

'NABIO808' (Syn. 'NAROBAN5'): A tasty cooking banana cultivar with resistance to pests and diseases

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Abstract: 'NABIO808' is a newly released, conventionally-bred triploid cooking banana cultivar in Uganda. It produces an average bunch yield of 54.5 t ha⁻¹ yr⁻¹ and is resistant to weevils, nematodes, and black Sigatoka. Additionally, its food is yellow, soft, and tasty, like that of most preferred landrace cultivars, making it more acceptable to end-users.

Keywords: Matooke breeding, host plant resistance, weevils, nematodes, black Sigatoka


INTRODUCTION

Banana (*Musa* spp.), a giant, heterogeneous, herbaceous, perennial, and vegetatively-propagated plant, is an important food and cash crop grown worldwide (FAOSTAT 2017). It is considered a staple food crop that significantly contributes to the caloric intake of low-income subsistence farmers in developing countries (Brown et al. 2017). In Uganda, bananas, especially the East African highland cooking banana (EAHCB) cultivars, occupy the third largest cultivated area among staple food crops (FAOSTAT 2017) and are grown by more than 75% of the farmers. Although the EAHCB cultivars are important, their yields in farmers' fields in Uganda are less than 30% of their potential. Furthermore, their longevity in planted fields in some areas of Uganda, especially in the lowlands of the Eastern and Central regions, has declined considerably to less than five years (Tushemereirwe et al. 2001).

The leading cause of reduced banana yield and longevity in planted fields is the susceptibility of local banana cultivars to the banana weevil (*Cosmopolites sordidus* (Germar), burrowing nematodes, and black Sigatoka (Gold et al. 2004; Tushemereirwe et al. 2001). This poses a serious threat to the future sustainability of banana production and may further destabilize food security and household incomes across the East African region.

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One of the most appropriate and cost effective interventions currently used in Uganda to address the banana pest and disease challenge is developing resistant banana cultivars. Resistant cultivars offer enormous spill-over benefits for human health and have positive environmental impacts (Sharm and Ortiz 2002; Silva et al. 2001). This article presents the development process, agronomic performance, and attributes of a newly released cooking banana cultivar in Uganda ('NABIO808') that was developed with the aim of improving bunch yield and resistance to weevils, nematodes, and black Sigatoka. The cultivar was evaluated under code 'NABIO808' and later released as NAROBAN5 by the Ugandan Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) in April 2019.

PEDIGREE, BREEDING, AND EVALUATION METHODS

'NABIO808' is a secondary triploid cooking banana cultivar (AAA) derived from an interploidy cross between the tetraploid hybrid '660K-1' AAAA (derived from 'Enzirabahima' AAA x 'Calcutta 4' AA) with a matooke improved diploid '1345K-1' AA (derived from 'Nakawere' AAA x 'Calcutta 4' AA). Embryos extracted from hybrid seeds of this cross, together with those of other banana crosses made during 2008, were separately cultured *in vitro* as described by Uma et al. (2011). Three-hundred hardened seedlings pooled from all crosses were established in a single-site, non-replicated, research-station early-evaluation trial at the National Agricultural Research Laboratories (NARL) - Kawanda in Uganda from 2009 to 2012. Eleven cooking-type triploid banana hybrids identified by flow cytometry (Nsabimana and van Staden 2006), with resistance to black Sigatoka [selected according to Orjeda (1998)], pendent bunches, and a bunch weight of ≥ 10 kg plant⁻¹, were selected and multiplied *in vitro* for further evaluation in replicated, multi-location preliminary yield trials (PYTs) from 2013 to 2015.

