5	0
Ingumba y'imbihire	AAA/EAHB	cooking	2/10	20	2.2 cde	8.5	1	0
Intamakamwe	AAA/EAHB	beer	2/10	20	2.4 bcd	8	1	0
Intare	AAA/EAHB	cooking	2/9 [α]	22	2.6 bcd	21	4	0
Inyabubere	AAA/EAHB	beer	2/10	20	2.3 cde	17.5	4	0
Isha	AAA/EAHB	beer	1/6 [α]	17	1e	6	1	0
Nakitembe	AAA/EAHB	cooking	2/9[α]	22	2.1 cde	24	2	0

Nyakibuzi	AAA/EAHB	beer	4/10	40	2.6 bcd	14	3	0
Poyo	AAA/Cavendish	dessert	7/8 [α]	87	2 cde	11	2.16	0
Yangambi Km 5	AAA/Ibota	beer	22/95 [α]	23	2.8 bcd	2.7	1.2	0
Corne Plantain	AAB/plantain	cooking	4/10	40	3.2 abc	18.66	4	0
Guindi	AAB/Pome,	beer	7/9 [α]	78	2.5 bcd	16.2	3.2	0
Igjindi	AAB/plantain	cooking	2/10	20	3.7 ab	24.5	3.5	0
Kamaramasenge	AAB, dessert	dessert	4/10	40	2.3 cde	25	8	70
Mumbulu	AAB/plantain	cooking	1/10	10	3.9 a	13	4	0
Pisang Ceylan (Mysore)	AAB, dessert	dessert	4/10	40	2.6 bcd	12	3	0
Pisang raja	AAB/Nendra padaththi	beer	2/10	20	2.6 bcd	11.5	3.5	10
Prata	AAB	dessert	0/10	0	2.4 bcd	NA	NA	0
Cacambu	ABB/Bluggoe	cooking	1/10	10	2.5 bcd	22	7	60
Fougamou1	ABB/Pisang Awak	beer	1/10	10	2.5 bcd	25	6	80
Gisandugu	ABB/Pisang Awak	beer	0/10	0	2.5 bcd	NA	NA	60
Kayinja	ABB	beer	0/10	0	3 a-d	NA	NA	30
Monthan	ABB	cooking	4/10	40	3.3 abc	18.25	3	10
Pisang Awak	ABB	beer	0/10	0	2.7 bcd	NA	NA	0
Saba	ABB	cooking	0/10	0	2.1 cde	NA	NA	0
FHIA-03	AABB	beer	0/6 [α]	0	2.35 b-e	NA	NA	0
CV (%)					30.04	51.13	68.79	
F-test					***	*	NS	
LSD (5%)					0.86	19.74	5.62	

NS: non-significant; *, **, ***: significant at $P < 0.05$, 0.01 and 0.001 respectively.

Means followed by the same letter in each column are not significantly different from each other according to Student-Newman-Keuls test at $P < 0.05$;

[α]: some plants did not establish.

#: NA - not applicable given that no symptoms were observed.

[1] Corresponding cycle number (first crop = 1st cycle; first ratoon = second cycle; second ratoon = third cycle, etc…) when disease symptoms first appeared.

Table 2. Plant height and pseudostem circumference at flower emergence during the first cropping cycle, average number of healthy bunches produced 28 months after trial establishment and average bunch weight during healthy crop cycles for each genotype.

