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Assessment of Different Accessions of the Hausa Potato (*Solenostemon rotundifolius* (Poir) J. K. Morton) for Productivity in Jos-plateau Environment

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Authors' contributions

This work was carried out in collaboration between both authors. Author OATN initiated the project, designed the study, wrote the protocol and supervised the study and project report. Author SAO collected field data, performed statistical analysis, wrote the first draft of the manuscript and managed the literature search. Both authors read and approved the final manuscript.

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ABSTRACT

The Hausa potato (*Solenostemon rotundifolius* (Poir) J. K. Morton) is a tropical, multipurpose crop with different uses. Its productivity is, however, limited by a lack of balance between source potential and sink capacity. This results in generally low yields in all the cultivated varieties. Consequently, many farmers have abandoned its cultivation, thereby endangering the perpetuity of the crop. This study was, therefore, designed to screen different accessions of the Hausa potato for productivity in the Jos-Plateau environment, Nigeria. The nine accessions (Manchok 1, Manchok 2, Bokkos 1, Bokkos 2, Bikka-Baban, Mujir, NRCRI, (White), Tukwak and Langtang) were laid out in a randomized complete block design with five (5) replications. Results show that percentage emergence, number of branches per plant, leaf area index, days to flowering, number of flowers per plant, relative growth rate, net assimilation rate and stand count varied with accession. Tuber length, tuber girth, root-top ratio, mean tuber weight, dry matter content and total tuber yield also

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varied with accession. The study demonstrates that with a proper understanding of the physiology of yield, there is prospect for improving the productivity of the Hausa potato in the Jos-Plateau environment.

Keywords: Assessment; accession; Hausa potato; productivity.

1. INTRODUCTION

The Hausa potato (*Solenostemon rotundifolius* (Poir) J. K. Morton) is a tropical, multipurpose, minor tuber crop. It has been reported to be one of the best staple tuber crops in terms of its distinctive fragrance, peculiar taste, medicinal, nutritional and economic values. It is cultivated in the West African countries of Ghana and Nigeria [1].

Currently, its genetic resources are disappearing into extinction due to undesirable features such as small tuber size [1], branching of the tubers, lack of balance between the source potential and sink capacity which results in low tuber yield as well as the intense labour required in its production. Consequently, it is being replaced by more popular root and tuber crops like the Irish potato, sweet potato, cassava and yam.

The plant is a small herbaceous, dicotyledonous annual, 15-30 cm high, prostrate or ascending, with a succulent stem and thick leaves. It has an aromatic mint-like smell. Flowers are small and may be white, blue, pink or pale-violet in colour; they are produced on an elongated terminal with distal inflorescence and slender false spikes [2]. It has small dark-brown edible tubers produced at the base of the stem.

The Hausa potato has the potential of increasing the food bank, solving malnutrition problems, improving food security and increasing yield per unit area of land because of its higher biological efficiency and adaptation to different environments. It also has the potential and prospects for enlarged adoption into other agro-ecological zones in Nigeria and thereby contributing to food security, diversification of the local food base and sustaining livelihood. However, farmers growing this crop follow indigenous methods which result in relatively low yield because of lack of high-yielding varieties and poor agronomic practices. Consequently, the cultivation of the Hausa potato has declined considerably, and this has affected its importance as a starchy vegetable and a staple crop. It has almost disappeared from areas where it was hitherto widely cultivated [3]. The yield can be increased by adopting improved production technologies and cultivars [4]. The objective of this study was to evaluate the productivity of some Hausa potato accessions in the Jos-Plateau environment.

2. MATERIALS AND METHODS

The experiment was conducted between July 2016 and January 2017 at the Potato sub-station of the National Root Crops Research Institute, Kuru in Jos-South Local Government Area of Plateau State (latitude 09°44'N, longitude 08°47'E; altitude1,293.3 m above sea level). The soil is ferrallitic cambisol developed from volcanic rock [5].

Nine accessions (which were named after their native areas) were obtained from the germplasm of the National Root Crops Research Institute (NRCRI), Kuru and from some farmers in Bokkos, Langtang, Bikka-Baban, Tukwak, Mujir and Manchok. These include Machok 1, Machok 2, Bokkos 1, Bokkos 2, Bikka–baban, Mujir, NRCRI (white variety), Tukwak and Langtang spread cross three states of Kaduna, Plateau and Taraba in Nigeria.

