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Evaluating the performance of improved sweet potato (*Ipomoea batatas* L. Lam) advanced lines in Kano, Sudan savanna of Nigeria

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Abstract

Field trials were conducted in the 2014 rainy season at the Teaching and Research Farm of Bayero University, Kano (11°58'N and 8°25'E) and Agricultural Research Station Farm, Minjibir (12°11'N and 8°32'E). The objective of the study wasto evaluate the performance of improved sweetpotato lines with a view to identify those that may be adaptable with high yielding potential in the study area.The treatments consisted of 16 sweetpotato advanced lines: Centennial, AYT/08/055, TIS8164, TIS87/0087, NRSP12/097, UMUSPO/2, UMOSPO/1, SOLOMON-1, EA/11/022, EA/11/025, EA/11/003, UM/11/015, NRSP/12/095, UM/11/001, UM/11/022, and a local check (Kantayiidda). These were laid out in a Randomized complete block design with 3 replications. Significant differences were observed in number of roots per plant, number of marketable roots, number of pencil roots, flesh colour, root shape and root yield. Kantayiidda produced significantly ($p<0.05$) higher root yield (10315kg/Ha) than all other lines. Solomon-1, Umuspo/1, EA/11/022, UM/11/001 and TIS87/0087 were found to be promising among the advanced lines evaluated; thus could relatively compete with Kantayiidda local for adaptation and high root yield in the study area.

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Introduction

Sweetpotato (*Ipomoea batatas* L.) is a member of the morning glory family (Convulvulaceae), producing edible storage roots, and leaves. The crop is cultivated in all regions where there is sufficient moisture to support its growth. Sweet potato can yield large amounts of energy-rich nutritious foods during relatively short cropping seasons. It is grown in tropical and sub-tropical areas of sub-saharan Africa with yields ranging from 4 – 6 tons/ha. This yield levels can however, be increased to 15 ton/ha under rain fed conditions if key recommended practices are used. Sweet potato production in Nigeria has increased over the last two decades from 143,000 tonnes in 1990 to over three million tonnes in 2013 (FAO, 2014). The crop is presently cultivated in all agro-ecologies of Nigeria.

The increase in production however, is attributed to the increase in area under cultivation (381,000 – 510,000) hectares, as yield still remains very low (NRCRI, 2008).Low resistance to sweet potato virus disease, susceptibility to sweet potato weevil, lack of tolerance of some important cultivars to random drought and poor soil fertility are among the production constraints of sweet potato in Nigeria. Erroneous beliefs tied to its consumption such as male sterility, impotence and pile, poor marketing mechanism, low value addition as well as lack of improved desirable varieties have also militated against its production and consumption in the country.

The dominant sweet potato varieties grown by farmers in sub-saharan Africa including Nigeria have white or cream flesh, which contain little or no beta-carotene (Stathers *et al.,* 2005). In a study conducted to evaluate the performance and acceptability of orange fleshed sweetpotato (OFSP) cultivars in Eastern Uganda, Ssebuliba *et al.* (2006) reported that the OFSP cultivars gave lower yields than the local white cultivars. Beta-carotene content was however, higher in OFSP cultivars than the white fleshed types. Laurie and Magoro (2008) reported the continuous cultivation of old land races of sweet potato as limiting sweet potato production in South Africa.

Consequent upon the aforementioned constraints, the International Potato Center (CIP) and the National Root Crops Research Institute (NRCRI) Umudike, Nigeria began to focus on developing several improved sweet potato lines with greater root yield and disease resistance potentials as well as significant amounts of beta-carotene. The potentials of the improved lines cannot be realized unless they are evaluated to identify genotypes with desirable attributes in the study area. Therefore, the objective of this study was to evaluate selected improved genotypes for adaptation, higher root yield potential, and beta-carotene content with a view to selecting superior ones for introduction into the production system in the study area.

Materials and methods

Study Areas

The trials were conducted in the 2014 rainy season at the Teaching and Research Farm of Bayero University, Kano, BUK (11°58'N and 8°25'E) and Agricultural Research Station Farm, Minjibir (12°11'N and 8°32'E). The climates of the locations are characterized by two seasons: The wet season (May – September) and the dry season (October – April) with annual rainfall of 800 – 1000 mm (KNARDA, 2012).

