In vitro screening for drought tolerance of orange-fleshed Sweetpotato genotypes

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Abstract

Orange-fleshed sweetpotato is rich in beta carotene that the body easily converts into vitamin A. This reduces maternal and child mortality. However, drought susceptibility of OFSP is a major draw back in the promotion in the sub Saharan Africa. Simulation of drought stress under invitro condition using tissue culture regeneration process constitutes a conventional way to study the effects of water stress.

In this study, drought induced alterations in early shoot and root development of 59 sweetpotato genotypes from Lima, Peru and two Kenyan checks cultivars Marooko (drought tolerant) and K566632 susceptible) were assessed with different concentrations of polyethylene glycol (PEG 6000MW) at three levels 0, 10 and 15 g litre with three replications in factorial completely randomized design. . Data on shoot and root growth was recorded during tissue culture regeneration. Analysis of variance was performed and significant differences among treatment means calculated by the least significant differences (LSD) test at a probability level of 0.01.

Analysis of variance indicated evidence that all effects: genotype, Salt levels and Salt Level X genotype interaction, were highly significant ($p<0.01$) with respect to all the responses.. At 15 g/l concentration of PEG, genotypes 189135.9, 194515.5, 440024, 441724 and 440001 exhibited long roots that were above that of Marooko. This level of stress severely affected the production of biomass for most of the genotypes .Genotypes 189135.9, 192033.5, 194515.5, 194539.3, 401055, 441724, 440429, 441097, 441538,441768 were observed with outstanding ability to continue root and shoot growth under *in vitro* stress conditions at all salt levels indicating their ability to fight with sever water stress situation. Susceptible genotypes observed were 189151.38, 420027, 440034, 440166, 440132, 441755, 421111 and 440104.

In-vitro technique was shown to be useful in identifying relatively salt-tolerant genotypes at early stages of development and this can be a very useful tool for screening large number of breeding lines of genotypes within a short time

Keywords: drought tolerance, genotype, in-vitro screening; polyethylene glycol salt.

Introduction

Sweetpotato (Ipomea batatas) is one of the most important staple crops in densely populated parts of Eastern Africa and is quickly becoming an important supplementary staple in the southern part of the continent (Silver et al, 2004). Sweet potato is vital to small scale farmers with limited land, labor and capital. They are easy to grow and the average consumer can afford them. One of the greatest values is its ability to be harvested piecemeal for home consumption or income generation. Presently, the predominant Sweetpotato cultivars for Eastern and Southern Africa are white-fleshed varieties that contain negligible amounts of beta-carotene, a micronutrient that the body uses to produce vitamin A (Silver et al 2004).

Orange-fleshed Sweetpotato is rich in beta-carotenes that the body converts easily into vitamin A. Adding 100 g of the Sweetpotato to the daily diet can prevent vitamin A deficiency in children, dramatically reduce maternal mortality and lower the risk of mother-to-child transmission of HIV/AIDS. The drought susceptibility of OFSP is a major drawback when promoting OFSP in SSA. Lower yields and increased susceptibility to pests on water stressed plants decrease the farmer acceptability of this otherwise very valuable crop type

Drought is one of the most common environmental stresses affecting plant growth and productivity (Boyer, 1982). Under field conditions, drought severity, timing and duration vary from year to year and a cultivar, which is successful in one year, might fail to in another year hence the need to do in-vitro screening. The unpredictable and variable forms in which drought stress manifest, complicates the selection of superior plant materials as well as breeding programs .Plant cell and tissue culture has been a useful tool to study stress tolerance mechanism under in vitro conditions (Baijji et al 2000). In vitro culture techniques minimize environmental variations due to defined nutrient media, controlled conditions and homogeneity of stress application (Sakthivelu et al 2008). In addition, the simplicity of such manipulations enables studying large plant population and stress treatments in a limited space and short period of time. Polythylene glycols (PEG) of high molecular weights have been long used to stimulate drought stress in plants as non-penetrating osmotic agents lowering the water potential in away similar to soil drying (Larher et al, 1993). Selection for drought tolerance at early stage of seedlings is most frequently carried out by including chemical drought induced molecules like poly ethylene glycol (PEG6000) in the medium. This can be used to modify the osmotic potential of nutrient solution culture and thus induce plant water deficit in a relatively controlled manner, appropriate to experimental protocols (Zhu et al., 1997.

