Release and diffusion orange sweetpotato cultivars, 'NASPOT 9 O', 'NASPOT 10 O' in Uganda

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Abstract

Two orange-fleshed sweetpotato (Ipomoea batatas L. (Lam.) cultivars, NASPOT 9 O (Namulonge Sweetpotato 9 orange-fleshed) and NASPOT 10 O were approved for release by the Ugandan Plant Variety Release Committee in July 2007. The two cultivars were evaluated for five seasons, on-station at Namulonge in seedling, observation, preliminary, and intermediate trials, between 2002 and 2004 to confirm field resistance to sweetpotato virus disease (SPVD). They were further evaluated for three seasons, on-station and on-farm between 2004 and 2006 in replicated, standardized, multi-location yield trials. The root yields of the cultivars fluctuated across agroecologies in both on-station and on-farm trials (5.3-35.4 t•ha^{-1}), but were above the national average of 4.0 t•ha^{-1}. The yield of the two cultivars were similar to the local check cultivars in most sites on-station and on-farm. The two cultivars have acceptable storage root shapes when grown in light soils. They also have high average dry matter content (about 30%), and good to excellent consumer acceptance. NASPOT 9 O and NASPOT 10 O have high pro-vitamin A, hence potential to alleviate widespread vitamin A deficiency. However, the cultivars were susceptible to sweetpotato weevils in no choice laboratory tests and under dry season field conditions but have moderate field resistance to Alternaria stem blight. The cultivars have moderate field resistance to SPVD which is the most devastating disease of sweetpotato in Uganda. Since their release, they have spread widely, promoted by government, non-government organizations, and farmer groups.

Keywords: Alternaria bataticola *blight,* Cylas puncticollis*,* Cylas brenneus*, selection.*

Introduction

Two orange-fleshed sweetpotato (Ipomoea batatas L. (Lam.) cultivars, NASPOT 9 O and NASPOT 10 O were approved for release by the Uganda Plant Variety Release Committee in July 2007 (Mwanga et al., 2007a). The cultivars were part of the fourth group of sweetpotato cultivars to be officially released by the Sweetpotato Program in Uganda. The first three groups were released in different years; six in 1995 (Mwanga et al., 2001), six in 1999 (Mwanga et al., 2003), and two in 2004 (Mwanga et al., 2007c). The two orange-flehed cultivars described herein are pro-vitamin A (beta-carotene) rich. They have acceptable storage root shapes when grown in light soils. They also have high dry matter content (about 30%), and good to excellent consumer acceptance, particularly among women and children below six years (Wamaniala, 2008; Potts and Nagujja, 2007; Mwanga et al, 2007b, Odongo et al. 2002). The cultivars have moderate levels of field resistance to sweetpotato virus disease (SPVD) and Alternaria bataticola blight, and high storage root yields compared to the average national storage root yield of 4.0 t•ha^{-1} (International Potato Center, 1999). The release of these cultivars provides consumers and farmers with high quality sweetpotatoes with storage roots that are high in pro-vitamin A content. The high pro-vitamin A content in the two cultivars presents potential to alleviate widespread vitamin A deficiency in Uganda and other developing countries (Low et al. 2007; Jaarsveld et al. 2005; Ruel, 2001; UDHS, 2001).

Origin and nomenclature

Throughout evaluation at the National Crops Resources Research Institute (NaCRRI), Namulonge and in on-station and on-farm trials in major selected agroecologies in Uganda, the two clones were coded using the following nomenclature: Namulonge *Ipomoea* selection (NIS)/the initial year selected/the female parent/the selection (genotype) number/similarity code number (if present). The codes for the releases were 'NASPOT 9 O' and 'NASPOT 10 O'. The two cultivars are seedling selections from the sweetpotato program at NaCRRI; the population from which they were selected was bulked seed from an open-pollinated polycross nursery of 24 parents grown during 2000-2001. The 24 parents in the polycross block consisted of 10 released cultivars, 3 introductions, 5 advanced clones from the Ugandan sweetpotato breeding program and 6 landrace cultivars (Table 1). Zapallo (PI420027), Jewel (PI440031), and Beauregard (PI440132) were introductions from the International Potato Center (CIP), Lima, Peru, as pathogen-free in vitro plantlets. The landraces and the districts (in parenthesis) from where they were collected were 'Arivumaku-2' and 'Ngujja' (Arua), 'Kala' (Kumi), 'Kanyasi' (Kabale), 'Araka' (Soroti), and 'Bunduguza' (Kamuli). The 24 parents were included in the polycross nursery for improvement or as sources of one or a combination of genes for desirable traits such as orange-fleshed roots (pro-vitamin A), high dry matter (30%), early maturity (3-4 months), resistance to SPVD and Alternaria stem blight (Table 1).