Soils and Weather Data

Soils of the experimental sites were collected at 0 – 30cm depths prior to planting. These were bulked and analyzed using standard procedures as described by Black (1965). The soils were sandy-loam (Table 1). These were also moderately acidic (5.27-6.10), with low organic carbon and organic matter. The available phosphorus of the soils was however high, thus the soils were moderately fertile, with Bayero University, Kano (BUK)soils being relatively more fertile than those of Minjibir. The mean annual precipitation received was greater in BUK than Minjibir (Table 2). There was however an extension of the rains up to November in Minjibir whereas this terminated in October at BUK.

Table 1. Physico-chemical properties of the soils (0-30cm) at the experimental sites in 2014.

Character	BUK	Minjibir
Particles size distribution		
Sand (%)	72.96	80.76
Silt (%)	16.00	5.70
Clay (%)	11.04	6.54
Textural class	Sandy loam	Sandy loam
Chemical properties		
pH in H_2O	5.27	6.10
Organic carbon(gkg^{-1})	0.618	0.487
Total Nitrogen(gkg^{-1})	0.28	0.18
Available P(mgkg^{-1})	15.90	14.43
Organic matter (gkg^{-1})	1.07	0.60
Exchangeable Bases(Cmol kg^{-1})		
Ca++	2.12	0.30
Mg++	1.01	2.12
K+	0.61	0.54
Na+	0.32	0.32
CEC	4.31	4.11

Treatments and Experimental Design

Treatments consisted of sixteen (16) sweetpotato advanced breeding lines: Centennial, AYT/08/055, TIS8164, TIS87/0087, NRSP12/097, UMUSPO/2, UMOSPO/1, SOLOMON-1, EA/11/022, EA/11/025, EA/11/003, UM/11/015, NRSP/12/095, UM/11/001, UM/11/022, and a local check (Kantayiidda). These were laid out in a Randomized complete block design with 3 replications.

Agronomic Practices

Sweet potato vines of 30cm long bearing at least four nodes were planted on 40cm high erected ridges at 30 × 75 spacing. Dead stands were supplied after 7 days of planting. Each plot consisted of 4 rows of 3 meter long with a net plot of 4.5m^2 (1.5 × 3m). Weeds were controlled manually using hoe at 3 and 6 weeks after planting, while NPK 15 – 15 – 15 fertilizer was applied at 400kg/ha as recommended by Alleman (2004). Vines were cut at the soil surface to facilitate curing at physiological maturity and left for 7 days after which the roots were manually harvested using hoe.

Table 2. Metreological data of BUK and Minjibir in 2014.

Month	BUK					Minjibir				
	Rainfall (mm)	Temp (°C)		Rh (%)		Rainfall (mm)	Temp (°C)		Rh (%)	
		Min	Max	Min	Max		Min	Max	Min	Max
June	168.8	23.0	37.0	43	51.0	87.2	25.0	37.0	44	63.0
July	247.3	21.0	33.0	67	73.0	194.2	24.0	33.0	60	70.0
August	230.7	20.0	31.0	69	74.0	283.1	23.0	31.0	68	77.0
September	133.7	25.0	35.0	63	67.0	112.7	23.0	32.0	60	71.0
October	6.5	27.0	37.0	45	55.0	25.3	22.0	35.0	39	54.0
November	0.0	15.0	34.0	29	34.0	11.3	23.0	30.0	27	35.0
Total	787.0					713.8				

Source: Meteorological units of BUK and IAR Station, Minjibir.

Data Collection and Analysis

Data were collected on some qualitative characters such as plant type, vine colour, skin colour, flesh colour, root shape and root damage. Insect infestation damage was scored on 0 – 5 scale as described by NRCRI (2008) as follows:

0 – No infestation
1 – Very little portion of the roots infected
2 – Little portion of the roots infected
3 – Nearly half of the roots infected
4 – More than half of the roots infected
5 – Entire roots infected

Root deformation was also assessed visually on a scale of 0 and 1 as follows:

0 – No root deformation

1 – Root deformed by crack

Similarly, the number of roots per plant, marketable roots, pencil roots, vine weight, and root yield were also recorded. Total carotenoid of the evaluated lines were also determined using standard procedure as described by Rodriguez – Amaya (2004). Data collected were subjected to analysis of variance as described by Snedecor and Cochran (1967), using Genstat 16th Edition. Significantly different means were ranked using Tukey HSD.

Results and discussion

Qualitative characters of the evaluated advanced breeding lines

Table 3 shows some of the qualitative characters of sweet potato as influenced by variety, location and their interactions. All the evaluated lines were predominantly spreading types. There were no significant effects between variety and location on the types of plant recorded in this study.