Land preparation, including clearing, ploughing, ridging and plot mapping, was done manually on July 4th and 5th, 2016. The net plot size was 3 m x 3 m (9 m^2) and the gross plot size was 37 m x 17 m. Fresh and healthy tubers were selected and planted at inter- and intra-row spacings of 1 m and 0.3 m, respectively, giving a total of 33, 333 plants per hectare. Planting was done on July 8, 2016. The accessions were laid out in a randomized complete block design (RCBD) with five replications. One of the replicates was used for the growth analysis studies. The plots were weeded manually at 21, 45 and 90 days after planting to control weeds. They were earthed up at 21 DAP to keep the tubers from being exposed to sunlight. Fertilizer (NPK 15:15:15) was applied at the rate of 200 kg/hectare.

Field observations and data collection were commenced at 15 days after planting (DAP) and continued until harvest. The emergence rate was computed as the ratio of the number of tubers that emerged out of the total number planted and multiplying by 100 as follows:

Percentage emergence =

$$\frac{Number\ of\ tubers\ that\ emerged}{Total\ No.\ of\ tubers\ planted}\ x\ 100\%$$

Values were subjected to arcsine transformation before the analysis, after which the means were de-transformed.

The number of primary branches (branches arising from the main stem) was physically counted for each of the two plants sampled from each plot. The mean number of braches per plant was used for the statistical analysis.

Two plants were sampled from each plot for the growth analysis studies at 45, 90 and 126 days after planting. Each plant was washed and separated into roots, stems and leaves. All the plant parts were placed in separate envelopes, labeled and dried in a moisture-extraction oven at 100°C to obtain a constant weight. Leaf area index (LAI), relative growth rate (RGR) and net assimilation rate (NAR) were thereafter computed.

Leaf area index was computed using the leaf-disc method as reported by Namo [6]. The total dry weight of the area/weight relationship of a sample taken from the mass of leaves with a punch of a known diameter was determined. The cross-sectional area of the punch used for this experiment was 1.77 cm^2. One hundred discs were taken from each sample and placed in envelopes for drying to constant weight in a moisture-extraction oven at 100°C for 48 hours. The remaining leaves with the punched leaves were placed in separate envelopes and dried at the same temperature and time. Leaf area index was computed using the formula:

LAI = {(Area of 1 disc X No of discs X Total leaf dry weight / Land area occupied by sampled plant) / Dry weight of leaf discs}

The relative growth rate was computed on the basis of increase in dry weight of the plant parts over a fixed period, using the method of Cheema et al. [7] as follows:

$$RGR = \frac{\ln W_2 - \ln W_1}{t_2 - t_1}$$

Where,

W_1 and W_2 = Total dry weight at times t_1 and t_2.

The net assimilation rate, defined as the rate of increase in dry weight per unit leaf area, was computed from the data obtained on dry weights of plants using the method proposed by Gregory [8] as reported by Namo [6].

$$NAR = \frac{W_2 - W_1}{t_2 - t_1}\ X\ \frac{Ln\ L_2 - Ln\ L_1}{L_2 - L_1}$$

Where,

W_1 and W_2 are the total dry weight of harvested parts at times t_1 and t_2, respectively.
L_1 and L_2 are the leaf area at t_1 and t_2.
Ln = natural log

The number of days from the date of planting to when the first flower appeared in each plot was recorded as the number of days to flowering. The number of flowers in each of the five plants sampled from each plot was counted at 90 days after planting. The mean number of flowers per plant was used for the statistical analysis. At harvest, the shoot (the stems and leaves) and the root (the tubers) were harvested from each of the two plants sampled from each plot and weighed separately. The ratio of the weight of the tubers to that of the shoot was computed as the root-top ratio using the formula:

$$\text{Root-Top Ratio} = \frac{\text{Weight of tubers}}{\text{Weight of shoot}}$$

Stand count at harvest was recorded as the total number of plants in each plot at the time of harvest. Five tubers were sampled from each plot and measured from the tip to the bottom. The mean tuber length was used for the statistical analysis. The tuber girth was measured as the circumference of the widest portion of the tuber. Five tubers were sampled from each plot and measured using a measuring tape. The mean tuber girth was used for the statistical analysis. The total number of tubers harvested from each plot was divided by the number of plant stands at harvest to obtain the mean number of tubers per plant. All the tubers harvested from each plot were weighed and the weight was divided by the total number of tubers from the respective plot in order to obtain the mean tuber weight for each accession.

