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Effect of varying levels of Potassium and Irrigation Interval on Sweet Potato Tuber Quality (*Ipomoea batatas* L.) In Sudan Savanna

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Abstract

Field trials were conducted during 2011/2012 dry season at UsmanuDanfodiyo University Teaching and Research Fadama Farm, Sokoto and Bakolori Irrigation Project, Talata Mafara to study the effects of different rates of potassium fertilizer and irrigation intervals on sweet potato tuber quality. The experiment consisted of five rates of potassium (0, 50, 100, 150 and 200 kg K_2O ha^{-1}) and three irrigation intervals (7, 14 and 21 days). The fifteen treatment combinations were laid out in a randomized complete block design and replicated three times. Results obtained showed that marketable tubers were optimized at 100kg K_2O ha^{-1} in Sokoto and 150 kg K_2O ha^{-1} at Talatamafara, Tuber weight were significantly increased by the application of 150kg K_2O ha^{-1} at Sokoto and 200kg ha^{-1} at Talatamafara. Irrigating at 21days intervals produced significantly higher tuber weight and marketable tubers in both locations. Thus, application of 100 to 200kg K_2O ha^{-1} with 21 day irrigation interval has the potential to improve both quality and size of sweet potato tubers and is therefore recommended.

***Keywords**: Sweet Potato; Marketability; Potassium; Irrigation; Sudan Savanna*

Introduction

Sweet potato (*Ipomoea batatas* L.) belongs to the family *Convolvulaceae* and is widely grown in the tropics and warm temperate regions of the world (Woolfe, 1992). Sweet potato is a short duration crop adaptable to a wide range of growing conditions, exhibiting no strict seasonality, making it suitable as a combined crop with other crops. In developing countries, it is ranked fifth in economic value, sixth in dry matter production, seventh in energy production and ninth in protein production (Lobenstein, 2009). Sweet potato is an important root crop having tremendous potential for utilization in food, feed and industrial sectors, especially for the production of starch, flour, glucose and alcohol (Wheatly *et al*., 2009). Sweet potato is a good source of vitamin C, B2, B6 and E as well as dietary fiber, K, Cu, Mn and Fe (Baybutt *et al*., 2000). The high nutrient content coupled with its anti-carcinogenic and cardio-vascular disease preventing properties has gained recognition for the crop as a health food.

Plant nutrients are essential for the production of qualitative crops that provide healthy food for world expanding population (Chen, 2006). Potassium is the third most essential nutrient, after nitrogen and phosphorous, to limit plant productivity (Brady and Weils, 2002). Sweet Potato crop has strict requirement for a balanced fertilization management without which potassium deficient plants are highly sensitive to fungal, bacterial, insect, mite, nematode and virus infections (Havlin *et al*., 1999 and Marschner, 2002). With a shortage of potassium, a whole range of

quality criteria such as nutritional and technological (processing) quality of harvested products particularly fleshy tubers is impaired (Marschner, 2002). Excessive moisture and high nutrient levels has resulted in decreased root yield and quality of sweet potato Chya and Kays (1981); Sajjapongse and Roan, 1982).Yield and tuber quality of sweet potato could be improved by the application of appropriate rate of potassium coupled with optimum irrigation levels.
This research is therefore, aimed at investigating the optimum potassium and irrigation levels on sweet potato tuber quality.

Materials and Methods

Trials were conducted at UsmanuDanfodiyo University Research farm, Sokoto(latitudes 12^0 and 13^0 05\` N and longitudes $4^0$ 8\` and 6^0 4 E) and Bakolori Irrigation Project site, TalataMafara (latitudes 12^0 3^0 and 12^0 50\` N and longitudes $5^0$ 59' and $6^0$ 20\` E) during 2011/2012 cropping season.
The lands were cleared, harrowed and made into 0.75 m row ridges and a gross plot size of 13.5 m^2 and net plot was 7.2 m^2 and one meter was left between blocks and 0.5 m between plots. Treatment consisted of five levels of potassium (0, 50, 100, 150 and 200 kg K_2O ha $^{-1}$) and three irrigation rates (7, 14 and 21 days). The fifteen treatment combinations were laid out in a randomized complete block design (RCBD) with three replicates. Nitrogen rate of 40 kg $ha^{-1}$was supplied using (Urea 46 %), 40 kg ha^{-1} phosphorous was supplied using SSP (18 % P_2O_5) and potassium were applied using muriate of potash (K_2O 60 %) as per treatments. Half of N, all of P and K were applied at planting and the second dose of N was applied at four weeks after planting. Vines of *Dan-Kano*, a yellow-orange skinned with orange flesh was sourced from the locality and used for planting. Planting was done manually using hoe at inter and intra row spacing of 75 and 30 cm, respectively. The fields were irrigated shortly after planting. Irrigation treatments of 7, 14 and 21 days interval were imposed at 3 weeks after planting using controlled flooding of individual plots using check basin to bring the soil to field capacity. Harvesting was done manually when the crop reached physiological maturity as shown by falling of the leaves; change in color of leaves to yellow and cracking of the soil. Soil samples were collected from the sites for analysis to determine the physical and chemical properties. Data were collected on marketable tuber, non-marketable tubers, weight per tuber and culled tubers. The data collected were subjected to analysis of variance (ANOVA) technique using SAS system (SAS, 1989). The treatments were separated using Duncan's New Multiple Range Test (DMRT) at 5 % level of significant.