Table 3. Qualitative characters of advanced sweetpotato lines grown in 2014 rainy season at Kano.

Treatment	Plant Type	Vine Color	Skin color	Flesh Color	Root Shape
Variety(V) Centennial	Spreading	Purple	Orange	Orange	Elliptic
AYT/08/055	Spreading	Green	Milk	Milk	Ovate
TIS 8164	Spreading	Green	Purple	White	Oblong
TIS 87/0087	Spreading	Green	Purple	White	Ovate
NRSP/12/097	Spreading	Green	Purple	Milk	Elliptic
UMUSPO/2	Spreading	Green	Purple	Milk	Elliptic
UMUSPO/1	Spreading	Green	Purple	Light orange	Oblong
Solomon-1	Spreading	Green	Purple	Milk	Ovate
EA/11/022	Spreading	Green	Milk	Milk	Ovate
EA/11/025	Spreading	Green	Purple	White	Elliptic
EA/11/003	Spreading	Green	Purple	Milk	Ovate
UM/11/015	Spreading	Green	Purple	Milk	Irregular
NRSP 12/095	Spreading	Green	Milk	White	Elliptic
Kantayiidda	Spreading	Green	Milk	Orange	Ovate
UM/11/001	Spreading	Green	Purple	Milk	Oblong
UM/11/022	Spreading	Green	Purple	Milk	Elliptic

The colour of vine of the advanced lines evaluated were predominantly green except for Centennial which was purple. Interactions of the varieties and location on the colour of vine was also not significant. The non-significant variation on the plant types and vine colour observed in this trial is an indicative role of genotype in the control of these characters. Several authors had reported similar observations for wide variability in sweet potato genotypes for many characters in sweet potato, Mukhtar *et al.* (2010) and Tewe *et al.* (2003).

The sweet potato genotypes evaluated in this trial showed three distinct descriptors for skin color (Table 3). Centennial was the only genotype with orange skin. Most other varieties were predominantly purple with only few such as AYT/08/055 being milky. With the genotypes expressing distinct skin colour without colour overlaps, skin colour might be under the control of few major genes that exhibit dominance – recessive gene action. The same distinct colour trend observed among the genotypes evaluated for skin colour was also observed in sweet potato flesh colour. Three colour types characterized the root flesh colour – orange, white and milk. Most of the genotypes were observed to be predominantlymilk-fleshed. Only four genotypes had white flesh roots, while only Centennial and Kantayiidda expressed orange flesh colour. Flesh colour is usually under the control of genes with little or no effect of environment. Different shades of the orange colour of the flesh due to dosage effect are known, but this was not observed among the two orange-fleshed genotypes involved in this trial. As the orange colour is as a result of the accumulation of beta-carotene, a precussor to vitamin A in these cultivars, intensity of the orange colour in sweet potato root flesh has been reported to influence the content of carotenoid in the roots. Several authors (Ameny and Wilson, 1997. Hagenimana *et al.,* 1999. Martin, 1983 and Woolfe, 1992), had reported that sweet potato with dark orange flesh has more beta-carotene than those with white flesh, while Hussein *et al.* (2014) further reported that of all other flesh colours, orange-fleshed sweet potato has the highest pro-vitamin A content, followed by yellow-flesh, purple-flesh and white-flesh in that order.

For root shape, the study indicated that TIS8164, UMUSPO/1 andUM/11/001 were oblong shaped, while Centennial, NRSP12/097, UMUSPO/2, EA/11/025, NRSP/12/095 and UM/11/022 have elliptic shaped roots. Same trend for root shape across genotypes was observed in both locations, indicating that location did not impact on root shape.

Almost half (7) of the genotypes exhibited root cracks, while the rest nine genotypes had no cracks (Table 4). Intensive root cracks were however noticed from genotypes with relatively longer roots. Cracks in sweet potato is a common phenomenon in some genotypes. Egbe *et al.* (2012) had also observed intensive deep cracks on nearly all roots that weigh more than 150g in one of their studies. Location did not have any effect on root crack as roots of genotypes that cracked exhibited the trait in both locations.

Table 4. Root deformation and insect score on the advanced sweetpotato lines evaluated in Kano, 2014.