Simulation of drought stress under in vitro conditions during the regeneration process constitutes a convenient way to study the effects of drought on morphogenic responses

In vitro selection for drought tolerant genotypes or breeding lines has been conducted for various crops like for wheat genotypes Asif et al; 2006; Tomatoes Shtereva et al 2007; Rice Biswas et al 2002, Lestari,(2005, 2006); Soya bean cultivars Sakthivelu et al 2008, Husni et al; 2006 green grams mungbean (Vigna radiate L.) Gulati and Jaiwal, 1993) and hence can also be used for sweetpotato

The possibility of using in vitro screening for orange-fleshed Sweetpotato genotypes for drought tolerance was investigated, with the aim of identifying at early stages of development those genotypes that are drought tolerant and drought susceptible.

Materials and methods

Trial site

The experiment was conducted in the tissue lab at Kenya Plant Health Inspectorate Quarantine station, Muguga, Kenya

Planting material and preparation of growth media

This consisted of 59 mega sweetpotato genotypes having CIP accession no were received as in-vitro plantlets from International potato centre (Lima, Peru) with contrasting drought resistance, beta carotene and mineral content levels. These were transferred on in vitro for regeneration of apical cuttings with 2-3 nodes.

Treatment and experimental design

Murashige and Skoog (1962) basal media with various concentration of polyethylene glycol salt (PEG6000) at 0, 10 and 15g/lit was prepared, poured into Kilmer jars and autoclaved at 121 ^{o}C and 15lb/sq inch for 15 minutes. Five cuttings per genotype with 2 -3 nodes each were placed onto the media in Kilmer jars. All the planted jars were maintained under optimum culture conditions at 10 photoperiod 70 µmol M^2/s and $28^{o}C$ temperature. The experiment was laid out in factorial complete randomized design with three replications. Plantlet growth study was recorded on regeneration. Data analysis was done using the SAS package (SAS version 8 of SAS Institute, Inc, 1999

Data collected

Root length (cm); this was determined by measuring the length of the longest root from each sample plant using a meter scale

Root weight (g); Root samples from plants from each jar were heated to a constant weight in an oven for 48 h at > 65 ^{0}C and re-weighed to determine the dry weight

Leaf area (cm2); the linear dimensions of Length (L) and width (W) at the broadest part of the lamina of each 3rd leaf from the bottom of the plant were measured with a ruler. The leaf area was then calculated as A= LXW

Shoot length (cm); this was determined at harvest by measuring the plants in each treatment from the surface of the media in the jar to the tip of the tallest leaf

Shoot fresh and dry weight (g); the shoot samples from plants from each jar were collected and weighed and then heated to a constant weight in an oven for 48 h at 65 ^{0}C. These were re-weighed to determine the dry weight.

Results

Fisher's F-test indicates existence of adequate evidence that all effects i.e. Salt levels, Clones and Salt Level X Clone interaction, are highly significant ($p<0.01$) with respect to all the responses (table 1) . Virtually all major processes contributing to crop yield including, leaf expansion, shoot and root growth were inhibited as stressed increased. These growth-supporting processes showed no further net growth (i.e. increase in biomass) at 15g/lit of PEG (Figures 1 and 2).

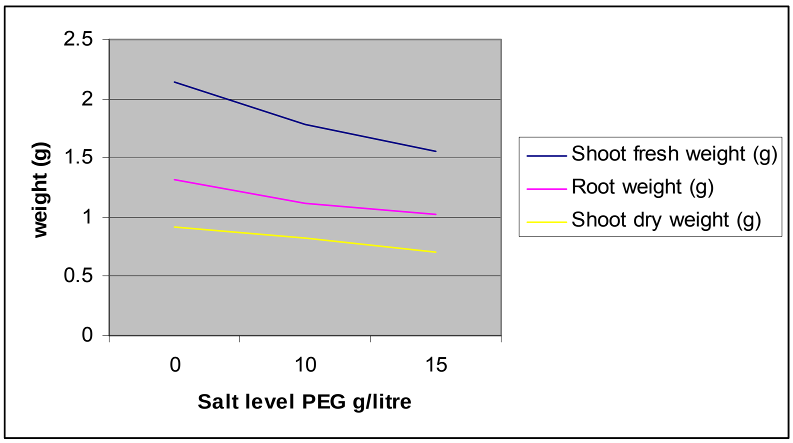

Figure 1. Effect of different salt levels on shoot fresh weigh, Root weight and shoot dry weight for the screened 59 Sweetpotato genotypes

