Screening, yield evaluation and Drought Tolerance indices of Orange-Fleshed Sweetpotato (*Ipomoea batatas Lam*) hybrid genotypes

PhD thesis: Findings/Results

Sweetpotato Breeders Annual Meeting
Kigali, Rwanda April 22nd -26th 2013

Agili, Sammy- CIP,NAIROBI

Supervisors
Dr. Bernard Nyende
Prof. K. Ngamau
Dr. P. W. Masinde

SWEETPOTATO ACTION FOR SECURITY AND HEALTH IN AFRICA

Presentation outline

- Introduction
- Objectives for the study
- Experiment-1 In Vitro screening
- Experiment-2 Rapid field screening and selection
- Experiment-3 Multi-location field evaluation
- Experiment-4 Morpho-physiological traits responsible for drought tolerance in sweetpotato genotypes
- Overall conclusions and recommendations
- Current status

Importance of sweetpotato

- Major source of food/nutrition in developing countries
- Food security crop- low/ease of production/ability to produce under adverse weather/soil conditions
- Short maturity period/possible to have two crops in a year
- OFSP types-contains sufficient levels of beta carotene

Types of sweetpotato based on root-flesh color

Dark orange High β- carotene

-ight orange

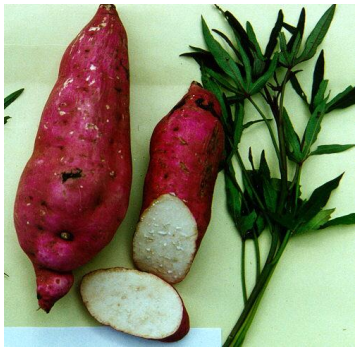
-Orange with yellow patches

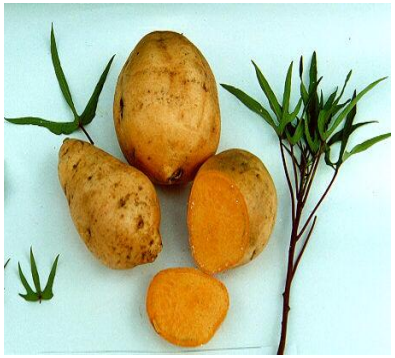
-Yellow with orange patches

-Yellow

-cream Low β- carotene

-white

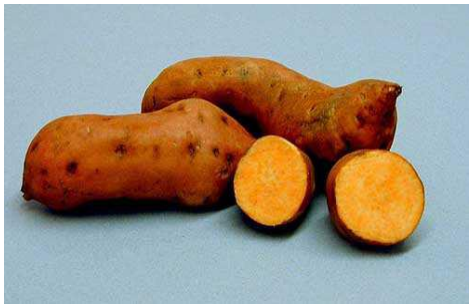




Why OFSP T

- Vitamin A deficiency in SSA
- Current efforts to address vitamin A deficiency
- Easiest way to introduce more vitamin A into diet is to consume OFSP why ?
- Current efforts of promoting OFSP in SSA
- Challenges in promoting OFSP in the region

OBJECTIVES



- **Overall objective for the study**
- To identify through selection, high yielding drought tolerant OFSP genotypes
- **Specific objectives**
  - Screen and select OFSP genotypes for drought tolerance
  - Multi-location screening for OFSP genotypes with high nutrition and drought tolerance
  - Selection for high yielding OFSP genotypes in drought conditions
  - Identify morpho-physiological traits responsible for drought tolerance in SP

Genetic material

Consisted of 59 out of 72 genotypes received from CIP. 13 genotypes never survived and were not evaluated. These genotypes had contrasting beta carotene and mineral content levels.

Experiment 1

In vitro screening of OFSP genotypes for drought tolerance using polyethylene glycol

- **Objective**
- Using *in vitro* screening to identify at early stages of development those OFSP genotypes that are either drought tolerant or susceptible

- **Place- Plant Tissue Laboratory, KEPHIS, Muguga**

Growth media/Growth conditions

- MS basal media + PEG (6000) at 0,10 and 15g/l
- 5 cuttings with 2-3 nodes/kilner jar/genotype/Factorial/CRB D/3 replications
- Growth condition- 10photoperiod/70µmol m^2/s, 28ºC for 65 days

Data gathered

- Root length (cm)
- Root dry weight (g)- dried for 48h at 65ºC
- Leaf Area (cm^2)
- Shoot length (cm)
- Shoot fresh weight (g)
- Shoot dry weight (g)- dried for 48h at 65ºC
- Data analysis-SAS version 8

Results

Effect of water stress on root length (cm) and Root dry weight (g) of 59 sweetpotato genotypes during in vitro screening using different concentrations of polyethylene glycol

Root length(cm)	Salt concentration (g/l)				Root dry (g)	Salt concentration (g/l)			
Genotype	0	10	15	Mean	Genotype	0	10	15	Mean
Marooko*	26.0a	22.0a	21.3a	23.1	Marooko*	1.3a	1.6a	2.2a	1.7
189135.9	33.0a	33.5a	35.3a	34.0	189135.9	6.0b	7.9a	5.0bc	6.3
194515.5	31.3a	33.3a	30.7a	31.8	194515..5	4.8a	0.6b	3.8a	3.1
441097	32.5a	34.2a	25.3a	30.7	441097	1.3bc	1.3b	3.5a	2.0
441768	32.7a	25.8a	22.2a	26.9	441768	5.9b	0.3a	5.4bc	3.9
441724	29.3a	25.0a	29.7a	28.0	441724	0.8b	2.7a	0.9c	1.5
440031	5.3a	4.3a	3.8a	4.5	440031	0.0a	0.0a	0.01a	0.0
440286	11.9a	2.9a	1.4a	5.4	440286	0.3a	0.0a	0.0a	0.1
420027	17.8a	3.6a	2.6a	8.0	420027	0.1a	0.0a	0.0a	0.0
K566632**	13.7a	8.0a	4.5a	8.7	K566632**	0.1a	0.0a	0.0a	0.0

Effect of water stress on shoot fresh and dry weight (g) of 59 sweetpotato genotypes during in vitro screening using different concentrations of polyethylene glycol

shoot fresh weight (g)	Salt concentration (g/l)				shoot dry weight (g)	Salt concentration (g/l)			
Genotype	0	10	15	Mean	Genotype	0	10	15	Mean
Marooko*	1.6a	1.6a	2.2b	1.8	Marooko*	0.7a	0.7a	1.0a	0.8
189135.9	6.45c	5.6b	2.8a	5.0	189135.9	2.8bc	2.4b	1.2a	2.1
194515.5	4.8a	4.3a	2.7b	4.0	194515.5	1.8bc	2.1b	2.6a	2.2
441097	4.1a	4.5a	5.7b	4.8	441097	2.0bc	1.9b	1.2a	1.7
441768	5.5c	4.8b	2.2a	4.2	441768	2.5bc	2.2b	4.4a	3.0
441724	6.1a	5.7a	3.1b	5.0	441724	1.4a	4.3c	0.1b	1.9
440031	0.3a	0.2a	0.0a	0.2	440031	0.1a	0.1a	0.0a	0.1
440286	0.3a	0.3a	0.1a	0.2	440286	0.2a	0.0a	0.2a	0.1
420027	0.3c	0.2b	0.3a	0.3	420027	0.4a	0.0a	0.0a	0.1
K566632**	0.2a	0.3a	0.0a	0.2	K566632**	0.1a	0.0a	0.0a	0.1

Effect of water stress on leaf area (cm^2) and shoot length (cm) of 59 sweetpotato genotypes during in vitro screening using different concentrations of polyethylene glycol

Leaf area (cm^2)	Salt concentration (g/l)				shoot length (cm)	Salt concentration (g/l)			
Genotype	0	10	15	Mean	Genotype	0	10	15	Mean
Marooko*	5.5a	6.5a	5.7a	5.9	Marooko*	7.2a	5.2a	8.5a	7.0
189135.9	7.0a	7.3a	5.2b	6.5	189135.9	15.3a	12.8a	13.2a	13.8
194515.5	4.2a	6.3b	6.4b	5.6	194515.5	10.3a	14.7b	12.2ab	12.4
441097	5.1a	9.5b	5.8c	6.8	441097	10.3bc	11.5b	18.2a	13.3
441768	5.7a	10.0b	6.5a	7.4	194539.36	9.3bc	10.0b	16.7a	12.0
441724	7.0a	11.3b	3.8c	7.5	441724	16.2a	16.0a	12.7ab	15.0
440031	0.6a	0.6a	1.5a	0.9	187017.1	10.3b	13.8a	14.9a	13
440286	1.1a	1.5a	0.6a	1.1	440286	5.8b	1.0a	1.2a	2.7
420027	2.8a	0.9a	0.8a	1.5	420064	10.3bc	11.5b	18.2a	13.3
K566632**	11.2a	2.0b	1.7b	5.0	K566632**	4.5a	3.5a	1.9a	3.3

Conclusions

- 10 genotypes were identified as drought tolerant:194515.5, 194539.36, 441724, 441538, 189135.9, 401055, 441768,192033.5, 440027 and 440429. All showed higher leaf expansion, higher stem length elongation, high root and shoot growth and high dry matter production at high salt concentration level
- Correct/clear expression of genotypes can be evaluated by this method using different PEG concentrations

Experiment 2

Rapid field screening and selection of OFSP genotypes having drought tolerance potential and high β-carotene

Objective

- Rapid field screening of 59 Sweetpotato genotypes in order to identify 10-20 promising drought tolerant OFSP genotypes that could be advance for further evaluation, testing and selection
-

Experimental site

- KARI Kiboko experimental field (Latitude 010 15’ S; Longitude 360 44’ E; Altitude 975m above the sea level).