In the PYTs, genotypes were evaluated for bunch yield (BYL); responses to black Sigatoka, weevils, and nematodes; and consumer acceptability. Consequently, two promising hybrids ('NABIO808' and 'NABIO306') that combined high BYL (≥ 30 t ha⁻¹ yr⁻¹); resistance to black Sigatoka, weevils, and nematodes; and high-quality fruit attributes were selected for advancement to on-farm trials. The two genotypes selected ('NABIO808' and 'NABIO306'), together with two most market-preferred landrace cultivars (Kibuzi and Mbwarzirume), were established in seven regional on-farm trials. The trial locations were Mbarara (lat 0° 36' 16" S, long 30° 38' 54" E, alt 1422 m asl), Bushenyi (lat 0° 32' 13" S, long 30° 11' 08" E, alt 1607 m asl), Fort Portal (lat 0° 39' 42" N, long 30° 16' 29" E, alt 1518 m asl), Hoima (lat 1° 25' 38.478" N, long 31° 20' 54.402" E, alt 1131 m asl), Jinja (lat 0° 26' 20" N, long 33° 12' 11" E, alt 1187 m asl), Kamuli (lat 0° 56' 49" N, long 3° 07' 10" E, alt 1120 m asl), and Kawanda (lat 0° 25' 14" N, long 32° 32' 26" E, alt 1300 m asl), and plants were evaluated for two ratoon crop cycles from 2016 to 2018. 'Yangambi-KM5', a local check cultivar resistant to weevils and nematodes, was included in the NARL-Kawanda trial as the only site that was designated for weevil and nematode assessment. Kawanda is a hotspot for banana weevils, nematodes, and black Sigatoka. The seven trial sites represented the major banana-growing areas in Uganda and are located in three diverse agro-ecological zones (Wortmann and Eledu 1999).

On-farm trials were established using 2.5-month-old tissue culture plants of each genotype planted at a spacing of 3 m by 3 m within and between rows, for a plant population density of 1111 plants/ha. At planting, about 7 kg of well decomposed cow dung manure were applied to each hole. Trials were laid out in a randomized complete block design with three replications. Blocks were surrounded by 'Mbwarzirume', a check cultivar susceptible to black Sigatoka, weevils, and nematodes. No supplemental irrigation was applied, and the trials were regularly weeded, de-trashed and de-suckered to ensure a suitable environment for banana plant growth.

Bunch yield and its components [total number of hands (TNH), fruit length (FL), and fruit circumference (FC)] were assessed at harvest, whereas the plant growth traits [plant height (PH), plant girth (PG), and number of green functional leaves (NFL)] were assessed at flowering. The genotype response to black Sigatoka infection was also assessed at flowering using the index of non-spotted leaf (INSL) (Orjeda 1998). Banana cultivars with an INSL of $\geq 70\%$ are resistant, according to Orjeda (1998). Their response to weevil damage was assessed according to Twesigye et al. (2018), whereas response to nematodes was assessed according to Dochez et al. (2005).

In order to select the banana cultivar with acceptable end-user fruit quality attributes, consumer acceptance tests of the cooked food of the genotypes were performed by 465 banana farmers (264 women and 201 men) from all seven trial sites. The tests were based on five sensory attributes: taste, aroma, mouth feel, colour, and general acceptability — using a scale of 1 to 6, where 1 = dislike extremely, 2 = dislike, 3 = like fairly, 4 = like, 5 = like very much, and 6 = like extremely.

All the data collected across seven trial sites and two ratoon crop cycles were averaged and analysed using GenStat, version 14 (Payne et al. 2011). Trait means were separated using least significance differences at $P < 0.05$ (Payne et al. 2011).

PERFORMANCE CHARACTERISTICS

Genotypes were significantly different for most of the traits assessed (Tables 1, 2, and 3). The highest mean performance for BYL, TNH, FC, PG, NFL, and INSL across sites and crop cycles was recorded for 'NABIO808' (Table 1). 'NABIO306', however, recorded the highest FC (Table 1). For short plant height, 'NABIO808' emerged as the second best cultivar, after 'NABIO306' (Table 1). Shorter banana plants (≤ 300 cm) are more desirable than taller ones because taller plants are more prone to wind damage. Generally, for all the agronomic traits assessed, except FL, 'NABIO808' emerged as the best cultivar. It also exhibited the highest level of resistance to black Sigatoka, one of the key banana breeding targets of the National Agricultural Research Organisation (NARO) in Uganda. Its INSL, the measure of resistance to black Sigatoka, was 76.4%. Orjeda (1998) revealed that bananas require more than 70% of active leaf foliage at flowering for proper development and filling of their fruits. Severe infestation of bananas with black Sigatoka, a fungal disease, caused by *Mycosphaerella fijiensis* (Morelet), can lead to a considerable reduction in the photosynthetic leaf area of the plant. Consequently, bunches and fruits of infected plants produce lower bunch weight in comparison to those of healthy banana plants (Arzanlou et al. 2007). Vuylsteke et al. (1993) revealed that resistance to black Sigatoka results from the interaction between a major recessive gene and two modifiers with additive effects.

