HortScience 51(5):597–600. 2016.

'Alisha', 'Anamaria', 'Bie', 'Bita', 'Caelan', 'Ivone', 'Lawrence', 'Margarete', and 'Victoria' Sweetpotato

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Additional index words. Ipomoea batatas, additive main effect multiplicative interaction, antioxidant, biofortification, provitamin A, multienvironment trials

It takes on average 7 to 8 years to breed a suitable sweetpotato cultivar in Africa adapted to local farmer and consumer needs. For southern Africa, the major sweetpotato breeding objectives are high storage root and vine yield, high β-carotene levels, and drought adaptation. Orange-fleshed sweetpotato (OFSP) cultivars alleviate vitamin A deficiency in African rural households (Hotz et al., 2012; Low et al., 2007). Furthermore, sweetpotato needs in southern Africa a critical amount of vine yield to plant the next growing season and for feed, particularly where land availability is scarce. However, food and fodder dual-purpose cultivars were not available in African sweetpotato germplasm (Niyireba et al., 2013) until the recent release of RW cultivars by the Rwanda Agriculture Board and the International Potato Center (CIP) (Shumbusha et al., 2014). Purple-fleshed sweetpotatoes (PFSP) are the sources of antioxidants (Teow et al., 2007), and anthocyanins derived from PFSP affect the growth of human retinal pigment damage-protective activities on epithelial cells (Kubow et al., 2016; Sun et al., 2015). Moreover, PFSP can be used for natural food coloring, which is a relatively new market for sweetpotato and cultivars high in anthocyanin, are increasingly becoming popular in Asia used fresh or in a variety of processed snacks (Gilbert, 2005; Timberlake and Henry, 1988). This is a report on nine new cultivars bred together by CIP and the Instituto de Investigação Agrarian de Mozambique (IIAM).

Origin

The nine new cultivars are known as (breeding code used during evaluation in brackets): 'Alisha' (Uejumula-U07-13), 'Anamaria' (MUSGP0646-126), and 'Ivone' (MUSG11022-11) OFSP; 'Bie' (MUSG11049-7), 'Caelan' (MUSG11016-6), and 'Margarete' (MUSG11016-1) PFSP; and 'Bita' (MUSG11016-12), 'Lawrence' (MUSG11016-16), and 'Victoria' (MCKSG0820-6) dual-purpose sweetpotato (Fig. 1). This sweetpotato germplasm was derived from either an open-pollinated polycross breeding nursery or a biparental crossing block setup by CIP in Mozambique. The parents were African landraces, CIP breeding clones, and cultivar introductions. 'Alisha', 'Anamaria', and 'Victoria' are selections from an open-pollinated progeny polycross nursery and their female parents are 'Ejumula', '105421', and '98-21-1', respectively, while their male parents are unknown. 'Bie' and 'Ivone' are selections from the biparental crosses 'Tacna' × 'Resisto' and 'Manhissane' × 'Resisto', respectively, while 'Bita', 'Lawrence', 'Margarete', and 'Caelan' are selections from 'Huambachero' × 'Resisto'.

Description and Production

The nine sweetpotato cultivars (Table 1; Fig. 1) were characterized using descriptors developed by CIP, Asian Vegetable Research and Development Center (AVRDC), and International Board for Plant Genetic Resources (IBPGR) (1991). These cultivars are either semierect or spreading plant type with short and thin internodes. Most cultivars have green vine pigmentation except the PFSP 'Margarete' and 'Bie', whose predominant vine pigmentation is purple. 'Bie', 'Bita', 'Caelan', and 'Margarete' have a purple secondary pigmentation. The mature leaf shape descriptors are diverse among these nine clones, while their foliage is mostly green except for 'Victoria' and 'Ivone' that have purple foliage or green foliage with a purple edge, respectively. Most cultivars have purple petiole pigmentation except 'Alisha', 'Anamaria', and 'Ivone'. Their storage root shape is either elliptic (most of