- Climate data taken/soil samples collected from the experimental field analysis

Experimental design/treatment/crop husbandry

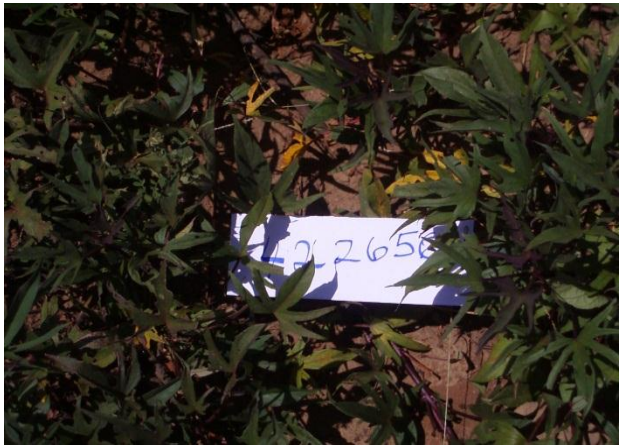
- RCBD- 3 replications/ plot size- 2.4m² row (2.4m x 1m) with 8 plants/plot.
- Vine tip cuttings 30cm length/ used as planting material
- Planting distance 0.30m (8 x 0.30 = 2.4m²).
- Two checks: - drought susceptible - K566632 & drought resistant - Marooko.
- crop irrigated 3-and 4-day intervals using a 15mx15m grid overhead sprinkler system with a 3-main sprinkler lines until four weeks after planting.
- Weeding done until sufficient ground foliage cover to smother the weeds was achieved.
- Earthing–up done during weeding/ seal any soil cracks through which roots could be exposed.
- Plants left to grow under natural conditions for a period of 5 months before harvesting

Data measurement

- Number of plants established per plot
- Vine vigor: was recorded in scores from 1-9
- Plants harvested per net plot
- Weight of the vines in kg per plot
- Number of plants with storage roots per net plot,
- Number of commercial roots per net plot
- Number of non-commercial roots per net-plot
- Weevil damage of the roots
- Root dry matter content
- Root flesh color
- Statistical analysis- GML model, SAS package (SAS, version 8 of SAS Institute, Inc, 1999.

Selection criteria for the promising genotypes for advanced screening and evaluation		
Variable/trait	Acceptable level	Comments
Root-flesh color	Orange-deep orange	Deep orange being an indicative of high beta carotene content Ejumula and Resisto to act as a basis for selection
Dry matter content	> 25% acceptable by most consumers	Resisto and Ejumula range is between 25- 27%
Average Yield	> 15 t/ha	
Total sum of ranking for various attributes †	Top 20 to be selected	
† Ranked summation index		

Results



Agronomic performance

- The dry matter range- 15 to 35 % with majority of the dark orange to orange genotypes falling below 30%.

- The foliage yield for most of the genotypes ranged from 4-15t/ha although generally recording high root yield.

- Dark orange to orange genotypes recorded high number of roots compared to the cream to white-fleshed genotypes.

- Total root yield ranged from 7.43 to 45.83t/ha.

- The selection criteria classified the genotypes into three major groups based on the flesh-color: Dark orange (21), Orange (12), Light orange (12), yellow (3) and light cream (11).

- In the screening trial, it was observed that β-carotene content was associated with storage root flesh color as reported by Zhang and Xie (1998) and Lin *et al* (1989).

- 47.5% of the genotypes screened had a dry matter content of 25%; 25.4% had dry matter content below 20% and 27.1% of the genotypes screened had dry matter content greater than 30% that was above that of Resisto and Ejumula.

- It was found that the intensity of the orange-flesh color was negatively correlated with dry matter content which is in confirmation with the observation of Hernandez *et al* (1967);

Ranking of observed attributes for sweetpotato genotypes screened at Kiboko

	Foliage vigor	Number of plants harvested	Number of plants with storage roots	Foliage fresh yield t/ha	Number of commercial roots	Total number of roots	Average number of roots/plant	Yield of commercial roots t/ha	Total root yield t/ha	% weevil damage	Total score of the ranking	Rank
187017.1	4	1	1	4	8	7	21	3	4	4	57	1
422656	2	1	1	31	1	1	6	15	16	1	75	3
420014	4	1	1	6	10	7	14	6	6	27	82	4
189135.9	12	31	26	54	2	2	3	12	11	12	165	11
440287	12	10	8	17	11	26	38	17	17	31	187	15
440286	12	25	21	20	31	19	30	29	25	18	230	19
K566632	44	10	8	16	38	16	32	27	31	8	230	19
194515.15		12	55	54	35	35	33	4	29	27	305	21
194549.6	4	25	26	22	21	39	40	37	41	39	294	28
441538	58	34	31	11	16	27	29	33	36	24	299	30

Ranking of observed attributes for sweetpotato genotypes screened at Kiboko												
Genotype	Foliage vigor	Number of plants harvested	Number of plants with storage roots	Foliage fresh yield t/ha	Number of commercial roots	Total number of roots	Average number of roots/plant	Yield of commercial roots t/ha	Total root yield t/ha	% weevil damage	Total score of the ranking	Rank
Marooko	3	18	16	3	47	51	58	44	43	35	318	34
440240	12	18	16	41	41	39	49	43	44	34	337	36
189148.21	12	41	43	38	38	31	10	55	52	19	339	37
421066	12	31	37	22	28	44	43	33	39	55	344	39
440001	44	1	21	56	33	25	31	47	49	37	344	39
441097	12	44	37	7	45	55	56	16	24	52	348	41
441725	12	41	37	25	19	42	33	45	48	46	348	41
194573.9	12	41	36	33	41	48	54	23	30	44	362	45
192033.5	4	34	31	14	55	43	46	49	45	49	370	47
401055	12	49	49	47	48	44	28	33	37	28	375	49

Selected 18 genotypes and 2 checks at KARI Kiboko for phase 2 evaluation													
Genotype		Predominant color	Foliage vigor	Number of plants harvested	Number of plants with storage roots	Foliage fresh yield t/ha	Number of commercial roots	Total number of roots	Average number of roots/ plant	Yield of commercial roots t/ha	Total root yield t/ha	% Weevil damage	DM%
1	194549.6	Dark orange	3.0	7.0	6.7	12.50	11.33	17.33	2.67	17.37	20.17	16.00	25
2	422656	orange	3.3	8.0	8.0	9.87	22.33	36.67	4.60	24.33	30.63	5.33	25
3	440287	Dark orange	2.7	7.7	7.7	13.20	11.00	20.67	2.70	22.93	28.93	13.33	25
4	440240	Orange	2.3	7.3	7.3	8.30	8.33	17.33	2.33	16.30	18.93	14.00	30
5	441097	Dark orange	3.0	7.0	6.7	10.40	12.67	18.67	2.90	14.60	18.10	11.00	25
6	192033.5	Dark orange	2.3	5.3	5.3	5.27	11.67	21.67	4.17	22.90	28.47	13.00	25
7	194573.9	Dark orange	2.7	5.7	5.7	9.03	8.33	12.67	2.13	21.57	24.67	18.33	25
8	441538	Dark orange	2.7	6.0	6.0	15.73	12.67	20.33	3.33	18.07	22.50	11.33	25
9	194515.15	Dark orange	2.3	3.7	3.7	9.00	9.00	19.00	5.20	18.77	25.30	10.67	25
10	440286	Dark orange	2.3	7.0	7.0	13.17	10.00	22.67	3.30	18.77	25.70	10.00	25

Selected 18 genotypes and 2 checks* at KARI Kiboko for phase 2 evaluation												
Genotype	Predominant color	Foliage vigor	Number of plants harvested	Number of plants with storage roots	Foliage fresh yield t/ha	Number of commercial roots	Total number of roots	Average number of roots/ plant	Yield of commercial roots t/ha	Total root yield t/ha	% Weevil damage	DM%
189135.9	Orange	2.3	6.3	6.3	4.90	18.67	35.33	5.47	27.10	34.03	9.33	25
187017.1	Orange	3.0	8.0	8.0	26.40	16.00	28.67	3.60	36.20	43.77	7.33	25
421006	Orange	2.0	4.7	4.7	10.40	10.67	26.67	4.00	17.37	22.90	7.67	25
K566632*	Dark orange	2.0	7.7	7.7	13.87	8.67	24.67	3.23	19.43	23.73	9.00	25
420014	Orange	3.0	8.0	8.0	21.57	15.00	28.67	3.83	33.33	40.70	12.33	25
189148.18	Orange	2.3	4.0	5.0	8.47	6.67	19.67	2.23	8.20	15.97	7.33	25
401055	Orange	2.3	4.3	4.3	6.97	7.00	15.00	3.37	18.07	22.23	12.67	25
441725	Dark orange	2.3	5.7	5.3	12.07	11.67	16.00	3.07	15.30	17.83	19.00	25
440001	Dark orange	2.0	8.0	7.0	3.50	9.33	21.00	3.27	11.10	17.33	14.67	25
Marooko*	Light cream	3.3	7.3	7.3	26.43	7.33	12.00	1.67	16.00	19.37	14.33	35
	LSD(0.05)	0.94	2.12	2.44	10.06	7.43	13.44	2.38	11.93	13.19	16.77	

Experiment 3

Multi-location field evaluation of the identified potential drought tolerant genotypes

Objectives

- Conduct Multi-location field evaluation of the identified potential drought tolerant genotypes
- Select for high yields in OFSP in drought prone conditions

Plant material/ propagation

- Test material /18 genotypes that were earlier selected from the rapid screening trial conducted at KARI Kiboko.
- Planting material/ sourced from the bulking plot at KARI Kiboko.
- The 18 genotypes were tested against 2 local checks: Marooko (drought tolerant) and K566632 (drought susceptible).

Experimental sites

- Kenya Agricultural Research Institute experimental fields Kiboko (Latitude 010 15’ S; Longitude 360 44’ E; Altitude 975 m above sea level)
- KARI Marigat (Latitude 0° 28’ 0” N, Longitude 35° 59’ 0” E; Altitude 1067m above sea level)

Experimental design/treatment/crop husbandry

- At each location, 3 blocks were planted with irrigation and 3 without irrigation.
- In each block, the 18 genotypes plus the 2 checks were included.
- Selected non-rooted sweetpotato apical stem cuttings approximately 30cm long displaying 3 nodes were planted below the soil surface.