Results and Discussion

Effect of potassium fertilizer

Effect of potassium rate and irrigation intervals on marketable tubers is presented on Table 2. The result indicated a significant response of potassium fertilizer on both locations. Where 100, 150 and 200kg K_2O ha^{-1} recorded the highest but statistically similar result in Sokoto and TalataMafara produced the highest but similar marketable tubers at the application of 150 and 200 kg K_2O ha^{-1}.

Table 1: Physical and chemical soil properties at the experimental sites

Parameters	Talata – Mafara	Sokoto
Physical properties		
Sand (%)	81.2	71.4
Silt (%)	14.7	20.4
Clay (%)	4.1	8.2
Textural Class	Sandy loam	Sandy loam
Chemical properties		
pH (H_2O) 1:1 ratio	6.6	6.2
pH($CaCl_2$)	6.1	5.7
Organic C (g/kg)	2.2	5.8
Available P (mg kg^{-1})	0.59	0.63
Total nitrogen (g/kg)	0.7	0.7
Exchangeable bases (C_{mol} kg^{-1})		
Ca	1.65	2.3
Mg	0.8	0.9
K	0.21	1.23
Na	1.48	0.74
CEC	6.8	5.4

Table 2: Effect of potassium rate and irrigation interval on marketable tuber at Sokoto and TalataMafara in 2011/2012 dry season

Treatment	Sokoto	TalataMafara
Potassium rate (kg K_2O ha^{-1})		
0	247.62^{c}	244.07^{c}
50	259.29^{b}	250.93^{bc}
100	340.00^{a}	267.62^{b}
150	288.88^{a}	319.41^{a}
200	301.85^{a}	321.48^{a}
SE±	25.623	12.106
Irrigation interval (days)		
7	263.34^{ab}	245.05^{b}
14	273.33^{a}	257.80^{b}
21	325.92^{a}	327.26^{a}
SE±	19.848	9.308
Interaction		
K X I	NS	NS

Means with the same letter (s) are not significantly different at $P \leq 0.05$ level of significance using DNMRT

Perhaps, this could be attributed to the role potassium plays in promoting synthesis of photosynthates and their transport to roots resulting in significant improvement in tuber size, and quality. This agrees with Martin-Prevel (1989) who observed that potassium fertilizer promotes large size of sweet potato tubers. Similarly, Hartemink, (2003) reported that potassium fertilizer significantly increase weight of marketable tubers. Data in Table 3 shows effect of potassium rate and irrigation levels on non-marketable tubers. The result revealed that plots that received no potassium recorded the highest number of non- marketable tubers in both locations. This could be related to the effect of potassium on tuber performance. It was observed by Togari, (1950) that inadequate potassium fertilizers retard the production of large tuberous roots and favors the formation of non – marketable tubers.Significant effect was observed due to K fertilizer on culled tuber , this could probably be due to the role potassium plays in improving a whole range of quality criteria of sweet potato tubers, which include; tuber size, storage content, shipping quality and shelf life, cooking and processing qualities, chips color, storability, resistance to mechanical damage (Jackson and Thomas, 1960; Nicholaides e*t al*., 1981; Onwueme, 1981; Yeh*et al*., 1981; Hammett and Miller, 1982; Hammet, 1984; Patricia and Bansal, 1999).Marschner, (2002), reported that increase in culled tuber of sweet potato may be due to the toxic effect of the fertilizer as a result of excessive stored content in the tubers which affect both its quality and quantity. Similarly, Havlin*et al*. (1999) observed that potassium deficient crops are highly sensitive to fungal, bacterial, insects, mites, nematode and viruses.