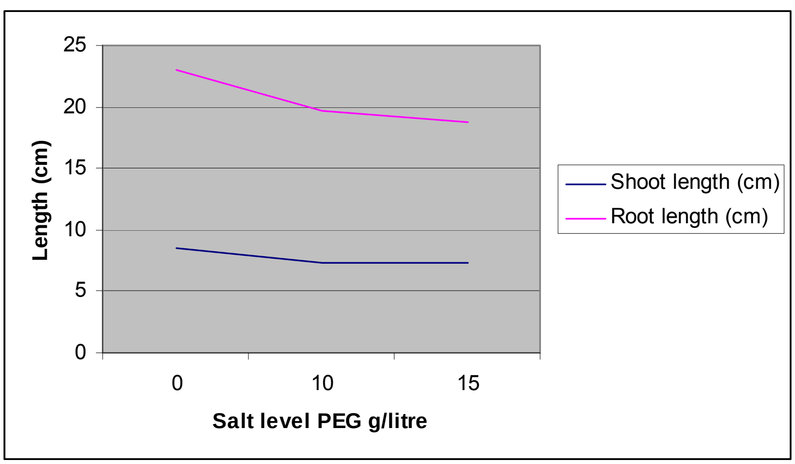

Figure 2. Effect of different salt levels on shoot and Root length for the screened 59 Sweetpotato genotypes

Leaf area

Leaf expansion and growth is one of the major processes that contribute to crop yield Significant decrease in leaf area for genotypes 420027, 440034, 440104, 194549.6 and 440643 was observed with increasing **PEG** concentration. This decrease ranged from 0.17cm^2 to 0.57 cm^2 At the same higher concentration of 15g/litre genotypes 189135.9, 194515.5, 441097 and 441768 recorded higher leaf expansion that ranged from 5.70 to 6.63 cm^2 although not significantly different from that of the check (5.67 cm^2) (table 2)

Root length

Under controlled treatment genotypes 189135.9, 421066, 440396, 440429, and 441097 formed the longest roots that ranged from 32cm to 38cm this was above the tolerant (table 2) check length (25.97cm) although not significantly different. At 15 g/l concentration of PEG, genotypes 189135.9, 194515.5, 440024, 441724 and 440001 exhibited long roots that ranged from 29.67 cm to 40.17 cm (Table 2). Poor root growth at the same level was observed for genotypes 440031 (4.71cm) and 440286 (5.10), 440025 (3.53cm), 440132 (1.87) and 420027 (2.63cm). The performance of genotypes 440024, 194515.5, 441077 and 189135.9 are worth noting. These genotypes registered high mean root length across the salt levels

Root weight

Under control treatment genotypes 189135.9, 441538 and 441768 registered higher root weight that ranged from 5.23 to 6.0 g. These were significantly different from that of the check (1.27cm) table 2.There was significant root weight reduction as stressed increased. Genotypes that exhibited higher root weight at 15 g/l concentration of PEG were 189135.9 (5g), 194569 .1 (5.03g), 440429(4.37g) and 441768(5.37g). These were significantly higher than of the check (2.20g). Higher mean root weight across the salt levels was recorded for genotypes 194515.5, 441538, 440378 (figure 3), 441097 (Figure 4) and 441768 and this ranged from 3.05 g to 5.62 g

Figure 3. Tolerant genotype 440378- (0,5,15 g/lit of PEG)

Figure 4. Tolerant genotype 441097 (0,5,15 g/lit of PEG)

Shoot dry weight

Shoot dry weight reflects a fundamental trade off in plant functioning between a rapid production of biomass and an efficient conservation of nutrients. In the control treatment genotypes 189135.9,440328, 440170, 440378 and 441538 produced significantly high root dry matter content that ranged from 2.13g to 2.79g compared to the check (0.70g), where as genotypes 440429, 194539.36, 441538, 401055, 194515.5 and 189135.9 recorded higher shoot dry weight at 15g/litre of PEG concentration .The same genotypes recorded higher mean shoot dry weight across the salt levels that were significantly higher than that of the check (0.70g). Lowest mean shoot weight were recorded for genotypes 194541.45, 4200014, 420027, 440024, 440050, 440167, 440240 and 440286, and this ranged from 0.11 g to 0.29 g (Table 3)

Shoot fresh weight (g)

Under controlled treatment high shoot fresh weight above that of the tolerant check(1.63g) were recorded for genotypes 189135.9 (6.48g), 440170 (4.90g), 440328 (5.30g), 441538 (5.48g). A sharp and significant decrease in shoot fresh weight was recorded for genotypes 194541.45, 420027, K566632, 440167 and 440027 at high 15g/lit PEG concentration. At the same level of stress genotypes 194515.5, 194573.9, 401055, 440429, 441097, 441538 and 441768 recorded high fresh root weight (Table 3).

Shoot length

Increased stress at 15g/litre induced longer shoot length for genotypes 187016.2, 187017.1, 194539.36, 420064, 440378, and 441097 which ranged from 13.83 to 18.23 way above that of the tolerant check (8.50cm). The same genotypes registered high mean shoot values across the salt level. Significant reduction in growth was observed for genotypes 189148.65, 194541.45, 440286 (Table 3).