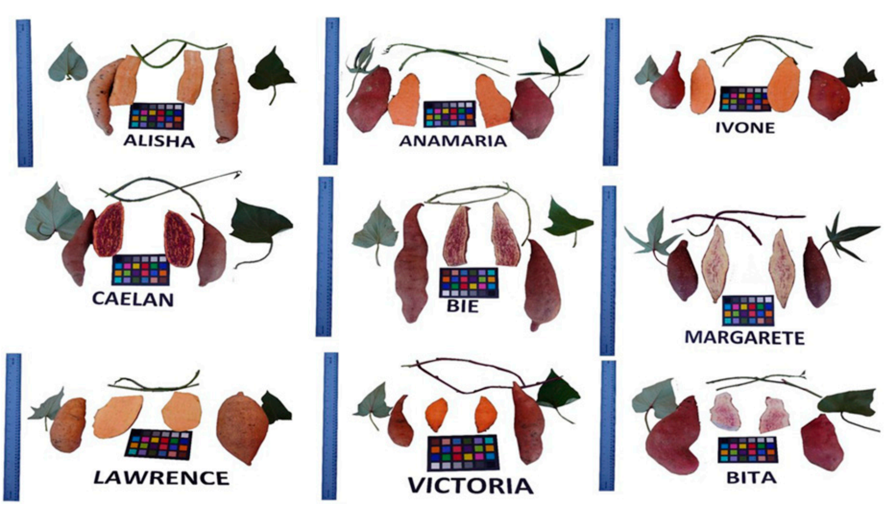

Fig. 1. Foliage and storage root of sweetpotato bred cultivars with orange and mostly purple flesh cultivars evaluated in Mozambique, 2011 to 2014: 'Alisha', 'Anamaria', and 'Ivone' orange-fleshed (top row); 'Caelan', 'Bie', and 'Margarete' purple-fleshed (center row); and 'Lawrence', 'Victoria', and 'Bita' dual-purpose.

Received for publication 19 Nov. 2015. Accepted for publication 7 Mar. 2016.
This work was supported in part by a grant from the Bill & Melinda Gates Foundation and USAID.
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Table 1. Morphological descriptors of nine sweetpotato newly bred cultivars evaluated in Mozambique, 2011 to 2014.[z]

	Cultivar								
Descriptor	Alisha	Ivone	Anamaria	Victoria	Lawrence	Bita	Caelan	Margarete	Bie
Breeding codes	Uejumula-U07-13	MUSG11022-11	MUSGP0646-126	MCKSG0820-6	MUSG11016-16	MUSG11016-12	MUSG11016-6	MUSG11016-1	MUSG11049-7
Plant type									
Type	Spreading	Semierect	Spreading	Spreading	Semierect	Extremely spreading	Spreading	Semierect	Semierect
Vine internode									
Length	Short	Very short	Very short	Short	Short	Short	Short	Short	Very short
Diameter	Very thin	Very thin	Very thin	Very thin	Very thin	Very thin	Thin	Thin	Thin
Vine pigmentation									
Predominant	Green	Green	Green	Purple	Green	Green	Green	Purple	Dark purple
Secondary	Absent	Green tip	Absent	Absent	Purple nodes	Purple tip	Purple	Absent	Absent
Mature leaf shape									
Outline	Triangular	Triangular	Lobed	Lobed	Almost divided	Triangular	Triangular	Almost divided	Almost divided
Lobe type	Very slight	Very slight	Moderate	Moderate	Very deep	Very slight	Very slight	Very slight	Very deep
Lobe number	1	1	5	5	5	1	1	7	5
Central lobe shape	Triangular	Triangular	Triangular	Semi-elliptic	Oblanceolate	Triangular	Triangular	Elliptic	Elliptic
Foliage color									
Mature leaf	Green	Green with purple edge	Green	Mostly purple	Green	Green	Green	Green	Green
Abaxial leaf vein	Green	Green	Green	Green	Green	Green	Purple spot at the base of main rib	Purple	Green
Immature leaf	Green with purple edge	Green with purple edge	Green with purple edge	Mostly purple	Mostly purple	Mostly purple	Mostly purple	Slightly purple	Slightly purple
Petiole pigmentation	Green	Green	Green	Purple	Green with purple near leaf	Purple	Mixture of purple and green petioles	Purple	Purple
Flowering									
Habit	Absent	Sparse	Absent	Absent	Absent	Absent	Absent	Profuse	Sparse
Storage root									
Shape	Long elliptic	Elliptic	Elliptic	Elliptic	Long elliptic	Ovate	Ovate	Elliptic	Long elliptic
Surface defects	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Skin color									
Predominant	Cream	Red	Red	Brownish orange	Orange	Purple-reddish	Red	Dark purple	Dark purple
Intensity	Intermediate	Intermediate	Dark	Intermediate	Intermediate	Intermediate	Dark	Intermediate	Intermediate
Secondary	Absent	Absent	Absent	Absent	Absent	Red	Absent	Absent	Absent
Flesh color									
Predominant	Intermediate orange	Toward deep orange	Dark orange	Dark orange	Intermediate orange	White with anthocyanins	Light orange with anthocyanins pigments	Strongly pigmented with anthocyanins	Pigmented with anthocyanins
Secondary	Absent	Absent	Absent	Absent	Yellow	Purple	Absent	Absent	Absent
Flesh group	Orange-fleshed sweetpotato						Purple-fleshed sweet potato		

[z]Following CIP, AVRDC, and IBPGR (1991).

them) or ovate ('Bita' and 'Caelan') and none has surface defects. The skin color varies from cream to dark purple (only in PFSP), while their flesh is either orange (most of them) or purple ('Bie', 'Bita', 'Caelan', and 'Margarete').