Ten (10) g of fresh tuber sample was taken from the harvested tubers, weighed and dried in a moisture-extraction oven to constant weight at 100°C for 48 hours. The dry matter percentage (DM %) was then computed as follows:

$$DM\% = \frac{b}{a} \times 100$$

Where,

a = fresh weight of sample
b = dry weight of sample.

The harvest index was computed at each sampling date at 45, 90 and 126 days after planting as follows:

$$HI = \frac{\text{Dry weight of tubers}}{\text{Total dry weight}}$$

All the tubers harvested from each plot were weighed and the weight was converted to the equivalent in tonnes per hectare.

Data collected were subjected to the Analysis of Variance (ANOVA) and the F-test was used to test the significance of treatment effects. Means were separated using the Duncan's new Multiple-Range Test [9].

3. RESULTS AND DISCUSSION

3.1 Percentage Emergence

Table 1 shows the percentage emergence in some Hausa potato accessions grown in Kuru in 2016. The accession NRCRI (White) had the highest percentage emergence of 87.51%. The accession Mujir had the lowest percentage emergence (30.94%), which did not differ significantly from accessions Bokkos 2 (33.98%) and Langtang (32.39%).

Significant variations observed in percentage emergence might have been caused by differences in the genetic make-up of the different accessions used in this study. The accession NRCRI (White) which recorded the highest percentage emergence had bigger seed tubers than Mujir. Rykbost et al. [10] observed that small seed tubers resulted in delayed emergence in all varieties of the Hausa potato.

3.2 Number of Branches per Plant

The highest mean number of branches per plant was observed in the accession Manchok 2 (28.75), followed by Manchok 1 (21.38), Bikka-Baban (17.88), and NRCRI (White) (17.00). The lowest number of branches per plant (6.50) was observed in the accession Langtang (Table 1). Namo [6] also reported variations in the mean number of branches per plant in the sweet potato and noted that the number of branches produced by a plant is primarily a genetic character and that it is influenced by Indole Acetic Acid (IAA) in the plant as well as prevailing environmental conditions. The number of branches contributes to the total dry matter produced by the plant, which in turn may lead to higher tuber yield.

Table 1. Percentage emergence and number of branches per plant in some Hausa potato accessions grown in Kuru in 2016

Accession	Percentage emergence*	No of branches per plant
Manchok 1	49.80^{b}	21.38^{ab}
Manchok 2	50.09^{b}	28.75^{a}
Bokkos 1	36.08^{cd}	16.63^{bc}
Bokkos 2	33.98^{d}	15.63^{bc}
Bikka-Baban	46.72^{bc}	17.88^{bc}
Mujir	30.94^{d}	12.25^{cd}
NRCRI(White)	87.51^{a}	17.00^{bc}
Tukwak	48.83^{b}	16.00^{bc}
Langtang	32.39^{d}	6.50^{d}
CV (%)	14.20	31.93

*Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability (Duncan's new Multiple-Range Test). *Values were subjected to arcsine transformation before the analysis, and thereafter de-transformed*

3.3 Leaf Area Index

Table 2 shows the leaf area index (LAI) in some Hausa potato accessions at different stages of growth in Kuru in 2016. The LAI increased with time up to 90 DAP and thereafter decreased in all except accessions Manchok 2, Bokkos 1 and Bokkos 2. At 45, 90 and 126 DAP, the highest LAI values were observed in the accession NRCRI (White) while the lowest values were observed in Bokkos 1, Manchok 2 and Tukwak, respectively. Deshi et al. [11] reported that LAI in potato increased in all varieties to a peak and then declined due to senescence of leaves and decrease in dry matter production and distribution to the various parts of the plant.

