International Journal of Plant & Soil Science
11(3): 1-12, 2016; Article no.IJPSS.25964
ISSN: 2320-7035

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Growth and Yield of Sweet Potato (*Ipomoea batatas* (L.)) as Influenced by Irrigation Interval and Variety in Sokoto Sudan Savannah, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Authors MBS and MIG designed the study, wrote the protocol and author MIG wrote the first draft of the manuscript. Author MIG managed the literature searches, and the experimental process. Author MBS analyzed the results. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2016/25964
Editor(s):
(1) Mirza Hasanuzzaman, Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.
Reviewers:
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(2) Crépin Pene, Academy of Sciences and Arts (ASCAD), Ivory Coast.
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(4) Magdalena Valsikova, Slovak University of Agriculture in Nitra, Slovakia.
Complete Peer review History: http://sciencedomain.org/review-history/14763

Original Research Article

Received 28th March 2016
Accepted 9th May 2016
Published 24th May 2016

ABSTRACT

Field trial was conducted at the Usmanu Danfodiyo University Teaching and Research Fadama farm Sokoto during the 2015 dry season at Sokoto to determine the influence of irrigation interval and variety on the growth and yield of sweet potato in Sokoto Sudan savannah, Nigeria. Treatments consisted factorial combination of four irrigation intervals (7, 14, 21 and 28 days), two local varieties of sweet potato (Ex-Kano and Ex-Zaria) laid out in a split plot design, replicated three times. The results showed that 7 days irrigation interval significantly ($P < 0.05$) influence growth, yield and yield components of sweet potato. The highest numbers of leaves per plants were recorded at 7 days interval whereas 28 days interval recorded fewer number of leaves per plant. Irrigation and variety had no significant effect on Leaf area index and vine length. Number of tubers per plant, marketable tubers and vine weight were significantly higher at 7 days irrigation interval. On the other hand, the highest number of non-marketable tubers was recorded at 28 days irrigation

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interval, similarly the lowest number of non-marketable tubers was produced at 7 days irrigation interval. Ex-Zaria Significantly ($P < 0.05$) differed from Ex-Kano with higher number of tuber per plant, Marketable tuber and tuber yield ha^{-1}. Therefore 7 days irrigation interval and Ex-Zaria cultivar is recommended for Sokoto and other areas with similar climate.

Keywords: Sweet potato; marketable tuber; non-marketable tuber; culled tuber; vine length.

1. INTRODUCTION

Sweet potato (*Ipomoea batatas* (L.) Lam) belongs to Convolvulaceae family, it is a perennial crop usually grown as an annual in the tropical, sub-tropical and frost-free temperate climatic zones of the world [1]. It ranks fifth as the most important food crop after rice, wheat, maize and cassava in developing countries [2]. [3] reported that 115 countries produced 108,274,685 tonnes of sweet potato in 2010 with China producing the largest, 82,474,410 tonnes, followed by Indonesia, 2,083,623 tonnes. Far behind, but ranked second in the world after Asia, is Africa with its contribution of up to 14% of global production put at 14,441,099 tonnes in 2010. Nigeria ranks second in Africa after Uganda with the production figure of 2,883,408 tonnes which has shown an increasing trend over the years [4]. Sweet potato is valued for its tubers which are boiled, fried, baked or roasted for humans or boiled and fed to livestock as a source of energy. The tubers can also be processed into flour for bread making, starch for noodles as well as used as raw material for industrial starch and alcohol Ukom et al. [5]. The flour is utilized also in sweetening local beverages like *Kunu-zaki, burukutu,* and for fortifying baby foods and fufu/pounded yam in Nigeria Tewe et al. [6]. The leaves are used as vegetables in yam and cocoyam porridge and are rich in proteins, vitamins and various minerals. Sweet potato tubers are rich in vitamins A, B and C and minerals such as K, Na, Cl, P and Ca [1]. It can therefore be a high value-added food particularly for children and pregnant women who are more often exposed to vitamin A deficiency in Sub-saharan Africa [7]. Nutritionally; sweet potatoes usually have rather higher protein content than other tubers such as yam and cassava. Protein content varies from 1 to 2.5%. Carotenes precursors of vitamin A are often present in yellow varieties. [8] reported that sweet potato is rich in antioxidants; it also has anti-aging nutrients, which are photochemical or substances (mostly present in fruits and vegetables), which neutralizes the free radicals generated by the body during metabolism; when not neutralized free radicals travels through the body cell disrupting the structures of protein, lipids, carbohydrates and cause cell damages and such damage is believed to contribute to aging and development of degenerative diseases such as cancer and heart diseases among others. Sweet potato hold potential in the production of ethanol for use as liquid fuel [9] and the use of sweet potato for ethanol production was reported in the USA because of the increasing demand for ethanol, alternative and non-conventional raw materials among them Mussatto et al. [10]