Host plant resistance of 'NABIO808' to weevils and nematodes was higher than that of the landrace cultivars ('Mbwazirume' and 'Kibuzi') and 'NABIO306' but closest to that of 'Yangambi-KM5', a check cultivar resistant to weevils and nematodes (Table 2), indicating that 'NABIO808' is a cultivar resistant to weevils and nematodes. The host plant resistance of 'NABIO808' to weevils and nematodes was not significantly different ($P > 0.05$) from that of 'Yangambi-KM5'. Banana host plant resistance to weevils and nematodes is likewise a pertinent breeding objective of NARO.

Table 1. Mean performance of four cooking banana cultivars evaluated for eight traits across seven sites and two crop cycles from 2016 to 2018

Genotypes	Traits							
	BYL (t ha ⁻¹ yr ⁻¹)	TNH	FC (cm)	FL (cm)	PH (cm)	PG (cm)	NFL	INSL (%)
NABIO808 (NAROBAN5)	54.5	9.1	13.1	16.6	332.8	53.6	13.2	76.4
NABIO306	53.3	9.0	13.0	16.8	316.9	50.8	12.4	72.1
Kibuzi (local cultivar)	45.6	8.7	13.0	16.4	384.3	46.7	9.5	66.2
Mbwazirume (local cultivar)	34.0	8.3	12.3	15.2	333.5	51.7	8.2	56.3
Mean	46.8	8.8	12.8	16.8	384.3	50.7	10.8	67.8
LSD _{0.05}	4.30	0.16	0.58	1.1	34.7	1.4	0.82	6.7
F-Probability	<0.001	<0.001	0.018	0.013	<0.001	<0.001	<0.001	<0.001

LSD_{0.05} = least significant difference at 5%, BYL = bunch yield, TNH = total number of hands, FC = fruit circumference, FL = fruit length, PH = plant height, PG = plant girth, NFL = number of green functional leaves, and INSL = index of non-spotted leaf.

Table 2. Mean performance of five banana cultivars for percentage of total cross-sectional damage to corm by weevils and root necrosis by nematodes across two ratoon crop cycles at NARL-Kawanda from 2016 to 2018

Genotypes	Root necrosis by nematodes (%)	Total cross-sectional damage to corm by weevils (%)
NABIO808 ('NAROBAN5')	3.2	1.5
NABIO306	3.5	1.7
Yangambi-KM5 (resistant check)	3.9	1.4
Kibuzi (susceptible check)	47.3	28.3
Mbwazirume (susceptible check)	62.3	49.4
MEAN	24.0	16.5
LSD _{0.05}	0.9	1.1
F-Probability	<0.001	<0.001

LSD_{0.05} = least significant difference at 5%

These pests greatly reduce yields and the longevity of bananas in planted fields in the banana growing communities in Uganda (Tushemereirwe et al. 2001; Gold et al. 2004), and are therefore a key breeding target of the Banana Breeding Programme of NARO in Uganda.

The sensory attributes of ‘NABIO808’ (taste, aroma, mouth feel, and colour) were consistently ranked closest to those of ‘Mbwazirume’ (Table 3). ‘Mbwazirume’ is one of the most consumer-preferred landrace cooking banana cultivars due to high quality attributes of its cooked food. It dominates the banana markets in Uganda and is therefore highly marketable.