3.4 Days to Flowering

The highest number of days to flowering was observed in the accession Tukwak (87.00 DAP), which was followed by the accession Mujir (80.25 DAP). The lowest number of days to flowering (71 DAP) was observed in the accession Bokkos 1 (Table 3). The differences in the number of days to flowering indicates that this trait is genotypically controlled [1].

Table 2. Leaf area index in some Hausa potato accessions at 45, 90 and 126 days after planting in Kuru in 2016

Accession	Growth Stage (Days After Planting)		
	45	90	126
Manchok 1	0.06^{ab}	0.29^{ab}	0.18^{bcd}
Manchok 2	0.04^{ab}	0.22^{b}	0.24^{bc}
Bokkos 1	0.02^{b}	0.13^{b}	0.26^{b}
Bokkos 2	0.06^{ab}	0.25^{ab}	0.40^{a}
Bikka-Baban	0.09^{ab}	0.30^{ab}	0.19^{bcd}
Mujir	0.02^{b}	0.29^{ab}	0.09^{d}
NRCRI (White)	0.13^{a}	0.44^{a}	0.40^{a}
Tukwak	0.12^{ab}	0.21^{b}	0.11^{d}
Langtang	0.03^{ab}	0.29^{ab}	0.13^{cd}
CV (%)	8.45	33.79	19.93

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability (Duncan's New Multiple-Range Test)

3.5 Number of Flowers per Plant

Table 3 shows the number of flowers per plant in some Hausa potato accessions grown in Kuru in 2016. The number of flowers observed in all the accessions did not differ significantly (P = 0.05). Contrary to this observation, Mwanja et al. [12] reported that the number of flowers per plant in the Livingstone potato differed significantly with variety.

Table 3. Days to flowering and number of flowers per plant in some Hausa potato accessions grown in Kuru in 2016

Accession	Days to flowering	No of Flowers per plant
Manchok 1	72.00^{dc}	99.90^{a}
Manchok 2	75.00^{cd}	70.43^{a}
Bokkos 1	70.75^{e}	98.35^{a}
Bokkos 2	73.00^{cde}	89.29^{a}
Bikka-Baban	75.25^{c}	86.84^{a}
Mujir	80.25^{b}	95.24^{a}
NRCRI (White)	75.00^{cd}	102.15^{a}
Tukwak	87.00^{a}	114.45^{a}
Langtang	72.25^{cde}	120.78^{a}
CV (%)	2.53	10.13

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability (Duncan's New Multiple-Range Test)

3.6 Relative Growth Rate

Table 4 shows the relative growth rate (RGR) in some Hausa potato accessions grown in Kuru in 2016. The highest RGR values in all the accessions were observed at 45 days after planting (45 DAP) except in the accessions Bokkos 1 and Mujir, where RGR peaked at 90 DAP. At 45 DAP, the highest RGR was observed in the accession NRCRI (White) (0.69 gg^{-1} day^{-1}), but this did not differ significantly from those of accessions Manchok 1 (0.49 gg^{-1} $day^{-}1$), Manchok 2 (0.61 gg^{-1} day^{-1}), Bokkos 1 (0.46 gg^{-1} day^{-1}), Bokkos 2 (0.51 gg^{-1} day^{-1}), Bikka-Baban (0.56 gg^{-1} day^{-1}) and Tukwak (0.67 gg^{-1} day^{-1}). The lowest RGR of 0.20 gg^{-1} day^{-1} was observed in the accession Mujir. At 90 DAP, the highest RGR was observed in the accession Bokkos 1 (0.50 gg^{-1} day^{-1}) while the lowest value was observed in the accession Manchok 2 (0.10 gg^{-1} day^{-1}). At 126 DAP, the highest RGR value of 0.24 gg^{-1} $day^{-1}$was observed in the accession Bokkos 2, while the lowest RGR was observed in the accession Langtang (0.04 gg^{-1} day^{-1}). Kuhlase et al. [13] and Vimala and Hariprakash [14] also reported a decrease in relative growth rate over time. In this study, the decrease in RGR over time showed that there was a decrease in total dry matter accumulated and partitioned to various parts of the plants. Usually, more dry matter is partitioned to the tubers at the latter stages of growth compared to the proportion distributed to the leaves and stems.

