EFFECTS OF RAINFALL VARIABILITY ON MISSING STANDS AND YIELD IN SWEET POTATO (*Ipomoea batatas* (L.) Lam.) PRODUCTION

*Afolabi Michael Segun[1], Lamidi Wasiu Agunbiade[2] and Akoroda Malachy O[3]

[1]Department of Agronomy, College of Agriculture, Ejigbo, Osun State University, Osogbo, Nigeria

[2]Department of Agricultural Engineering, Faculty of Engineering, Osun State University, Osogbo, Nigeria

[3]Department of Agronomy, University of Ibadan, Oyo State, Nigeria

Corresponding author: afolabimike97@gmail.com

ABSTRACT

Sweet potato is grown across a wide range of agro ecological zones. In Nigeria, tuber yields differ considerably across agro ecological zones and even from farmer to farmer. This wide variation in tuber yields is a matter of concern because it means that the total output of the crop is lower than it should be. This variation could be as a result of factors such as inadequate supply of water from either rainfall or irrigation, temperature and humidity level of the location, soil fertility, relative humidity and varieties of the sweet potato plant. In order to better understand the variations in sweet potato tuber yield in different locations and seasons, results from 10 sweet potato varieties from four different environments over two years were examined. Field experiments were conducted at the same time in four locations (Igbon via Ejigbo (Osun State), Ibadan (Oyo State), Idofian and Ilorin (Kwara State) for two growing seasons in 2015 and 2016. Ejigbo (Osun State) and Ibadan (Oyo State) belong to the rainforest zone while Idofian and Ilorin (Kwara State) belong to southern guinea savannah. Rainfall data for the period of the experiment were obtained from the metrological stations in these areas. At four weeks after planting data was taken on dead plants. Also, at harvest data on the yields of the sweet potato from the four locations were collected and subjected to statistical analysis. The estimation of field condition assessment was good for Ibadan and Igbon due to high amount of rainfall in the area. Also, the sweet potato tuber yield was consistently higher for all the varieties in this rainfall zone; however, the situation is contrary in Ilorin and Idofian. As a result, rainfall variability (rainfall amount) was identified as a factor that could lead to missing stands (plant that failed to germinate and could not survive after planting) and poor yield. It is recommended that care should be taken by sweet potato growers to address the factor so as to increase productivity of their sweet potato production.

Key word: Rainfall, sweet potato, productivity, missing stands, yield.

1. INTRODUCTION

Sweet potato (*Ipomoea batatas* (L.) Lam.) is an important crop in many countries. It is cultivated for food, animal feed and industrial raw materials. It originated from Central Africa (Nwauzor and Afuape, 2005), and is the only member of the genus Ipomoea whose roots are edible. It is also one of the world's most important food crops due to its high yield and nutritive value (Salcch and Hartojo, 1995). It is extensively cultivated in tropical and sub-tropical zones (Islam *et al.*, 2002). It belongs to the Convolvulaceae family, and it is grown for both human and animal consumption (Nwadili *et al.,* 2007). Sweet potato is a highly recommended feed for livestock. It is the crop that can help Nigeria ride out of the turmoil created by food price increases (Fuglie, 2007). In the nearest future, it is expected to be used in immense quantity as raw materials for biodegradable plastics and for fuel of automobiles (Quin, 2001). Therefore, this root crop will become more important in the 21st century than in the 20th century.

Sweet potato (*Ipomea batatas* L) is a major crop that had suffered serious neglect in the past, but which now occupies global position as a source of food and industrial raw material (Ojiako *et al*.,2007). China is the highest producer of sweet potato in the world (75.80 metric tons/year); Nigeria ranks third in the world and second in Africa with a production figure of 2.43mt (FAO, 2009). This is because sweet potato is a widely grown crop in Nigeria, the cultivation and production of which is still on the increase in Nigeria (Afuape *et al.,* 2006). As a result, the crop has moved up from the minor crop status it used to occupy (Agbo and Ene, 1994) to an enviable position of being the fourth most important root and tuber crop in Nigeria after cassava, yam and cocoyam. Its production has increased from 149,000 metric tons in 1961 to 106,197 million metric tons (FAO, 2015). The high nutritive value and performance under resource-poor condition make it attractive to farmers and households (Wang *et al*., 2003).

