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Survival of sweetpotato (*Ipomoea batatas* [L] Lam) vines in cultivars subjected to long dry spells after the growing season in Mozambique

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Abstract: Optimisation of sweetpotato production potential is not realized in sub-Saharan Africa where dry spells are common after the growing season. Lack of seed cultivars at the beginning of the rainy season is the challenge and identifying those cultivars with the ability to survive a 4 to 7-month dry spell is an important objective in these regions. To this end, the purpose of the present study was to estimate survival of vines of different cultivars under drought stress. Three harvesting times set as 5, 9 and 11 months after planting were established at Umbeluzi, Nwallate and Gurue in 2015. For each harvesting time, 37 clones were evaluated in a randomized complete block design with two replications. Data collected on yield, vine length and number of sprouts were analysed using SAS 1996. Resisto had long stems but no vines after 9 months at any of the sites. The ability of some clones to reach 9 months and 11 months with few vines at Umbeluzi and Nwallate offer sources of planting material for the subsequent season. Sprouting had broad sense heritability above 50%. Sprouting is known to be an important aspect of cultivar survival. While we show that vine length and thickness could be traits responsible for sweet potato drought tolerance

Keywords: plant morphology, photosynthates, sweetpotato, sprouting, biomass

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1 Introduction

A number of factors limit sweetpotato productivity in the world, considering that the majority of the producers are smallholder farmers. One of the greatest challenges is obtaining seed material at the beginning of the planting season especially in Southern Africa where rainfall is unimodal and the gap between dry and wet season may be as long as 5 to 8 months (Barker *et al.* 2012). In this region, the majority of smallholder farmers use farm-saved, vegetatively propagated seed (Gibson *et al.* 2009). A study by Labarta (2008) in six villages in Mozambique demonstrated the difficulty of conserving planting material by smallholder farmers. Only 37% of the farmers that had received vines of orange-fleshed sweetpotato in two previous seasons managed to retain them for planting in 2008. Scarcity of surviving varieties also affects farmers' choices (Kapinga *et al.* 1995).

The long dry spells experienced in Southern Africa after the main crop growing season have a negative impact on conservation of sweetpotato vines and timely re-supply at the beginning of the rainy season (Barker *et al.* 2012). Innovative measures need to be put in place to allow farmers to obtain planting material at the right time early in the rainy season. One way is by conserving and multiplying vines near water bodies such as dams, perennial rivers and boreholes. Major constraints associated with this policy include (i) lack of water bodies in all areas and (ii) high competition for water during the dry season by people, animals and other high value horticultural crops which serve as food sources at this critical time (Gibson *et al.* 2011). Sweet potato varieties which put out vines which can survive through the dry period or viable options of root storage offer easier ways of ensuring that farmers get planting material on time. The single most important improvement to sweetpotato seed production is generating an abundance of appropriate plant material which can be made available for planting at the beginning of the rainy season (Gibson *et al.* 2009).

Little has been done to study the heritability of vine survival of sweetpotato cultivars exposed to prolonged dry spells after the growing season. To unlock the role of sweetpotato in food security and livelihood improvement, studies in vine survival are important (Mwinje *et al.* 2014). The objectives of this study were to estimate survival of vines of different sweet potato clones under drought stress and document their root-sprouting abilities after four months of storage.

2 Materials and methods

A total of 37 genotypes were evaluated for heritability of vine survival (Table 1).

Each of Three treatments was a different harvesting time; 5, 9 and 11 months after planting at 3 sites: Umbeluzi, Nwallate and Gurue in February 2015. A single row 4 m long was assigned to each genotype, organized as a randomised block design with two replications. A row-to-row distance of 0.9 m and a plant-to-plant spacing of 0.3 m was maintained. Data on storage root yield, vine yield, vine length, petiole length and stem diameter were recorded. After the first harvest at 5-months 10 small and medium sized roots were selected from Umbeluzi and Nwalate and stored in dry sand at Nwalate. Five of the stored roots were drawn in November 2015 and planted in a seed nursery for sprouting. Data on the number of sprouts at 2 and 3 weeks and length of the vines at 5 weeks, vine yield and length at 5 months were recorded. The collected data were analysed using SAS 1996.

3 Results

A combined analysis of morphological data (vine length, number of branches per plant, petiole length and stem diameter) measured at 90 days after planting across the three sites showed differences among genotypes. The means for these traits are presented in Table 2. Variation of vine length ranged between 68.07 cm to 175.80 cm while number of branches per plant was between 6 and 15.