Experimental design/treatment/crop husbandry

- Split plot design was used with two levels of treatment – non-irrigated and irrigated as the main factor and genotypes as the sub-factor.
- All the treatments were laid out in a randomized complete block design.
- Individual plots consisted of five 1.2m long ridges 1m apart with 4 Plants per ridge. Planting distance was 0.3m and this gave a gross plot area of 4.8m²

- Overhead irrigation - done for all the blocks for 4 weeks until all the plants had established. Thereafter stress treatment imposed throughout the growth period for the non-irrigated treatment but continued with irrigation for the irrigated treatment for a period of 5 months.

Data measurement-/ Agronomic

- The number of plants established per plot / determined 3 weeks after planting.
- During harvesting the two outer rows in each plot were left out and only the three inner rows with a net plot size of 2.4 m^2 was used for data collection.
- Weight of the vines in kg per plot.
- Fresh samples of leaves taken and dried in the oven at 70ºC for 72 hours for dry matter determination
- Number of plants harvested per net plot,
- Number of plants with storage roots,
- Number of commercial and non-commercial roots per net plot

Data measurement-/ Agronomic



- β-carotene values for the fresh storage roots. Recorded during harvesting as per the RHS color chart developed by Burgos *et al.*, (2009) from CIP, Lima, Peru.

- The weevil damage of the roots/ recorded on plot basis as scores from 1 to 5, 1 - None; 5 – Very severe (>80% of roots affected)

Evaluation of susceptibility and tolerance of the genotype

- Stress tolerance indices/biplot display of principal component analysis were used to identify stress-tolerant and high yielding genotypes and to study the interrelationship between the stress-tolerant attributes.
- The six drought tolerance indices were calculated based on their root yield in normal irrigation and water deficit conditions.

Stress indices used:

- Stress Susceptibility Index (Fischer and Maurer, 1978)
- Mean Productivity (Rosielle and Hamblin, 1981)
- Tolerance (Rosielle and Hamblin, 1981)
- Stress Tolerance Index (Fernandez, 1992):
- Geometric Mean Productivity (Fernandez, 1992)
- Harmonic Mean Productivity (Farshadfar *et al.*, 2001)

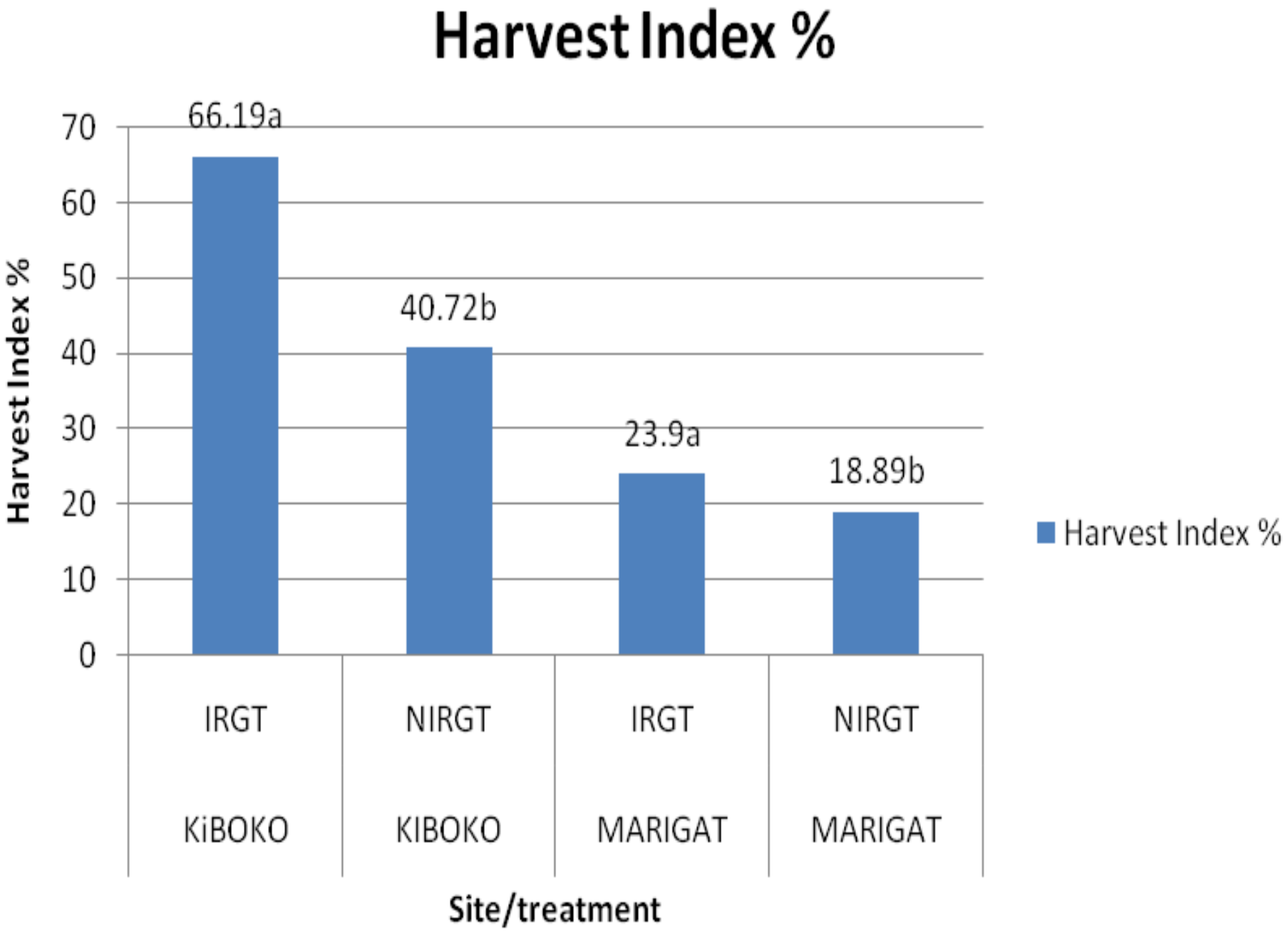
Statistical analysis

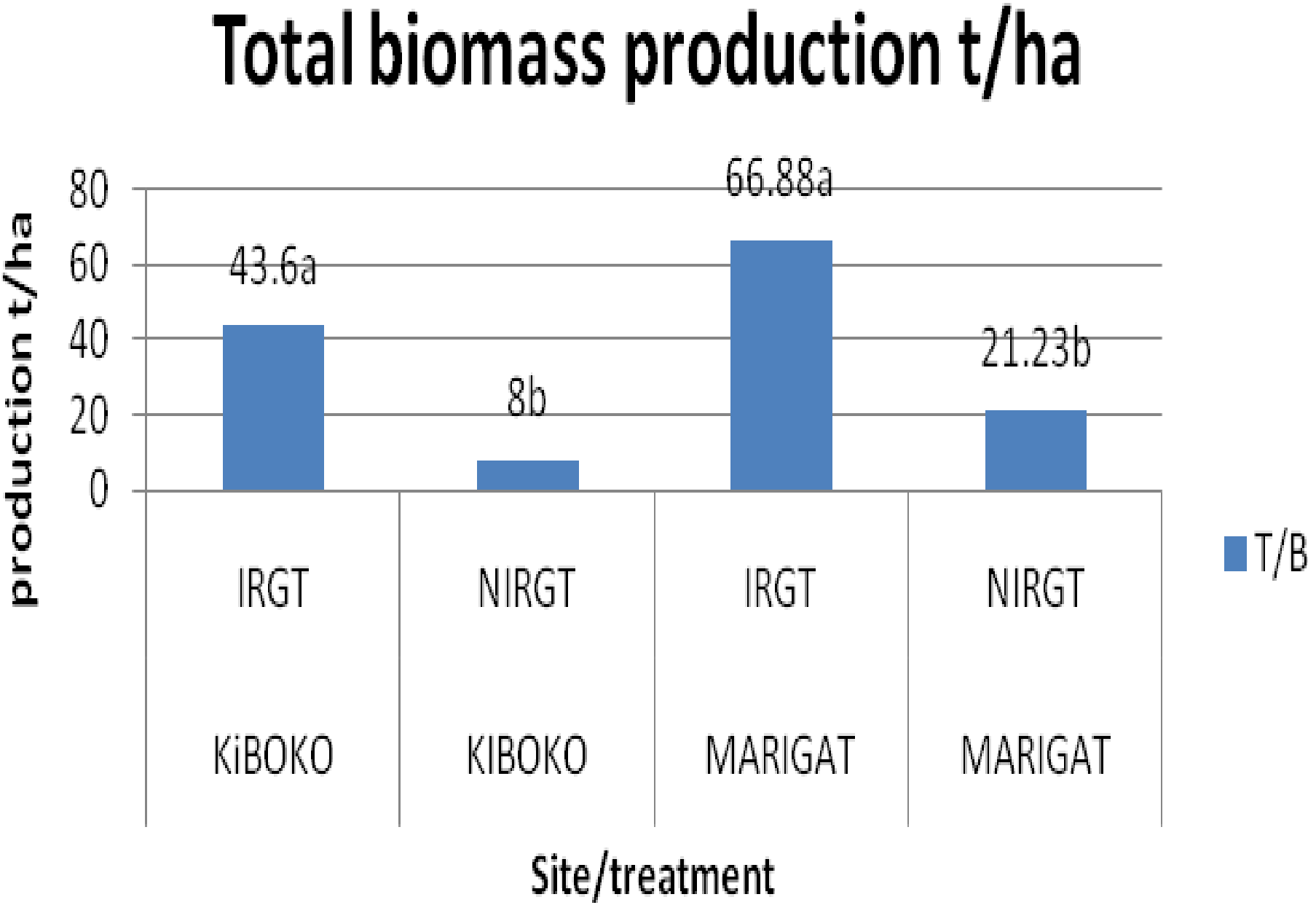
- The statistical significance of comparisons of equality of genotype effect (G), Irrigation (I), Genotype x Irrigation (GxI) interaction effects was simultaneously compared.
- The least significant difference at $p<0.05$ level was used for comparison of the treatment means. Data for each site was analyzed separately.
- The PC-SAS procedures, GLM, PRINCOMP, GPLOT (SAS 1988) and PRINQUAL (SAS 1988) were used in developing the SAS codes to display the biplots