However, despite the increase in the production of sweet potato and its economic importance to the teeming populace in Nigeria, it still has not been produced to meet the food and industrial needs of the country. This is because there are some factors or problems affecting its growth and yield. This could be attributed to inadequate supply of required water for the growth and yield of the sweet potato plant; poor genetic, abiotic and biotic components of the parent sweet potato plant; high post-harvest losses, and high rate of missing stands due to abiotic stress (Akoroda and Egeonu 2008). Sweet potato is grown

using 20-30 cm vine portions called slips or cuttings. The cutting parts could be base, middle or apical. It was recommended that planting the apical parts is the best in order to get maximum tuber yield (Afolabi and Adebayo, 2016). The usual spacing of sweet potato planting to produce tuber is 1 m by 0.3 m giving 33,333 plants/ha.

The sweet potato stem planted does not die on the day of planting, though there could be sign of wilting. However, it may not survive if rain fails to fall and there is no water supply by irrigation for about 5-8 days, depending on the moisture content of the soil. Many stands are often lost due to varied factors, most especially lack of adequate water supply to the soil. Erratic pattern of rainfall would result to water shortage during the growth stage which could affect the sprouting or germination of the sweet potato stem after planting and this inadequate water supply by rainfall due to erratic rainfall pattern will affect the yields. The objective of this study was to determine the effect of rainfall amount or inadequate rainfall on missing stands and yields of 10 varieties of sweet potato.

2. MATERIALS AND METHODS

The experiments were conducted at the same time in four different locations in south west Nigeria. The locations are Igbon via Ejigbo (Osun State), Ibadan (Oyo State), Idofian and Ilorin (Kwara State). Ejigbo (Osun State) and Ibadan (Oyo State) belong to the rainforest zone while Idofian and Ilorin (Kwara State) belong to southern guinea savannah. Ilorin is about 140 km north of Ibadan, while Igbon is in between both cities. The experiment was done for two growing seasons in 2015 and 2016. Ten sweet potato germplasms obtained from the germplasm collection of the Department of Agronomy, University of Ibadan, Nigeria were used for this study (Table 1). Vines from each variety were cut into required 25cm and planted on the same day in all the locations at a spacing of 1 m x 0.30 m to make a population of 33,333 plants/ha. The experiment consisted of one row of 3m long ridge with 1m between the ridges in three replications arranged in Randomised complete Block Design. The land was prepared in one ridge-per plot entry. Two border rows were planted to envelope the experimental area in order to avoid border effects. On each ridge-plot, the vines were planted with the recommended spacing between consecutive plants. The field were weeded regularly before the ground is covered by vines development in all the locations. Insecticides were used to prevent the plants against insect pests as well.

Rainfall data for the period of the experiment were obtained from National Centre for

Agricultural Mechanization, Ilorin located at Idofian for Idofian location; Lower Niger River Basing for Ilorin; Department of Geography, University of Ibadan for Ibadan, and Metrological Station, Ido-Osun for Igbon. At four weeks after planting, data was taken on dead plants. Also, at harvest, data on the yields of the sweet potato from the four locations were collected and subjected to statistical analysis.

Below is the classification of thefield conditions assessment (FCA) according to Leon-Velarde *et al*. (1997) based on percentage missing stands at each location:

i. field conditions assessment (FCA) <30%=good
ii. field conditions assessment (FCA) 30-59= fair
iii. field conditions assessment (FCA) >60%=bad

Data were subjected to statistical test and graphical representation.

Table 1: Sweet potato varieties used for the study

Code	Variety	Flesh colour
1	Ex-Igbariam	Orange
2	TIS87/0087	White
3	TIS 8441	White
4	Famgbe	White
5	Resisto	Orange
6	Hernerndez	Orange
7	Blesbok	Cream
8	Barth	Cream
9	Naspot 5	Cream
10	Ejumula	Orange

Figures 1 and 2 below show the rainfall distribution pattern across four different locations for the period of the study. Rainfall amount in Ibadan and Igbon were consistently higher during the period of May to September, 2015 and 2016. However, rainfall distribution pattern in Ilorin and Idofian were consistently lower because they are in savanna zone and they have erratic rainfall compared to Ibadan and Igbon.