Storage root and vine yield recorded at 5, 9 and 11 months after planting differed widely among genotypes. Table 3 shows the means for the two traits across Umbeluzi, Nwalate and Gurue Research Stations. The population means for storage root yield decreased from 31.86 t/ha at 5 months after planting to 15.86 t/ha at 11 months after planting. The most sensitive genotypes were Resisto and Nhacoongo 1.

Table 1: List of germplasm evaluated for the heritability of vine survival trait

No.	Genotype	Merit	No.	Genotype	Merit
1	Xitsekele	Local cultivar	20	Japon	Foreign
2	Namanga	Released in 2011	21	Nhacoongo 1	Local cultivar
3	Cordner	Foreign	22	Chissicuana 2	Local cultivar
4	Lourdes	Released in 2011	23	Caromex	Local cultivar
5	Melinda	Released in 2011	24	NASPOT	Foreign
6	Irene	Released in 2011	25	NASPOT 5	Foreign
7	Delvia	Released in 2011	26	SPK-004	Foreign
8	Ininda	Released in 2011	27	Resisto Moz	Check
9	Amelia	Released in 2011	28	Nhacutse 1	Local cultivar
10	Xiadla-xau	Local cultivar	29	Jonathan Moz	Check
11	Jane	Released in 2011	30	Lo323	Foreign
12	Gloria	Released in 2011	31	Tacna	Foreign
13	Esther	Released in 2011	32	MGCL01	Foreign
14	Mwazambane	Local cultivar	33	5 houras	Local landrace
15	Lawrence	Released in 2016	34	Chingova	Foreign
16	Bita	Released in 2016	35	Caelan	Released in 2016
17	Alisha	Released in 2016	36	MUSG11016-1	Released in 2016
18	Bie	Released in 2016	37	Victoria	Released in 2016
19	Ivone	Released in 2016			

The number of sprouts per root and vine length also differed widely among genotypes. Table 4 shows the genotypic means for the traits measured for the sprouting experiments. Bita and Bie had the longest and shortest vines respectively at 5 weeks after sprouting. The number of sprouts per root increased with the number of days.

Broad sense heritabilities for some of the measured traits ranged from 28.67 to 84.48% (Table 5).

Table 2: Genotypic means for vine length (cm), number of branches per plant, petiole length (cm) and stem diameter (mm) measured at 90 days after planting of analysed data across Umbeluzi, Nwalate and Gurue Research Stations in 2015

Genotype	Vine length (cm)	No. Of branches	Petiole length (cm)	Stem diameter (mm)
Caelan	175.80	6.73	21.63	5.8
Xiada-xikau	156.73	8.60	19.53	6.9
Alisha	155.77	5.40	20.90	6.3
MGCLO1	155.53	11.22	14.81	5.3
Resisto	152.15	5.77	12.00	2.8
Xitsekele	150.05	11.23	14.28	5.6
Bita	135.87	8.83	22.87	6.7
Tacna	134.60	13.50	19.53	7.2
5 Horas	133.03	6.22	18.06	6.7
Nhacoongo 1	124.54	15.00	16.27	3.1
Glória	120.40	9.90	21.10	6.1
Melinda	119.33	10.00	17.10	5.4
Delvia	116.12	10.63	21.17	6.0
Chissicuana 3	113.53	8.00	16.93	7.3
Nhacutse 1	110.45	11.41	17.47	5.5
Ivone	109.67	13.93	17.43	4.5
Victoria	107.33	7.50	17.87	6.5
Jonathan	101.37	9.72	16.40	7.3
Lawrence	100.80	7.70	18.13	6.2
Amelia	97.43	8.70	20.03	6.4
Lourdes	96.30	8.90	14.73	6.6
Naspot 5	90.73	9.53	22.00	6.1
Chissicuana 2	90.51	10.33	15.35	7.3
Namanga	87.87	9.57	15.38	4.2
Jane	87.08	11.68	19.60	6.2
Mwazambane	86.82	9.65	16.13	5.3
Esther	86.70	6.50	11.97	5.1
Japon	85.47	10.60	17.17	6.1
Bie	84.87	6.77	19.50	6.7
Lo 323	80.33	7.77	17.63	7.1
Naspot	79.63	8.57	16.77	6.5
SPK 004	79.30	11.40	20.26	5.2
Irene	75.17	12.70	16.30	5.4
Ininda	71.40	11.27	20.43	5.2
MGSG 11016-1	71.13	7.63	15.97	7.0
Chingova	68.07	9.37	19.13	6.2
Mean	**108.11**	**9.51**	**17.83**	**5.94**