Effect of irrigation levels

Result shows that marketable tubers was significantly influenced by irrigation treatment. Analysis indicated that marketable tubers under 21 days interval recorded the highest marketable tuber weight in both locations as shown in Table 2. Similarly, tuber weight showed positive response to 21 days irrigation level compared with other treatments. This could be due to the longer period allowed for moisture loss that improve soil aeration necessary for optimum plant growth and development. This agrees with Yadav *et al*. (2009) who reported that better availability of soil aeration is ascribed to increase in sweet potato growth. Non-marketable tubers were higher but similar at 7 and 14 day irrigated plots as shown in Table 3. This may be due to excessive moisture content of the soil which might have resulted to soil compaction that reduced roots bulk uniformity. Miller *et al*. (1992) observed that excessive irrigation brings changes in soil physical properties, basically acting as soil lubricant, influencing soil compaction. Result in Table 4 showed that tuber weight under 21 days interval recorded the highest mean for Sokoto and TalataMafara. This is justifiable, because the root system of sweet potato can expand under condition of water shortage. It is obvious that continuous application of water at optimum levels would result in improvement in yield attribute (Mohamed *et al*., 2006).

Table 5 shows response of irrigation treatment on culled tubers. Result indicated that no significant effect in Sokoto, but TalataMafara produced the highest culled tubers at 7 days irrigation level. It is obvious that excessive moisture condition often affect flowering stages, causes diseases, splitting or low quality fruit (fruit rot) that causes low yield which might in turn resulted in a significant reduction in both yield and quality (Schulthesis (2001).

Table 3: Effect of potassium rate and irrigation interval on non- marketable tuber at Sokoto and TalataMafara in 2011/2012 dry season

Treatment	Sokoto	TalataMafara
Potassium rate (kg K_2O ha^{-1})		
0	204.74^{a}	203.70^{a}
50	172.62^{ab}	157.41^{a}
100	184.15^{ab}	181.48^{ab}
150	142.03^{b}	152.92^{b}
200	146.96^{b}	111.09^{c}
SE±	15.677	10.069
Irrigation interval (days)		
7	138.89^{b}	146.10^{b}
14	181.42^{a}	148.42^{b}
21	190.02^{a}	189.45^{a}
SE±	12.144	7.799
Interaction		
K X I	NS	NS

Means with the same letter (s) are not significantly different at P ≤ 0.05 level of significanceusing DNMRT

Table 4: Effect of potassium and irrigation rate on tuber weight (g) at Sokoto and TalataMafara in 2011/2012 dry season

Treatment	Sokoto	TalataMafara
Potassium rate (kg K_2O ha		
0	264.82^{b}	237.07^{c}
50	272.92^{b}	253.92^{bc}
100	247.07^{b}	245.63^{bc}
150	302.01^{ab}	260.08^{b}
200	343.55^{a}	287.15^{a}
SE±	18.196	7.208
Irrigation interval (days)		
7	277.64^{b}	231.06^{c}
14	268.89^{b}	263.93^{b}
21	327.89^{a}	280.71^{a}
SE±	7.208	5.583
Interaction		
K X I	NS	NS

Means with the same letter (s) are not significantly different at P ≤ 0.05 level of significance using DNMRT

Table 5: Effect of potassium rate and irrigation interval on culled tuber (g) at Sokoto andTalataMafara in 2011/2012 dry season

Treatment	Sokoto	Talatamafara
Potassium rate (kg K_2O ha^{-1})		
0	231.50^{a}	0.00^{c}
50	175.98^{ab}	78.71^{b}
100	193.52^{ab}	116.67^{a}
150	88.93^{c}	101.85^{a}
200	50.00^{c}	104.26^{a}
SE+	34.643	5.323
Irrigation interval (days)		
7	103.92^{c}	156.17^{a}
14	160.02^{b}	69.23^{b}
21	180.00^{a}	15.50^{c}
SE+	5.323	4.123
Interaction		
K X I	NS	NS

Means with the same letter (s) are not significantly different at $P \leq 0.05$ level of significance using DNMRT

Conclusion

From the foregoing, it can be seen that marketable tubers were optimized at 100kg K_2O ha^{-1} in Sokoto and 150 kg K_2O ha^{-1} at Talatamafara, Tuber weight were significantly increased by the application of 150kg K_2O ha^{-1} at Sokoto and 200kg ha^{-1} at Talatamafara. Irrigating at 21days intervals produced significantly higher tuber weight and marketable tubers in both locations. Thus, application of 100 to 200kg K_2O ha^{-1} with 21 day irrigation interval has the potential to improve both quality and size of sweet potato tubers and is therefore recommended.

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