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Multi-locational evaluation of cooking banana cultivars 'NARITA 4' hybrid and 'Mpologoma' in Rwanda

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This study assessed the growth and yield of two introduced cooking banana cultivars 'Mpologoma' and 'NARITA 4' relative to seven local highland cooking cultivars, across three sites in Rwanda, namely Karongi (1496 m a.s.l.), Gatore (1523 m a.s.l.) and Rwinzuki (1671 m a.s.l.). Data were obtained during two cropping cycles (plant crop cycle and the 1st ratoon). Data on pseudostem girth (cm) at 100 cm above the ground was collected at flowering, while number of hands per bunch, number of fingers of the second lowest hand and bunch weight (kg) were obtained at bunch harvest. Significant differences for all assessed growth and yield parameters were observed between cultivars (p<0.001). Generally, the two exotic cultivars ranked high with respect to number of fingers on the second lowest hand and number of hands per bunch. 'Mpologoma' had the largest bunch with a mean bunch weight of 23 kg, whereas 'NARITA 4' had a bunch weight of 17 kg which was comparable to the local cultivars. Thus, these 2 cultivars could potentially be adopted by farmers.

Key words: Banana germplasm, local cultivars, plant crop, ratoon crop.

INTRODUCTION

Musa spp. (banana and plantain) is a major staple food crop, source of income and employment for millions of people, and it is cultivated in up to 130 countries, mainly in the tropical and sub-tropical regions (FAOSTAT, 2017). Banana and plantain are grown under various types of cropping systems over a harvested area of approximately 10 million hectares worldwide, with an annual production of 144.8 million tons (Mt) (FAOSTAT, 2017). The vast

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majority of producers are small-scale farmers who grow the crop either for home consumption or for sale in local markets. The banana fruit is eaten cooked as a vegetable or ripe as a fruit, and it is also used to produce beer and wine (Rishirumuhirwa, 2010). Besides being a cheap and easily produced source of energy, it is also a good source of vitamins A, C, B6 and minerals, such as potassium (Davey et al., 2007; Ekesa et al., 2013). Rwanda with an annual per capita consumption of 258 kg (Jagwe et al., 2008) and production of 1.8 Mt (FAOSTAT, 2017), ranks among the top banana producers in the world.

Like the entire African Great lakes region, the most common and economically important cultivars in Rwanda belong to the East African highland banana group (*Musa* AAA-East Africa [-EA] genome) and are mainly used for cooking and beer/wine production (Karamura et al., 1998; Ocimati et al., 2013, 2016). East African highland banana plants grow and perform well at altitudes ranging from 1000 to 2000 m above sea level (m a.s.l.) (Karamura et al., 1998). Nevertheless, Rwanda has experienced declines in banana diversity and production in the past decades due to several factors including social unrest/insecurity, land/population pressure, pests and diseases (such as Fusarium wilt and Xanthomonas wilt of banana), and declining soil fertility (Okech et al., 2002; Nsabimana and van Staden, 2005; Ocimati et al., 2014). Increasing the diversity of banana germplasm through the introduction of high-yielding conventionally bred hybrids and other commercial cultivars/landraces forms an integral part of technology packages for improving banana diversity and production in the central African region.

In this study, the performance of two exotic cooking banana cultivars, namely 'Mpologoma' and 'NARITA 4' hybrid were evaluated against seven local cooking cultivars. Assessment of the *Musa* cultivars was carried out across three sites/agro-ecosystems in Rwanda. 'Mpologoma' is a high yielding AAA-EA cooking cultivar with a high market value/demand in neighboring Uganda, while 'NARITA 4' is a promising highland cooking banana hybrid bred by the International Institute of Tropical Agriculture (IITA) and the National Agricultural Research Organization (NARO) of Uganda for resistance to black leaf streak and high yield. Depending on the growth and yield performance under Rwandese agro-ecological conditions, these cultivars could potentially provide an additional source of high quality germplasm/seed for higher farm productivity and household income.

MATERIALS AND METHODS

Banana germplasm evaluations were carried out between April, 2007 and March, 2011 at three different sites in Rwanda, namely Karongi (S 2° 5' 29''; E 29° 23' 3''; 1496 m a.s.l.), Gatore (S 2° 16' 44''; E 30° 34' 37''; 1523 m a.s.l.) and Rwinzuki (S 2° 39' 2''; E 28° 55' 36''; 1671 m a.s.l.), with varying altitude, soil fertility and rainfall (Table 1).