Table 4. Relative growth rate (gg^{-1} day^{-1}) ($x10^{-1}$) at 45, 90 and 126 days after planting (DAP) in some Hausa potato accessions grown in Kuru in 2016

Accession	Growth Stage (Days After Planting)		
	45	90	126
Manchok 1	0.49^{ab}	0.34^{ab}	0.18^{ab}
Manchok 2	0.61^{ab}	0.10^{c}	0.07^{bc}
Bokkos 1	0.46^{ab}	0.50^{a}	0.17^{ab}
Bokkos 2	0.51^{ab}	0.32^{ab}	0.24^{a}
Bikka-Baban	0.56^{ab}	0.37^{ab}	0.10^{b}
Mujir	0.20^{c}	0.31^{ab}	0.12^{b}
NRCRI (White)	0.69^{a}	0.12^{c}	0.15^{ab}
Tukwak	0.67^{ab}	0.23^{bc}	0.12^{b}
Langtang	0.41^{bc}	0.20^{bc}	0.04^{c}
CV (%)	21.65	43.83	44.43

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability (Duncan's New Multiple-Range Test)

3.7 Net Assimilation Rate

The highest net assimilation rate (NAR) values were observed at 45 days after planting (45 DAP) in all the accessions (Table 5). Thereafter, NAR decreased with time in most of the accessions. At 45 DAP, the highest NAR value of 15.89 gm^{-2} $week^{-1}$ was observed in the accession Manchok 2, but this did not differ significantly from accessions Bokkos 1 (12.45 gm^{-2} $week^{-1}$) and NRCRI (White) (9.15 gm^{-2} $week^{-1}$). The lowest NAR value of 5.92 gm^{-2} $week^{-1}$ was observed in the accession Bikka- Baban. The highest NAR value at 90 DAP (3.11 gm^{-2} $week^{-1}$) was observed in the accession Bokkos 1; the lowest value of 0.10 gm^{-2} $week^{-1}$ was observed in the accession Langtang (P = 0.05). At 126 DAP, the NAR values observed in all the accessions did not differ significantly at P = 0.05 (Table 5).

Table 5. Net assimilation rate (NAR) (gm^{-2} $week^{-1}$) ($x10^{-3}$) at 45, 90 and 126 days after planting (DAP) in some Hausa potato accessions grown in Kuru in 2016

Accession	Growth Stage (Days After Planting)		
	45	90	126
Manchok 1	6.73^{b}	1.20^{ab}	0.44^{a}
Manchok 2	15.89^{a}	0.42^{b}	0.42^{a}
Bokkos 1	12.45^{ab}	3.11^{a}	0.40^{a}
Bokkos 2	6.68^{b}	1.08^{b}	0.88^{a}
Bikka-Baban	5.92^{b}	1.98^{ab}	0.28^{a}
Mujir	7.76^{b}	0.19^{b}	0.74^{a}
NRCRI (White)	9.15^{ab}	0.47^{b}	0.43^{a}
Tukwak	7.91^{b}	1.60^{ab}	0.54^{a}
Langtang	6.43^{b}	0.10^{b}	0.57^{a}
CV (%)	36.22	48.01	45.51

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability (Duncan's New Multiple-Range Test)

The net assimilation rate varied with genotype and the stage of growth in this study. In most accessions, NAR was higher at the early than at the latter stages of growth. As the cropping season progresses, light interception improves and the rate of dry matter production goes up. But due to mutual shading, photosynthesis no longer exceeds respiration in older leaves, which then cease to be net producers of dry matter [6]. However, in accessions where NAR was higher at the latter stages of growth, there might have been less mutual shading of leaves, due to leaf orientation, which might have resulted in a continuous production of dry matter.

3.8 Stand Count at Harvest

Table 6 shows stand count in some Hausa potato accessions grown in Kuru in 2016. The highest stand count of 25.25 was observed in the accession NRCRI (White), and this was followed by Manchok 2 (17.50), Manchok 1(17.25) and Bikka-Baban (16.50). The lowest number of stand counts at harvest was observed in the accession Langtang (1.75). The differences observed in stand count among the Hausa potato accessions could be attributed to their genotypic differences.

