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Multi-Location Assessment of Improved Sweet Potato (*Ipomoea batatas* L. Lam) Varieties in Kano State of Nigeria

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ABSTRACT

Multi-location experiment was conducted in farmers' field at 3 local government areas of Kano state (Bagwai, Kibiya, and Rimingado) during 2016 rainy season with aim of evaluating performance of newly introduced improved sweet potato varieties for possible recommendation to the local farmers in the study areas based on their yield potential. The design of the experiment was randomised complete block design (RCBD). Data collected were subjected to analysis of variance using Genstat 17[th] edition and the means were separated using Duncan Multiple Range Test at 5% level of probability. The result revealed significant differences among the varieties and the locations on growth characters and total root yield. The varieties differ significantly in all the growth parameters measured except crop growth rate 9-12 WAP and net assimilation rates 6-9 WAP. Centennial produced the highest vine yield (31.1 t ha^{-1}) while Mother delight produced the lowest vine yield of 1.4 t ha^{-1}. Among the newly introduced improved varieties King J was found to produce the highest total root yield (20.4tha^{-1}) which was at par with the Local check variety Danchina (25.5 t ha^{-1}). They were followed by AO305 (12.2 t ha^{-1}) which was at par with T121 (10.3t ha^{-1}), Mothers delight (5.1 t ha^{-1}), Sumaia (4.8 t ha^{-1}), Delvia (4.5 t ha^{-1}). Centennial (1.7 t ha^{-1}) and Lourdes (1.4 t ha^{-1}) were significantly lower in root yield. Similarly location showed significant differences except on crop growth rate, number of leaves at 9 WAP and net assimilation rate at 9-12 WAP. Kibiya was significantly higher than all the location on both vine and root yield (34.2 and 16.4 t ha^{-1}), respectively. The significant differences among the varieties observed in this study on total yield indicates that genotypes trial would, enable selection of high yielding varieties to improve yields and income of local farmers in order to achieve maximum benefit of the crop especially towards alleviating hunger and mal-nutrition in the study area. Varieties that recorded high vine yield but low storage root yield could be recommended for fodder production.

Keywords: Location, assessment, yield and sweet potato variety

INTRODUCTION

Sweet potato (*Ipomoea batatas* (L.) Lam), belongs to morning glory family (*Convolvulaceae*), the only member of the genus Ipomoea whose roots are edible. Sweet potato is a nutritious root crop that contains significant amounts of fibre, beta carotene and vitamin C, particularly in varieties with highly coloured roots. Approximately 50.6% of the population of Africans lack access to adequate food and what is available is of poor nutritional value and quality (CBS, 2010). Sweet potato is a cheap source of carbohydrates and Vitamin A in OFSP varieties. It contributes to agro-processing and rural industries, trade, poverty alleviation, improved nutrition and natural resource management (Karanja *et al.,* 2016). The leaves and vines are cherished as fodder and hay by livestock. In Nigeria, most of the sweet potato landraces (local varieties) have white-fleshed roots with negligible amounts of beta-carotene (Leigh, 2012). Initiatives have spawned to encourage the production and consumption of orange-fleshed sweet potato varieties that are rich in beta-carotene and help fight vitamin A deficiencies. Vitamin A deficiency (VAD) is one of the three most common deficiencies in the world and in sub-Saharan Africa. The reason why the crop is promoted by various organizations in Sub-Saharan Africa (Laurie and Heerden, 2012).Although the crop is consumed in all parts the part of Nigeria, its production still remain low. Lack of improved varieties suitable for different agro-ecologies and adapted to a specific area is one of the main constraints among others towards increasing its yield ha^{-1} (Desalegn *et al.,* 2015).

Considering the potentiality of the crop in alleviating hunger and malnutrition, there is a prime need for developing/ identifying varieties suited to specific agro-ecological conditions (Madawal *et al.,* 2015) as sweet potato is sensitive to environmental variation, despite wide adaptability to harsh growing conditions. Therefore this experiment was conducted with the aim of finding adaptable, high yielding newly introduced improved sweet potato varieties as a strategy to increase its productivity toward alleviating hunger and malnutrition in the study areas.