Discussion

The present study revealed different response of genotypes to various levels o PEG concentrations. Higher concentration of PEG at 15g/litre reduced significantly growth parameters in susceptible genotypes like 420027, 440034, 440104, 440643, 189148.65, 194541.45, 420014 and 440131. Such negative effects have been observed for susceptible genotypes in wheat Razi (2003**),** Soya bean *(*Sakthivelu et al 2008).At the same level of stress genotypes 189135.9, 194515.5, 194539.3 401055, 440429,441097,441538 and 441768 were observed with outstanding ability to continue root and shoot growth indicating their ability to tolerate stress. Leaf expansion is among the most sensitive of the processes that are affected by water deficit. High concentration of PEG severely reduced leaf expansion in the susceptible genotypes like 440034,440104, 420027,189140 and 421111 unlike in tolerant genotypes 189135.9, 194515.5, 440131, 441097 and 441768 that showed high leaf expansion. This reduced expansion results to drastic reduction in transpiration surface (Alfredo et al 2004, Barta et al 2002)) resulting to low biomass production. This reduction may be due to inhibition of cell division which results to fewer cells per leaf (Tardeo et al 2000; Alfredo et al 2004). Early Detection of such genotypes with low leaf expansion under moisture stress condition can save resources in the breeding process. . Two major dimensions describe the root: root depth and root-length density. Early and rapid elongation of roots is important indication of drought tolerance; this facilitates deep soil moisture extraction under limited water conditions. Ability of continued elongation of the root under situation of water stress was remarkable character of some of the genotypes screened. Genotypes 189135.9, 194515.5, 441097, 187017.1, 440034,441768 and 441538 observed with high root length and weight have the ability to survive under high moisture stress conditions. Drought stress significantly reduced dry matter production in susceptible genotypes 194541.45, 420014, 420027, 440167 and 440394, their means were not significantly different from the of the susceptible variety K566632 Genotypes 189135.9, 194515.5, 194539.36, 440027, 440429, 441538, 401055 were observed to be relatively tolerant with her dry matter production at high PEG concentration of 15g/lit. Similar observation has been made in crops like Alfalfa (Berta et al 2002). Stress affects rate of photosynthesis thus reducing the supply of assimilate to various parts of the plant (Hall and Twidwell, 2002).

Conclusion

The results showed significant variations among the genotypes for salt tolerance based on plant growth characters. Higher concentration of the salt at 15g/litre severely affected the production of biomass for most of the genotypes .Genotypes 189135.9, 192033.5, 194515.5, 194539.3, 401055, 441724, 440429, 441097, 441538,441768 were observed with outstanding ability to continue root and shoot growth under *in vitro* stress Conditions at all salt levels indicating there ability to fight with sever water stress situation. Most susceptible genotypes observed were 189151.38, 420027, 440034, 440166, 440132, 441755, 421111 and 440104. Greater leaf area expansion under high moisture stress condition was observed for genotypes 189135.9, 194515.5, 441097 and 441768. Poor leaf expansion area was recorded for genotypes 194549.6, 420027 and 440034. All major processes contributing to crop yield including, leaf expansion, shoot and root growth were inhibited as stressed increased. In-vitro techniques were shown to be useful in identifying relatively salt-tolerant genotypes and can be a very useful tool for screening large number of breeding lines

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Table 1. Summarized analysis of variance table showing mean square values for various variables measured during the in vitro drought screening of sweet potato genotypes

Source of variation	Root length (cm)	Root dry weight (g)	Shoot length (cm)	Shoot fresh weight (g)	Shoot dry weight (g)	Leaf area (cm2)
Genotype	907.9**	20.88**	135.22**	14.19**	3.52**	2.24**
Salt level	1889.3**	10.33**	195.03**	45.53**	7.07**	
Clone* salt	907.9**	1.77**	18.52**	9.50**	8.02**	90.59**
						7.96**

**=significant at P <   0.001; * Significant at P< 0.005.

Table 2. Effect of three salt levels on Leaf Area, Root Length and root dry weight of 59 orange-fleshed sweetpotato genotypes screened for drought tolerant