Table 6. Stand count at harvest and root-top ratio in some Hausa potato accessions grown in Kuru in 2016

Accession	Stand count	Root-top ratio
Manchok 1	17.25^{b}	1.20^{cd}
Manchok 2	17.50^{b}	0.37^{e}
Bokkos 1	10.50^{c}	1.60^{c}
Bokkos 2	10.75^{c}	2.10^{b}
Bikka-Baban	16.50^{b}	0.96^{d}
Mujir	4.00^{de}	2.47^{b}
NRCRI (White)	25.25^{a}	3.28^{a}
Tukwak	8.50^{cd}	0.90^{d}
Langtang	1.75^{e}	1.41^{c}
CV (%)	4.43	16.69

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability (Duncan's new Multiple-Range Test).

3.9 Root-Top Ratio

Table 6 shows the root-top ratio in some Hausa potato accessions grown in Kuru in 2016.The highest root-top ratio was observed in NRCRI (White) (3.28), followed by accessions Mujir (2.47) and Bokkos 2 (2.10). The lowest value of 0.37 was observed in the accession Manchok 2 (0.37). Accessions with high root-top ratios are believed to have large sink capacities which enable them to capture assimilates produced by the source (leaves and stems). In other words, more assimilates were partitioned to the tubers in these accessions compared to the leaves and stems [15]. In this study, the accessions NRCRI (White), Mujir and Bokkos 2 with high root-top ratios also had high total fresh tuber yields.

3.10 Tuber Length and Tuber Girth

The highest tuber length of 7.08 cm was observed in the accession Tukwak and this was followed by accessions Bokkos I (6.70 cm), NRCRI (White) (6.25 cm), Manchok 2 (6.15 cm), Manchok 1 (5.70 cm) and Bikka-Baban (5.58 cm). The lowest tuber length was observed in the accession Mujir (4.65 cm). The accessions did not differ significantly (P = 0.05) in tuber length (Table 7). Tuber girth was highest in the accession NRCRI (White) (8.50 cm), but this did not differ significantly from the accession Manchok 2 (6.85 cm). All the other accessions were statistically similar in tuber girth.

Table 7. Tuber length and tuber girth in some Hausa potato accessions grown in Kuru in 2016

Accession	Tuber length (cm)	Tuber girth (cm)
Manchok 1	5.70^{a}	5.80^{b}
Manchok 2	6.15^{a}	6.85^{ab}
Bokkos 1	6.70^{a}	6.58^{b}
Bokkos 2	5.18^{a}	5.13^{b}
Bikka –Baban	5.58^{a}	4.95^{b}
Mujir	4.65^{a}	6.40^{b}
NRCRI (White)	6.25^{a}	8.50^{a}
Tukwak	7.08^{a}	6.30^{b}
Langtang	4.63^{a}	5.73^{b}
CV (%)	26.40	18.85

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability (Duncan's New Multiple-Range Test.

Namo [6] noted that selection based on length of tubers was highly desirable for improving sweet potato yield. This could also be true of the Hausa potato. Tuber length and tuber girth varied in all accessions. Ogedengbe et al. [16] reported that variations in tuber length and tuber girth were due to tuber size and the genetic make-up of the plant.

3.11 Mean Tuber Weight

The highest mean tuber weight of 7.15 g was observed in the accession Bokkos 2, which did not differ significantly from accessions Bokkos 1 (3.99 g), Bikka-Baban (2.66 g), Mujir (3.18 g), NRCRI (White) (2.99 g), Tukwak (2.97 g) and Langtang (4.47 g). The lowest mean tuber weight was observed in the accession Manchok 2 (2.12 g) (Table 8). The generally low mean tuber weight in this study confirms the poor yield in the Hausa potato. Many tubers are produced per plant, but are small in size due, perhaps, to slow rate of translocation of assimilates from the source to the sink.

