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PERFORMANCES OF PRO-VITAMIN A CASSAVA GENOTYPES TO WATER STRESS UNDER SCREEN HOUSE CONDITION IN UYO, SOUTH EASTERN NIGERIA

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Abstract

The study was carried out at University of Uyo, Akwa Ibom State to evaluate the performances of ten pro-vitamin A cassava genotypes under water stress condition. The experiment was 10 x 3 factorial laid out in a randomized complete block design (RCBD), replicated three times. Factor A were 10 pro-vitamin A cassava genotypes; TMS 01/1368, TMS 01/1412, TMS 01/1371, NR 07/0246, NR 07/0240, NR 07/0145, TMS 1070134, TMS 1070337, TMS 070593 and TMS 1061635 while factor B were the water field capacities (FC); 25, 50 and 75%. Growth and yield parameters were assessed. Results showed that all the cassava genotypes tested for had highest vegetative and growth parameters at 75% FC, followed by 50% FC while least at 25%. At 25%, TMS 01/1371 genotypes had the highest storage root yield kg/ha in 2012 and 2013 cropping seasons respectively, while TMS 01/1412 and NR 07/0240 had the highest potential storage root yield at 75% with the least yield at 25% FC. Therefore the study suggests that TMS 01/1371, TMS 07/0145, TMS 07059 and TMS 1061635 genotypes should be recommended to cassava growers in areas with short duration of rainfall.

Keywords: Water stress, field capacity, cassava genotypes.

INTRODUCTION

Cassava (*Manihotesculenta* Crantz) is the third largest source of food carbohydrate in the tropics, after rice and maize (FAO, 2014). Millions of people depend on cassava in Africa, Asia and Latin America (FAO, 2014). Cassava is vital for both food security and income generation. Cassava is a food security crop providing 2.2 times as many calories per hectare as maize, 2.7 times as much as yam and 1.5 times as much as sweet potatoes (FAO, 1986). The crop is one of the most dominant and main crop components in crop mixtures in South-eastern Nigeria (Ikeorgu and Iloka, 1994) and it is gradually gaining importance as an industrial crop (Mouneke and Mbah, 2007). Nigeria annual production of cassava is estimated at 49 million tones (Aba, 2010) and bout 90 percent of it is used as food (Awoyinka, 2009). Yet Nigeria, the world's largest producer of cassava (FAOSTAT, 2014) has not attained self-sufficiency in cassava production as 100 million tones of the commodity is required to contribute in guaranteeing food security for the nation where about 65 percent are food-insecure, i.e. insufficient access to the amount and variety of food for a healthy and productive life (Aba, 2010). Cassava is used in the production of ethanol and biofuel which is targeted at decreasing the demand for petroleum. It is also used worldwide for livestock feed production. Cassava flour is used for the preparation of various dishes and for baking cakes, bread, pan cake and biscuits (Akata, 2015). Starch is obtained from cassava for the preparation of gravies, sauces, baby food, jelly or thickening agents. It is also used in modified forms in livestock feeds, textile paper adhesive and a precursor of some drugs in pharmaceutical industries (IITA, 1990).

Cassava research and extension in Nigeria and sub-Sahara Africa at large have successfully focused on breeding and integrated pest management (IPM) strategies to control major pests and diseases. The major focus of such efforts was placed on coping with biotic constraints, relatively little attention has been given to abiotic crop management and socio-economic constraints (Fermont, 2009). Understanding the relative importance of these factors to the yield gap is a necessary step to guide the design of relevant research for development interventions aimed at improving cassava productivity. This has been acknowledged on the contribution of various constraints to the cassava yield gap in many agro-ecological regions where cassava is grown (Generation Challenge Proramme, 2008).