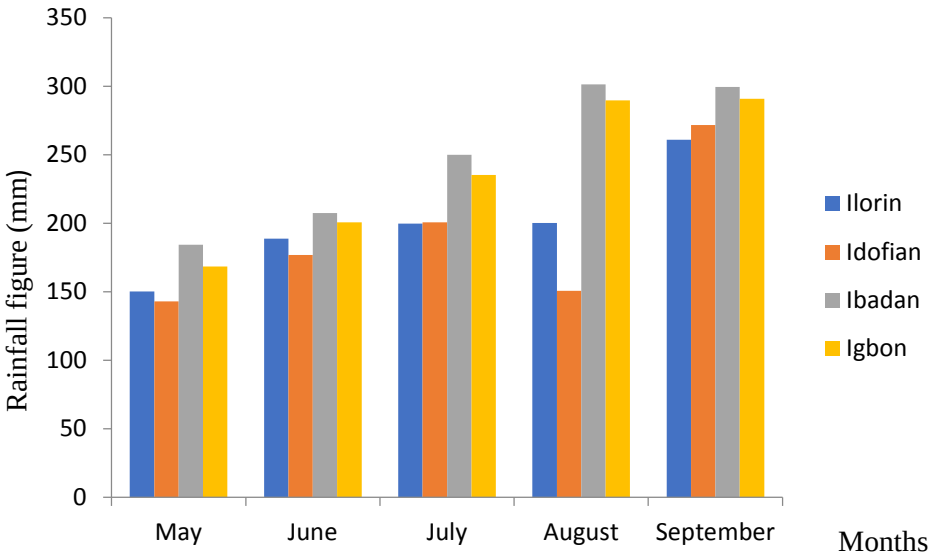

Figure 1: Amount of rainfall for the experimental period across the four locations of the study area in 2015

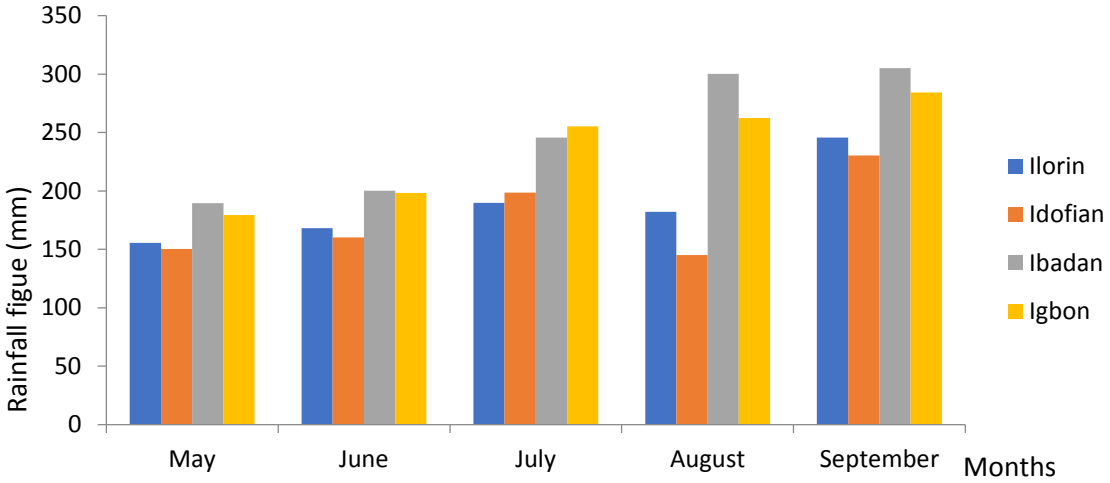

Figure 2: Amount of rainfall pattern for the experimental period across the four locations of the study area in 2016

3. RESULTS AND DISCUSSION

The percentage missing stands across four locations as well as their field conditions assessments in 2015 and 2016 were presented in Table 2.

Table 2: Description of the sweet potato varieties for percent missing stands across four locations in 2015 and 2016