3.12 Dry Matter Content

Table 8 shows the dry matter content in some Hausa potato accessions grown in Kuru in 2016. The highest dry matter content of 30.60% was observed in the accession Bikka-Baban, but this did not differ significantly from the other accessions. Dry matter content has been reported to be related to starch content in sweet potato [17]. The dry matter content of 27% and above has been observed to be acceptable to most processors of tubers [17]. Most of the accessions used in this study have dry matter content of 17% and above (Table 8). This implies that only accessions Bikka-Baban, NRCRI (White), Tukwak and Langtang could be considered for use in industrial processing.

Table 8. Mean tuber weight and dry matter content (%) in some Hausa potato accessions grown in Kuru in 2016

Accession	Tuber weight (g)	Dry matter content (%)
Manchok 1	2.15^{d}	17.55^{a}
Manchok 2	2.12^{e}	23.24^{a}
Bokkos 1	3.99^{b}	23.11^{a}
Bokkos 2	7.15^{a}	21.84^{a}
Bikka-Baban	2.66^{c}	30.62^{a}
Mujir	3.18^{c}	17.40^{a}
NRCRI (White)	2.99^{c}	27.00^{a}
Tukwak	2.97^{c}	25.46^{a}
Langtang	4.47^{b}	25.87^{a}
CV (%)	15.30	31.00

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability (Duncan's New Multiple-Range Test)

3.13 Harvest Index

Table 9 shows the harvest index in some Hausa potato accessions at different stages of growth. Generally, harvest index increased with time up to 126 DAP in all but accession Mujir. The highest harvest index at 45 DAP was observed in the accession Manchok 2 (0.64). The lowest harvest index was observed in the accession Langtang (0.20). At 90 DAP, the harvest index was statistically similar in all the accessions. At 126 DAP, the highest harvest index was observed in the accession Bokkos 1 (0.88) and this was followed by accessions Manchok 1(0.85) and Bikka-Baban (0.83); the accession Mujir had the lowest harvest index of 0.46. Harvest index is a major determinant of yield as it represents the efficiency of the crop to convert photosynthates to economically valuable products [18]. Namo [6] observed that harvest index increased with crop age in the sweet potato and that the peak period varied with genotype.

Table 9. Harvest index at 45, 90 and 126 days after planting (DAP) in some Hausa potato accessions grown in Kuru in 2016

Accession	Growth Stage (Days After Planting)		
	45	90	126
Manchok 1	0.23[de]	0.51[a]	0.85[ab]
Manchok 2	0.64 [a]	0.61[a]	0.70[ab]
Bokkos 1	0.22[de]	0.66[a]	0.88 [a]
Bokkos 2	0.38[cd]	0.57[a]	0.76[ab]
Bikka- Baban	0.32[cde]	0.55[a]	0.83[ab]
Mujir	0.37[cd]	0.51[a]	0.46[c]
NRCRI (White)	0.56[ab]	0.67[a]	0.76[ab]
Tukwak	0.43[bc]	0.64[a]	0.82[ab]
Langtang	0.20[e]	0.62[a]	0.63[bc]
CV (%)	18.29	22.64	12.00

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability (Duncan's New Multiple-Range Test)

3.14 Total Tuber Yield

Table 10 shows the total tuber yield in some Hausa potato accessions grown in Kuru in 2016. The highest total tuber yield of 3.83 t / ha was observed in the accession NRCRI (White). The lowest total tuber yield, which was observed in the accession Langtang (0.10 t / ha), did not differ significantly from those of accessions Bokkos 1 (1.21t / ha), Bokkos 2 (1.42 t / ha), Manchok 1 (1.05 t / ha), Manchok 2 (1.42 t / ha) and Bikka-Baban (0.92 t / ha). Total tuber yield was generally low in all the accessions, contrary to the findings of Enyiukwu et al. [19] and Reddy [20] who reported average tuber yields of between 5 and 15 t / ha. It has been observed that more dry matter could be left in the above-ground portion (leaves and stems) than in the roots at the end of the cropping season, suggesting, perhaps, a lack of balance between the source potential and sink capacity [6]. The low tuber yield observed in the study could also be due to the fact that all the accessions used in the experiment, except NRCRI (White), were newly introduced into the Jos-Plateau environment. An investigation into the source-sink relationship in the Hausa potato is hereby recommended.