Low rainfall, either during the first 6 months after planting or during total crop cycle was identified as the most important factor that affects cassava yield. Water stress during the first six months after planting is known to reduce storage root initiation and negatively affects root yields (Connor *et al.*, 1981). Cassava exhibits strong defense mechanisms against prolonged seasonal droughts, which include, amongst others, partial stomata closure, ability to maintain reasonable net photosynthetic rates, leaf area reduction, leaf folding and extraction of water from deeper soil layers (El-Sharkawy, 2004; 2007). In addition, the crop has the ability to recover from a seasonal drought period and compensate for its adverse effect through an increase in leaf canopy area and by higher photosynthetic rates in the newly developed leaves (Fermont, 2009). Thus, water stress between 3 to 4 months after planting (MAP) reduces the response to fertilizer as it limits the formation of additional sink (i.e storage roots) and source (i.e above ground biomass) capacity, while seasonal water stress after 3 to 4 months does not affect fertilizer response as the source capacity is able to quickly record from the experienced stress and can fulfill the carbohydrate demand of the sink (Fermont, 2009). Fukai (1987) reported that cassava can survive under severe soil moisture deficits; economic yield is adversely affected by low availability of water. Once stress develops and leaves are shed, cassava requires a long time to recover back to full canopy even after the stress elements have been suppressed and hence potential yield is reduced (Aina *et al.*, 2007).

Despite reports on the physiological responses of cassava to water stress and mechanisms underlying its tolerance to drought (El-Sharkawy, 2004, 2007; Cock *et al.*, 1981), further studies on the effect of moisture stress on the vegetative growth, yield and yield components of different pro-vitamin A cassava genotypes has not been studied. Therefore, there is the need to evaluate and identify varieties that will be specifically adapted to drought especially in the tropical Africa where expectation of drought and desertification due to climate change is high.

MATERIALS AND METHODS

A field experiment was carried out in screen house of Department of Crop Science University of Uyo, Akwa Ibom State Nigeria in 2012 and 2013 Cropping Seasons. Uyo is located between latitude 5.17^o and 5.27^o and longitude 7.27^o and 7.58^{o}E, with a mean altitude of 38.1m above sea level (UCCDA, 1989). The area lies with the humid tropical rainfall zone of South-Eastern Nigeria and has a bimodal rainfall pattern with a mean rainfall of 2000 mm per annum. This has given rise to two cropping seasons – early (March- July) and late (August- December) with the traditional dry spell known as *August break*. The mean sunshine hour is 3 hours, 31 minutes, while annual temperature ranges from 26^{o}C – 28^{o}C and relative humidity between 75-95%. Evaporation rate ranges from 1,500 – 1,800mm annually, while the soil has been described as an ultisol (Enwezor *et. al.*, 1990).

The experiment was laid out in a randomized complete block design replicated three times in 3 x 10 factorial arrangements. Factors A were three moisture regimes (25%, 50% and 75%), while factor B constitute ten pro-vitamin A cassava genotypes; TMS 01/1368, TMS 01/1412, TMS 01/1371, NR 07/0246, NR 07/0240, NR 07/0145, TMS 1070134, TMS 1070337, TMS 070593 and TMS 1061635. These cassava genotypes were raised in large polythene bags of 60 cm length and circumference of 107 cm for a period of four months. Bags were filled with top soils with a sandy loam texture classified as ultisol and pH (in water) of 5.5, organic matter of 2.01%, total nitrogen of 0.18%, available phosphorus (P) 87.66mg/kg with calcium and magnesium values of 4.52 and 0.91 cmol/kg respectively. Cassava stem cuttings of 25 cm with 7 nodes were planted in each polythene bag mixture. Plants were well watered for four weeks after which moisture conditions were imposed by irrigating plants to field capacity (FC) of 75% as control, 50% and 25%. FC was determined following the procedure of Anderson and Ingram (1993). The different moisture treatments were used to stimulate field conditions under moisture stress with 50% and 25% FC as moderate and severe moisture stress conditions, respectively. Plants were irrigated once in a week in between 4- 6 pm, with 3.94, 2.63 and 1.31 litres of water respectively for 75%, 50% and 25% FC (Aina *et al*, 2007 method). After four months (4) all the samples were kept in an open field till ten months harvesting.

The following vegetative traits and yield parameters were assessed; number of leaves per plant, number of lobes per plant and number of branches per plant were assessed at 4 months after planting (MAP) while storage root tubers were harvested and weighed at 10 months after planting. All the vegetative and yield data collected were statistically analyzed with analyzed of variance using Genstat Package Discovery

Edition 2012. Significant means were separated with the least significant difference (P<0.05).