Karongi is located in the Lake Kivu border agricultural zone of Rwanda, with good to excellent soil and climate conditions for agricultural production, while Gatore and Rwinzuki are located in the Eastern plateau and Impara agro-ecological zones, respectively. All three sites possess conducive conditions for banana production. A detailed description of the site's agro-ecological characteristics is provided in Table 1. The geographical coordinates of each experimental site were recorded using a GARMIN Geographical Positioning System (GPS).

Seven East African highland cooking banana (*Musa* AAA-EA) landraces from Rwanda, one AAA-EA landrace from Uganda (but grown on a limited scale in Rwanda at the time of the trial) and an East African AAA-EA secondary triploid hybrid (Table 2) were planted and evaluated at each of the three sites. The IITA/NARO hybrid ('NARITA 4') was multiplied at the Phytolabu tissue culture (TC) laboratory in Bujumbura, Burundi, while sword suckers (lateral shoots with lanceolate type leaves and a pseudostem length of 80 to 120 cm) sourced from well-managed and disease-free fields were used for the 8 landraces. It was assumed that the differences in the planting material types would not significantly affect subsequent plant growth and yield. The TC-derived plantlets were hardened (acclimatized) over three months (until they were on average, 30 cm high and had at least 3 to 4 functional green leaves) before planting. In contrast, the sword suckers with the remaining 30 cm long pseudostem section were pared (all cord roots and outer corm tissue were removed using a machete) and treated with hot water to eliminate all pests. The treated suckers were planted with a small portion (15 cm) of the pseudostem sticking above the ground.

Fifteen plants of each cultivar (in 3 reps of 5 plants) were planted at each experimental site. Plants were spaced at 3 × 2 m (in a rectangular design), giving a total of 1,667 plants/ha. A randomized complete block design comprising 3 blocks with one replicate (of 5 plants) for each cultivar was used. The overall experimental field at each of the 3 sites was 810 m^2 large. The size of the planting hole was 60 × 60 × 60 cm and 10 kg of decomposed cow manure was applied in each planting hole at planting. No additional manure was applied during the growth period of the plants. Weeding was carried out at 3-month intervals, while de-suckering (the removal of all excess lateral shoots) and de-trashing of dead/dried leaves was practiced on a case-by-case basis. Three plants were kept per mat (parent, first ratoon (or daughter sucker) and second ratoon (or granddaughter sucker)). A mat comprises of physically interconnected/attached shoots. Mulching was carried out at the beginning of each dry season (in December and June). Where necessary, forked wooden poles were used to support mature plants with heavy bunches to prevent plant toppling (a plant getting uprooted due to the weight of the bunch, leading to loss of a bunch) and doubling (the pseudostem of a plant breaking due to weight of the bunch).

Banana growth and yield data were obtained during two cropping cycles (that is, plant crop cycle and 1st ratoon crop). Data on pseudostem girth (cm) at 100 cm above the ground were collected at flowering stage (bunch emergence) of each cropping cycle, while number of hands per bunch, fingers of the second lowest hand and bunch weight (kg) were obtained at bunch harvest during each cropping cycle. Mature bunches were harvested when the fingers of the second lowest hand had attained a round shape.

Data are presented as means across the two cropping cycles, in order to eliminate seasonal effects. Statistical analysis was carried out using GenStat 11th Edition (VSN International Ltd, 2008). Means were separated using the least significant difference at 5%.

RESULTS AND DISCUSSION

Significant differences ($p < 0.001$) in pseudostem girth (cm) at 100 cm height, measured at plant flowering,

Table 1. Altitude, rainfall, soil characteristics and agricultural value of the agricultural zones where the *Musa* germplasm field evaluations were carried out.

Trial site	Agro-ecological zone	Altitude (m a.s.l.)			Rainfall (mm)			Soil characteristics	Agricultural value
		Min	Average	Max	Min	Average	Max		
Rwinzuki	Impara	1,400	1,700	1,900	1,300	1,400	2,000	Very fine, red, basalt	Good
Karongi	Lake Kivu border	1,460	1,600	1,900	1,150	1,200	1,300	Shallow, clay loam	Good-excellent
Gatore	Eastern plateau	1,400	1,500	1,800	900	950	1,000	Laterite soil	Moderate-good

Source: Verdoodt and Van Ranst (2003).