Evaluation of cultivars

The two cultivars were evaluated for five seasons on-station at Namulonge in seedling, observation, preliminary and intermediate trials between 2002 and 2004, and for three seasons in on-station and on-farm trials between 2004 and 2006 in replicated, standardized, multi-location yield trials (3 major agoecologies). The agroecologies agroecologies were: (1) the warm, sub-humid short grasslands where sweetpotato weevils and drought are important; (2) the warm, moist, tall grasslands where SPVD is severe; and (3) the cool, moist, south-western highlands where Alternaria stem blight (AB) and low soil fertility stresses are prevalent. Mwanga *et al.* (2007a) provides detailed descriptions of pedigree, test sites, cultivars, planting materials, on-station and on-farm trials, planting and harvesting dates, farmer selection criteria, experimental designs, stability analysis, production package, and cultivar maintenance. For pest and disease rating scale the following coding was used: S =Susceptible - considerable damage or numbers present to severe damage or very high numbers present, respectively; moderately resistant (MR) = moderate damage or moderate numbers present (resistant = little or no apparent damage or few or no insects present).

The agroecologies (sites) are represented as follows: Namulonge is the warm, moist, tall grasslands (high SPVD pressure agroecology); Ngetta and Serere are in the warm, sub-humid short grasslands (has high weevil population during dry periods); and Kachwekano is the cool, moist, south-western highlands (has high Alternaria blight pressure). In Table 3 yield was a mean of four replications. Planting was in a randomized complete block design (RCBD); 80 plants on 5 ridges (1 m x 30 cm) per plot; only the 48 middle plants were harvested for yield determination. Other details were as follows: DMC = Dry matter content, SPVD and Alternaria blight severity rating scale, 1 = no symptoms; 2 = mild symptoms; 3 = mild symptoms; 4 = severe symptoms; and 5 = very severe symptoms.

A total of eight multilocational on-station and 13 on-farm trials were conducted under rain-fed conditions but only data for 2004/2005-2006 are presented where the original number of clones (68,874) selected from the seedling nursery had been reduced to less than 10 for on-farm trials (Mwanga *et al.*, 2007a). The cultivars were evaluated to confirm resistance to SPVD, AB, and sweetpotato weevils, *Cylas puncticollis* (Boheman) and *C. brunneus* (Fabricius) (Tables 2 and 3). Classifications of the relative resistance to disease and weevil damage were based on field evaluation under natural disease and weevil population pressures as described by Mwanga *et al.* (2002, 2007b,). Root samples of cultivars were analyzed for pro-vitamin A concentration using spectrophotometry and high performance liquid chromatography (HPLC). The level of disease infection varied from low to high depending on agroecology; Namulonge for high SPVD pressure, Kachwekano for high AB pressure; and Serere and Ngetta for high weevil populations during dry periods. Storage root dry matter content, root yield, and taste and storage root yield, were also evaluated. The mean root yields of the released cultivars across sites varied in on-station (Table 3) and on-farm trials (Table 4), but they were above the national average of 4.0 t•ha^{-1}. Though 'NASPOT 9 O' and 'NASPOT 10 O' varied in root yield and biomass, they have orange fleshed-storage roots (Fig. 1) with more pro-vitamin A than Dimbuka-Bukulula, and Tanzania which have cream-fleshed roots.

For on-firm trials, Mpigi and Wakiso districts represent the warm, moist tall grasslands, Nakasongola and Busia, the warm sub-humid short grasslands, and Kabale, the cool moist south-west highlands. Yields were based on 10-15 farms per district, gross plot was 30 m^2 (30 mounds), middle or net plot harvested was 12 m^2 (12 mounds of 36 plants); each farm in a district was treated as a replicate. Taste rank was based on the aggregate pair-wise comparison of the panel (farmers); n = number of farmers in the tasting panel, m = male, f =female; 1 = most preferred; 6 = least preferred.