RESULTS AND DISCUSSION

Number of leaves per plant differs significantly in all the cassava genotype under varying field capacities in both year of study at 4 MAP (Table 1). In both years of study, under 25% field capacity the genotype TMS 01/1371 significantly produced more leaves than other genotypes studied which had 35.6 and 38.1 in 2012 and 2013 respectively. At 50% field capacity genotypes significantly differs in both years where genotype NR 07/0246 had produced more numbers of leaves when compared with others while fewer number of leaves was obtained from TMS 1061635. Cassava genotype NR 07/0240 significantly produced more number of leaves at field capacity of 75% in both years producing (116.2) and (112.2) leaves per plant in 2012 and 2013 respectively.

Table 2 showed a significant difference among the cassava genotypes and field capacity treatments on plant height. All the cassava genotypes were tallest when grown on 75% FC followed by 50% FC while shortest plants were recorded at 25% FC. Comparing number of lobes per plant (Table 3), TMS 01/1371 was the only cassava genotypes that had 7 lobes in all the FC in both trials except 6.7 lobes on the average recorded at 25% FC in 2013 season. All the cassava genotype had up to 7 lobes at FC of 75% in both cropping seasons whereas all of them had up to 7 lobes at 25% FC except TMS 01/1371 genotype in the first trial. Number of branches per plant also varied significantly (P<0.05) (Table 4). The result showed that TMS 01/1412, TMS 07/0246, NR 07/0240 had the least number of branches per plant at 25% FC, where among the genotypes that produced the highest number of branches per plant at 75% FC in both cropping seasons. Cassava genotypes like TMS 1061635, TMS 070593, TMS 1070337, TMS 1070134 and NR 07/0145 where the only genotypes that had up to two branches per plant at field capacity of 25%.

Table 5 shows the results of storage root yield in kg per plant differed significant difference (P<0.05) among cassava genotypes and under different field capacities. TMS 01/1412, NR 07/0246 and NR 07/0240 were among the genotypes that had the least storage yield at 25% FC but were among the genotypes that had higher yield at 75% in both cropping seasons. Among the cassava genotypes; TMS 01/1371, TMS 106135 and TMS 07/0145 were among the genotypes that had the highest storage root yield at 25% FC.

The variation recorded in the number of branches per plant could be attributed to inherent differences. This agreed with IITA (1990) that branching is a function of genotype or variety and environmental conditions where cassava is grown. IITA (1990) stressed that water stress and cool temperatures during growth circle may delay the formation of branches. The result of the study shows that some cassava genotypes were able to produce higher number of leaves per plant at 25% FC, this observation agreed with IITA (1990) that some cassava can grow in areas where the annual rainfall ranges from 600 to 750 mm and can survive in areas with dry seasons as long as 6 to 8 months. Lower number of leaves per plant recorded in some genotypes like TMS 01/1412, NR 07/0240 and NR 07/0246 at 25% FC with higher number of leaves per plant at 75% FC was in consonance with IITA (1990) that various environmental factors can affect the pattern of growth and development in cassava. Significant difference (P<0.05) recorded in tuber yield could be attributed to varietal differences as reported by Ikeh *et al.* (2013), while low yield was recorded in 25% FC from some genotypes like TMS 01/1412, NR 07/0240 and NR 07/0246 with high yield at 75% FC shows that these genotypes may not perform well under water stress while some genotypes like TMS 01/1371 and TMS 1061635 were able to produce appreciable yield compared to other. This indicated that those genotypes could not do well under droughty conditions. This observation was also in line with IITA (1990) that various environmental factors can affect the pattern of development and yield of cassava varieties. Cassava genotypes can thus tolerate drought through some mechanisms such as stomata closure and osmotic adjustment that ensure plant survival (EL-Sharkawy, 2007) while partitioning of assimilates for root bulking is impaired resulting into a high decline in economic yield (Fukai and Hammer, 1987; Aina *et al*, 2007).

CONCLUSION

Results of the study showed that different cassava genotypes evaluated responded differently to moisture stress. All the parameters evaluated were highest at 75% FC, although some genotypes still adapted at 25% and 50% FC. The spread of cassava cultivation towards arid and semi-arid ecological zones as a result of its increasing importance, it has becomes necessary for farmers to be able to choose most of the promising genotypes that could withstand drought for a reasonable period and still produce appreciable yield. The study therefore suggests that TMS 01/1371, TMS 1061635, TMS 07/0145 and TMS 070593 could be beneficial to farmers in drought prone areas.