Genotype	Genome group / Subgroup	Type	Plant height (cm)	Pseudostem circumference (cm)	Number of bunches	Average bunch weight
Akondro Mainty	AA	beer	318 b-f	68.65 def	1.20 d-g	9.33 efg
Figue Sucrée	AA	dessert	276 c-g	98.90 b-e	1.80 b-f	7.48 fg
Musa balbisiana 10852	BB	wild	411 ab	118.35 bc	-	-
Musa balbisiana type Butuhan	BB	wild	400 ab	84.70 b-f	-	-
***Musa balbisiana* type Tani**[#]	BB	wild	**413 ab**	**125.95 b**	**-**	**-**
Kingala	AB	dessert	285 b-g	67.95 def	1.90 b-f	6.95 fgh
Kisubi	AB	beer	291 b-g	65.45 def	2.30 a-d	6.01 fgh
Ney Poovan	AB	beer	291 b-g	61.85 ef	1.60 b-g	6.09 fgh
Americani	AAA/Cavendish	dessert	266 c-g	69.25 def	2.00 b-e	15.86 b-e
Barabeshya	AAA/EAHB	cooking	340 b-e	72.00 def	1.90 b-f	13.74 b-f
Chibula ngombe	AAA/EAHB	beer	255 c-g	66.05 def	2.70 a-d	12.21 c-f
Gisahira Uganda	AAA/EAHB	cooking	331 b-f	75.45 def	3.30 ab	12.31 c-f
Guineo Negro	AAA/EAHB	cooking	283 b-g	64.55 def	2.40 a-d	8.95 efg
Highgate[#]	AAA/Gros Michel	dessert	**229 e-g**	**80.55 def**	**0.88 d-g**	**16.02 b-e**
Ingaju	AAA/EAHB	cooking	333 b-f	74.66 def	3.22 abc	13.61 b-f
Ingumba y'imbihire	AAA/EAHB	cooking	318 b-f	80.15 def	1.50 c-g	17.34 bcd
Intamakamwe	AAA/EAHB	beer	277 c-g	65.25 def	2.30 a-d	15.85 b-e
Intare	AAA/EAHB	cooking	318 b-f	76.22 def	2.11 a-e	13.55 b-f
Inyabubere	AAA/EAHB	beer	292 b-g	73.40 def	2.70 a-d	12.77 c-f
Isha	AAA/EAHB	beer	246 c-g	49.83 ef	0.85 d-g	3.30 gh
Nakitembe	AAA/EAHB	cooking	227 e-g	80.55 c-f	0.22 fg	3.77 fgh
Nyakibuzi	AAA/EAHB	beer	313 b-f	69.00 def	2.10 a-e	11.72 def
Poyo	AAA/Cavendish	dessert	191 g	50.75 ef	0.87 d-g	6.98 fgh
Yangambi Km 5	AAA/Ibota	beer	266 c-g	61.55 ef	1.30 d-g	9.99 d-g
Corne Plantain	AAB/plantain		281 b-g	78.95 def	2.40 a-d	20.37 b
Guindi	AAB/Pome,	beer	238 d-g	65.55 def	3.00 a-d	5.97 fgh

Igjindi	AAB/plantain	cooking	321 b-f	74.70 def	1.70 b-f	15.44 b-e
Kamaramasenge	AAB, dessert	dessert	282 b-g	71.85 def	1.80 b-f	5.68 fgh
Mumbulu	AAB/plantain		307 b-f	72.70 def	3.00 a-d	6.39 fgh
Pisang Ceylan	AAB, dessert	dessert	224 fg	46.20 f	3.70 a	5.09 fgh
Pisang Raja	AAB/Nendra padaththi	beer	326 b-f	105.75 bcd	2.50 a-d	13.25 b-f
Prata[#]	AAB	dessert	**411 ab**	**87.40 b-f**	**2.50 a-d**	**8.37 fg**
Cacambu	ABB/Bluggoe	cooking	372 abc	84.25 b-f	3.00 a-d	18.55 bc
Fougamou1	ABB/Pisang Awak	beer	401 ab	91.60 b-e	1.90 b-f	15.33 b-e
Gisandugu[#]	ABB/Pisang Awak	beer	**373 abc**	**122.60 b**	**0.50 efg**	**14.21 b-f**
Kayinja[#]	ABB	beer	**298 b-g**	**82.75 b-f**	**2.50 a-d**	**10.56 d-g**
Monthan	ABB	cooking	455 a	153.90 a	1.20 d-g	27.20 a
Pisang Awak[#]	ABB	beer	**402 ab**	**87.61 b-f**	**2.60 a-d**	**8.89 efg**
Saba[#]	ABB	cooking	**350 bcd**	**79.70 def**	**3.30 ab**	**20.36 b**
FHIA-03[#]	AABB	beer	**278 b-g**	**82.60 b-f**	**0.80 d-g**	**22.85 ab**
CV (%)			20.94	30.87	55.49	35.92
F-test			***	***	***	***
LSD (5%)			81.97	30.82	1.32	6.83

*, **, ***: significant at $P < 0.05$, 0.01 and 0.001 respectively.
Means followed by the same letter in each column are not significantly different from each other according to the Student-Newman-Keuls test at $P < 0.05$.
[#]: Genotypes with no visible disease symptoms 28 months after trial establishment.