Results

Mean for number of plants with roots and commercial root yields of sweetpotato genotypes evaluated at Kiboko and Marigat, Kenya					
Genotypes	Treatment	Kiboko		Marigat	
		Number of plants with roots	Commercial root yield t/ha	Number of plants with roots	Commercial root yield t/ha
187017.1	IRGT	10.00±1.73	39.73±23.40	6.33±2.52	23.73±11.10
	NIRGT	2.50±0.71	2.95±1.20	4.00±2.00	6.12±5.45
189135.9	IRGT	7.67±1.53	15.13±3.76	6.00±1.73	15.00±4.41
	NIRGT	4.00±1.00	4.77±1.34	6.33±1.15	7.20±2.78
189148.2	IRGT	11.00±1.00	26.67±17.09	7.00±2.00	16.93±10.55
	NIRGT	3.00±0.03	2.10±1.10	6.33±1.15	5.42±2.19
192033.5	IRGT	8.33±2.08	26.70±15.37	4.33±2.52	5.55±4.60
	NIRGT	3.33±2.52	2.50±0.03	6.00±1.56	1.70±0.24
194515.2	IRGT	10.00±1.00	20.13±14.75	5.00±0.01	9.30±5.93
	NIRGT	4.33±1.15	5.00±0.40	3.33±2.08	7.10±2.51
194549.6	IRGT	7.00±1.73	25.57±15.19	5.50±3.54	0.40±0.01
	NIRGT	1.33±0.58	2.50±1.13	4.00±2.88	1.85±0.24
194573.9	IRGT	8.67±2.08	31.53±4.24	4.50±0.71	6.88±4.96
	NIRGT	5.67±2.89	4.17±0.85	6.33±1.53	9.43±5.27
401055	IRGT	4.33±3.51	4.03±3.37	9.00±1.41	7.10±0.56
	NIRGT	1.00±0.02	2.50±0.17	6.00±1.61	2.50±0.75
420014	IRGT	10.67±1.15	32.80±10.33	5.67±2.31	19.30±8.08
	NIRGT	3.33±2.31	2.37±1.76	5.33±1.15	7.07±2.89
421066	IRGT	9.00±0.24	47.27±19.56	5.00±1.00	17.62±7.78
	NIRGT	4.33±0.58	3.90±0.52	6.00±1.00	5.55±2.42
422656	IRGT	5.00±1.41	9.57±5.75	7.33±0.58	14.20±6.24
	NIRGT	3.00±1.41	1.70±0.56	4.00±0.12	5.00±0.28
440001	IRGT	7.00±1.73	4.43±1.37	7.33±1.15	15.17±11.68

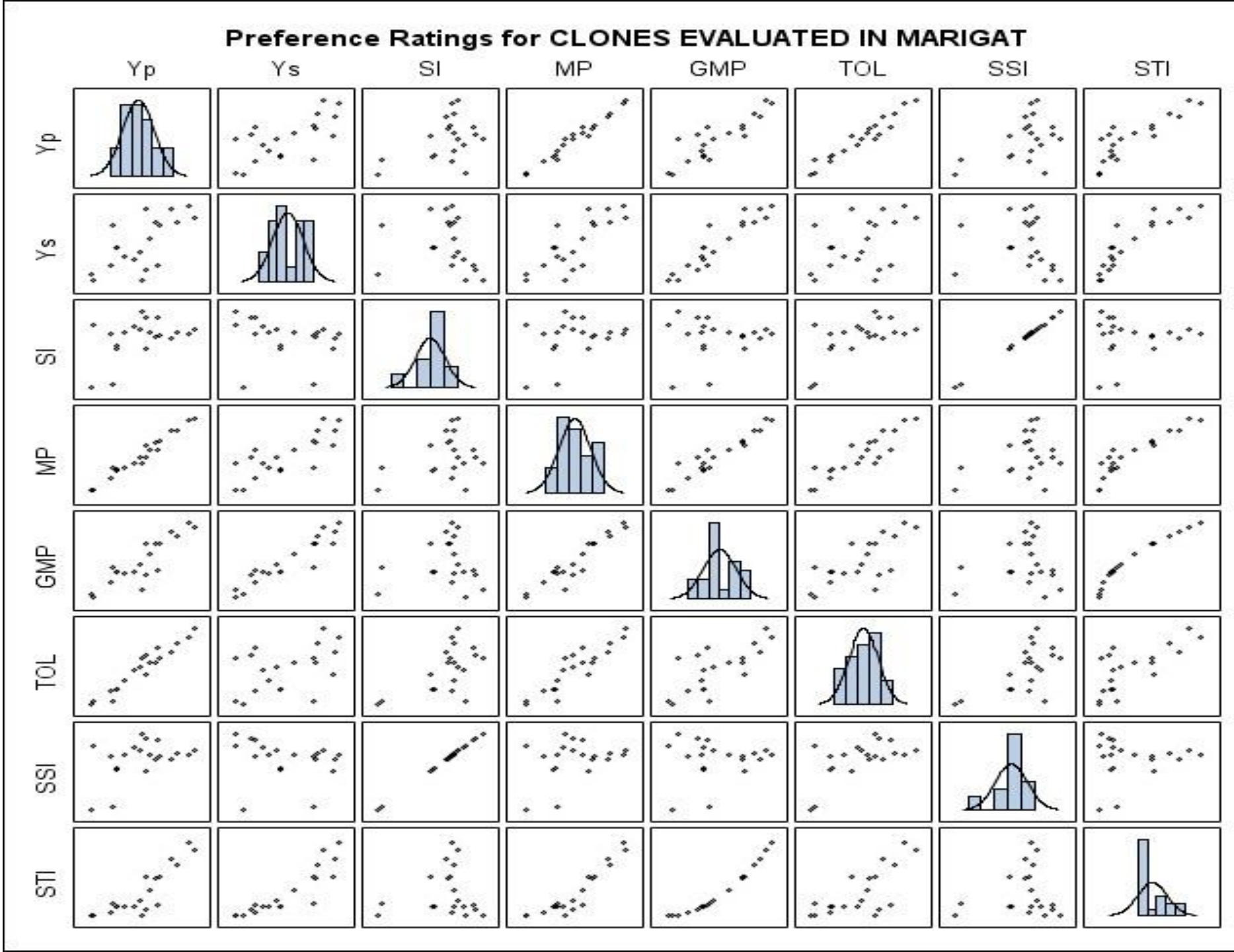
Mean for number of plants with roots and commercial root yields of sweetpotato genotypes evaluated at Kiboko and Marigat, Kenya					
Genotype	Treatment	Kiboko		Marigat	
		Number of plants with roots	Commercial root yield t/ha	Number of plants with roots	Commercial root yield t/ha
440240	IRGT	8.33±1.53	16.83±6.39	4.00±1.00	15.15±`14.18
	NIRGT	1.00±0.05	1.70±0.43	3.33±2.52	2.90±0.13
440286	IRGT	8.67±2.52	25.900.85	6.00±1.00	33.60±29.62
	NIRGT	1.50±0.71	2.10±0.57	4.50±2.12	7.90±3.54
440287	IRGT	9.00±1.00	23.17±13.74	8.33±2.08	19.33±17.73
	NIRGT	2.67±1.53	1.97±0.23	4.00±1.41	8.95±5.56
441097	IRGT	8.33±1.53	36.67±31.60	5.50±2.12	11.25±9.51
	NIRGT	3.00±0.01	2.70±0.85	5.67±1.15	2.08±1.85
441538	IRGT	6.00±2.65	23.47±15.15	5.33±1.15	0.97±0.67
	NIRGT	2.00±1.00	1.70±0.16	1.50±0.71	0.84±0.11
441725	IRGT	8.67±4.16	8.47±1.86	6.50±0.71	26.90±17.39
	NIRGT	5.00±1.73	5.83±1.65	5.33±1.53	9.60±5.04
K566632	IRGT	10.00±1.00	26.53±9.39	6.33±0.58	13.77±7.26
	NIRGT	3.00±1.41	2.30±0.28	6.00±1.45	1.07±0.23
Marooko	IRGT	7.33±0.58	14.036.29	3.67±1.53	2.08±1.51
	NIRGT	2.00±1.00	1.00±0.52	2.00±0.04	3.53±2.85
	LSD(0.05)	0.95	6.90	0.79	4.27