Clone	Leaf Area (cm2)					Root length (cm)					Root dry weight (g)				
	Salt level					Salt level					Salt level				
	0	10	15	Mean	STR	0	10	15	Mean	STR	0	10	15	Mean	STR
Marooko*	5.50	6.47	5.67	5.9	T	25.97	22.00	21.33	23.10	T	1.27	1.57	2.20	1.7	T
187016.2	2.33	1.67	1.50	1.8	S	17.67	14.67	13.33	15.22	S	0.33	0.30	0.06	0.2	S
187017.1	3.17	2.67	2.33	2.7	S	27.00	26.33	27.00	26.78	T	0.33	0.99	0.39	0.6	S
189123.68	4.00	0.60	1.67	2.1	S	18.00	16.67	15.33	16.67	S	0.22	0.38	1.33	0.6	S
189135.9	7.00	7.33	5.20	6.5	T	33.00	33.53	35.33	33.95	T	6.00	7.87	5.00	6.3	S
189140	1.90	1.63	1.20	1.6	S	29.13	28.83	25.77	27.91	T	0.07	0.01	0.04	0.03	S
189148.21	3.83	2.50	3.23	3.2	S	17.33	14.80	17.50	16.54	S	0.03	0.04	0.02	0.03	S
189148.65	5.10	1.70	2.50	3.1	S	10.33	5.67	8.00	8.0	S	0.43	0.02	0.02	0.2	S
189150.1	5.33	4.33	3.43	4.4	S	15.33	7.17	5.33	9.28	S	0.57	0.23	0.13	0.30	S
189151.38	2.63	5.67	5.50	4.6	S	11.00	17.67	13.33	14	S	0.70	2.00	1.07	1.30	S
192033.5	4.17	6.33	6.42	5.6	S	12.67	17.67	15.67	15.34	S	0.73	1.00	0.88	0.9	S
194515.5	5.10	9.50	5.77	6.8	T	31.33	33.33	30.67	31.78	T	4.77	0.63	3.77	3.1	T
194521.2	5.33	2.10	2.00	3.1	S	26.33	21.67	12.17	20.06	S	1.34	0.64	0.42	0.8	S
194539.36	4.33	6.00	5.30	5.2	S	23.83	23.67	23.67	23.72	T	1.50	2.27	3.17	2.3	T
194541.45	4.17	3.00	4.50	3.9	S	10.53	21.50	24.93	18.91	S	1.03	0.78	0.65	0.8	S
194549.6	0.57	0.60	1.50	0.9	S	17.33	9.00	24.33	16.89	S	0.13	0.21	1.03	0.5	S
194555.7	2.20	3.77	1.40	2.5	S	7.33	29.00	16.10	17.48	S	0.49	0.11	0.05	0.3	S
194569.1	3.53	2.50	4.83	3.6	S	21.00	4.00	9.17	11.39	S	4.80	0.01	5.03	3.3	T
194573.9	2.00	0.82	3.83	2.2	S	8.50	4.67	9.73	7.63	S	0.39	0.60	0.29	0.37	S
400011	5.33	4.33	4.33	4.7	S	16.33	25.00	20.33	20.55	T	0.51	0.23	0.60	0.40	S
401055	5.13	7.17	5.63	6.0	S	9.83	6.33	10.90	8.99	S	0.46	0.81	0.39	0.60	S
420001	7.00	1.17	1.83	3.3	S	28.33	23.67	14.50	9.02	S	1.81	0.80	0.62	1.1	S
420014	4.60	6.13	3.37	4.7	S	19.30	16.27	13.50	22.14	S	1.73	1.73	0.54	1.3	S
420027	1.07	1.53	0.57	1.1	S	17.83	3.60	2.63	16.36	S	0.06	0.01	0.02	0.03	S
420064	2.20	1.83	6.60	3.5	S	20.00	23.00	17.83	8.02	S	3.15	0.82	0.70	1.6	S
421066	2.47	2.33	1.50	2.1	S	38.00	16.67	21.67	20.28	S	0.97	0.33	0.30	0.50	S
421111	3.80	2.83	1.23	2.6	S	2.06	27.27	5.00	11.44	S	0.06	0.08	0.17	0.10	S
422656	8.00	2.43	4.40	4.9	S	29.67	25.17	16.67	23.84	T	2.21	1.21	1.13	1.50	T
440001	2.20	3.00	2.17	2.5	S	24.67	15.00	31.67	23.78	S	1.67	0.30	0.20	0.56	S
440017	1.50	2.33	3.50	2.4	S	24.33	33.67	5.43	21.14	S	2.7	1.40	0.01	0.90.	S
440023	4.00	4.33	2.83	3.7	S	21.00	10.50	13.17	14.89	S	0.87	0.44	0.37	1.40	S
440024	1.10	8.73	4.63	4.8	S	28.77	69.67	40.17	27.87	T	0.03	0.87	0.48	0.60	S