MATERIALS AND METHODS

Experimental Sites

The experiment was conducted in farmers' fields during rainy season of 2016 at 5 sites; Bagwai (12°09′28″N 8°08′09″E), Kibiya (11°32′N 8°40″E) and Madobi (11°46′38″N8°17′18″E) Local Government Areas of Kano State in Sudan Savannah of Nigeria.

Treatments and Experimental Design

The treatments consisted of 8 improved varieties and 1 local variety as check of sweet potato (Table 1). They were laid in randomized complete block design. Each gross plot consisted of 4 ridges of 3 m long and spaced 0.75 m apart. The 2 innermost ridges served as net plots (4.5m^2) for data collection.

Agronomic Practises

The fields were cleared off stump and ridges were constructed based on the field layout above. Vine cuttings with at least 3 nodes were planted on each ridge at spacing of 30 cm between the plants. Supplying was done at 2 week after planting. Hoe weeding was done at 4 and 8 weeks after planting. Fertlizer (400 kg ha^1) of NPK 15:15:15 was applied at 4 weeks after planting as recommended by Alleman (2004). Insect pests were controlled by spraying with Optimal 20 SP and Cypermetrin at the rates of 250 g ai ha^{-1} and 1.0 l a.i ha^{-1} respectively. Care was taken to just lift the vines periodically and hilling-up was done by hoeing up the soil around the base of the plant to ensure the developing storage roots are well covered and not exposed to sun and attack by weevils. Harvesting was done on attainment of harvesting maturity characterized by cracking of soil.

Data Collection

Data on monthly rainfall of the experimental sites during the period of the study were obtained from Kano Agriculture and Rural Development Authority. Soil samples were collected from the experimental fields using soil auger at depth of (0-30 cm) before the experiment and analysed for; soil pH using Electrode pH Meter, Organic carbon by Walkey-Black wet oxidation method (Walkey and

Black, 1934). Macro-Kjeldhal method was used to determine total nitrogen (%), available Phosphorous was determined by method of Olsen *et al.,* (1954). Ammonium saturation method was used to determine the Cation Exchange Capacity (CEC), potassium, sodium, calcium and magnesium (Black, 1965). Particle size distribution and Electrical Conductivity were determined by Bouyoucos (Hydrometer Method) and Soil and water ratio procedure respectively.

Percentage establishment was determine at 2 weeks after planting using the relationship: % Establishment $= \frac{\text{Number of cutting take}}{\text{Number of cutting planted}} \text{x}100$. Number of leaves per plant at 6, 9 and 12 weeks after planting (WAP) were counted from 4 tagged plants in net plot and mean taken. Leaf area (LA) were determined from randomly selected leaves of the upper, middle and lower portion of the canopy and the leaf area was calculated using formula of Sharma, 1987; LA= L × B × K. Where, LA= leaf area from maximum length and breadth; L = length from the base of lamina to the tip of the leaf and B = maximum breadth of leaf. K= constant based on shape of the leaf; AO305 (0.921), Centennial and Mothers delight (0.856) all the other varieties (0.479) as suggested by (Sestak, *et al.,* 1971) Leaf area index (LAI) was determined at 6, 9 and 12 WAP using the relation LAI= LA/GA. Where LA = Leaf area and GA ground area covered by the plant (Kuhlase *et al.,* 2009). Leaf chlorophyll content was measured at 6, 9 and 12 WAP from the 4 tagged plants using SPAD-Meter (CCM-200 PLUS) and mean recorded. Shoot dry weight at 6, 9 and 12 WAP was determined from 2 randomly selected plant in the sampling rows which where oven dried at 70°C for 48 hours until constant weight, then measured and recorded. At 6-9 and 9-12 (WAP), Crop growth rate was determined using the mathematical formula: $\text{CGR} = \frac{\text{W2}-\text{W1}}{\text{T2}-\text{T1}}$g / week (Hunt, 1978). Where W_2 and W_1 are the dry matter weight at time T_2 and T_1 respectively. Net assimilation rates (NAR) above the ground were determined at 6-9 and 9-12 WAP, using the mathematical formula: $\text{NAR} = \frac{\text{W2}-\text{W1}) (\text{In A2} - \text{In A1})}{(\text{A2}-\text{A1}) (\text{t2}-\text{t1})}$$\text{gm}^{-2}\text{wk}^{-1}$. Where W_2, W_1 and A_1, A_2 are shoot dry weight and leaf area per plant measured at t_2 and t_1 respectively (Hunt, 1978). Vine and root yield of each variety was determined by weighing the fresh vine and root weight in the net plot at harvest and extrapolated to t/ha using the relationship: Yield $tha^{-1} = \frac{\text{Net plot vine/root } wieght\ in\ Kg}{\text{Area } of\ net\ plot(M2)} X \frac{10{,}000\text{M2}}{1000}$