Significance of the Research

Bio-fortified cassava is now in circulation in the country, through Harvest plus Nigeria, National Root and Research Institute, ADPs and Non Governmental bodies. There is no in-depth study on the ability of most varieties to thrive on water stress condition especially now that climate change and desert encroachment is alarming in Africa.

This study will provide ample information on most Pro-vitamin A Cassava that will survive under water stress.

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Table 1: Number of Leaves per Plant as influenced by Water Stress and Cassava Genotypes at 4 Months after Planting

	Field capacity (%)							
	2012				2013			
Cassava Genotypes	**25**	**50**	**75**	**Mean**	**25**	**50**	**75**	**Mean**
TMS 01/1368	28.75	65.31	96.75	**63.60**	31.60	64.95	103.40	**66.65**
TMS 01/1412	27.11	51.30	83.11	**53.84**	28.14	58.12	91.52	**59.26**
TMS 01/1371	35.60	41.08	64.25	**46.98**	38.12	45.40	81.09	**58.87**
NR 07/0246	29.20	75.12	102.40	**68.91**	31.06	71.71	111.33	**71.37**
NR 07/0240	24.75	70.88	116.25	**70.63**	21.08	64.13	112.16	**65.79**
NR 07/0145	17.25	36.12	61.70	**38.36**	20.11	32.60	60.42	**37.71**
TMS 1070134	18.20	40.25	85.50	**47.98**	17.22	37.64	91.70	**48.85**
TMS 1070337	21.67	51.14	95.33	**56.05**	24.31	53.92	97.18	**58.47**
TMS 070593	29.34	60.70	103.66	**64.57**	28.55	61.55	109.22	**66.44**
TMS 1061635	32.41	35.77	61.08	**44.09**	28.60	32.17	67.18	**51.68**
Mean	**26.43**	**52.77**	**87.00**		**26.88**	**52.22**	**92.52**	
LSD (P<0.05)	**1.83**	**2.75**	**2.08**		**2.11**	**2.98**	**3.16**	

Table 2: Cassava Height (cm)as influenced by Water Stress and Cassava Genotypes at 4 Months after Planting

	Field capacity (%)							
	2012				2013			
Cassava Genotypes	**25**	**50**	**75**	**Mean**	**25**	**50**	**75**	**Mean**
TMS 01/1368	56.70	81.45	101.36	**76.84**	60.20	85.63	112.52	**86.12**
TMS 01/1412	61.75	93.68	142.14	**121.63**	62.18	101.75	141.09	**101.67**
TMS 01/1371	107.50	116.30	128.41	**117.40**	100.33	120.01	131.35	**117.23**
NR 07/0246	99.70	108.75	125.36	**111.27**	96.70	110.40	128.14	**111.75**
NR 07/0240	59.80	80.60	128.33	**88.29**	55.51	82.25	133.59	**90.45**
NR 07/0145	77.12	99.75	105.31	**94.06**	80.22	98.14	109.34	**95.90**
TMS 1070134	90.67	114.30	130.30	**111.76**	95.83	112.70	135.30	**114.61**
TMS 1070337	59.70	74.18	98.14	**77.34**	61.68	80.08	95.05	**78.94**
TMS 070593	50.61	61.64	78.61	**63.42**	52.75	63.70	79.96	**65.47**
TMS 1061635	62.40	70.12	79.91	**70.81**	61.95	68.29	83.43	**71.22**
Mean	**72.60**	**90.02**	**111.79**		**72.74**	**92.30**	**114.98**	
LSD (P<0.05)	**2.85**	**3.16**	**3.58**		**2.77**	**3.60**	**3.90**	

Table 3: Number of Lobesas influenced by Water Stress and Cassava Genotypes at 4 Months after Planting