Water is the most important compound in actively growing plants and constitutes more than 80 % of the growing tissue. The inability of a plant roots to supply such demands is one of the principal constraints of productivity [11]. In arid or semi-arid areas, crop growth is mainly dependent on irrigation. Irrigation methods and management are important to soil water status and thus, to plant water [12]. Water for irrigation is becoming both limited and expensive and necessitates its utilization in an economic manner. According to [13], irrigation allows farmers to apply water at the most beneficial times for the crop, instead of being subjected to erratic timing of rainfall. According to [14], the basic function of irrigation scheduling is to make the most efficient use of water to crop land at the right time and in the right place for optimum productivity. The report further stressed that the idea behind irrigation management in the tropical agriculture was borne out of the necessity to avoid possibility of under utilizing the rich agricultural lands in the ecological zones by adapting irrigation scheduling.

The growth, development and consequently yield of crops are highly influenced by available soil moisture Thakuria et al. [15]. Yields of sweet potato grown at several locations were increased by irrigation [16], According to Yadav et al. [17], improvement in growth and developments under more frequent irrigation was due to higher availability of soil moisture which might have helped in better nutrient uptake by the crop which in turn resulted in translocation of photosynthates toward sink. Similarly, Chowdhury et al. [18]

reported a higher tuber volume at higher irrigation levels and it inversely relates to soil penetration resistivity. Sweet potato varieties are classified as erect, bushy, intermediate, or spreading, based on the length of their vines [19]. Sweet potato cultivars are highly variable in their total number of leaves per plant ranging from 60 to 400 Somda et al. [20]. Petiole length varies widely with genotypes and may range from approximately 9 to 33 cm in African varieties Yen [21]. Sweet potato cultivars vary widely in their yield potential Kubota et al. [22].

In spite of sweet potato importance as food and vegetable, very little attention has been paid for improvement in cultural practices [23]. Sweet potato yields in Africa (5 t ha^{-1}) are low due to poor crop management as compared to Asia (16 t ha^{-1}) and South America (10 t ha^{-1}) [1]. In Nigeria 4.9 t ha^{-1} was the national average and 32 t ha^{-1} is the experimental figure living yield gap of 19t and 146 percent possible improvement. Onunka et al. [24] confirmed that yields of sweet potato is presently restricted by many factors among which are low soil fertility, varietal selection, planting date, weather condition, soil type, weed, insect and disease pressure and crop management practices among others.

The potential of sweet potato to guarantee food security is under-estimated as its use is often limited to a substitute food in African countries. Nigeria is now the third highest producer of sweet potato in the world with a production of 2.12 million metric tons [25].

The increasing worldwide shortage of water and cost of irrigation are leading to an emphasis on developing techniques of irrigation that minimize water use, [26]. The goal of irrigation scheduling is to make the most efficient use of water to crop land at the right amount and in the right place for optimum productivity [14]. Water scheduling, ability of small and frequent irrigation have created interest because of decreased water requirement, possible increased production and better quality produce. Though, there have been studies of irrigation requirements [16], but there seems to be little information available on the influence of cultivar and irrigation scheduling on the growth and yield of sweet potato.

The objectives of the study are to determine the effect of cultivars on the growth and yield of sweet potato and also select the most appropriate irrigation interval for optimum growth and yield of sweet potato.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted during the 2014/2015 dry season at the Usmanu Danfodiyo University, Teaching and Research Fadama farm, Sokoto. Sudan savannah ecological zone of Nigeria, Sokoto lies between latitudes 12º and 13º 05^1 N and longitudes 4º 8^1 and 6º 4^1 E with an altitude of 350 m above sea level Mamman et al. [27]. With an annual rainfall of 814.7 mm, Maximum temperature of 36.3ºC, Minimum temperature of 22.4ºC, potential evapo-transpiration of 52.87 and Radiation of 19.2 MJ/m^2/Day [28].