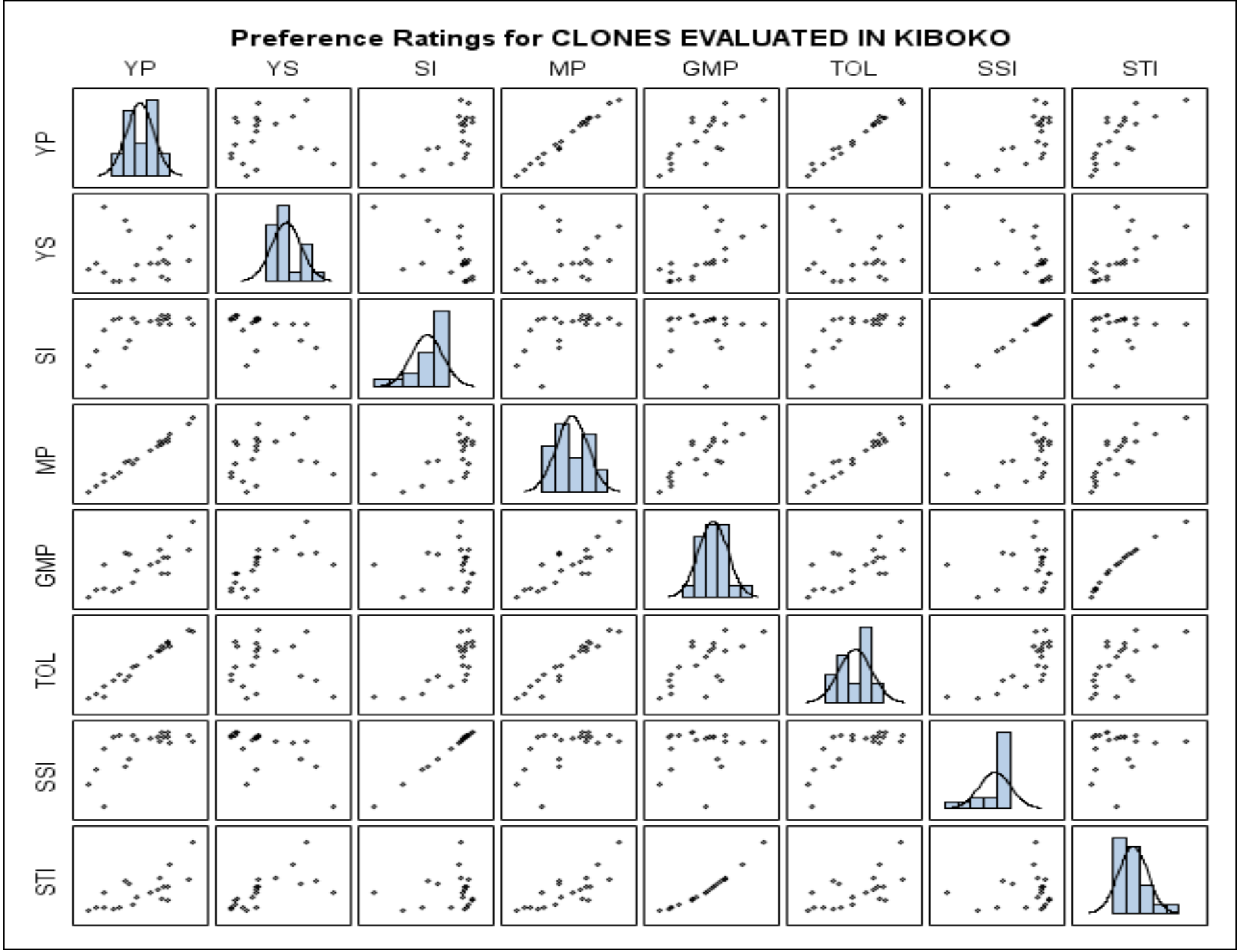

Harvest Index %
66.19a
40.72b
23.9a
18.89b
70
60
50
40
30
20
10
0
Harvest Index %
IRGT
KiBOKO
NIRGT
KIBOKO
IRGT
MARIGAT
NIRGT
MARIGAT
Site/treatment
Harvest Index %


Total biomass production t/ha
production t/ha
80
60
40
20
0
43.6a
8b
66.88a
21.23b
IRGT
NIRGT
IRGT
NIRGT
KiBOKO
KIBOKO
MARIGAT
MARIGAT
Site/treatment
T/B

Root flesh colors, beta carotene (mg/100g, FW) and Vitamin A (µgrRE/100g, FW) LEVELS FOR THE GENOTYPES EVALUATED IN Marigat and Kiboko trials						
Clone		Primary color	Secondary color	Beta-carotene mg/100g,FW	Vitamin A(µgRE/100, FW	**Dry matter content %**
1	192033.5	Pale- yellow orange	Intermediate orange	0.69	57.5	**30.17**
2	K566632	Deep orange	Intermediate orange	13.39	1032.5	**25**
3	194573.9	Intermediate orange	Intermediate orange	4.92	410	**25**
4	421066	Intermediate orange	Intermediate orange	4.92	410	**26.0**
5	187017.1	Intermediate orange	Intermediate orange	4.92	410	**25**
6	189148.2	Intermediate orange	Intermediate orange	7.23	602.5	**25**
7	441097	Intermediate orange	Intermediate orange	3.76	313.3	**26.1**
8	441725	Deep orange	Intermediate orange	11.03	919.2	**25**
9	**440240**	**Intermediate orange**	**Intermediate orange**	**7.23**	**602.5**	**30**

Root flesh colors, beta carotene (mg/100g, FW) and VitaminA (µgRE/100g, FW) LEVELS FOR THE GENOTYPES EVALUATED IN Marigat and Kiboko trials						
Clone		Primary color	Secondary color	Beta-carotene mg/100g,FW	Vitamin A(µgRE/100, FW	**Dry matter content %**
10	194549.6	Pale orange	Intermediate orange	4.47	260	**29.7**
11	401055	Orange	Intermediate orange	6.12	510	**25**
12	440287	Pale orange	Pale orange	1.65	137.5	**25**
13	420014	Pale yellow orange	Intermediate orange	1.5	125	**25**
14	440286	Deep orange	Intermediate orange	10.5	875	**25**
15	194515.2	Pale yellow orange	Intermediate orange	1.38	115	**25**
16	189135.9	Orange	Intermediate orange	6.12	510	**25**
17	422656	Pale orange	Pale orange	1.65	137.5	**25**
18	440001	Deep orange	Intermediate orange	14.37	1197.5	**25**
19	441538	Deep orange	Intermediate orange	12.39	1032.5	**25**
20	**Marooko**	**Cream**	**-**	**0.03**	**2.5**	**37.1**