RESULTS AND DISCUSSIONS

Soil Physico Properties

The result of the soil physical and chemical properties of the experimental sites as presented in Table 2 shows that textural class of the soils at Bagwai and Rimingado were loamy sand while that of Kibiya was sandy loam. Based on Esu (1991) description, the soil of all the experimental sites were moderately acidic, with low organic carbon and total nitrogen content. Available phosphorous of Kibiya and Bagwai were moderate while that of Rimingado was high. Potassium content of the entire sites was high.

Effect of Variety on Growth and Yield

The rate of number of leaves production was high from planting and decrease from 9 WAP in all the variety. The decline in the rate of leaf production after the 9^{th} week was probably due to bulking of the tubers as photosynthates were partitioned to the tuber for bulking at the expense of the production of leaves and vines. This confirmed the report of Amoah, (1997) that the rate of leaf production was very high from time of planting up to the 8th week after planting and thereafter declined and became almost constant at the time of harvesting. AO305, Centennial, Delvia King J maintained the highest LAI throughout the sampling periods due to either higher LA or number of leaves than other varieties. This was in agreement with the findings of Bhagsari and Ashley, (1990) who reported that LAI varies widely among sweet potato cultivars depending on the number of leaves retained and their size. The increased in LAI from 6 to 9 WAP and subsequent decrease in 12 WAP could be attributed to increase in leaf area and number of leaves at 6-9 WAP and senescence of older leaves and formation of new leaves with small leaf area at 12 WAP. This is in conformity with Mukhopadhyay *et al.*, (1992) who reported that changes in the leaf area index during growth of sweet potato occur in three phases: it steadily increases from the second week after planting in the first phase reaching a plateau from 8 WAP and declines during the third phase due to leaf senescence. The observed differences on shoot dry weigh among sweet potatoes may be mainly attributed to the genetic constitution. This statement is in agreement with Teshome *et al.* (2012) who reported that above ground fresh and dry biomass yield is genetically controlled trait in sweet potato. Crop growth rates and Net assimilation rate (NAR) measured in this experiment is based on shoot growth. The wider variation at different sampling periods could probably be attributed to variation of samples and genetic differences. Bouwkamp, (1986) reported that source, sink and partitioning rate changed during growing season and differed among cultivars. The significantly higher CGR of King J, Delvia, Centennial, Sumaia, AO305 and Danchina at 6-9 WAP could be attributed to their high LAI at 6 and 9 WAP which enhanced light interception and photosynthetic activities for production of assimilates hence high dry matter accumulation. The decreased in NAR as the season progresses (6-12 WAP) in this experiment confirmed the statement by Hunt (1978) , who mentioned that NAR is not constant with time but show downward drift with plant age, and the age drift is accelerated by unfavourable environment. The significant higher vine yield of Centennial, A0305, Delvia, Lourdes and King J could be attributed to their earlier significant higher leaf areas. This implies that maintaining large leaves may help in increasing the vine yield of different sweet potato varieties. This coincides with the view of Perey, (2015) that among the contributory factor to high vine yield is the maintenance of large leaf area. T121 can be described as variety with high sink capacity among all other introduced varieties because despite its low leaf area index and number of leaves at 6 WAP yet it produces higher marketable yield than all the introduced improved varieties except King J. This means it divert most of it assimilates to storage root initiation and development. This finding agreed with the results obtained by Enyi, (1977) and Li and Yen, (1988) who reported that sweet potato cultivars with higher yields divert larger portions of assimilates to the storage roots. The variation among varieties for total yield might be ascribed to the genetic potential differences in producing number of storage roots per plant and weight of the storage roots. Nedunchezhiyan *et al.* (2007) reported wide variations among sweet potato clones for root yield performance due to genetic variation. The local check (Danchina) and King J produced significantly higher total storage root yield than all the tested varieties due to their higher performance in growth and yield attributes that collerated to the total yield. The total root yield for the local varieties were generally higher than the introduced varieties. This may be attributable to the adaptability of the local varieties to the local environment. Gasura *et al.,* 2008 reported that root yield depends on the number of storage roots per plant. Therefore, tuber number could be useful for estimating yielding potential of given cultivars.