Treatments consisted of factorial combinations of two sweet potato varieties (Ex-Kano is yellow-orange skinned with orange flesh and Ex-Zaria which is reddish purple skinned with white flesh) and four irrigation intervals (7, 1 4, 21 and 28 days) laid out in a split plot design replicated three times. Irrigation schedule was assigned to the main plots, while cultivars were allocated to the sub plots.

Prior to planting, soil samples were collected from 0 – 30 cm horizon for physic-chemical analysis Ogunwale et al. [29]. The land was cleared, harrowed and leveled. Gross plot size was 3 m X 3 m (9 m^2), while net plot size was 3 m^2. Water channels constructed and plots of four ridges of 3m long, spaced 75 cm apart while intra row spacing was 50 cm. Plots were kept weed free by regular manual weeding. The recommended rate of 40 kg/ha N was supplied using (Urea 46%), 45 kg/ha phosphorous was supplied using single super phosphate (SSP) (18% P_2O_5) and 60kg/ha potassium was supplied using Muriate of Potash (K_2O 60 %). Half of N, all of P and K were applied at land preparation and the second dose of N was applied four weeks after planting. On 15th February, 2015, planting was done manually using hoe at inter and intra row spacing of 75 and 50 cm, respectively. Cuttings of 30cm were planted. Two cuttings were inserted into the soil at an acute angle to the ground with half to two third of the length buried in the soil with nodes pointing upward. The field was irrigated shortly after planting. Surface irrigation (control flooding) was used in irrigating the field. The system consists of a tube well and a pumping machine for pumping water to the water channels located at the field. The plots were flooded to their capacity as per the treatments. The irrigation treatment was imposed

three weeks after planting. Pests were controlled by spraying Karate ® three times at 2 weeks interval while diseased plants were controlled by uprooting whenever noticed. Weeds were controlled manually using hoe, On 20th May, 2015, harvesting was done manually when the crop reached physiological maturity as shown by yellowing and falling of leaves and also cracking of the soil. The field was irrigated 3 days prior to harvesting to facilitate lifting of the tubers in order to minimize bruising of tubers.

Data was collected in respect of:

2.1.1 Vine length (cm)

This was determined by measuring the vine length of four randomly tagged plants from the base to the tip of the vine at 3, 6, 9, 12, 15 and 18 weeks after planting (WAP) using a meter rule in each net plot and was recorded as vine length.

2.1.2 Number of leaves per plant

The leaves of the four tagged plants were counted at 3, 6, 9, 12, 15 and 18 WAP and the average was calculated and recorded as number of leaves per plant.

2.1.3 Leaf area index (LAI)

The leaf area index was calculated using the following formulas described by [30].

A (leaf area) = 0.56 x P x 6.20

Where: P = length x breath of sweet potato leaves, 0.56 and 6.20 are constants which account for the irregularity of sweet potato leaves [30].

LAI (Leaf area index) = $\frac{Leaf\ Area}{Land\ Area}$

2.1.4 Number of tubers per plant

Number of tubers was determined at harvest by counting tubers from the four randomly tagged plants from each net plot and average recorded as number of tubers per plant.

2.1.5 Number of marketable tuber per plant

The number of marketable tubers per plant was determined by counting the harvested tubers of the four randomly tagged plants, of weight ranging from >100 g [31].

2.1.6 Number of non-marketable tuber per plant

This was determined by separating harvested tubers of weight less than >100 g [31] from the four randomly selected plants. The average of these tubers is then computed and recorded.

2.1.7 Average weight of tuber per plant

This was computed by weighing harvested tubers from the four randomly tagged plants within net plot area. The average is then computed and recorded as tuber weight per tuber.

2.1.8 Average weight of marketable tubers

Marketable tubers are tubers that had no wounds and having weight between >100 g [31]. Tubers from the four randomly tagged plants were weighed and the average computed as average weight of marketable tubers per plant.

2.1.9 Average weight of non-marketable tubers

Tubers that sustain wounds/bruises before or during harvesting and those below marketable weight >100 g are recorded as non-marketable tubers.

2.1.10 Culled tuber weight (kg/ha)

These are tubers infected either by insect, pest or injured. They were determined by weighing the number of culled tubers obtained from the four randomly harvested tagged plants. The average is recorded as culled tuber yield in kilogram per hectare.