Clone	Leaf Area (cm2)					Root length (cm)					Root dry weight (g)				
	Salt level					Salt level					Salt level				
	0	10	15	Mean	STR	0	10	15	Mean	STR	0	10	15	Mean	STR
440025	3.50	5.00	3.33	3.9	**S**	17.83	25.80	3.53	15.72	S	1.17	0.19	0.03	0.50	S
440027	2.23	5.50	1.50	3.1	**S**	30.33	28.33	16.67	25.11	T	0.68	2.33	0.04	1.00	S
440031	5.93	5.67	1.80	4.5	**S**	5.33	4.33	3.83	4.50	S	0.03	0.02	0.01	0.02	S
440034	2.80	0.87	0.83	1.5	**S**	29.80	27.20	28.07	28.26	T	0.07	0.02	0.05	0.04	S
440050	2.00	4.20	4.00	3.4	**S**	13.30	10.20	9.83	11.11	S	0.01	0.04	0.42	0.20	S
440104	7.33	3.87	0.17	3.8	**S**	21.97	18.17	22.00	20.71	S	0.21	0.00	0.02	0.10	S
440131	5.70	10.20	1.47	5.8	**T**	13.63	10.83	9.83	11.43	S	4.33	0.06	0.06	1.50	T
440132	4.80	6.17	0.00	3.7	**S**	17.87	16.77	1.87	12.17	S	0.04	0.04	0.00	0.30	S
440166	2.33	1.50	1.67	1.8	**S**	18.67	17.33	12.00	16.0	S	0.30	0.63	0.04	0.10	S
440167	1.20	2.10	2.37	1.9	**S**	30.67	7.53	6.50	11.57	S	0.06	0.05	0.04	1.10	S
440170	2.50	2.83	2.93	2.8	**S**	20.67	20.17	24.00	21.61	S	2.00	1.73	1.90	1.90	T
440240	4.17	0.38	2.17	2.2	**S**	21.33	13.80	12.63	15.93	S	0.04	0.16	0.14	0.10	S
440286	5.20	0.00	0.00	1.7	**S**	11.87	2.93	1.43	5.41	S	0.34	0.00	0.00	0.10	S
440287	6.10	5.77	0.00	4.0	**S**	27.30	29.87	3.50	20.22	S	0.31	0.40	0.07	0.30	S
440328	8.25	3.33	4.20	5.3	**S**	28.33	26.00	17.67	24.0 0	T	2.22	1.39	1.73	1.80	S
440378	2.00	2.33	2.50	2.3	**S**	22.00	48.33	12.67	21.00	T	1.93	0.93	0.83	1.20	S
440394	1.50	1.17	2.50	1.7	**S**	19.67	10.33	5.13	11.71	S	2.00	1.50	0.05	1.20	S
440396	5.00	8.33	4.00	5.8	**S**	36.00	14.00	8.73	19.58	S	2.13	1.93	1.23	1.80	T
440429	3.67	3.50	4.50	3.9	**S**	32.33	25.67	21.17	23.06	T	2.30	1.70	4.37	2.80	T
440643	1.17	5.57	0.57	2.4	**S**	16.90	9.33	3.80	10.01	S	1.10	0.24	0.01	0.50	S
441097	5.67	10.00	6.50	7.4	**T**	32.50	34.17	25.33	30.17	T	1.30	1.27	3.53	2.00	T
441538	5.67	7.30	5.83	6.3	**S**	31.33	21.47	13.67	22.16	S	5.23	6.13	3.07	4.80	T
441724	3.50	4.33	2.00	3.3	**S**	29.33	25.00	29.67	28	T	0.77	2.73	0.90	1.5	S
441725	4.13	5.60	6.33	5.4	**S**	31.33	25.50	19.33	25.39	T	0.50	0.04	0.07	0.2	S
441755	0.30	5.03	3.43	2.9	**S**	8.70	9.67	10.83	9.78	S	1.93	0.75	0.68	1.10	S
441768	7.03	11.33	3.80	7.5	**T**	32.67	25.80	22.17	26.88	T	5.87	0.27	5.37	3.90	T
K566632**	11.23	2.00	1.70	5.0	**S**	13.67	8.00	4.53	8.73	S	0.05	0.02	0.04	0.04	S
Mean	**3.82**	**4.09**	**3.06**	**3.37**		**22.95**	**19.73**	**15.47**	**18.81**		**1.32**	**1.12**	**0.95**	**1.03**	
LSD(0.01)	**0.35**					**3.49**					**0.23**				
	LSD(0.01)- - for salt level= 0.06; clone= 0.25; means with the same level= 0.49; means with different salt level = 0.49					**LSD(0.01)**- means- for salt level= 3.49; clone= 8.88; means with the same level= 17.84; means with different salt level = 17.77					**LSD(0.01)**- means- for salt level= 0.23; clone= 0.50; means with the same level= 1.01; means with different salt level = 1.00				

Table 3. Effect of three salt levels on shoot dry weight, shoot fresh weight and shoot length of 59 orange-fleshed sweetpotato genotypes screened for drought tolerant