S/N	Variety	Locations	Missing plants (%)				FCA*	
			2015	Mean in location,2015	2016	Mean in location, 2016	2015	2016
1	1	Ibadan	4.20	14.06 ± 7.64	5.70	15.70 ± 8.82	Good	Good
2	2	Ibadan	5.70		10.40		Good	Good
3	3	Ibadan	10.30		10.70		Good	Good
4	4	Ibadan	15.40		17.50		Good	Good
5	5	Ibadan	17.50		15.40		Good	Good
6	6	Ibadan	31.4		37.50		Fair	Fair
7	7	Ibadan	15.8		21.20		Good	Good
8	8	Ibadan	10.60		15.80		Good	Good
9	9	Ibadan	12.20		10.60		Good	Good
10	10	Ibadan	17.50		12.20		Good	Good
11	1	Ilorin	26.60	53.13 ± 18.83	26.60	54.13 ± 18.95	Good	Good
12	2	Ilorin	24.70		24.70		Good	Good
13	3	Ilorin	50.2		50.20		Fair	Fair
14	4	Ilorin	40.6		40.60		Fair	Fair
15	5	Ilorin	64.80		64.80		Bad	Bad
16	6	Ilorin	55.60		55.60		Fair	Fair
17	7	Ilorin	72.22		72.20		Bad	Bad
18	8	Ilorin	83.30		83.30		Bad	Bad
19	9	Ilorin	50.60		60.60		Bad	Bad
20	10	Ilorin	62.70		62.70		Bad	Bad
21	1	Igbon	12.00	16.18 ± 8.65	8.30	15.91 ± 10.72	Good	Good
22	2	Igbon	6.70		7.50		Good	Good
23	3	Igbon	7.20		12.30		Good	Good
24	4	Igbon	18.40		6.70		Good	Good
25	5	Igbon	17.30		7.20		Good	Good
26	6	Igbon	33.60		38.40		Fair	Fair
27	7	Igbon	27.50		17.30		Good	Good
28	8	Igbon	10.30		23.60		Good	Good
29	9	Igbon	12.50		27.50		Good	Good
30	10	Igbon	16.30		10.30		Good	Good
31	1	Idofian	30.20	45.78 ± 14.40	23.50	51.98 ± 18.74	Fair	Good
32	2	Idofian	27.50		30.20		Good	Fair
33	3	Idofian	37.51		43.70		Fair	Fair
34	4	Idofian	32.02		37.30		Fair	Fair
35	5	Idofian	43.09		50.20		Fair	Fair
36	6	Idofian	62.06		72.30		Bad	Bad
37	7	Idofian	63.69		74.20		Bad	Bad
38	8	Idofian	60.34		70.30		Bad	Bad
39	9	Idofian	41.20		48.00		Fair	Fair
40	10	Idofian	60.17		70.10		Bad	Bad
Mean			31.78		33.43			

The percentage missing stand for both Ibadan and Igbon for all the varieties was relatively low. The estimation of field condition assessment was good for Ibadan and Igbon except for variety Hernerndez for both locations during the two years. Field condition assessments of Ex-Igbariam and TIS 87/0087 were good for the two years in Ilorin. However, the field condition for varieties TIS 8441, Famgbe and Hernerndez was fair while the remaining varieties were bad for the two years. In Idofian, variety Ex-Igbariam had very moderate missing stands in 2015, but in 2016 the percentage missing stands was high as a result of reduced rainfall in 2016. Also, variety TIS87/0087 had low percentage missing stands in 2015 but high percentage missing stand in 2016. The remaining varieties had very high percentage mossing stands for both 2015 and 2016.

The results from combined analysis of variance revealed that effect of variety was highly significant for both percentage missing stands and tuber yield (Table 3). Also, the effect of location was highly significant for percentage missing stands and tuber yield. However, the effect of two growing seasons in 2015 and 2016 on missing stands and tuber yield were not significant. The interaction of variety x year, variety x locations and year x location were significant for both percentage missing stands and tuber yield. It could be concluded that locations greatly affect the number of plants that failed to germinate and that could survive upon germination after planting, resulting in missing stands. Missing stands could also be due to the variety of the parent sweet potato vine planted as well as soil differences from location to location. Most especially, missing stands could arise from differences in the rain fall intensity of the locations where the research was carried out.

Figure 3 shows the mean distribution of tuber yield of the ten sweet potato varieties for the four locations for years 2015 and 2016. Sweet potato tuber yield was consistently higher for all the varieties in Ibadan. The yield of variety Hernandez was not significantly different for Ibadan and Igbon, but significantly higher for Ilorin and Idofian. The average rain fall amounts for Ilorin and Idofian were lower than those for Ibadan and Igbon. Temperature and humidity are functions of the rainfall intensity; thus, the temperature and humidity obtained in the locations where variety Hernandez could not germinate or survive well after their germination were lower than those of the locations where the variety survived and yielded well. This could mean that variety Hernandez does not require as much water as the other varieties.