2.1.11 Total tuber yield (t/ha)

This was determined by weighing the total tuber yield from net plot area and extrapolated as tuber yield per hectare.

2.1.12 Vine weight (t/ha)

This was determined by weighing the total vines of the net plot after harvest and extrapolated to vine weight per hectare.

The data collected was subjected to analysis of variance (ANOVA) [32] using GenStat Discovery

Edition 4.10,3DE (PC/Windows). Bibinu et al. [33] and [34]. Means were separated using Duncan's Multiple Range Test at 5% level of probability [35].

3. RESULTS AND DISCUSSION

3.1 Physical and Chemical Properties of the Soil

The soil of the experimental site is sandy loam, slightly acidic, low in organic Carbon, Nitrogen, CEC and exchangeables cations (Table 1).

3.2 Vine Length (cm)

Vine length as influenced by variety and irrigation interval is presented in Table 3. The results indicated that irrigation interval and variety had no significant influence on vine length at 3, 6, 9, 12, 15 and 18 weeks after planting. Interaction effect between variety and irrigation interval is not significant.

3.3 Number of Leaves per Plant

Number of leaves per plant as influenced by irrigation interval and variety is presented in Table 4. Irrigating at 7 days intervals differed significantly ($P < 0.05$) with higher number of leaves at 3, 12, 15 and 18 weeks after planting. The fewer number of leaves was obtained from 28 days irrigation interval; this may be due to the difference in moisture enjoyed by the plants. Sufficient moisture level increase photosynthesis and transfer of assimilates to leaves production. This conforms to the findings of [36] that consistent irrigation at 7 days intervals produced significantly higher number of leaves. Chowdhury et al. [18] reported that frequent water application recorded higher growth and yield attributes in sweet potato. However, variety and the interaction between irrigation interval and variety had no significant difference.

3.4 Leaf Area Index (LAI)

Influence of Irrigation Interval and Variety on Leaf Area Index is presented in Table 5. Neither irrigation interval nor variety had any significant effect. The interaction between variety and irrigation interval was not significant.

3.5 Number of Tubers per Plant

The results on Table 6 indicated that the influence of Irrigation interval and Variety on Number of tubers per plant. Significant difference was recorded with both irrigation interval and variety, at 7 days irrigation intervals, the number of tubers produced are significantly ($P < 0.05$) higher than those produced at 14, 21 and 28 days intervals which were statistically the same. This may be due to availability of moisture at 7 days interval which could result to translocation of more photosynthate to the roots thereby resulting in greater extraction of moisture with increasing level of irrigation hence more tubers are produced. This is supported by Chowdhury et al. [18] who reported that frequent water application recorded higher growth and yield attributes in sweet potato owing to more moisture availability to the crop for growth and development.

The number of tubers recorded differs with variety as Ex-Zaria produced higher number of tubers than Ex-Kano, The difference in number of tubers between the varieties may be due to the better rooting system of Ex-Zaria which helped in better nutrient uptake by the crop which in turn resulted in assimilation of photosynthates toward sink for optimum tuber growth. The interaction between irrigation interval and variety shows no significant difference.

Table 1. Physical and chemical properties of the soil in the experimental site prior to the study

Parameters	
Sand (%)	72
Silt (%)	19.8
Clay (%)	8.2
Textural class	Sandy loam
pH (H2O)	6.1
pH (CaCl2)	5.8
Organic carbon (%)	0.58
Nitrogen (%)	0.07
Exchangeable cations	_
Magnesium (C_{mol} kg^{-1})	0.9
Phosphorous (mg/kg)	0.6
Potassium (C_{mol} kg^{-1})	1.23
Sodium (C_{mol} kg^{-1})	0.74
CEC	2.56

Analysis conducted at the Soil Science Laboratory, Usmanu Danfodiyo University, Sokoto, Nigeria (2015)