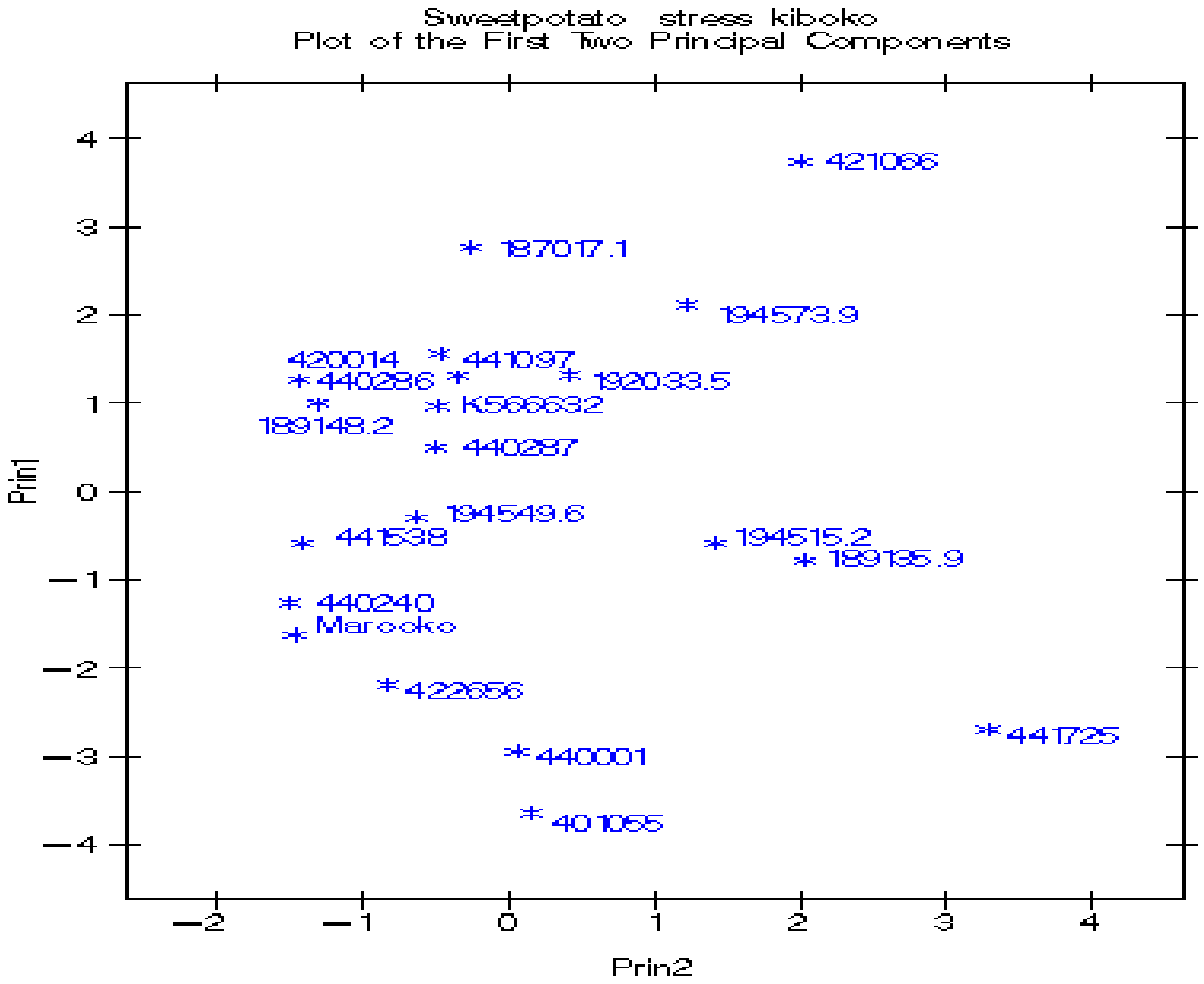

Preference Ratings for CLONES EVALUATED IN MARIGAT
Yp
Ys
SI
MP
GMP
TOL
SSI
STI


Preference Ratings for CLONES EVALUATED IN KIBOKO
YP
YS
SI
MP
GMP
TOL
SSI
STI

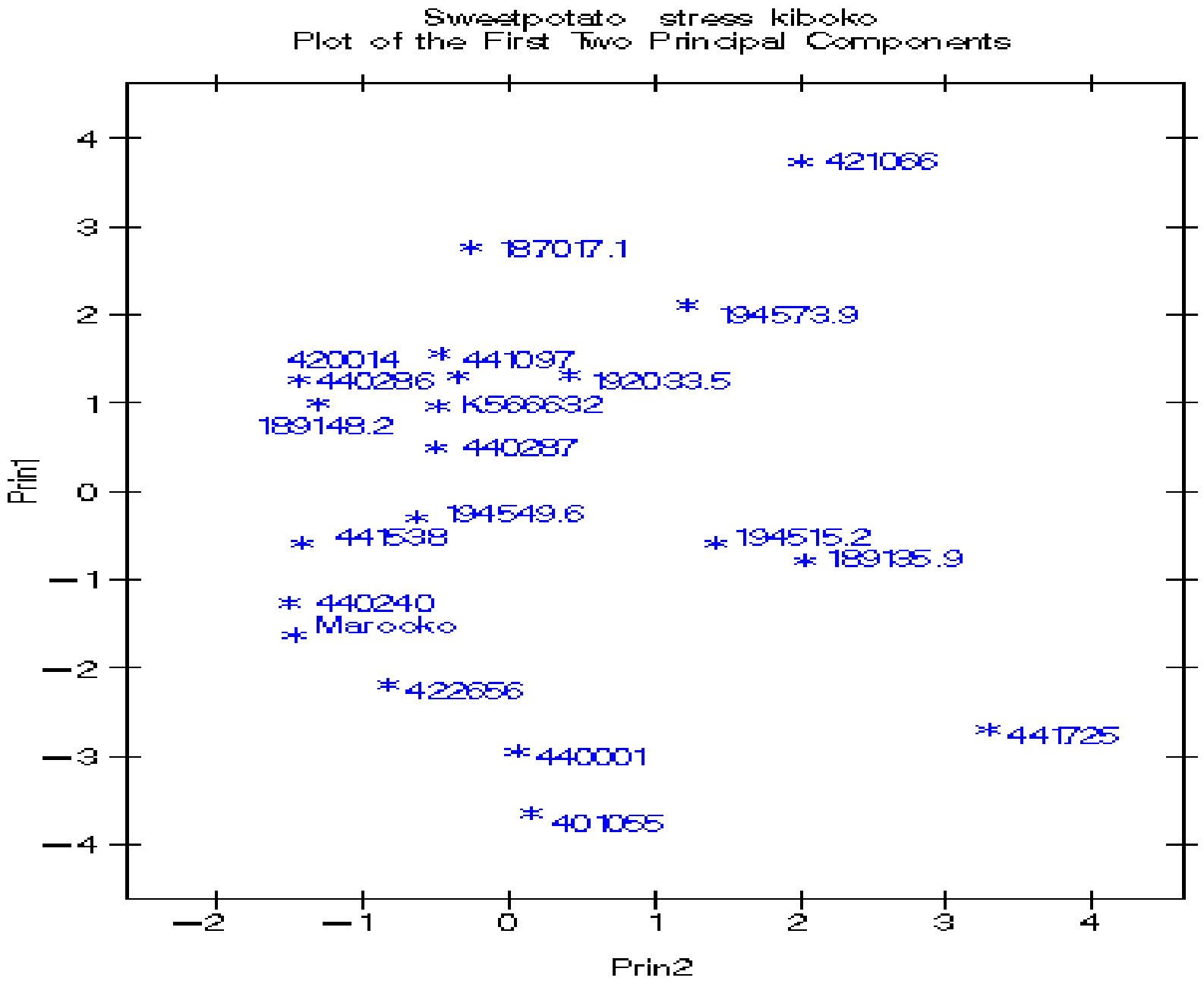
Estimation of drought tolerance indices- Kiboko							
Genotype	Yp	Ys	Mp	GMP	TOL	SSI	STI
421066	53.1	6.1	29.69	18.00	47.0	1.006	0.375
194573.9	42.6	5.3	23.95	15.03	37.3	0.995	0.261
192033.5	38.1	4.2	21.15	12.65	33.9	1.011	0.185
187017.1	51.3	3.1	27.20	12.61	48.2	1.068	0.184
189135.9	21.8	6.7	14.25	12.09	15.1	0.787	0.169
194515.2	23.3	5.8	14.55	11.62	17.5	0.853	0.156
420014	39.4	3.1	21.25	11.05	36.3	1.047	0.141
441097	41.8	2.9	22.35	11.01	38.9	1.058	0.140
K566632	36.9	2.9	19.90	10.34	34.0	1.047	0.124
440287	33.1	2.9	18.00	9.80	30.2	1.037	0.111
441725	12.2	7.8	10.00	9.76	4.4	0.410	0.110
194549.6	26.9	2.7	14.80	8.52	24.2	1.022	0.084
189148.2	38.8	1.7	20.25	8.12	37.1	1.087	0.076
440286	41.4	1.5	21.45	7.88	39.9	1.095	0.072
441538	25.3	1.5	13.40	6.16	23.8	1.069	0.044
422656	12.5	2.1	7.30	5.13	10.4	0.945	0.030
440240	19.6	1.3	10.45	5.05	18.3	1.061	0.029
440001	8.5	2.9	5.70	4.97	5.6	0.749	0.029
Marooko	16.5	1.3	8.90	4.64	15.2	1.047	0.025
401055	5.0	2.3	3.65	3.39	2.7	0.614	0.013
Mean	29.41	3.41	16.41	9..39	26.00	0.95	0.12
LSD(0.05)	5.64	1.35	6.51	3.73	10.32	0.38	0.05

Estimation of drought tolerance indices- Marigat							
Genotype	Yp	Ys	Mp	GMP	TOL	SSI	STI
421066	30.7	8.00	19.35	15.67	22.70	0.999	0.959
194573.9	32.3	6.80	19.55	14.82	22.50	1.067	0.858
192033.3	25.0	7.70	16.35	13.87	17.30	0.935	0.752
187017.1	26.8	6.30	16.55	12.99	20.50	0.034	0.660
189135.9	17.4	7.60	12.50	11.50	9.80	0.761	0.517
194515.2	21.6	6.00	13.80	11.38	15.60	0.976	0.506
420014	20.4	6.29	13.30	11.25	14.20	0.941	0.494
441097	18.4	4.60	11.50	9.20	13.80	1.014	0.331
K566632	15.7	3.22	9.46	7.11	12.48	1.074	0.197
440287	7.1	6.00	6.55	6.52	1.10	0.209	0.166
441725	20.9	1.70	11.30	5.96	19.20	1.241	0.139
194549.6	8.7	3.60	6.15	5.59	5.10	0.792	0.122
189148.2	13.6	2.30	7.95	5.59	11.30	1.123	0.122
440286	8.4	3.60	6.00	5.50	4.80	0.772	0.118
441538	10.6	2.70	6.65	5.35	7.90	1.007	0.112
422656	17.6	1.30	9.45	4.79	16.30	1.252	0.089
440240	6.4	1.70	4.05	3.30	4.70	0.992	0.043
440001	15.9	0.20	8.05	1.79	15.70	1.334	0.012
Marooko	0.9	0.80	0.85	0.84	0.10	0.150	0.003
401055	1.2	0.18	0.69	0.45	1.02	1.149	0.001
Mean	15.98	4.03	7.67	7.67	11.96	0.94	0.31
LSD(0.05)	3.56	1.04	2.16	1.84	2.96	0.12	0.10

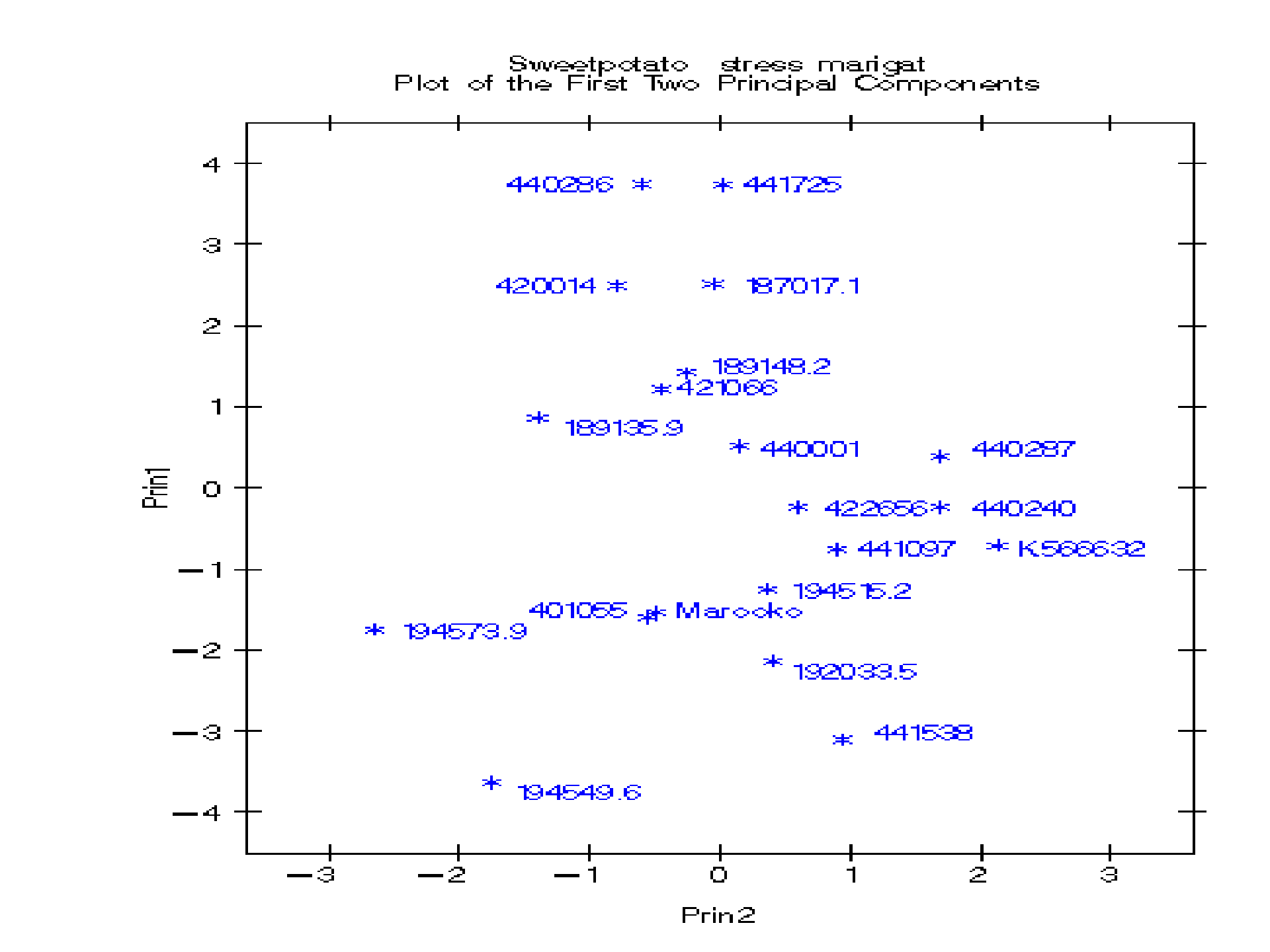
Principle component loading for biplot analysis- Kiboko							
Component	Cumulative %	Yp	Ys	Mp	TOL	SSI	STI
1	66.05	0.499	0.057	0.497	0.491	0.333	0.385
2	96.64	-0.027	0.723	0.070	-0.125	-0.511	0.440
3	99.10	-0.029	0.177	-0.259	-0.031	0.709	0.467
4	100.00	0.069	0.638	0.153	-0.018	0.354	-0.066
5	100.00	-0.814	0.002	0.407	0.414	0.000	0.000
6	100.00	0.000	0.187	-0.070	0.688	0.000	0.000