The observed wide variation in yield is attributed to variation in environmental factors such as erratic rain during some seasons, and differences in farm management and soil types in the different agroecologies. The wide variation in pro-vitamin A (beta-carotene) content is attributed to various factors such as agroclimatic factors [e.g. different soil types, time of sampling (wet/ dry season)], different methods used in its determination, age and size of the sampled roots, methods of harvesting and post-harvest handling of root samples, processing and storage]. Although relative ranking in taste preference varied on different farms the released cultivars had high acceptability on most farms (Table 4).

Diffusion of cultivars

The global HarvestPlus Program (Pfeiffer and McClafferty, 2007; HarvestPlus, 2007) was involved in an effectiveness case study to promote orange-fleshed sweetpotato (OFSP) to alleviate vitamin A deficiency in Uganda. The OFSP high pro-vitamin A cultivars, 'NASPOT 9 O' and 'NASPOT 10 O' (Bengtsson *et al.,* 2008), were given new names, 'Vita' and 'Kabode', respectively in the HarvestPlus project areas (Wamaniala, 2008). By September 2008, three seasons after the farmers in the three HarvestPlus project target districts received the cultivars, 3,261 farmers were growing them in Bukedea, 3,504 in Kamuli, and 3,511 in Mukono. This represented 100, 90, and 80% adoption rates in the respective districts (Wamaniala, 2008). The released cultivars have already reached 19 other districts in Uganda; Amuria, Busia, Jinja, Kabale, Kampala, Karamoja, Katakwi, Kayunga, Kumi, Lira, Manafwa, Masaka, Mayuge, Mpigi, Nakasongola, Padel, Soroti, Tororo, and Wakiso, albeit absence of a seed company that deals in sweetpotato planting materials (Potts and Nagujja 2007; Wamaniala, 2008).

Availability of cultivars

The cultivars are maintained as pathogen-tested plants in the screenhouse at the Quarantine Station, Muguga, Kenya, and are maintained in the field by NaCRRI in Uganda. Requests for these cultivars should be addressed to: Seed Unit, CIP, P.O. Box 25171, Nairobi, Kenya. Requests for planting materials within Uganda should be directed to: Sweetpotato Program, NaCRRI, P.O. Box 7084, Kampala.

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Table 1. Origin and main attributes of 24 sweetpotato parents used in the 2001/2002 polycross nursery at Namulonge, Uganda

Female parent	Origin of parent	Year released/ status/ germplasm (GM)	Desirable / undesirable trait
SPK004 (Kakamega)	Kenya	2004	Orange-flesh (OF) of storage roots, high dry matter (HDM)(≥30%), moderately resistant to sweetpotato virus disease (SPVD)
Ejumula	Uganda (landrace)	2004	OF, HDM, highly susceptible to SPVD
NASPOT1	Uganda (bred clone)	1999	OF, HDM, high root yield, susceptible to Alternaria blight (AB)
NASPOT3	Uganda (bred clone)	1999	HDM, moderately resistant to SPVD
NASPOT4	Uganda (bred clone)	1999	Resistant to SPVD
NASPOT5	Uganda (bred clone)	1999	OF, HDM, resistant to SPVD, susceptible to AB
New Kawogo	Uganda (landrace)	1995	HDM, resistant to SPVD, susceptible to AB, aggressive to weeds
Bwanjule	Uganda (landrace)	1995	HDM, resistant to SPVD
Sowola	Uganda (landrace)	1995	HDM, early maturity, light canopy
Tanzania	Uganda (landrace)	1995	HDM, taste, moderately resistant to SPVD
Zapallo (420027)	CIP / Peru	GM	OF, moderate resistance to AB, susceptible to SPVD
Beauregard (44013)	CIP / Peru	GM	OF, good root shape, susceptible to SPVD
Jewel (440132)	CIP / Peru	GM	OF, susceptible to SPVD
NIS/199/23/60	Uganda (bred clone)	Breeding line	OF, susceptible to SPVD
NIS/93/29	Uganda (bred clone)	Breeding line	HDM, resistant to SPVD
NIS/199/18/1	Uganda (bred clone)	Breeding line	OF, susceptible to SPVD
NIS/199/4/4	Uganda (bred clone)	Breeding line	OF, HDM, susceptible to SPVD
NI/1990/Sowola-6	Uganda (bred clone)	Breeding line	OF, susceptible to SPVD
Ngujja	Uganda (landrace)	GM	OF, susceptible to SPVD
Arivumaku-2	Uganda (landrace)	GM	OF, low root yield
Bunduguza	Uganda (landrace)	GM	HDM, resistance to sweetpotato weevil
Araka	Uganda (landrace)	GM	Adapted to short grassland area
Kala	Uganda (landrace)	GM	OF, HDM,
Kanyasi	Uganda (landrace)	GM	HDM, susceptible to AB