Treatment	Root Deformation	Insect Score
Variety (V)		
Centennial	None	0
AYT/08/055	None	1
TIS 8164	None	0
TIS 87/0087	None	1
NRSP/12/097	None	0
UMUSPO/2	Crack	3
UMUSPO/1	Crack	4
Solomon 1	None	1
EA/11/022	None	1
EA/11/025	Crack	4
EA/11/003	Crack	3
UM/11/015	None	1
NRSP/12/095	Crack	3
KantayiIdda	Crack	3
UM/11/001	Crack	3
UM/11/022	None	0

Cylas puncticollis is an important sweet potato weevil that affects both roots and shoots of the crop. Losses due to *Cylas* weevil damage in susceptible genotypes could range from 1 to 100% (Alvarez, 1987). The sweet potato advanced breeding genotypes evaluated in this study differed in terms of their susceptibility or otherwise to the weevil damage. *Cylas* holes and larvae were noticed in all the infested roots. Some genotypes like Centennial, TIS8164, NRSP/12/097 and UM/11/022 showed some level of resistance to insect pests. Absence of marketable roots may be the reason as with case of Centennial, while the highest incidence of insect infestation was recorded from UMUSPO/1 and EA/11/025.

Root yield and yield components of advanced sweet potato breeding lines

Root yield is one of the most important traits that drive the adoption of new varieties by farmers. Therefore, many crop breeders have always considered the development of high-yielding varieties first before the improvement of other traits. Usually, selection for high yield is done by indirectly selecting for important root yield components. The root yield and yield components of sweet potato studied in this field trial indicated significant ($P<0.05$) genotype differences for number of roots per plant (Table 5). Centennial had significantly higher number of roots per plant compared to other genotypes except NRSP/12/095, NRSP/12/097/ TIS87/0087 and Kantayi idda. The least number of roots per plant was recordedby EA/11/025. Comparing the two locations for higher number of roots across genotypes, BUK supported higher ($P<0.05$) number of roots than

Minjibir. Interaction between variety and location for number of roots per plant was not significant. The ability of Kantayi idda to produce significant and competing number of roots per plant may probably be attributed to its long adaptation to the environment as observed by Erksine and Khan (1977) for cowpea. Similarly, the higher number of roots recorded from BUK may be due to the better fertility status of the soils compared to that of Minjibir.

Table 5. Effects of variety, location and their interactions on yield components and root yield of advanced sweet potatolines grown at Kano in 2014.

Treatment	Mean Number of Roots perPlot	Mean Number of Marketable Roots per plot	Mean Number of Pencil Roots per plot	Mean Vine Weight kg/plot	Total Carotenoid (µg/g)	Root Yield (kg/ha)
Variety (V)						
Centennial	91.2a	6.7h	84.5a	19.2	20.79a	2061d
AYT/08/055	61.8abc	11.3b-g	50.5bc	14.8	15.10ab	2259d
TIS 8164	47.7bc	17.7cde	30.3cde	12.1	3.59c	4630c
TIS 87/0087	62.5abc	19.5b-e	43.0b-e	16.8	4.01c	6593b
NRSP/12/097	62.0abc	5.3fg	56.7b	16.9	16.36ab	1733e
UMUSPO/2	57.0bc	11.0efg	48.0bcd	15.9	6.98b	3126cd
UMUSPO/1	53.8bc	22.3bc	31.3cde	23.1	7.32b	5889bc
Solomon-1	58.8bc	29.7b	27.7cde	20.7	8.92b	6481b
EA/11/022	56.2bc	22.0bcd	34.2cde	20.5	15.50ab	6148bc
EA/11/025	39.5c	13.7c-g	25.8de	18.5	6.79b	5078c
EA/11/003	56.5bc	15.5c-f	41.0b-e	14.0	7.45b	4000cd
UM/11/015	51.0bc	3.0gh	47.0bcd	11.2	7.39b	2259d
NRSP/12/095	65.7ab	18.8cde	46.8bcd	15.9	4.49c	5111c
KantayiIdda	63.8ab	41.7a	22.2e	19.4	16.33ab	10315a
UM/11/001	57.0bc	15.0c-f	42.0b-e	15.8	4.01c	6019bc
UM/11/022	55.7bc	9.8efg	45.8bcd	21.1	7.32b	1981e
SE±	4.66	2.11	4.41	3.37	5.487	103.731
Location (L)						
BUK	88.0a	27.7a	60.3a	19.2a	9.38	6573a
MJB	29.0b	3.7b	25.3b	16.3b	9.47	2347b
SE±	2.98	1.97	2.68	1.36	4.191	253.610
Interaction						
V*L	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within columns are not significantly different Tukey HSD.