Clone	Shoot dry weight (g) Salt level					Shoot fresh weight (g) Salt level					Shoot length (cm) Salt level				
	0	10	15	Mean	INF	0	10	15	Mean	INF	0	10	15	Mean	INF
Marooko*	0.70	0.68	0.99	0.80	T	1.63	1.63	2.20	1.80	T	7.23	5.17	8.50	7.00	T
187016.2	0.31	0.36	0.13	0.25	S	1.10	0.97	0.33	0.80	S	10.33	12.17	14.00	12.20	T
187017.1	1.05	1.01	0.26	0.80	T	2.30	1.94	0.75	1.7	S	10.33	13.83	14.90	13.00	T
189123.68	1.23	0.70	1.43	1.10	T	1.23	0.70	1.43	1.10	S	8.00	4.33	6.67	6.30	S
189135.9	2.79	2.35	1.22	2.10	T	6.48	5.57	2.83	5.00	T	15.33	12.83	13.17	13.80	T
189140	0.29	0.05	0.74	0.40	S	0.63	0.14	1.90	0.90	S	5.50	5.33	4.83	5.20	S
189148.21	0.29	0.44	0.44	0.40	S	0.67	1.00	0.97	0.90	S	5.50	5.00	8.63	6.40	S
189148.65	0.23	0.22	0.10	0.18	S	0.55	0.52	0.23	0.40	S	6.87	3.00	1.83	3.90	S
189150.1	0.87	0.87	0.90	0.90	T	1.93	2.00	2.13	2.20	T	4.83	4.33	5.00	4.70	S
189151.38	0.67	1.77	0.98	1.10	T	1.58	4.50	2.30	2.80	T	7.00	11.00	9.67	9.20	T
192033.5	0.86	1.97	0.74	1.19	T	1.46	4.77	2.19	2.80	T	10.33	14.67	12.17	12.40	T
194515.15	1.99	1.90	1.21	1.70	T	4.80	4.33	2.73	4.00	T	12.57	10.00	11.00	11.20	T
194521.2	1.26	0.38	0.69	0.80	T	2.95	0.88	1.60	1.80	S	14.00	8.40	8.30	10.2	T
194539.36	1.83	2.08	2.58	2.2 0	T	4.07	4.53	5.73	4.80	T	9.33	10.00	16.67	12.00	T
194541.45	0.69	0.30	0.03	0.30	S	1.64	0.69	0.06	0.80	S	6.67	4.50	1.33	4.20	S
194549.6	0.38	0.32	0.65	0.50	S	0.73	0.70	1.43	0.70	S	1.83	2.83	7.67	4.10	S
194555.7	0.44	0.26	0.09	0.30	S	1.31	0.63	0.17	0.70	S	6.67	4.83	6.50	6.00	S
194569.1	0.68	0.10	0.76	0.50	S	1.60	0.24	1.67	1.70	S	8.00	1.50	7.33	5.60	S
194573.9	0.45	0.44	0.42	0.40	S	1.06	1.08	2.50	1.50	S	7.00	7.67	9.67	8.10	T
400011	0.80	0.69	0.69	0.70	S	2.03	1.27	1.93	1.70	S	5.67	4.83	5.57	5.40	T
401055	0.53	0.55	1.19	0.80	T	1.16	2.00	2.65	1.90	T	8.00	8.37	10.17	8.80	T
420001	1.03	0.39	0.44	0.60	S	4.34	1.03	1.69	2.40	T	16.33	8.17	8.33	10.90	T
420014	0.58	0.32	0.10	0.30	S	1.39	0.85	0.24	0.80	S	6.70	5.87	5.77	6.10	S
420027	0.14	0.10	0.05	0.09	S	0.31	0.21	0.04	0.19	S	6.70	1.93	2.80	3.80	S
420064	0.68	0.33	0.45	0.46	S	1.55	1.16	0.97	1.20	S	10.33	11.47	18.23	13.30	T
421066	0.77	0.47	0.33	0.41	S	2.20	1.03	0.73	1.30	S	11.00	6.00	6.33	7.80	S
421111	0.31	0.41	0.44	1.00	T	0.73	0.81	1.01	0.90	S	8.93	10.07	4.77	7.90	T
422656	1.63	0.67	0.70	0.60	S	4.40	1.58	1.65	2.50	T	16.33	11.20	9.73	12.40	T
440001	0.91	0.54	0.32	1.00	T	2.50	1.33	0.83	1.60	S	9.33	5.33	8.33	7.70	T
440017	1.78	1.09	0.13	0.60	S	4.43	2.30	0.29	2.30	T	9.00	10.33	1.27	6.90	T
440023	1.04	0.38	0.45	0.30	S	1.97	0.87	1.00	1.30	S	5.67	2.00	2.67	3.40	S
440024	0.05	0.54	0.19	0.40	S	0.14	1.36	0.49	0.70	S	2.80	7.13	6.83	5.60	S
440025	0.48	0.51	0.23	1.9	T	1.07	0.93	0.50	0.80	S	2.00	8.17	2.77	4.30	S
440027	1.43	4.33	0.07	0.20	S	1.43	4.33	0.07	1.90	T	7.00	10.33	8.00	8.40	T
440031	0.25	0.14	0.08	0.90	T	0.57	0.42	0.21	0.40	S	7.33	4.23	7.67	6.40	T
440034	1.06	0.91	0.64	0.20	S	3.13	2.00	1.47	2.20	T	0.23	5.50	4.57	3.40	S