Table 2. Yield, quality attributes and disease and insect pest reaction of two orange sweetpotato cultivars released in Uganda in July 2007

Attribute	Naspot9 O	Naspot10 O	Tanzania (local check)
Dry matter % (range)	30.1 (27.5-31.1)	30.5 (27.8-32.5)	32.0 (27.5-35.5)
Cooked texture	Somewhat dry	Somewhat dry	Somewhat dry
Sweetness	Moderate	Moderate	Moderate
Field reaction to weevils	Susceptible (S)	S	S
Field reaction to sweetpotato			
virus disease (SPVD)	Moderately resistant (MR)	MR	MR
Field reaction to			
Alternaria stem blight	MR	MR	MR
Maturity (days)	125	110	120
Mean and (range) of			
storage root yields			
in various yield trials ($t \cdot ha^{-1}$)	16.5 (8.1-27.6)	16.0 (5.3-35.4)	17.6 (3.9-32.9)
Mean storage root yield			
(% of local check)	94	91	100
Beta-carotene content (•/g DM)	314.5 (206.3-460.3)	246.2 (185.6-324.8)	21.5 (13.8-36.3)

Table 3. Yield of four sweetpotato cultivars including 'NASPOT 9 O' and 'NASPOT 10 O' in four sites in Uganda [dry matter content- DMC; sweetpotato virus disease – SPVD; if not applicable – NA are indicated)

Cultivar	Site				Mean across sites	Biomass across sites (t•ha^{-1})	DMC across sites %	SPVD at Namu longe	Alternria at Kachwe kano
	Namu longe	Kachwe kano	Ngetta	Serere					
	Storage root yield^{y} (t•ha^{-1})								
	2004								
NASPOT 9 O	50.4	33.7	12.8	6.0	25.7	62.5	29.4	1.8	2.3
NASPOT 10 O	38.3	28.0	9.8	7.9	21.0	43.2	32.6	2.3	2.0
Dimbuka-Bukululа	58.4	52.1	19.5	15.9	36.5	64.0	32.3	3.0	3.0
Tanzania (Check)	32.9	58.4	16.5	5.3	28.3	77.3	34.6	2.2	2.0
Mean	47.0	45.1	13.2	8.8	28.6	68.7	31.6	2.2	2.2
$LSD_{0.05}$	13.1	15.8	5.0	3.8	5.4	9.3	NA	0.4	0.9
	2005								
NASPOT 7	28.7	19.7	7.4	13.2	17.3	42.8	31.5	1.4	2.0
NASPOT 8	23.5	20.7	8.1	4.6	14.2	40.4	31.4	1.3	2.0
NASPOT 9 O	17.1	11.2	15.6	9.5	13.4	28.4	30.3	2.3	2.3
NASPOT 10 O	16.4	15.4	12.1	19.7	31.8	34.3	30.6	2.1	2.3
Dimbuka-Bukululа	16.5	29.0	15.6	14.5	18.9	32.8	32.9	2.1	3.0
Tanzania (Check)	24.3	20.9	14.8	11.7	17.9	28.8	30.9	1.6	2.0
Mean	21.1	19.5	12.3	12.2	18.9	34.6	31.3	1.8	2.3
$LSD_{0.05}$	5.3	6.3	2.8	5.0	2.3	5.8	NA	0.9	0.9
	2006								
NASPOT 7	41.7	52.5	8.7	17.5	30.1	57.9	30.5	2.3	1.5
NASPOT 8	28.6	35.7	7.0	32.3	25.9	50.0	30.1	2.3	1.3
NASPOT 9 O	25.4	32.0	6.8	21.7	21.5	43.7	30.3	2.8	1.8
NASPOT 10 O	26.6	28.6	5.8	31.8	23.2	48.6	33.9	2.3	1.5
Dimbuka-Bukululа	53.0	51.4	11.2	50.2	41.5	63.9	32.3	3.0	2.0
Tanzania (Check)	22.9	20.7	10.1	16.1	17.5	52.8	31.5	3.0	1.9
Mean	33.0	36.8	8.3	28.3	26.6	52.8	31.4	2.6	1.7
$LSD_{0.05}$	14.5	14.2	3.5	8.4	6.2	13.2	NA	0.6	0.8