Table 3: Genotypic means for storage root yield (t/ha) and vine yield (t/ha) across Umbeluzi, Nwalate and Gurue in 2015

	RYTHa	**RYTHa**	**RYTHa**	**Vine yield**	**Vine yield**	**Vine yield**
Genotype	5months	9 months	11 months	5months	9months	11months
Namanga	19.75	22.73	24.05	28.83	16.65	4.93
Lourdes	17.23	17.60	23.13	31.35	24.63	16.04
Ininda	20.93	20.23	23.28	49.48	31.30	17.27
Irene	26.35	30.85	43.02	30.10	22.88	20.82
Delvia	26.83	31.30	22.39	30.83	17.68	18.97
Melinda	22.19	19.28	18.50	31.51	37.00	22.38
Amelia	11.63	14.39	18.18	41.21	18.57	17.95
Jane	9.80	20.63	7.40	38.30	21.05	6.11
Gloria	13.80	17.38	5.28	38.53	24.05	12.95
Esther	8.00	11.93	12.20	23.70	10.00	2.22
NASPOT	10.00	17.15	11.96	9.40	12.90	8.20
Japon	17.68	21.13	24.79	20.25	22.88	6.13
Nhacoongo 1	11.49	4.39	0.00	30.88	35.13	0.00
Chissicuana 2	27.28	29.65	29.48	29.28	14.35	18.63
Xitsekele	11.13	19.38	28.49	32.55	34.48	23.45
NASPOT 5	17.28	17.68	26.73	26.90	17.93	12.60
Mwazambane	15.18	20.33	29.39	29.25	31.28	22.33
TACNA	17.05	25.75	21.45	49.58	30.73	13.94
SPK-004	24.04	20.88	20.63	41.90	37.18	26.37
Resisto	12.05	17.60	2.30	15.13	12.38	0.00
Chingova	21.35	23.05	20.99	24.50	18.43	18.53
Bie	19.13	21.68	12.03	41.85	19.98	23.24
Jonathan	23.91	13.74	8.48	44.02	21.43	21.46
Nhacutse 1	16.24	16.08	3.70	42.76	23.20	3.70
LO323	24.28	23.53	13.05	27.23	16.68	11.38
Xiada-xikau	12.78	11.35	16.81	40.30	27.03	39.02
MGCL01	6.43	6.80	16.56	22.23	37.48	24.15
Bita	17.53	33.45	26.01	44.78	28.78	14.93
Chissicuana 3	13.93	20.65	27.75	23.83	16.65	17.07
5 Horas	13.33	19.80	18.81	37.18	18.23	18.75
Caelan	17.33	26.63	17.02	32.53	31.85	8.24
MGSG11016-1	17.25	26.93	10.42	14.13	18.80	2.99
Victoria	12.33	19.73	13.61	22.20	15.03	12.27
Lawrence	9.24	8.60	29.90	29.52	21.68	14.30
Alisha	25.80	34.80	18.81	32.85	18.20	11.10
Ivone	21.31	28.54	42.09	37.99	19.50	27.75
Mean	**17.00**	**20.43**	**19.13**	**31.86**	**22.94**	**15.84**

RYTHa: storage root yield (t/há)

Table 4: Results of the sprouting experiments at Umbeluzi, Nwalate and Gurue Research Stations in 2015 with number of sprouts during the second and third week as well as vine length at 5 weeks recorded. Vine length and yield were estimated as well at five months after the first sprouting date