Table 2. Meteorological data of Sokoto during the year 2015

Months	Rainfall (mm)	Rain day	Potential evaporation (PET) mm/day	MAX °C	MIN °C	Growing degree day (GDD)	Radiation MJ/m^2/Day
January							
21-31	0	0	68.8	35.7	17.0	201.9	26.5
February							
1-10	0	0	70.6	39.5	19.2	213.6	28.4
11-20	0	0	63	38.4	22.6	222	24.9
21-28	0	0	48.8	35.6	19.7	156.9	25.3
March							
1-10	0	0	64.4	37.0	19.9	204.4	26.3
11-20	0	0	62.6	39.0	24.6	238.2	24.2
21-31	0	0	69.2	38.8	23.9	256.8	24.5
April							
11-20	0	0	64.5	38.6	21.0	218	25.8
21-30	0	0	67	42.2	25.1	256.5	25.1
May							
1-10	15.2	1	61.4	41.3	26.3	258.1	22.9
11-20	0	0	56	40.9	27.9	263.9	20.7
21-31	0	0	62.5	41.1	27.2	287.9	21.2
June							
1-10	19.2	1	49	37.9	26.7	242.7	18.8
11-20	0	0	51.2	39.0	26.9	249.5	19.4
21-30	75	3	47	36.4	25.3	228.4	18.4
July							
1-10	62.7	3	47.2	35.7	24.4	220.7	18.8
11-20	58.5	3	45.5	34.7	24.2	214.4	18.3
21-30	19	4	45.6	31.9	23.0	214.1	17.2
August							
1-10	22.3	5	43.2	32.6	23.5	200.5	17
11-20	75.1	8	42.3	31.3	22.3	187.7	17.8
21-30	11.8	3	47.7	31.9	23.2	215.2	18
September							
1-10	138.5	5	43.7	31.7	23.0	181.6	18.2
11-20	312	4	46.6	32.7	23.3	199.9	19.2
21-30	5.4	2	51.2	34.6	23.9	212.8	20.6
October							
1-10	0	0	50.9	35.0	24.6	218.4	20.3
November							
December							
21-31	0	0	4.7	29.1	15.9	159.2	21.6
Total	**814.7**	**42**					
Average			**52.87**	**36.3**	**22.4**	**220.12**	**19.2**

Source: Nigerian Meteorological Agency (NIMET)

3.6 Number of Marketable Tubers

The result on number of marketable tubers as influenced by irrigation intervals and variety is presented in Table 7. Irrigation showed a significant difference ($P < 0.05$). Irrigating at 7 days interval yields more marketable tubers than tubers produced at 14, 21 and 28 days intervals. This can be attributed to the more soil moisture enjoyed by plants irrigated after every 7 days, and this result in more photosynthesis and translocation of photosynthates to tuber production. The result is in harmony with the findings that; the growth, development and

consequently yield of crops are highly influenced by available soil moisture [37]. Varietal differences also occurred as can be seen that Ex-Zaria produced more marketable tubers than Ex-Kano. This could be due to larger leaf surface area and better rooting system of the Ex-Zaria variety. However, interaction between irrigation intervals and the variety showed no significant difference.

3.7 Number of Non Marketable Tubers

Number of non-marketable tubers as influenced by variety and irrigation intervals is presented in Table 7. The result indicated that irrigation interval, variety and their interaction had no significant effect on the number of non-marketable tubers produced.

Table 3. Influence of irrigation interval and variety on vine length of sweet potato during the 2015 dry season at Sokoto Sudan Savannah Nigeria

Treatment	Vine length (CM)					
	Weeks after planting					
	3	6	9	12	15	18
Irrigation interval (days)						
7	35.38	48.0	61.4	58.4	62.8	64.1
14	34.83	46.2	56.4	58.2	59.8	61.7
21	33.92	42.9	55.5	57.0	58.7	60.2
28	32.54	39.1	53.5	54.6	55.3	57.2
Significance	NS	NS	NS	NS	NS	NS
SE±	2.573	6.10	5.55	3.42	4.21	4.70
Variety						
Ex-Kano	34.60	43.8	57.4	63.5	56.4	50.3
Ex-Zaria	33.73	44.2	56.0	60.6	53.9	47.8
Significance	NS	NS	NS	NS	NS	NS
SE±	1.820	4.31	3.93	2.42	2.98	7.05
Interaction						
I X V	NS	NS	NS	NS	NS	NS

Means with the same letter (s) is not significantly different (P < 0.05) according to Duncan New Multiple Range Test. NS=not significant

Table 4. Influence of Irrigation Interval and variety on number of leaves per plant of sweet potato during the 2015 dry season at Sokoto Sudan Savannah Nigeria