Effect of Location on Growth and Yield

The significant differences observed in the location on some growth characters and yield could be due to differences in amount and distribution of rainfall in the experimental sites during the period of the study. Moreover the soil physical and chemical properties of the experimental site also differed. The high vegetative growth experienced in Rimigado at 6 WAP could be due to the fact that they were the first place were the introduced vine cuttings were planted hence suffer less transportation shock / physiological stress, which enable the varieties grown in these sites to have high percentage establishment (Table 3) and earlier growth. The significant higher yield of Kibiya (Table 6) could be due to significantly higher performance on growth parameters at 9 and 12 WAP that enhanced production of assimilates which coincided with the dominate period of partitioning of the assimilates to storage roots. Many researchers reported that period of 8-12 WAP corresponds to higher diversion of assimilates to storage roots that enhance bulking and subsequently resulted to high yield (Stathers *et al.,* 2013 and Oswald *et al.,* 1994). The lowest total yield recorded at Bagwai (Table 6) could be related to the low organic carbon, nitrogen and especially low potassium content of its soil compared to the other locations (table 2). This was in consonance with the statement of O'Sullivan *et al.,* 1997 that sweet potato requires high potassium contents in the soil to promote tuber formation and development. In addition, the higher yield obtained in Kibiya than the other location could be due to textural class of the soil (sandy loam) as sweet potato does well on sandy loam(Table 2) . Many researchers reported that sandy loam soils that are light and well-drained are the best for growing sweet potato (Ames *et al.,* 1996; Brandenberger *et al.,* 2010; Valenzuela *et al.,* 2010and Nedunchezhiyan *et al.,* 2012).

CONCLUSION AND RECOMMENDATION

The newly introduced improved sweet potato varieties could be categorized into three classes as high, medium and low yielders; high (King J, AO305 and T121) medium (Mothers delight, Sumaia and Delvia) and low (Centennial and Lourdes) yielders. The significant differences observed among the improved varieties on total yield indicates that variety trial would enable selection of high yielding varieties to improve yields output of the local farmers towards achieving optimum benefit of sweet potato with regards to alleviating hunger and mal-nutrition in different locations in Kano state. Kibiya was found to be the location most suitable for production of these newly introduced improved varieties among the areas where this study was conducted.

Considering the unfavourable condition especially low or lack of rainfall toward the end of the field trial of this research, lack of adaptation of the introduced improved varieties to the locality and more so the average yield t ha^{-1} in semi- arid tropic of Nigeria reported to be 3-6 t ha^{-1}(Leigh, 2012 et *al.,* 2007); all the varieties evaluated in this study that recorded total yield within such range could be considered as having potential for adoption in the study area especially if to be grown under optimum condition of production. Therefore it implies that all the introduced varieties except Centennial and Lourdes could be regarded as having potential to be recommended to local farmers in the study area. However these varieties (Centennial and Lourdes) had high vine yield which make them worth to be recommended as fodder for livestock feeding. There is a need to repeat the experiment in the study areas in order to validate these findings.