Table 3: Mean squares from combined analysis of variance for percentage missing stands and tuber yield among 10 sweet potato varieties evaluated in 2015 and 2016 in four locations

Treatment	Df	% Missing Stand	Tuber yield (t/ha)
Variety (V)	9	23.45**	23.48**
Year (Y)	1	31.45	4.59
Location (L)	3	27.58**	66.54**
V x Y	9	23.55**	21.53**
V x L	9	32.45**	33.48**
Y x L	3	26.54**	23.32**
Pool error	27	33.45	93.48

** Significant at P<0.01 level of probability

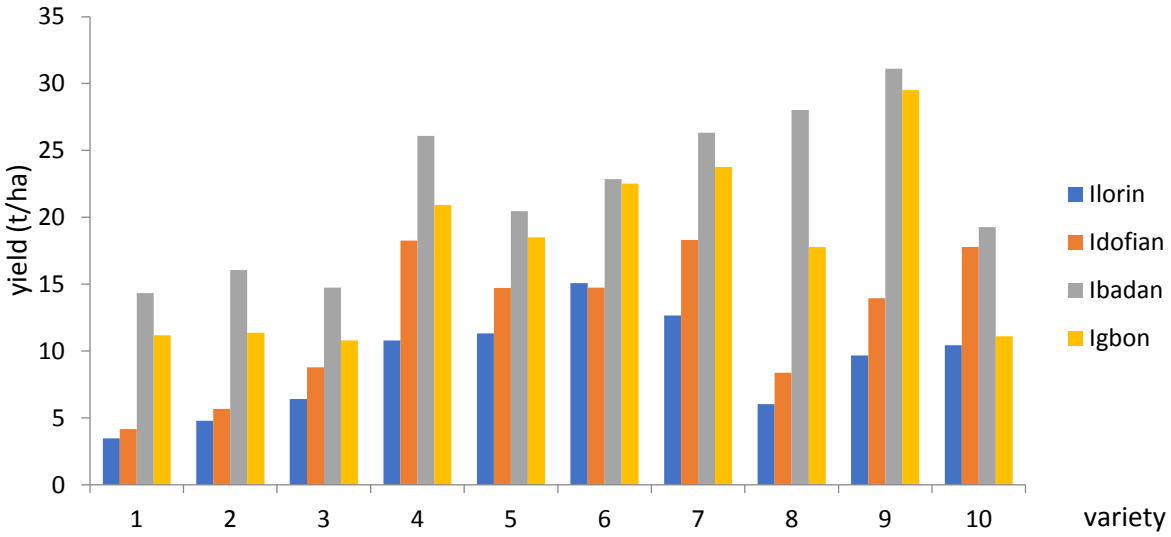

Figure 3: Mean distribution for sweet potato yield under four different locations for 2015 and 2016

The reason for varietal evaluation of sweet potato across different agro-ecological stations in Nigeria was to identify the influence of locations on the variety. Generally, rainfall pattern during the growing periods in the two years played a significant role in the expression of percentage missing stands and yield in this study. The reflection of rainfall amount during the early stage of planting of vines might stimulate the establishment of the plant for root formation. For instance, rainfall pattern was evenly distributed during the early planting stage of vines in Ibadan and Igbon because they were situated inthe rain forest zone. This condition favoured formation of adventitious roots from vines. A study

carried out by Gruneberg *et al*., (2005) showed that the highest mean sweet potato tuber yields were obtained in a location with 600mm rainfall in the growing season. This could be because it had high rainfall pattern, with rainfall being adequately enough for sweet potato, number of missing stands will be favourable as earlier found by Andrade and Josse (2000).

Sweet potato vines planted in Ilorin and Idofian had 160mm of rainfall during adventitious root formation at the early stage of May and June (Table 2). It could be deduced that this rainfall amount (160mm) is not sufficient for the formation of adventitious roots in sweet potato vines because there were averagely high number of missing stands in both locations (53.13 in 2015 and 48.57 in 2016 in Ilorin; 45.78 in 2015 and 51.98 in 2016 in Idofian) compared to Ibadan and Igbon with 15.70 and 16.18, respectively. Therefore, locations with enough rainfall for sweet potato during early planting time will record low percentage of missing stands. The significant differences among sweet potato varieties may be surmised to have accounted for the higher deviations in the numbers of missing stands and this could also be attributed to the presence of sufficient genetic variability in the varieties (Table 2). This also indicates that there were significant amount of phenotypic variability and that all the varieties differ from one another. Interaction of location, year and genotype confirms the diversity of the variety and their differences in rainfall response across the two years. This confirms the study by Islam *et al.* (2002) which reported that differences in tuber yield of sweet potato could be genetically manipulated by varying the environment, especially rainfall.