Treatment	Number of leaves per plant					
	Weeks after planting					
	3	6	9	12	15	18
Irrigation interval (days)						
7	19.25^{a}	40.12	48.95	72.20^{a}	78.62^{a}	83.83^{a}
14	15.29^{b}	37.54	47.45	61.66^{b}	65.45^{b}	72.08^{b}
21	12.16^{c}	35.62	45.29	59.75^{b}	62.20^{b}	67.25^{bc}
28	10.25^{c}	35.08	44.62	57.75^{b}	60.70^{b}	64.45^{c}
Significance	*	NS	NS	*	*	*
SE±	0.76	1.87	1.60	2.5	2.48	2.61
Variety						
Ex-Kano	14.83	37.37	43.83	63.55	58.85	47.66
Ex-Zaria	13.64	39.31	43.83	61.87	55.14	45.64
Significance	NS	NS	NS	NS	NS	NS
SE±	0.76	1.87	1.60	2.5	2.48	2.61
Interaction						
I X V	NS	NS	NS	NS	NS	NS

*Means with the same letter (s) is not significantly different (P < 0.05) according to Duncan New Multiple Range Test. *=significant, NS=not significant*

Table 5. Influence of irrigation interval and variety on leaf area index of sweet potato during the 2015 dry season at Sokoto Sudan Savannah Nigeria

Treatment	Leaf area index					
	Weeks after planting					
	3	6	9	12	15	18
Irrigation interval (days)						
7	0.024	0.024	0.066	0.06	0.031	0.029
14	0.027	0.038	0.034	0.049	0.045	0.035
21	0.024	0.026	0.042	0.043	0.034	0.026
28	0.023	0.022	0.037	0.052	0.041	0.029
Significance	NS	NS	NS	NS	NS	NS
SE±	0.005	0.01	0.018	0.014	0.015	0.01
Variety						
Ex-Kano	0.025	0.023	0.04	0.058	0.031	0.024
Ex-Zaria	0.024	0.032	0.049	0.044	0.044	0.035
Significance	NS	NS	NS	NS	NS	NS
SE±	0.004	0.007	0.013	0.01	0.011	0.007
Interaction						
I X V	NS	NS	NS	NS	NS	NS

Means with the same letter (s) is not significantly different (P < 0.05) according to Duncan New Multiple Range Test. NS=not significant.

Table 6. Influence of irrigation interval and variety on number of tubers per plant during the 2015 dry season at Sokoto Sudan Savannah Nigeria

Treatment	Number of tubers per plant
Irrigation interval (days)	
7	10.17^{a}
14	7.33^{b}
21	6.33^{b}
28	5.50^{b}
Significance	*
SE±	0.707
Variety	
Ex-Kano	6.58^{b}
Ex-Zaria	8.08^{a}
Significance	*
SE±	0.5
Interaction	
I X V	NS

*Means with the same letter (s) is not significantly different (P < 0.05) according to Duncan New Multiple Range Test. *=significant, NS=not significant*

3.8 Average Tuber Weight per Plant (kg)

Average weight of tuber per plant as influenced by irrigation interval and variety is presented in Table 7. Irrigating at 7 and 14 days interval did not differ significantly (P < 0.05) but they significantly differed (P < 0.05) from 21 and 28 days irrigation interval with bigger tubers. This might be due to the wide difference of sufficient moisture enjoyed by plants irrigated at 7 days interval and those not receiving irrigation water until after every 28 days. Another reason for the difference in irrigating at 28 days may be as a result of moisture stressed conditions which reduces photosynthetic rate which in turn results in decreased growth and tuber weight. Variety and interaction between irrigation intervals and variety showed no significant difference.

3.9 Average Weight of Marketable Tubers (kg)

The results presented in Table 8 shows average weight of marketable tubers as influenced by irrigation interval and variety. Irrigation interval, variety and their interaction are not significant.

3.10 Average Weight of Non-marketable Tubers (kg)

Average weight of non-marketable tubers as influenced by irrigation intervals and variety is presented in Table 8. There is no significant difference either as a result of irrigation interval, variety and interaction between irrigation interval and variety.