Sweetpotato stress kiboko
Plot of the First Two Principal Components
Prin1
Prin2
421066
187017.1
194573.9
420014
441097
440286
192033.5
K566632
189148.2
440287
194549.6
441538
194515.2
189135.9
440240
Marocko
422656
441725
440001
401065
4
3
2
1
0
−1
−2
−3
−4
−2
−1
0
1
2
3
4

Principle component loading for biplot analysis- Marigat							
Component	Cumulative %	Yp	Ys	Mp	TOL	SSI	STI
1	73.08	0.471	0.370	0.476	0.435	0.169	0.444
2	96.22	0.107	-0.032	-0.032	0.304	0.763	-0.254
3	99.04	-0.259	0.509	-0.090	-0.491	0.624	0.191
4	100.00	0.158	0.463	0.241	0.026	0.00	-0.838
5	100.00	0.335	0.307	-0.084	0.295	0.000	0.000
6	100.00	-0.750	0.220	0.000	0.624	0.000	0.000


Sweetpotato stress kiboko
Plot of the First Two Principal Components
Prin1
Prin2
421066
187017.1
194573.9
420014
441097
440286
192033.5
K566632
189148.2
440287
194549.6
441538
194515.2
189135.9
440240
Marocko
422656
441725
440001
401065
4
3
2
1
0
−1
−2
−3
−4
−2
−1
0
1
2
3
4

Principle component loading for biplot analysis- Marigat							
Component	Cumulative %	Yp	Ys	Mp	TOL	SSI	STI
1	73.08	0.471	0.370	0.476	0.435	0.169	0.444
2	96.22	0.107	-0.032	-0.032	0.304	0.763	-0.254
3	99.04	-0.259	0.509	-0.090	-0.491	0.624	0.191
4	100.00	0.158	0.463	0.241	0.026	0.00	-0.838
5	100.00	0.335	0.307	-0.084	0.295	0.000	0.000
6	100.00	-0.750	0.220	0.000	0.624	0.000	0.000


Sweetpotato stress marigat
Plot of the First Two Principal Components
Prin1
Prin2
440286
441725
420014
187017.1
189148.2
421066
189135.9
440001
440287
422656
440240
441097
K566632
194515.2
401065
Marocko
194573.9
192033.5
441538
194549.6
4
3
2
1
0
−1
−2
−3
−4
−3
−2
−1
0
1
2
3

Grouping of genotypes based on biplot analysis for Marigat and Kiboko

Site	Group1 Good Performance, high drought tolerant PC1 scores>0; PC2 scores= 0	Group 2 low performance/stable less sensitive to drought PC1 scores<0; PC2 scores=0	Group 3 low- to moderate- yield performance and low relative sensitivity/ tolerance to drought PC1 scores>0; PC2 scores>0	Group 4 good performance but very sensitive to drought. PC1>0; pc2 scores<0
KIBOKO	420014,440286, 189148.2, 440287 and 44097	441538, 440240, 422656, 440001 and 194549.6	422656, 440240, 441097,	421066 and 194573.9
MARIGAT	440286, 420014, 421006 and 189135.9 and 441725	401055, 194573.9 and 194549.6	194515.2, 192033.5 and 441538	440001 and 440287

Experiment 4

Evaluating the adaptation of OFSP genotypes under moisture stress conditions under glasshouse conditions

Objectives

- Identify and evaluate traits associated with water stress in sweetpotato genotypes during growth period
- Evaluate physical plant growth performance of sweetpotato genotypes under water stress condition during growth period
- Rate the sweetpotato genotypes for adaptation under water stress condition during plant growth period

- **Experimental site**
- In the glasshouse at Kenya Plant Health Inspectorate Service Quarantine station, Muguga (lat. 1°17’68’S, long. 37°07’12’E, 2100m above sea level)

Plant material and propagation

- 5 orange-fleshed genotypes randomly selected from previous field drought screening trials and one drought tolerant local check Marooko .
- Initiation and multiplication of the 6 genotypes/ from nodal cuttings/ initially grown in MS media.
- Later transferred to sterilized vermiculate soil in polythene bags in the screen house for further multiplication and bulking.

Genotypes randomly selected from previous field screening trials for further evaluation under greenhouse condition at PQS Muguga				
Clone	Primary color	Secondary color	Beta-carotene mg/100g,FW	**Vitamin A (µgRE/100, FW**
194573.9	Intermediate orange	Intermediate orange	4.92	**4100**
421066	Intermediate orange	Intermediate orange	4.92	**410**
189148.2	Intermediate orange	Intermediate orange	7.23	**602.5**
441725	Deep orange	Intermediate orange	11.03	**919.2**
194515.15	Pale yellow orange	Intermediate orange	1.38	**115**
Marooko	**Cream**	**-**	**0.03**	**2.5**

Experimental design/treatment/crop husbandry

- A completely randomized design with five genotypes and one drought tolerant check,
- Two water levels stressed and unstressed with three replications.
- A total of 216 pots with a capacity of 20l were used, 108 for each treatment with each genotype having 6 pot per replication. Water levels consisted of drought and watered treatments.

- The plant cuttings with lower leaves removed were planted with 2 nodes below the surface area and 3 nodes above the soil surface to ensure uniformity of development
- During the establishment of the plants, the soil moisture was kept high (about 80%) by daily watering of all pots. Water treatments began at 4 weeks after transplanting.
- At the onset of the drought treatment, soil moisture in all pots was raised to 80%-90% pot water holding capacity (WHC).

- Thereafter, drought pots received no more water while watered pots were irrigated daily to maintain the soil moisture at 80%-90% WHC.
- The soil had gravimetric soil water content of 22.40% at 100% WHC/ Field capacity of 38.12 %.

Data measurement

- Soil moisture content of the pots
- Relative water content of the leaves
- Plant growth parameters
- Main stem length(cm plant-1).
- Internode diameter (mm plant-1)

- Leaf growth parameters This was determined after every 2 weeks
- Leaf Area, Leaf length (L) and width (W) at the widest part for leaf numbers 5, 6 and 7. Product LxW used to compute for Leaf area (cm2 plant-1).

- Leaf number per plant.
- Leaf fresh weight (g plant^{-1}).This was determined at harvest.
- Root dry weight (g plant^{-1}**).** Oven dried at 80°C for 72hrs
- Total Biomass (g).This was determined by adding the total dry weight of the leaves, vines and roots

Morpho-physiology and water relations parameters:

- Leaf dry matter content (g kg^{-1})
- Specific leaf area (cm^2 g^{-1}) (SLA)
- Final Soil water content (g water $plant^{-1}$) at time of harvest
- Soil moisture content determined at harvest

The plant available soil water

- This was expressed as the fraction of available soil water (FASW) for each pot in the drought-stressed plants.
- FASW at day i for each pot was calculated as:(FASW= GWat dayi- GW_{end} / $GW_{80\%}$ - GW_{end}; where: GW_{end} referred to the gravimetric soil water content at the end of the experiment when plants wilted and $GW_{80\%}$ refers to the gravimetric soil water content at 80% WHC.