	Vine length (cm)	**Vine length (cm)**	**No. Of sprouts**	**No. Of Sprouts**	**Vine yield (t/há)**
Genotype	**5 weeks**	**5 months**	**2 weeks**	**3 weeks**	**5 months**
Bita	126.82	208.88	9.89	11.13	45.57
Alisha	107.20	182.25	7.09	9.41	43.17
Xiada-xikau	101.13	165.00	8.33	8.09	47.17
TACNA	95.57	146.25	8.41	9.13	45.75
Mwazambane	94.18	97.00	6.71	7.38	30.99
Xitsekele	90.00	153.75	4.33	4.92	36.69
Chissicuana 3	87.15	118.25	5.75	6.75	33.45
Caelan	85.75	188.25	9.46	10.63	34.07
5 houras	81.83	147.00	8.04	8.12	41.30
Jonathan	76.55	119.75	3.42	3.58	25.29
Ivone	76.28	127.75	8.50	10.59	44.40
Nhacoongo 1	71.18	146.25	2.00	3.25	14.86
Victoria	70.28	126.00	4.75	7.50	38.23
Chingova	69.75	76.00	6.17	7.00	41.63
Ininda	69.38	89.00	7.67	7.33	49.95
NASPOT	62.93	94.75	5.24	8.91	44.17
Chissicuana 2	60.75	106.75	7.50	9.00	25.29
Irene	58.18	87.75	4.79	7.75	48.72
Delvia	56.80	124.50	9.50	12.42	45.02
Namanga	55.88	104.00	2.88	5.88	27.13
Lourdes	55.80	97.00	2.67	5.58	23.74
Melinda	55.67	150.25	4.03	5.93	26.08
NASPOT 5	53.50	107.00	7.17	8.84	36.08
Japon	53.50	96.50	6.50	8.29	30.06
Nhacutse 1	50.32	118.00	1.91	3.13	19.06
MGCL01	49.61	169.50	1.58	4.43	23.68
Lawrence	49.13	131.25	7.00	8.42	33.30
MGSG11016-1	46.08	78.50	4.92	6.25	33.15
Gloria	45.55	144.00	8.17	9.41	37.62
Cordner	44.55	82.50	3.42	4.58	26.91
Caromex	43.45	109.50	7.21	8.33	46.56
Jane	42.25	98.75	7.92	11.34	26.08
Lo323	38.92	96.75	9.75	9.92	39.47
SPK-004	28.57	94.75	6.89	9.78	40.57
Amelia	20.82	115.50	3.36	4.54	40.02
Resisto	19.08	146.25	0.50	2.71	12.18
Bie	5.82	69.38	4.58	7.38	9.81
Mean	**62.17**	**122.01**	**5.89**	**7.50**	**34.25**

Esther was excluded from the analysis due to rotten root samples

Table 5: Broad sense heritabilities for the measured traits across Umbeluzi, Nwalate and Gurue Research Stations in 2015

Trait	Broad-sense heritability (h2) (%)
Leaf size (cm)	84.48
Petiole length (cm)	79.08
Number of branches	68.54
Vine length (cm)	56.62
Number of sprouts at 3 weeks	56.42
Foliage biomass (kg/ha) at 9 months	39.49
Storage root yield (kg/ha) at 9 months	28.67

4 Discussion

The current study demonstrated the variation in vine survival that can occur among genotypes based on vine yield at 9 and 11 months after planting. The leaf canopy for Nhacoongo 1 and Resisto failed before 11 months. Resisto has previously been described as drought sensitive (Laurie *et al.* 2009). Contrary to Nhacoongo 1 and Resisto, there was another group of genotypes that had high vine yield at 11 months: Irene, Melinda, Xitsekele, MGCL01, Ivone and Xiadla-xikau. Previous reports indicated that MGCL01 (Persistente) was the most drought resistant OFSP variety in Zambezia Province (Barker *et al.* 2012).

Seeds are nature's answer to surviving adverse conditions, such as prolonged dry seasons. All the genotypes tested here sprouted, though at different rates. By five weeks after sprouting Bita, Alisha, Xiadla-xikau, Tacna, Mwazambane and Xitsekele had vine length enough to provide more than 8 cuttings for rapid multiplication. Other cultivars such as Irene, Ininda and Delvia also had long vines ready for cutting. The abundance of foliar cuttings on a sweetpotato allows wider distribution. The number of branches per plant is important in biomass production and Uganda farmers actually grow some varieties because of the amounts of vines they produce (Okonya *et al.* 2014). This could be the reason why most of the landraces are popular among farming communities despite their low storage root yield. Bie is a difficult variety to multiply even under field conditions (Maria Andrade personal communication). It is not surprising that it had smallest vines five weeks after sprouting.

Some traits such as vine length and other morphological traits measured contribute to vine survival and have high heritability. Vine length and stem diameter are key to vine survival. Resisto and Nhacoongo 1 had average stem diameter of 2.8 and 3.1 mm respectively, making them the thinnest cultivars in the study and their vines could not survive upto 11 months. These two genotypes are spreading with thin stems. Cultivars with Erect (short) and thick stems had a better survival rate during prolonged dry spells.

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