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Table1: Characteristics of the Improved Sweet potato varieties

Varieties	Vine colour	Skin colour	Flesh colour	Rootshape	Maturity periods	Source
AO305	Green	Pink	White	Ovate	4 Month	Umudike
Centennial	Purple	Brownish orange	Orange	Long elliptic	4 Month	Umudike
Delvia	Green	Purple	Pale orange	Elliptic	3.5 Month	Umudike
King J	Green	Deep purple	Orange	Elliptic	3 Month	BUK
Lourdes	Green	Pink	Pale orange	Elliptic	3.5 Month	Umudike
Mothers delight	Purple	Orange	Deep orange	Elliptic	3.5 Month	BUK
Sumaia	Green	Purple	Pale orange	Elliptic	3 Month	Umudike
T121	Green	Deep purple	Deep orange	Elliptic	3.5 Month	Umudike
Danchina*	Green	Cream	Cream	Elliptic	3 Month	Madobi

Source: Abdulkadir, 2017

KEY: *= Local (check), BUK= Bayero University Kano

Table 2: Soil physico-chemical properties of the experimental sites

Soil properties	Bagwai	Kibiya	Rimingado
Particle size distribution (%)			
Sand	79.60	73.60	79.60
Silt	15.28	21.28	13.28
Clay	5.12	5.12	7.12
Textural class	Loamy sand	Sandy loam	Loamy sand
Chemical properties			
Soil pH (H_2O)	5.92	6.04	5.95
Soil pH ($CaCl_2$)	5.21	5.89	5.63
EC (ds/m)	0.04	0.25	0.12
Organic carbon (gkg^{-1})	0.20	3.20	4.20
Nitrogen (gkg^{-1})	0.70	1.40	1.10
P (mg/kg)	4.76	8.22	23.36
Exchangeable bases (Cmol/ kg)			
Ca^{++} `	2.76	2.16	2.50
Mg^{++}	1.72	1.31	1.40
K^{+}	0.35	0.43	0.59
Na^{+}	0.16	0.19	0.52
CEC	5.66	4.59	5.93

Table 3: Effect of Variety and Location on Percentage Establishment and Number of Leaves per Plant of Sweet Potato in 2016 Wet Season

Treatment		Weeks after Planting		
	% Establishment	6	9	12
Variety				
A0305	75.6bcd	72.5bc	154.0abc	218.3a
Centennial	94.7ab	45.7c	77.7d	96.2b
Delvia	86.0abc	102.1ab	151.4abc	215.3a
King J	98.6a	111.0a	116.3ab	169.8ab
Lourdes	89.9abc	104.6ab	120.3bcd	118.5b
Mothers delight	70.1cde	46.6c	120.3bcd	161.3ab
Sumaia	85.1a-d	108.2ab	168.6ab	156.5ab
T121	80.9a-d	50.6c	85.4d	119.2ab
Danchina(local)	90.4abc	122.8a	200.9a	199.8a
SE±	9.19			
Significant level	**	**	**	**
Location				
Bagwai	73.8b	50.4c	120.6	162.9a
Kibiya	77.3b	80.0ab	161.6	208.1a
Rimingado	96.7a	92.6ab	126.5	134.6b
SE±		10.43	17.68	23.39
Significant level	**	**	NS	**

Means followed with the same letter in the same column are not significant at 5%level of probability using DMRT. NS= not significant, and **=highly significant

Table 4: Effect on Variety and location on Leaf Area (cm^2), Leaf Area Index and Shoot Dry Weight of Sweet Potato in 2016 Wet Season