Table 4. Performance of six sweetpotato varieties including 'NASPOT 9 O' and 'NASPOT 10 O' in on-farm trials in Uganda (m = men, f = female, NA = not applicable)

District/Year	Cultivar	Yield($t \cdot ha^{-1}$)			Disease severity		Taste rank
		Root	Biomass		SPVD	Alternaria	
Mpigi 2005							(n=15; m=4, f=11)
	NASPOT 7	11.2	30.7		2.2	3.0	6
	NASPOT 8	15.0	30.1		2.0	1.2	3
	NASPOT 9 O	13.7	26.1		2.0	1.5	2
	NASPOT 10 O	10.5	20.4		2.0	1.4	1
	Dimbuka-Bukulula	17.8	35.1		2.4	1.6	4
	Namubiru (Check)	8.2	20.0		2.6	1.4	5
	Mean	12.7	27.1		2.2	1.7	NA
	$LSD_{0.05}$	4.5	8.8		NS	0.8	NA
Mpigi 2006							(n=24; m=5, f=19)
	NASPOT 7	7.3	20.2		2.4	3.4	5
	NASPOT 8	12.7	29.4		2.6	2.2	3
	NASPOT 9 O	13.3	23.9		2.6	2.0	1
	NASPOT 10 O	9.7	20.8		2.6	2.0	2
	Dimbuka-Bukulula	12.4	27.5		3.0	2.2	4
	Semanda (Check)	12.1	31.3		3.0	2.6	6
	Mean	11.3	25.5		2.7	2.4	NA
	$LSD_{0.05}$	4.1	8.0		0.5	0.9	NA
Busia 2006							(n=20; m=3, f=17)
	NASPOT 7	14.0	28.5		2.0	1.0	3
	NASPOT 8	16.5	32.6		2.0	1.0	5
	NASPOT 9 O	14.9	22.9		1.8	1.4	2
	NASPOT 10 O	14.9	22.1		2.0	1.0	1
	Dimbuka-Bukulula	16.3	23.6		2.4	1.0	6
	Musiita (Check)	16.8	27.8		1.8	1.0	4
	Mean	15.6	26.3		2.0	1.1	NA
	LSD0.05	NS	8.3		NS	0.2	NA
Kabale 2006							(n=23; m=5, f=18)
	NASPOT 7	16.1	31.5		2.2	1.3	4
	NASPOT 8	23.0	78.4		1.7	1.0	5
	NASPOT 9 O	15.4	31.5		2.0	1.2	1
	NASPOT 10 O	17.2	34.4		2.0	1.2	6
	Dimbuka-Bukulula	21.0	43.7		2.0	1.2	2
	Nderera (Check)	24.0	49.7		2.2	1.2	3
	Mean	19.5	44.9		2.0	1.2	NA
	LSD0.05	NS	3.6		NS	NS	NA
Nakasongola 2006							(n=18; m=4, f=14)
	NASPOT 7	15.5	32.8		2.0	1.1	5
	NASPOT 8	14.4	30.4		1.8	1.2	3
	NASPOT 9 O	13.3	24.3		1.8	1.0	1
	NASPOT 10 O	14.4	30.0		1.8	1.3	2

District/Year	Cultivar	Yield(t·ha^{-1})			Disease severity		Taste rank
		Root	Biomass		SPVD	Alternaria	
	Dimbuka-Bukululа	18.7	34.0		2.0	1.1	4
	Nayiloni (Check)	9.8	25.6		2.0	1.0	6
	Mean	14.4	29.5		1.9	1.1	NA
	LSD0.05	5.1	5.6		NS	NS	NA
Wakiso 2006							(n=21; m=5, f=16))
	NASPOT 7	9.2	30.9		2.2	1.2	6
	NASPOT 8	11.4	33.7		1.4	1.1	3
	NASPOT 9 O	9.5	29.6		1.8	1.3	5
	NASPOT 10 O	5.8	17.9		2.0	1.4	2
	Dimbuka-Bukululа	11.1	36.1		2.2	1.2	4
	Nansana (Check)	9.9	36.2		2.6	1.2	1
	Mean	9.5	30.7		2.0	1.2	NA
	$LSD_{0.05}$	2.9	3.2		0.5	NS	NA

Figure 1. Cross section of roots and shoots of 'Dimbuka-Bukululа' compared with 'NASPOT 9 O', and 'NASPOT 10 O'