Statistical analysis

- Performed using the GLM procedure of SAS (SAS 1999).
- The relationships between relative parameters, i.e. SLA ratio, RWC ratio, and fraction of available soil water (FASW) were developed using a linear plateau regression using the nonlinear procedure of SAS:

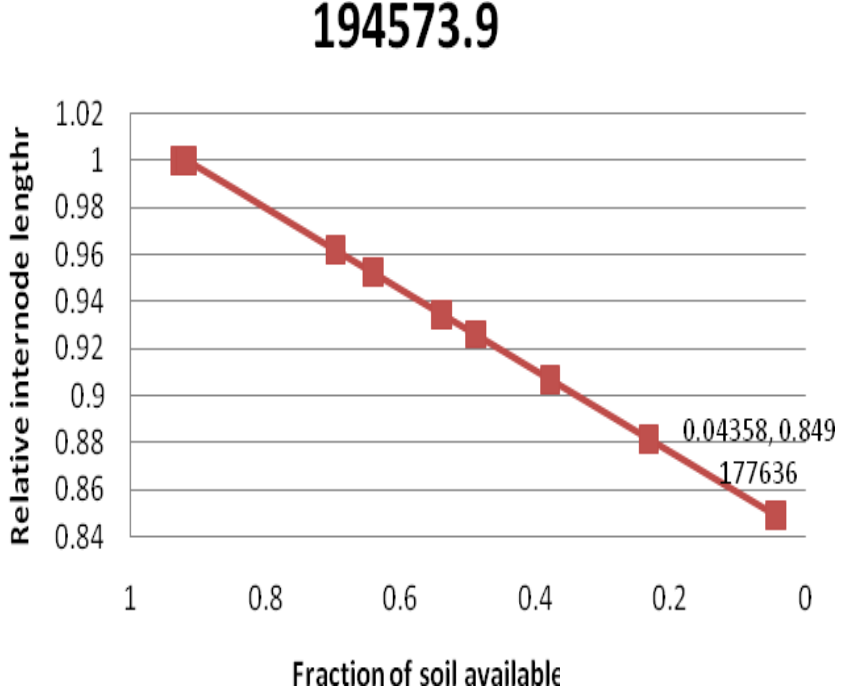
- Relative parameter = 1 if FASW > FASWt
- Relative parameter = 1 + A × (FASW - FASWt) if FASW < FASWt

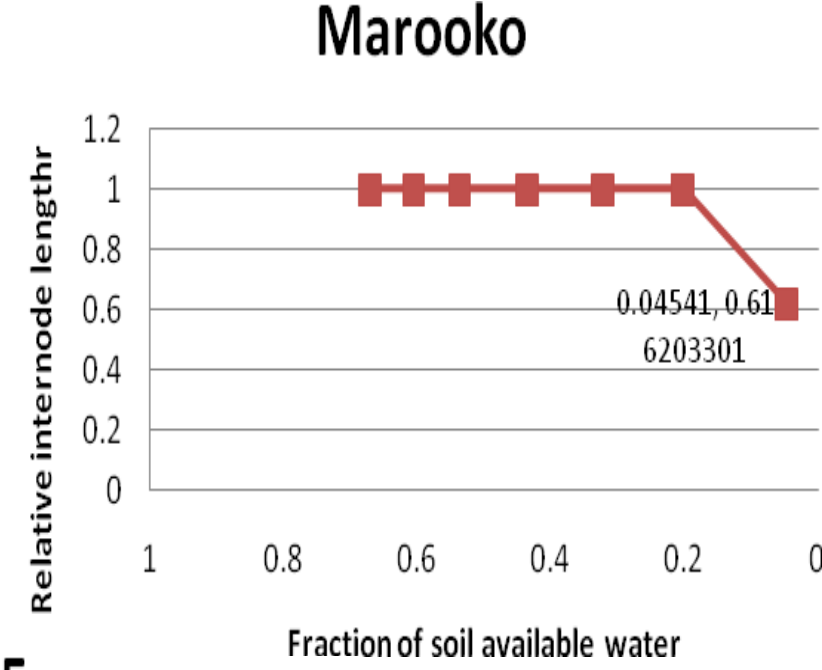
- Where A is the slope of the linear decline, and FASWt is the FASW threshold at which the relative parameter began to decline.
- R^2 values were calculated as: $R^2 = 1 - SSE/CSE$, where SSE is the sum of squares of the residue and CSE is the total corrected sum of squares

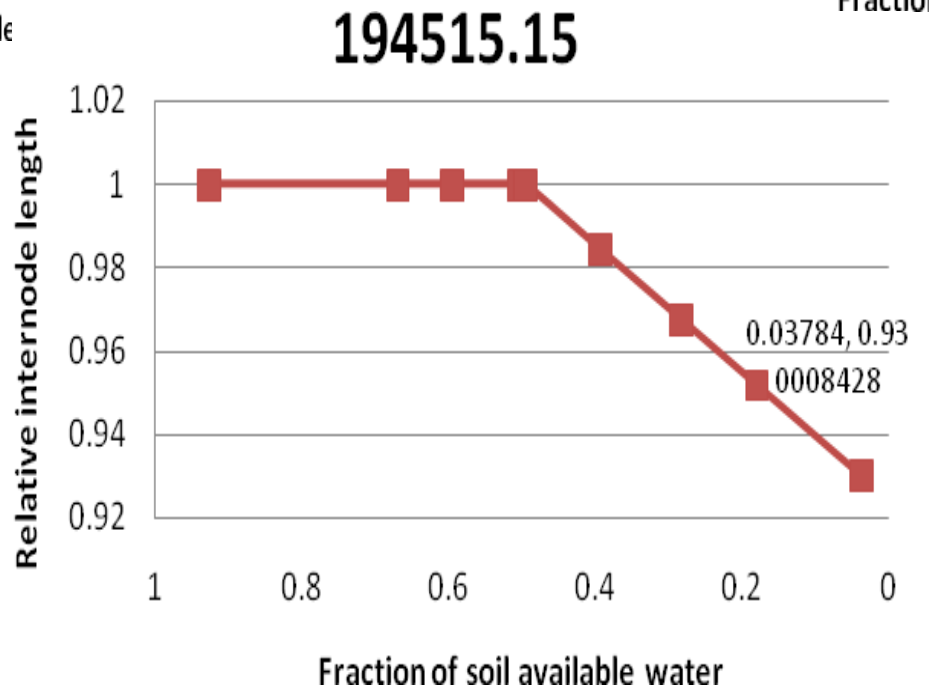
Results

Mean Leaf area (cm^2) for the 6 genotypes evaluated in the screen house at Plant Quarantine Station, Muguga, Kenya

Genotype		441725		421066		194573.9		Marooko		189148.2		194515.15	
week	Irrigated	Stress	Irrigated	Stress	Irrigated	Stress	Irrigated	Stress	Irrigated	Stress	Irrigated	Stress	LSD(0.05)
2	163.5	162.2	169	151.1	171.8	157.5	184.1	162.2	165.1	171.7	170.6	162.9	29.54
4	175.9	153	172.3	156.8	173.6	174.6	188.4	168.6	167.5	157.7	182.2	155.7	46.80
6	183.6	146.8	217.3	148.7	186.6	167.8	195.7	158	183	150.7	186.8	149	32.33
8	194.4	135.3	221.6	145.4	228	159.2	212.9	151.5	193.7	150.7	214.1	149.5	39.28
10	229	121	224.7	139.6	237	147.7	218.3	149.6	206.4	132.7	224.9	120.4	47.53
12	235.3	118.3	231.3	131.8	252.9	135.7	224.6	140.6	212.4	122.3	236.5	116.3	53.70
14	248.8	97.7	244.2	128.6	261.2	128.7	238.3	135.6	221.3	117.7	240.9	94.4	62.39
16	240.3	95.7	246.8	121.8	265.7	120.1	240.8	125.5	225.3	112.3	249.4	78.4	65.70


194573.9
Relative internode lengthr
1.02
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0.84
1
0.8
0.6
0.4
0.2
0
0.04358, 0.849
177636
Fraction of soil available


Marooko
Relative internode lengthr
1.2
1
0.8
0.6
0.4
0.2
0
1
0.8
0.6
0.4
0.2
0
0.04541, 0.61
6203301
Fraction of soil available water


194515.15
Relative internode length
1.02
1
0.98
0.96
0.94
0.92
1
0.8
0.6
0.4
0.2
0
0.03784, 0.93
0008428
Fraction of soil available water

Overall Conclusions

- In vitro screening method using PEG (6000) was found to be a simple enough to be used for evaluation of drought tolerance in a large number of genotypes in very short time.
- Out of the 10 genotypes identified as drought tolerant under in vitro screening 5 were confirmed to be tolerant under field conditions suggesting that in vitro screening can be a simple method of evaluating OFSP genotypes drought tolerance

- In this screening trial It was found that the intensity of the orange-flesh color was negatively related with dry matter content.
- Genotypes 420014, 440287, 421066, 194573.9, 192033.3, 187017.1, 441724 and 189135 had high values for beta carotene and could provide RDI of vitamin A for children under five years old. The same genotypes had higher storage root yields and were also observed to be tolerant to drought stress conditions.

- Correlation analysis revealed that Yield potential (Yp) and stress yield (Ys) had highly significant positive correlation coefficients with Stress Tolerance Index (STI), Mean Productivity (MP) and Geometric Mean Productivity (GMP) and they can be used as the most desirable indices for screening drought tolerance genotypes.
- Severe drought negatively affected the accumulation of fresh and dry weight for all the genotypes. Under stress conditions most of the genotypes had lower values for leaf number and leaf area than the well watered controls, indicating that drought induced premature leaf senescence and shedding

- Soil moisture changes not only affected the plant biomass, dry matter weight but also the distribution of assimilates to the roots and shoots. Some genotypes showed biomass partitioning that favored root system development to allow adequate water supply last longer during the dry period.
- Plant expansion process for sweetpotato-leaf number and leaf area were found to be very sensitive to moisture deficit, with the decline occurring at FASW of 0.89 for most of the genotypes

Current status

- The best six genotypes namely 420014, 440286, 440287, 189135.9, 194549.6 and 441725 are currently undergoing national performance trials in 5 sites in Kenya - Alupe, Kakamega, Siaya, Kabondo and Kabete

Publication of the work

- **Agili S,** Nyende B, Ngamau K, Masinde P (2012) Selection, Yield Evaluation, Drought Tolerance Indices of Orange-Flesh Sweet potato (*Ipomoea batatas* Lam) Hybrid Clone. **J Nutr Food Sci 2:138. doi:10.4172/2155-9600.1000138**

Acknowledgment

- HARVEST PLUS
- CIP/SASHA
- JKUAT
- KARI-KIBOKO/MARIGAT
- KEPHIS MUGUGA


Thank you very much for listening