The genotypes also exhibited significant differential in the number of marketable roots. This corroborates the findings of Nwankwo and Afuape (2013) of the presence of genotypic variability among sweet potato genotypes for number of marketable roots and root yield. Kantayi idda (the local check) produced significantly higher number of marketable roots (41.7) than the rest of the genotypes. The number of marketable roots produced Solomon-1 (29.7) was not significantly different from those of AYT/08/055, TIS87/0087, UMUSPO/1 and EA/11/022. The least number of marketable roots was produced by Centennial. This is expected because of the differences in their growth kinetics, as centennial has longest growth phase and hence its root development is much slower than that of the other genotypes. Similar observation shad been reported by several authors (Mukhtar *et al*., 2010; Tewe *et al*., 2003.) who attributed such differences to genetic compositions of the test crops. Significantly higher number of marketable roots was recorded in BUK than Minjibir. Interaction between genotype and location on the number of marketable roots was not significant. As number of marketable roots is an important yield component, the non-significant genotype-by-location interaction (GLI) affords the breeder to use only one site instead of the two in evaluating breeding lines for the trait and other traits with no significant GLI.

The genotypes also showed differences in the number of pencil roots they developed. Centennial with 84.5 pencil roots recorded the highest number of pencil roots per plant. This implied that Centennial took more days to develop marketable roots than all other genotypes evaluated. This was probably what accounted for the poor number of marketable roots developed by the genotype. Kantayi idda, with 22.2 pencil roots, had the least number of pencil roots per plot. This could be indicative of its long adaptability to the environment. There was significant location effect on the number of pencil roots of sweet potato with BUK having significantly higher number of pencil roots than Minjibir. This is could be as a result of the higher fertility of the BUK soil which was able to produce and support more roots, many of which tuberise to marketable roots while many form pencil roots.

All the sweet potato breeding lines (genotypes) evaluated produced statistically similar vine weights. This was expected as all the varieties were the spreading types and grewvery well, thus translating into a higher biomass. However, the significantly higher vine weights recorded from BUK could be ascribed to the relatively higher amount of rainfall and fertility status of the BUK soils, which consequently translated into higher photosynthetic effects and biomass growth. No significant interaction between genotype and location on vine weight of sweet potato varieties was observed in this trial.

The carotenoid content of the sweet potato lines under evaluation were significant. The results indicated that Centennial, has the highest carotenoid content. This was also at par with EA/11/022 and Kantayiidda local. Least corotenoid contents were observed from the white fleshed lines as reported by several authors (Hagenimana *et al.,* 1999. Ssebuliba *et al*., 2006; Wariboko and Ogidi, 2014), who ascertained the positive association of carotene with the orange fleshed cultivars. Non-significant interactions of variety and location on carotenoids of the sweet potato was recorded in this trial.

Root yield of sweet potato was significantly affected by variety in this study. Kantayi idda produced significantly higher root yield than all other advanced lines. Simiarly, TIS87/0087, UMUSPO/1, Solomon-1, EA/11/022, and UM/11/001 produced significantly high root yield among the advanced lines evaluated. This is in agreement with the work of Wariboko and Ogidi (2014) who reported TIS87/0087 as among the highest root yielder at Amasomma, Wilberforce Island and Yenagoa in Bayelsa State, Nigeria. Among the advanced genotypes evaluated, Centennial produced the least root yield compared to all other genotypes. This could be ascribed to its longer production cycle as well as delayed leaf senescence. This is supported by the report of Gwathmey *et al.* (1992) for adaptive attributes in cowpea. BUK produced significantly the higher root yield than Minjibir in this trial. This could be explained by the variations of the fertility status of the soils and amount of rainfall, with BUK being more fertile and producing more rainfall during the growing season. Good soil fertility and adequate supply of moisture usually support good growth and root yield of sweet potato.

Conclusion

Significant differences were observed in a number of roots per plant, number of marketable roots, number of pencil roots, flesh colour, root shape and root yield among the sweet potato genotypes evaluated. Kantayi idda, a local check produced significantly ($p<0.05$) the highest root yield (10315kg/Ha). Some of the improved lines were also promising in which, Solomon1, EA/11/022, UMUSPO/1, UM/11/001 and TIS87/0087 exhibited relative adaptation and high root yield potential in this agro-ecology; thus could relatively compete with Kantayi idda local to ameliorate an increased demand for sweet potato in the study area.

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