Performance Across Mozambique as a Proxy for Southern Africa

True seeds were scarified with concentrated sulfuric acid, and thereafter germinated to get seedlings whose vine cuttings were used to establish the breeding trials with two replications. There were 30,836 clones included in breeding trials from 2011 to 2014, of which 72 (27 OFSP, 25 PFSP, and 20 dual purpose) had high yield and were therefore selected for multienvironment trials (METs) at experimental stations of the IIAM in Chokwe (Gaza Province; 24°32 S, 33°01 E, 33 masl; silt clay loam, brown to dark grey soils, deep soils; April–November: 623 mm rainfall; a drought-screening site in semiarid agroecology), Gurue (Zambézia Province; 15°19 S, 36°6 E, 1000 masl; red to dark brown soils, clay loam, deep, well drained, good natural fertility; July–September: 1000 mm rainfall; virus-screening site), and Umbeluzi (Maputo Province, 26°03 S, 32°23 E, 12 masl; alluvial stratified soil: sandy loam in the top soil to sandy at 1.75 m depth; available water capacity of 200 mm at the 1.75 m deep soil profile; May–September: 679 mm rainfall).

The experimental layout of each MET was a randomized complete block design with four replications comprising 23 plants per plot for data recording. The data were analyzed using SAS (SAS Institute, Inc., 1997) for each MET separately and across respective MET set by an analysis of variance with a least significant difference comparison.

The new sweetpotato bred cultivars due to their orange flesh had almost 4-fold significantly ($P \leq 0.05$) greater storage root yield than control cultivar, Chingova (Table 2), while two of them, 'Alisha' and 'Ivone', had significantly lower dry matter content than the control cultivar, Chingova (Table 3). The foliage yield and harvest index of these bred cultivars were significantly above that of the cultivar control.

The storage root yield of the dual-purpose sweetpotato 'Bita', 'Lawrence', and 'Victoria' was not significantly higher than the control cultivars, while their foliage yield was within the range of the control cultivars, and that of 'Bita' equal or significantly above that of the control cultivars (Table 4). The harvest index of 'Lawrence' was significantly higher than all control cultivars, while that of 'Victoria' was significantly above that of 'Resisto'. The dry matter content of the storage roots of 'Bita' and 'Lawrence' was significantly higher than that of 'Jonathan'.

The storage root yield and harvest index of the highest yielding PFSP, 'Margarete' were significantly greater than the average of the trial mean (Table 5), while the other PFSP, 'Caelan', had a significantly higher dry matter content than the trial mean.

Quality

The β-carotene content in the flesh of the storage roots of the OFSP 'Alisha' and 'Ivone' was higher than those of the highest yielding control cultivar Chingova (Table 3). The dual-purpose sweetpotato, 'Victoria', had significantly higher Fe and Zn content than the control cultivars (Table 4), while the Fe content in the storage roots of 'Alisha' was also high. The taste of the OFSP was equal or better than that of the cultivar checks (Tables 3 and 4), while that of the PFSP was above the average of the evaluated genotypes (Table 5). PFSP cultivars show high anthocyanin in their roots (Xu et al., 2015), and their derived products such as fermented juice may contain essential antioxidants and show suitable sensory quality (Ray et al., 2011). These dual-purpose, OFSP and PFSP

Table 2. Storage root and forage yields of new orange-fleshed sweetpotato bred cultivars evaluated in sites in Mozambique, 2011 to 2014.

	Storage root yield ($t \cdot ha^{-1}$)				Foliage yield ($t \cdot ha^{-1}$)			
Cultivar	Chokwé	Gurué	Umbeluzi	Mean	Chokwé	Gurué	Umbeluzi	Mean
Alisha	25.3	19.3	8.5	17.7	26.1	17.4	18.0	20.5
Ana María	25.1	22.4	7.9	18.5	26.8	19.4	23.7	23.3
Ivone	26.8	19.9	7.4	18.0	24.0	29.3	20.7	24.7
Chingova (control)	5.4	6.6	1.9	4.7	20.7	17.7	18.8	19.1
$LSD_{0.05}$	6.5	6.4	7.8	6.9	8.1	6.2	10.3	8.2

LSD = least significant difference.

Table 3. Dry matter (DM), harvest index (HI), β-carotene (BC), iron (Fe), zinc (Zn) content and taste orange-fleshed sweetpotato bred cultivars evaluated across sites (Chokwé, Gurué, and Umbeluzi) in Mozambique, 2011 to 2014.