Treatment	Leaf Area per Plant			Leaf Area Index			Shoot dry weight		
	Weeks After planting								
	6	9	12	6	9	12	6	9	12
Variety									
AO305	74.0b	91.4b	81.4b	2.7a	6.2a	7.7a	25.8abc	51.1a	88.3ab
Centennial	138.0a	175.6a	129.2a	2.8a	6.0a	5.7b	25.0abc	58.0a	72.9ab
Delvia	56.9bc	66.8bc	50.1c	2.6a	4.5bc	4.2bc	18.5bc	44.4ab	77.1ab
King J	58.5bc	61.7cd	53.6c	2.9a	4.5bc	4.1bc	32.9ab	71.5a	87.7ab
Lourdes	54.5bc	65.3bcd	51.2c	2.8a	3.5c	2.8cd	27.4abc	44.6ab	70.9ab
Mothers delight	28.8e	32.4e	29.5d	0.6c	1.9de	2.5cd	5.4c	15.6c	31.4c
Sumaia	38.8de	42.0cde	39.6cd	2.1ab	3.2cd	2.6cd	13.8bc	45.6ab	54.6bc
T121	45.0d	48.3cde	44.9cd	1.2bc	1.9de	2.2cd	14.0bc	20.4bc	54.9bc
Danchina(local)	59.5bc	59.0cd	48.1c	3.3a	5.1ab	4.3bc	40.4a	63.4a	96.8a
SE±	15.99	13.08	7.78	0.57	0.66	0.88	9.03	12.48	15.67
Significant level	**	**	**	**	**	**	*	**	**
Location									
Bagwai	49.0c	54.1b	44.7	1.1c	3.0b	3.3bc	10.3c	30.8bc	46.3b
Kibiya	60.0ab	78.4a	57.5	2.1ab	4.8a	5.6a	22.0abc	49.8a	87.3a
Rimingado	62.4a	65.3a	54.4	2.8a	4.1a	3.3bc	27.6a	45.9ab	69.4a
SE±	7.32		6.94	0.39	0.44	0.59	6.09	8.42	10.57
Significant level	**	**	NS	**	**	**	*	*	**

Means followed with the same letter in the same column are not significant using DMRT at 5% level of probability. *=significant and **=highly significant

Table 5: Effect of Variety and Location on Crop Growth Rate (CGR) and Net Assimilation Rate (NAR) of Sweet Potato in 2016 Wet Season

Treatment	**CGR g/week**		**NAR g/m^2/week**	
	Weeks After Planting			
	6-9	**9-12**	**6-9**	**9-12**
Variety				
AO305	8.41a-e	12.39	10.1	6.6b
Centennial	11.03ab	4.95	14.1	5.1b
Delvia	8.75a-d	10.90	12.2	11.9b
King J	12.86a	5.41	16.2	6.1b
Lourdes	5.71b-e	8.77	12.5	11.1
Mothers delight	3.67de	5.33	22.6	7.8b
Sumaia	10.60abc	4.55	20.9	4.7b
T121	2.15e	11.52	7.6	32.1a
Danchina(local)	7.66a-e	12.47	8.3	9.7b
SE±	2.858	0.783	6.33	6.14
Significant level	*	NS	NS	*
Location				
Bagwai	6.83	6.21	21.3a	8.2
Kibiya	9.24	12.33	14.0ab	13.3
Rimingado	6.47	7.81	11.2b	9.5
SE±	2.858	2.550	4.26	4.14
Significant level	NS	NS	*	NS

Means followed with the same letter in the same column are not significantly different using DMRT at 5% level of probability. NS=not significant and * = significant

Table 6: Effect of Variety and Location Vine Yield and Root Yield of Sweet Potato in 2016 Wet Season.

Treatment	Vine yield (t ha^{-1})	Root yield (t ha^{-1})
Variety		
A0305	24.8ab	12.2
Centennial	31.1a	1.6d
Delvia	23.9abc	4.4bcd
King J	18.3a-d	20.4a
Lourdes	23.2abc	1.4d
Mothers delight	1.4d	5.7bcd
Sumaia	12.9bcd	4.7bcd
T121	16.8a-d	10.6bc
Danchina(Local)	14.2bcd	25.5a
SE±	7.24	3.73
Significant level	*	**
Location		
Bagwai	12.2bc	5.8b
Kibiya	34.2a	16.4a
Rimingado	18.4b	6.0b
SE±	4.88	2.51
Significant level	**	**

Means followed with the same letter in the same column are not significant different at 5% level of probability using DMRT

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