Table 2. Cultivar name, clone set, genome or sub-group and use.

Cultivar name	Cultivar/hybrid	Clone set	Subgroup (Genome group)	Use
Ingagara	Landrace	Nakitembe	AAA-EA	Cooking
Ingaju	Landrace	Nfuuka	AAA-EA	Cooking
Ingarama	Landrace	Mutika/Lujugira	AAA-EA	Cooking
Injagi	Landrace	Musakala	AAA-EA	Cooking
Intariho	Landrace	Nfuuka	AAA-EA	Cooking
Kisansa	Landrace	Musakala	AAA-EA	Cooking
Mbwazirume	Landrace	Nakitembe	AAA-EA	Cooking
Mpologoma	Landrace (introduced from Uganda)	Musakala	AAA-EA	Cooking
NARITA 4	Secondary triploid hybrid	Cross from Enzirabahima, Nfuuka clone set	AAA-EA	Cooking

Table 3. Mean plant pseudostem girth (cm), number of fingers on the second lowest hand on the bunch, number of hands per bunch and bunch weight (kg) for 9 cooking banana cultivars assessed at 3 three trial sites and over two growth cycles in Rwanda between 2007 and 2011.

Cultivar	Mean pseudostem girth at 100 cm height (cm)	Mean number of fingers on the second lowest hand of the bunch	Mean number of hands per bunch	Bunch weight (kg)
Ingagara	53.6±1.0	7.9±0.1	7.5±0.2	15.9±0.7
Ingaju	58.0±0.8	8.3±0.1	7.8±0.1	17.6±0.7
Ingarama	53.1±1.2	7.8±0.2	7.6±0.2	14.6±0.9
Injagi	58.0±0.9	8.0±0.1	7.8±0.1	19.2±0.7
Intariho	50.5±1.0	7.6±0.2	7.1±0.2	14.6±0.8
Kisansa	52.7±1.1	7.7±0.1	7.4±0.2	15.4±0.8
Mbwazirume	50.3±0.9	7.7±0.1	7.0±0.1	15.1±0.7
Mpologoma	58.1±0.9	8.5±0.1	8.1±0.1	22.8±0.7
NARITA 4	50.7±1	8.7±0.1	8.6±0.2	16.7±0.8
Lsd (5%)	2.3	0.3	0.4	1.8
Cv%	12.1	11.3	13.2	27.6
P value	<0.001	<0.001	<0.001	<0.001

mean number of fingers on the second lowest hand of the bunch, number of hands per bunch and bunch weight (kg) were observed between the cultivars. 'Mpologoma' had pseudostem sizes comparable to the best performing local landraces. In contrast, 'NARITA 4' had a small-sized pseudostem compared to the other cultivars (Table 3). The introduced cultivars 'NARITA 4' (with 8.7 fingers and 8.6 hands) and 'Mpologoma' (with 8.5 fingers and 8.1 hands) were significantly superior to the local landraces evaluated in this study in terms of the mean number of fingers on the second lowest hand and hands on the bunch (Table 3). 'Mpologoma' with an average bunch weight of 23 kg was the best performer among the 9 banana cultivars.

In contrast, the average bunch weight for 'NARITA4' was 17 kg, though comparable with most local cultivars (Table 3). Therefore, both exotic cooking cultivars produced acceptable bunches. As bunch size and market demand are important criteria in the selection of cooking cultivars for cultivation in Rwanda by farmers (Ocimati et al., 2014), 'Mpologoma' and even 'NARITA4' have a high chance to be adopted by farming communities.

Conclusion

'Mpologoma' performed as good as or better than the best local cooking cultivars, while 'NARITA4' performed better than half of the local cultivars. Considering the important shift from beer to cooking and dessert types in Rwanda, these 2 exotic cooking cultivars have the potential for wide-spread adoption. Additional organoleptic/taste panel assessments should however be carried out with various farming communities before embarking on large-scale multiplication and distribution efforts.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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