Understanding Drought Tolerance: Top Five Performers in Mozambique and their Characteristics

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Drought

- Droughts have affected **more people worldwide in the last 40 years** than any other natural hazard
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- From 1970 to 2000 the % of our planet stricken by serious drought **has more than doubled**

- 84% of the losses in developing countries caused by droughts **are to the agriculture sectors**
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- **12 Million hectare** are lost due to drought and desertification each year, an area where 20 million tons of grain could have been grown.
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Definition of drought

- There are as many possible definitions of drought

- In our context, drought is defined as the shortage of available water, which includes rainfall and stored soil moisture in quantity during the life cycle of sweetpotato.
- Causes are: low and unevenly distributed rainfall

Background

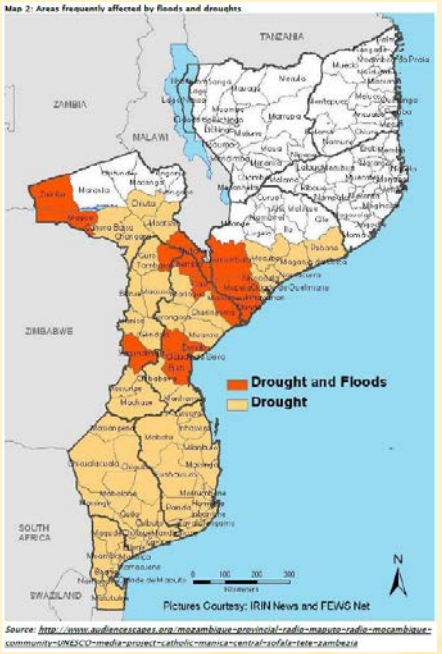
Mozambique has experienced 13 significant drought years between 1979 and 2016.
Adaptive trials resulted in the release of nine OFSP varieties in 2000.

In 2002 these varieties were widely distributed in southern Mozambique as a post-flood disaster recovery initiative.

They performed well in southern and central Mozambique until three seasons of consecutive drought hit in 2005.

- **Resisto**
- **Canasumana**

Breeding varieties to survive drought is a complex process.



For a variety to be permanently adopted, it needs to have vigorous vines and roots left in the ground at harvest (a traditional source of planting material) must sprout well at the beginning of the rains.

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Complexity of drought

- Occurrence, duration and magnitude of drought during the crop life cycle vary from place to place and from time to time.

- Three distinct categories of drought were defined by Ludlow and Muchow (1990) as early season, intermittent/mid-season and terminal depending on where it occurs during crop development.

Early season drought

- Early season drought might occur due to the delayed onset of rain that signals the beginning of the planting season.

- Another scenario for early season drought is that rain does come but is inadequate for vine establishment or before root initiation.

➢ Causes poor plant stand in the field and reduced yield

Intermittent drought

- Intermittent drought is a result of sporadic rainfall that causes intervals of drought at varying intensities during the vegetative phases of crop growth and root initiation phases (4 to 8 weeks after establishment).

- Depending on intensity and frequency of occurrence, crops become stunted in growth and the leaf area development becomes reduced

Terminal drought

- Terminal drought occurs when the crop encounters moisture stress during the root bulking stages due to an early ceasing of rains during the rainy season.

Drought mechanisms

Plants have developed a number of physiological and metabolic strategies to proof themselves against drought stress.

Broadly, these strategies may be classified into three groups namely drought escape, drought avoidance and drought tolerance.

Drought escape

Drought escape is the ability of a plant to complete its life cycle before severe soil and plant water deficits occur.

The mechanism involves early root formation and maturity.

Better mechanism in areas facing terminal drought

Benefits: the crop can provide the first food and first marketable product before harvesting of cereal crops.

Drought avoidance

Plants adjust their metabolic and physiological processes once they sense drought, in order to adapt to the changing environment.

Dehydration avoidance and dehydration tolerance are two main mechanisms

Dehydration avoidance is supported either by:

- efficient water absorption from roots or
- reducing transpiration from aerial parts (Levitt 1980).

One common challenge across SASHA

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Survival of planting material – vine survival

Considerable amount genetic variation for vine survival

Integrated approach needed Agronomy & Breeding

Genotype classes showing selection indices and the number of genotypes per class for 58 sweetpotato genotypes grown at Umbeluzi , Mozambique in 2005/2006 and 2006/2007 seasons in selection for drought tolerance. A higher selection index indicates higher drought tolerance and all-round suitability for use by farmers and consumers.