3.11 Tuber Yield (t/ha)

Influence of irrigation interval and variety on total tuber yield during the 2015 dry season at Sokoto Sudan savannah is presented in Table 8. Irrigating at 7 days interval shows significant

difference (P < 0.05) as compared to irrigation at 14, 21 and 28 days intervals. High tuber yield at 7 days irrigation interval could be because the rate of tuber yield increased with progressive increase in irrigation frequency, perhaps due to improved vegetative and root system which enables the plant to utilize more moisture from the soil. This conforms to the findings of [37] who also found that irrigating at 7 days interval results in higher tuber yield of sweet potato. Interaction between irrigation interval and variety had no significant influence on total tuber yield.

3.12 Culled Tuber Weight (kg)

The influence of irrigation interval and variety on culled tuber weight during the 2015 dry season at Sokoto Sudan savannah is presented in Table 9. Significant difference (P < 0.05) was observed with neither irrigation interval nor variety. That is to say the weight of culled tubers produced is statistically the same across all irrigation intervals and between the two varieties. The interaction between the irrigation interval and the variety did not also show any significant difference.

Table 7. Influence of irrigation interval and variety on number of marketable tubers, number of non marketable tubers and average tuber weight per plant (kg) during the 2015 dry Season at Sokoto Sudan Savannah Nigeria

Treatment	Number of marketable tubers per plant	Number of non-marketable tubers per plant	Average tuber weight per plant (kg)
Irrigation interval (days)			
7	7.83[a]	2.33	0.523[a]
14	3.83[b]	3.50	0.325[a]
21	2.17[b]	4.17	0.178[b]
28	1.33[b]	4.17	0.100[b]
Significance	*	NS	*
SE±	0.656	0.799	0.065
Variety			
Ex-Kano	3.17[b]	3.42	0.261
Ex-Zaria	4.42[a]	3.67	0.302
Significance	*	NS	NS
SE±	0.464	0.565	0.046
Interaction			
I X V	NS	NS	NS

*Means with the same letter (s) is not significantly different (P < 0.05) according to Duncan New Multiple Range Test. * = Significant, NS= Not significant*

Table 8. Influence of irrigation interval and variety on average weight of marketable tubers, average weight of non marketable tubers and tuber yield (t/ha) during the 2015 dry season at Sokoto Sudan Savannah Nigeria

Treatment	Average weight of marketable tubers (kg)	Average weight of non marketable tubers (kg)	Tuber yield (t/ha)
Irrigation interval(days)			
7	0.378	0.095	7.02[a]
14	0.228	0.056	5.82[b]
21	0.122	0.043	5.07[b]
28	0.178	0.054	5.02[b]
Significance	NS	NS	*
SE±	0.118	0.028	0.645
Variety			
Ex-Kano	0.247	0.055	6.11[b]
Ex-Zaria	0.207	0.069	7.85[a]
Significance	NS	NS	*
SE±	0.083	0.019	0.456
Interaction			
I X V	NS	NS	NS

*Means with the same letter (s) is not significantly different (P < 0.05) according to Duncan New Multiple Range Test. * = Significant, NS= Not significant*

3.13 Vine Weight (t/ha)

Influence of irrigation interval and variety on vine weight during the 2015 dry season at Sokoto Sudan savannah is presented in Table 9. There is no significant difference either as a result of irrigation interval, variety and interaction between irrigation interval and variety on vine weight.

Table 9. Influence of irrigation interval and variety on culled tuber weight and vine weight during the 2015 dry season at Sokoto Sudan Savannah Nigeria

Treatment	Culled tuber weight (kg)	Vine weight (t/ha)
Irrigation interval (days)		
7	0.041	3.92
14	0.02	3.50
21	0.02	3.53
28	0.025	3.72
Significance	NS	NS
SE±	0.02	0.472
Variety		
Ex-Kano	0.039	3.71
Ex-Zaria	0.014	3.62
Significance	NS	NS
SE±	0.014	0.334
Interaction		
I X V	NS	NS

*Means with the same letter (s) is not significantly different (P < 0.05) according to Duncan New Multiple Range Test. * = Significant, NS= Not significant*

4. CONCLUSION AND RECOMMENDATIONS

The results indicated that irrigating at 7 days interval result to better growth and yield than irrigating at 14, 21 and 28 days interval. Also ex-Zaria is found to be more yielding than Ex-Kano variety. Therefore 7 days irrigation interval and Ex-Zaria cultivar is recommended for Sokoto and other areas with similar climate.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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