	Field capacity (%)							
	2012				2013			
Cassava Genotypes	**25**	**50**	**75**	**Mean**	**25**	**50**	**75**	**Mean**
TMS 01/1368	5.31	6.50	7.10	**6.30**	5.50	6.70	7.00	**6.40**
TMS 01/1412	5.30	7.00	7.20	**6.50**	5.40	6.50	7.10	**6.33**
TMS 01/1371	7.00	7.00	7.00	**7.00**	6.70	7.00	7.00	**6.90**
NR 07/0246	5.51	6.10	6.55	**6.05**	5.25	6.91	7.10	**6.42**
NR 07/0240	5.01	6.25	7.30	**6.19**	5.09	6.33	7.25	**6.22**
NR 07/0145	6.50	7.00	7.00	**6.83**	6.33	6.59	675	**6.56**
TMS 1070134	6.52	6.75	7.00	**6.76**	6.25	6.80	7.00	**6.68**
TMS 1070337	6.10	6.70	7.00	**6.60**	6.00	6.56	7.00	**6.52**
TMS 070593	6.00	6.55	7.10	**6.55**	6.00	6.80	7.12	**6.64**
TMS 1061635	6.10	6.70	7.00	**6.60**	6.20	6.65	7.00	**6.62**
Mean	**5.94**	**6.66**	**7.03**		**5.87**	**6.68**	**7.03**	
LSD (P<0.05)	**ns**	**ns**	**ns**		**ns**	**ns**	**ns**	

ns = not significant

Table 4: Number of Branches per Plant as influenced by Water Stress and Cassava Genotypes at 4 Months after Planting

	Field capacity (%)							
	2012				2013			
Cassava Genotypes	**25**	**50**	**75**	**Mean**	**25**	**50**	**75**	**Mean**
TMS 01/1368	1.05	5.36	8.33	**4.91**	1.33	4.35	7.45	**4.38**
TMS 01/1412	0.12	6.25	12.60	**6.32**	0.14	5.95	13.14	**6.41**
TMS 01/1371	1.60	4.70	7.30	**4.53**	1.72	3.84	9.20	**4.92**
NR 07/0246	0.30	6.15	10.45	**5.63**	0.15	6.75	11.01	**5.97**
NR 07/0240	0.20	6.85	11.53	**6.19**	0.21	6.75	11.01	**5.97**
NR 07/0145	2.12	5.75	7.55	**5.15**	2.36	3.81	7.12	**4.43**
TMS 1070134	2.18	4.30	8.11	**4.86**	2.25	4.25	8.61	**5.04**
TMS 1070337	2.06	7.50	10.16	**6.57**	2.18	8.12	10.72	**7.01**
TMS 070593	2.14	5.12	9.18	**5.48**	2.71	5.01	9.33	**5.68**
TMS 1061635	2.30	4.77	6.25	**4.44**	2.48	4.52	6.33	**4.44**
Mean	**1.41**	**5.68**	**9.15**		**1.55**	**5.34**	**9.55**	
LSD (P<0.05)	**0.21**	**1.25**	**2.35**		**0.18**	**0.23**	**1.33**	

Table 5: Cassava Storage Root Yield kg/plant as influenced by Water Stress and Cassava Genotypes at 4 Months after Planting

	Field capacity (%)							
	2012				2013			
Cassava Genotypes	**25**	**50**	**75**	**Mean**	**25**	**50**	**75**	**Mean**
TMS 01/1368	0.59	1.02	1.87	**1.16**	0.45	1.13	1.80	**1.13**
TMS 01/1412	0.35	0.91	2.11	**1.05**	0.31	0.88	1.86	**1.02**
TMS 01/1371	0.91	1.25	1.55	**1.24**	0.87	0.94	1.61	**1.14**
NR 07/0246	0.30	0.81	1.98	**1.02**	0.31	0.85	1.92	**1.03**
NR 07/0240	0.25	0.93	2.09	**1.09**	0.28	0.92	1.26	**1.15**
NR 07/0145	0.75	1.14	1.62	**1.17**	0.78	1.03	1.52	**1.11**
TMS 1070134	0.56	1.03	1.45	**1.01**	0.57	1.12	1.40	**1.03**
TMS 1070337	0.68	1.10	1.60	**1.13**	0.70	1.11	1.55	**1.12**
TMS 070593	0.70	1.26	1.69	**1.22**	0.71	1.28	1.70	**1.23**
TMS 1061635	0.72	1.30	1.70	**1.24**	0.78	1.31	1.69	**1.26**
Mean	**0.58**	**1.08**	**178**		**0.58**	**1.06**	**1.90**	
LSD (P<0.05)	**0.08**	**0.89**	**0.61**		**0.06**	**0.75**	**0.81**	