- A: Xitsekele (22.78), ADMARC (20.50).
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- B: ST 870030 (19.20), Xiadla xa kau (19.17).Manhissane (18.54), **Canassumana** (18.48), Tacna (18.45),
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- C: 03/12/1998 (17.52), Ligodo (17.27), Cordner (17.11), Xihetamakote (16.82). Nhacutse 4 (16.63), 199062.1 (16.45), **Resisto (16.37),** Atacana (16.26), UNK0Malawe (16.21), Cinco Minutos (15.78).

Top 5 drought tolerant varieties in Mozambique

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Morphological characters related to drought tolerance

Variety name	Foliage biomass (t/ha)	Vine length (cm)	Stem diameter (mm)
Irene	22.32	75.17	5.4
Sumaia	24.89	93.4	5.6
Delvia	23.17	116.12	6.0
Ininda	25.39	71.40	5.2
Alisha	27.5	155.53	6.3
Xitsekele (local check)	21.2	150.05	5.6
Resisto (sensitive check)	10.5	152.15	2.8
Mean	**22.14**	**116.26**	**5.3**

Vine survival as a mechanism of drought tolerance

Variety name	Number of sprouts after 4 months of root storage	Length of sprouts 6 weeks after sprouting	Starch content (%) of roots at 5 month harvest	Starch content (%) at 4 months root storage
Delvia	14.37	78.42	68.70	64.61
Alisha	10.91	91.39	68.17	61.75
Irene	10.43	41.72	64.43	57.90
Ininda	9.16	56.38	65.57	59.89
Sumaia	11.64	53.75	66.30	60.10
Resisto	5.00	67.25	64.55	60.25
Mean	**10.25**	**64.41**	**67.14**	**60.76**

Storage root yield, Harvest Index and drought indices

Variety name	Storage root yield (t/ha) across optimal and drought environments	Harvest Index (%) across optimal and drought environments	Drought Tolerance Index	Drought Susceptibility Index
Irene	29.07	47	8.92	0.86
Ininda	27.92	49	7.68	0.81
Sumaia	26.05	47	4.28	0.5
Alisha	26.05	58	8.82	0.82
Delvia	14.75	44	4.35	1.14
Xitsekele	14.51	35	2.51	0.53
Resisto	12.70	26	12.23	1.68
Mean	**21.58**	**43.71**	**6.97**	**0.91**

Computation of drought indices

- DII=1- mean storage root yield of all clones under drought /mean storage root yield under irrigation.
- Drought stress index=(1-root yield in drought) / DII
- Drought tolerance index = mean storage root yield under irrigation – mean storage root yield under drought.

Early maturity

Name of variety	Commercial storage root yield (t/ha)		
	90 days after planting	120 days after planting	150 days after planting
Alisha	3.42	8.83	24.20
Irene	5.53	7.30	16.36
Delvia	5.14	5.57	16.89
Sumaia	4.81	6.91	17.44
Ininda	3.50	5.58	18.26
Resisto	0.0	1.58	14.54
Mean	**3.73**	**5.96**	**17.94**

Summary: Traits contributing to survival

Stem diameter and vine length are keys to vine survival under drought conditions

- Cultivars with thick stems had better survival rate during prolonged dry spells
- Cultivars with strong, short stems and small leaves are better than cultivars with long thin stems with numerous leaves

Summary: Early maturity

- Early maturing cultivars fit well in short growing seasons, especially now with the threats of climate change.
- High storage root yields at 3 months assist to break the hunger period and income generation where sweetpotato is a commercial crop
- Weevil damage and other root injuries are often associated with drought and significantly increased as harvesting was delayed.

Heritabilities of traits

Trait	Broad sense heritability (h^2) (%)
Vine length (cm)	56.62
Petiole length (cm)	79.08
Stem diameter (mm)	77.34
Foliage biomass at 9 months	39.49
Number of sprouts at 3 weeks	56.42

Conclusions and perspectives

Understanding mechanisms of drought tolerance forms the basis of developing drought tolerant crop varieties.

The use of drought indices together with HI and geometric or arithmetic yield means can facilitate selection of good cultivars.

Conclusions and perspectives

Dive into the dehydration avoidance mechanisms

1. Stomatal conductance
2. Deep rooting
3. Osmotic adjustment
4. Water Use Efficiency (WUE) &
5. QTL mapping of genes governing drought tolerance trait

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Thank you

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