Generally, ‘NABIO808’ is an agronomically superior banana cultivar, combining multiple resistances to weevils, nematodes, and black Sigatoka with high quality fruit attributes and stability across diverse environments in Uganda. Because of these pertinent qualities, ‘NABIO808’ is more acceptable to end-users. Akankwasa et al. (2013) clearly

Table 3. Mean performance of four green mature cooking banana cultivars for fruit quality attributes in sensory evaluations with participation of 465 banana farmers across seven sites and two cycles from 2016-2018

Genotype	Cooked food sensory traits (Hedonic scale: 1-6)				
	Taste	Aroma	Mouth feel	Colour	Overall Acceptability
NABIO808 (NAROBAN5)	5.60	5.35	5.65	5.90	5.70
NABIO306	5.55	5.25	5.45	5.85	5.55
Mbwazirume (local check cultivar)	5.75	5.60	5.75	5.95	5.80
Kibuzi (local check cultivar)	5.20	4.70	5.15	4.95	5.10
Mean	5.53	5.23	5.50	5.66	5.54
LSD _{0.05}	0.18	0.29	0.24	0.22	0.13
F-Probability	0.009	0.008	0.003	0.002	0.001

LSD 0.05 = least significant difference at 5%, Hedonic scale: 1-6, where 1 = dislike very much, 2 = dislike, 3 = like fairly, 4= like, 5 = like very much, and 6 = like extremely.

Table 4. Other characteristics (descriptors) of ‘NABIO808’

Plant part	Characteristics	Time of data collection	Behaviour	Score
Leaf	Leaf habit	At shooting	Intermediate	2
	Pseudo stem height (m)	At shooting	≥3	3
	Blotches at the leaf petiole base	At fruiting	Sparse blotches	1
	Leaf petiole margin colour	At shooting	Green	1
	Leaf blade length	At shooting	171-220 cm	2
	Leaf blade width	At shooting	71-80 cm	2
Pseudostem	Pseudostem colour (with sheath)	At flowering	Medium green	2
	Predominant underlying colour of the pseudostem	At flowering	Pink-purple	5
Bunch	Bunch position	At maturity	Slightly angled	2
	Bunch shape	At maturity	Cylindrical	1
	Peduncle pubescence	At maturity	Short hairs	3
	Bunch appearance	At maturity	Compact	2
Rachis	Bunch maturity time	Mature green	170 days	NA
	Rachis orientation of male phase	At maturity	Falling vertically	1
	Rachis appearance	At maturity	Bare	1
Male bud	Bract apex shape	At maturity	Obtuse	4
	Bract imbrication	At maturity	Imbricate	2
Fruit	Fruit shape	At harvest	Straight (or slightly curved)	1
	Fruit shape	At maturity	Straight in the distal part	2
	Transverse section of fruit	At harvest	Slightly ridged	3
	Fruit apex	At harvest	Blunt tipped	3
	Persistence of floral organs	At harvest	Absent	1
	Immature fruit peel colour	At fruiting	Light green	1
	Mature fruit peel colour	At harvest	Green-yellow	2
	Pulp colour	At maturity	Yellow	3

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indicated that for a new banana cultivar to meet end-user needs, it must be balanced in terms of yield, pest and disease resistance, and quality attributes. Consequently, based on the recommendations of both farmers and the NARO scientists, ‘NABIO808’ was officially released as ‘NAROBAN5’ and added to the National Cultivar List by MAAIF in April 2019. ‘NAROBAN’ denotes the institution NARO that developed the cultivar.

OTHER CHARACTERISTICS

Supplemental characteristics that define ‘NABIO808’ are shown in Table 4.

SEED PRODUCTION AND DISTRIBUTION


‘NABIO808’ was officially released as ‘NAROBAN5’ and added to the National Cultivar List by MAAIF. As ‘NAROBAN5’ is a vegetatively propagated cultivar, it is currently maintained in research-station fields and *in vitro* by the National Banana Research Programme of NARO in Kawanda, Uganda. Planting materials (suckers and tissue culture plants) can be accessed through NARO and designated private tissue culture laboratories in the country.

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