			BC	Fe	Zn	
Cultivar	DM[z] (%)	HI[y]	$mg \cdot 100\ g^{-1}$ (dry wt)			Taste[x]
Alisha	29.4	0.45	24.94	1.95	1.29	3.08
Ana María	30.0	0.43	4.56	1.69	1.16	3.78
Ivone	25.6	0.39	27.56	1.63	0.97	3.00
Chingova (control)	36.1	0.19	2.89	1.08	0.83	1.92
$LSD_{0.05}$	5.7	0.17	11.70	0.44	0.30	1.66

[z]Dry matter content (DM, %) was calculated using dry weight as a percentage of fresh weight by taking a sample of about 100 g after bulking three roots and oven drying at 70 °C for 72 h.
[y]Harvest index was computed as a percentage of root yield over biomass yield (Root yield/root yield + vine yield).
[x]Root cooking taste (COOT1) with the aid of a 1–5 scale, where 1 = very bad, 2 = bad, 3 = average, 4 = good, and 5 = excellent.
LSD = least significant difference.

Table 4. Storage root (SRY) and foliage (FY) yields, dry matter (DM), harvest index, β- carotene (BC), iron (Fe), zinc (Zn) and taste of dual-purpose sweetpotato bred cultivars evaluated at three sites (Chokwé, Gurué, and Umbeluzi) in Mozambique, 2011 to 2014.

					BC	Fe	Zn	
Cultivar	SRY ($t \cdot ha^{-1}$)	FY ($t \cdot ha^{-1}$)	DM[z] (%)	HI[y]	$mg \cdot 100\ g^{-1}$ (dry wt)			Taste[x]
Victoria	16.6	17.0	24.6	0.49	19.37	2.14	1.45	2.67
Bita	14.4	28.9	36.6	0.33	26.63	1.61	1.03	2.00
Lawrence	17.2	12.3	31.0	0.59	20.16	1.81	1.22	2.42
Resisto (control)	7.5	11.7	27.5	0.30	15.60	1.83	1.19	3.00
Jonathan (control)	10.0	8.8	23.6	0.34	14.15	1.54	0.93	2.22
$LSD_{0.05}$	9.1	10.1	3.3	0.18	7.51	0.27	0.17	1.51

[z]Dry matter content (DM, %) was calculated using dry weight as a percentage of fresh weight by taking a sample of about 100 g after bulking three roots and oven drying at 70 °C for 72 h.
[y]Harvest index was computed as a percentage of root yield over biomass yield (Root yield/root yield + vine yield).
[x]Root cooking taste (COOT1) with the aid of a 1–5 scale, where 1 = very bad, 2 = bad, 3 = average, 4 = good, and 5 = excellent.
LSD = least significant difference.

Table 5. Storage root (SRY) and foliage (FY) yields, dry matter (DM), harvest index, iron (Fe) and zinc (Zn) content, and taste of purple-fleshed sweetpotato bred cultivars from a breeding population that was evaluated at three sites (Chokwé, Gurué and Umbeluzi) in Mozambique, 2011 to 2014.

					Fe	Zn	
Cultivar	SRY ($t \cdot ha^{-1}$)	FY ($t \cdot ha^{-1}$)	DM[z] (%)	HI[y]	$mg \cdot 100\ g^{-1}$ (dry wt)		Taste[x]
Margarete	29.0	23.5	30.1	0.53	1.51	1.04	3.58
Caelan	17.8	30.9	36.2	0.32	1.30	0.86	2.92
Bie	17.5	18.5	27.9	0.46	1.50	0.98	2.92
Trial mean	10.1	21.2	32.7	0.30	1.61	1.09	2.83
$LSD_{0.05}$	9.1	10.1	3.3	0.18	0.27	0.17	1.51

[z]Dry matter content (DM, %) was calculated using dry weight as a percentage of fresh weight by taking a sample of about 100 g after bulking three roots and oven drying at 70 °C for 72 h.
[y]Harvest index was computed as a percentage of root yield over biomass yield (Root yield/root yield + vine yield).
[x]Root cooking taste (COOT1) with the aid of a 1–5 scale, where 1 = very bad, 2 = bad, 3 = average, 4 = good, and 5 = excellent.
LSD = least significant difference.

cultivars may lead to changes in sweetpotato consumption in Mozambique and neighboring countries in southern Africa. A social marketing strategy targeting diverse users could facilitate their spread and use on the continent. Capacity building through training on postharvest processing, seed multiplication, and marketing may contribute further to this endeavor.

Availability

The nine sweetpotato bred germplasm proposed for cultivar release are kept in the CIP breeding nursery in Mozambique. They are available for further use from CIP, which distributes its germplasm using a material transfer agreement. Requests for the dual-purpose, OFSP and PFSP should be sent to Dr. Maria Andrade, International Potato Center, IIAM, Av. FPLM 2698, P.O. Box 2100, Maputo, Mozambique or to M.Andrade@cgiar.org.

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