4. CONCLUSION

To enhance sweet potato production, we need better understanding of factors leading to missing stands and low tuber yield. This study highlights the fact that rainfall has a large role to play in plant establishment and economic yield. Many stands were lost due to erratic pattern of rainfall in the area where there is water shortage during the growth which could affect the sprouting or germination of the sweet potato stem after planting. Also, genotypic differences in the varieties could also have affected the interaction of location by year and the differences in amount of rainfall response. Thus, inadequate water supply due to erratic rainfall pattern affects yield.

REFERENCES

Afolabi, M.S. and Adebayo, A. I.(2016).Effects of cuttings parts on growth and yield of sweet potato (*Ipomea batatas* L. Lam) varieties. B. Agric.. Project Report, Department of Agronomy, Osun State University, Ejigbo Campus, 36pp

Afuape, S. O., Okocha, P. I., Nwazor, E. C., Nwankwo, I. M., and Njoku, D. J. (2006).Evaluation of new sweet potato gemplasm collections for yield and yieldcomponents.Proceeding of the 40th Conference of Agric. Society of Nigeria,National Root Crops Research Institute, Umudike 16-20 Oct. 2006 pp24-27.

Agbo, M. O. and Ene, L. S. O. (1994).Studies of sweet potato production and research in Nigeria.

Anrade M. I. and R. Josse. (2000). Evaluation of Nineteen Orange Fleshed sweet potato clones across fourteen different environment of Mozambique.

FAO (2009). Drought impact mitigation and prevention in the Limpopo River Basin: a situation analysis. Land and water discussion paper.Food and Agriculture Organization of the United Nations, Rome, Italy http://ftp.fao.org/agl/aglw.

FAO (2015). FAOSTAT. Food and Agriculture Organization of the United Nations, Rome, Italy, http://faostat.fao.org/ Accessed 9 Oct 2018

Fugilie, K. O. (2007). Priorities for sweet potato research n developing countries: Results of a survey. HortiScience 42 (5): 1200-1206.

Gruneberg W. J. K., Manrique, D., Zhang and M. Hermann. (2005). Genotype x environment interaction for diverse set of sweet potato clones evaluated across varyingecologeographic conditions in Peru. Crop Science 45: 2160-2171.

International potato centre (1994). Sweet potato situation and priority research in West and Central Africa. CIP, Lima, Peru. 124p

Islam, M. J., Haque, M. Z., Majundev, U. K. , Haque, M. M. and Hossain, M. F. (2002). Growth and yield potential of nine genotypes of sweet potato. Pakistan Journal of Biology science 5(5): 537-538.

Leon-Velarde, C., Roca J., Quispe, L. and Parraga, A. (1997). Perspectives on sweet potato: dualpurpose varieties. In: CIP programme Report 1995-1996. International Potato Centre (CIP), Lima, pp. 291-294.

Nwadili, C.O., Nwauzor, E.C., Afuape, S.O., Kahya, S.S., and Njoku, S.C. (2007): Investigation on the effects of different organic manure on incidence and severity ofroot rot disease of sweet potato in Nigeria. *NRCRI, Annual Report 2007.:64 - 67.*

Nwauzor, E.C. and Afuape, S.O. (2005): Collection and evaluation of sweet potato germplasm. *NRCRI , Annual Report 2005. : 49-50.*

Ojiako I. A.Asumugha G. N. Ezedinma C. and Uzokwe N. E. (2007). Analysis of production trends in the major root and tuber crop in Nigeria: 1961-2005. Research on Crops 8 (2): 371-380

Quin, F. M. (2001).Realising the potential of root crops in the 21st century: the modalities for sub-Sahara Africa. In Akoroda M. O. and Ngeve J. M. (eds). Root Crops in the 21stcentury.Proceding of the 7th symposium of the International Soceity for rootCrops- Africa Branch (ISTRC-AB), Cotonou, Benin. 11-17 October 1998. Pp 20-26

Wang, Y. P., Liu, Q. C., Li, A. X., Zhai, H., Zhang, S. S., and Liu, B. L. (2003). In vitro selection and identification of drought-tolerant mutants in sweet potato. AgricSci China 2:1314–1320