Clone	Shoot dry weight (g) Salt level					Shoot fresh weight (g) Salt level					Shoot length (cm) Salt level				
	0	10	15	Mean	INF	0	10	15	Mean	INF	0	10	15	Mean	INF
440050	0.08	0.03	0.35	0.30	S	0.21	0.28	0.83	0.40	S	4.10	5.57	9.00	6.20	S
440104	0.66	0.04	0.10	0.60	S	0.99	0.10	0.24	0.40	S	14.73	1.50	7.57	7.90	T
440131	1.43	0.02	0.40	0.20	S	3.50	0.05	0.81	1.50	S	7.93	2.30	11.60	7.30	T
440132	0.35	0.31	0.00	0.40	S	0.80	0.68	0.06	0.50	S	5.57	5.80	1.27	4.20	S
440166	0.44	0.47	0.17	0.10	S	1.17	1.13	0.40	0.90	S	9.00	15.17	13.17	12.40	T
440167	0.14	0.12	0.03	1.60	T	0.34	0.26	0.07	0.20	S	5.67	1.80	6.33	4.60	S
440170	2.43	1.27	0.97	0.10	S	4.90	2.83	1.70	3.10	T	7.67	12.33	12.00	10.70	T
440240	0.16	0.04	0.15	0.11	S	0.34	0.16	0.34	0.30	S	6.77	1.73	5.40	4.60	S
440286	0.44	0.00	0.00	0.10	S	1.02	0.06	0.03	0.40	S	5.83	1.03	1.17	2.70	S
440287	0.42	0.69	0.00	0.39	S	0.97	1.67	1.93	1.50	S	5.50	5.23	3.50	4.70	S
440328	2.09	0.69	0.86	1.20	T	5.30	1.67	2.08	3.00	T	17.00	9.17	10.97	12.40	T
440378	2.13	1.22	0.50	1.30	T	5.20	2.87	1.40	3.20	T	10.33	12.00	13.83	12.10	T
440394	1.65	1.06	0.13	0.89	T	3.93	2.47	0.29	2.20	T	7.00	6.50	2.00	5.20	S
440396	1.74	1.67	0.47	1.30	T	3.77	3.53	1.03	2.80	T	8.00	7.33	4.67	6.70	T
440429	1.57	1.40	1.74	1.60	T	3.77	3.07	3.87	3.60	T	15.33	9.33	12.33	12.30	T
440643	0.50	0.88	0.13	0.46	S	2.27	0.88	0.13	1.1	S	6.90	8.23	1.53	5.60	S
441097	0.67	2.22	4.35	1.20	T	1.90	3.13	4.30	3.10	T	12.67	15.67	13.67	14.00	T
441538	2.48	2.22	4.35	3.00	T	5.48	4.83	2.24	3.20	T	14.67	9.50	11.83	12.50	T
441724	0.77	2.56	0.64	1.30	T	1.80	6.20	1.47	3.20	T	9.00	10.67	8.00	9.20	T
441725	0.56	0.77	0.62	0.70	S	1.29	1.47	1.83	1.50	S	9.13	4367	7.33	7.08	T
441755	0.18	0.20	0.20	0.30	S	0.22	1.43	0.61	0.80	S	1.33	1.50	1.47	1.40	S
441768	2.54	1.28	1.28	1.70	T	6.08	5.70	3.10	5.00	T	16.17	16.00	12.67	14.90	T
K566632**	0.12	0.03	0.03	0.10	S	0.22	0.30	0.07	0.20	S	4.50	3.50	1.93	3.30	S
Mean	**0.92**	**0.82**	**0.61**	**0.70**		**2.14**	**1.78**	**1.32**	**1.56**		**8.50**	**7.27**	**7.66**	**7.35**	
	LSD(0.01)- for salt level= 0.06; clone= 0.25; means with the same level= 0.49; means with different salt level = 0.49					**LSD(0.01)** means- for salt level= 0.16; clone= 0.44; means with the same level= 0.88; means with different salt level = 0.87					**LSD(0.01)** means- for salt level= 0.76; clone= 1.67; means with the same level= 3.37; means with different salt level = 3.34				