Table 10. Total tuber yield (t / ha) in some Hausa potato accessions grown in Kuru in 2016

Accession	Tuber yield (t/ha)
Manchok 1	1.05[bc]
Manchok 2	1.42 [b]
Bokkos 1	1.21 [b]
Bokkos 2	1.42 [b]
Bikka-Baban	0.92[bc]
Mujir	0.12 [c]
NRCRI (White)	3.83 [a]
Tukwak	0.92[bc]
Langtang	0.10 [c]
CV (%)	33.88

Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability (Duncan's new Multiple-Range Test)

4. CONCLUSION

The results of this study show that percentage emergence, number of branches per plant, leaf area index, days to flowering, number of flowers per plant, relative growth rate, net assimilation rate, tuber length, tuber girth, root-top ratio, mean tuber weight, dry matter content and total tuber yield varied with accession. The total tuber yield was generally low in all the accessions. There is a need for further investigation into the source-sink relationship in the Hausa potato.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Nanema RK, Traore ER, Bationo P, Zongo J. Morphoagromical characterization of *Solenostemon rotundifolius* (Poir) J. K. Morton (Lamiaceae) germplasm from Burkina Faso. International Journal of Biological and Chemical Sciences. 2009; 3:1100-1113.
2. Steentoft M. Flowering Plants in West Africa. Cambridge. Cambridge University Press. 2009;268.
3. Nkansah GO. *Solenostemon rotundifolius* (Poir) J.K. Morton. Internet record from PROTA4U. G.J.H. and Denton, O.A. (Editors). PROTA (Plant Resources of Tropical Africa/ Resources vegetales de l'Afriquetropicale), Wageningen, Netherlands; 2004. Available:http://www.prota4u.org/search.asp

4. Akinpelu AO, Olojede AO, Amamgbo EF, Njoku SC. Response of Hausa potato to different NPK 15:15:15 Fertilizer Rates in NRCRI, Umudike, Abia State, Nigeria. Journal of Agriculture and Social Research. 2011;1(11):22-25.
5. Enwezo WO, Ohiri AC, Opuwaribo EE, Udo JE. Literature review on soil fertility investigations in Nigeria. Federal Ministry of Agricultural and Natural Resources, Lagos; 1990.
6. Namo OAT. Screening for source-sink potentials in some sweet potato (*Ipomoea batatas* (L.) Lam.) Lines in Jos – Plateau, Nigeria. Published Ph.D. Thesis, University of Jos, Jos, Nigeria. Published by Lambert Academic Publishing, Omniscriptum GmbH Co. KG, Deutschland, Germany. 2005;240.
7. Cheema SS, Dhaliwa BK, Sahota TS. Agronomy: Theory and Digest. Kalyana Publishers, New Delhi. 1991;276.
8. Gregory FG. Physiological conditions in cucumber houses. 3rd Annual Report of the Experimental Research Station, Nursery and Market Garden Industries Development Soc. Ltd., Chestnut. 1918;19-28.
9. Little TM, Hills FJ. Agricultural experimentation, design and analysis. John Wiley and Sons Ltd., New York, USA. 1977;350.
10. Rykbost KA, Locket KA, Maxwell J. Effect of seed piece size on performance of three potato varieties. Klamath Experiment Station Report; 1995. Available:http://oregonstate.edu/dept/kbrec/sites/default/files/16_-_95seedpiecesize
11. Deshi KE, Obasi MO, Odiaka NI, Kalu BA, Ifenkwe OP. Leaf Area Index Values of Potato (*Solanum tuberosum* L.) stored for Different Periods in Different Kinds of Stores. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS). 2015; 8(1):09-19.
12. Mwanja YP, Goler EE, Gugu FM. Flowering and seed-setting studies in Livingstone potato (*Plectranthus esculentus* N.E. BR.) in Jos-Plateau, Nigeria. International Journal of Plant Breeding and Genetics. 2015;9:275-279.
13. Kuhlase LM, Ossom EM, Rhykerd RL. Effect of plant population on morphological and physiological parameters of intercropped sweet potato (*Ipomoea batatas* (L.) Lam.) and groundnut (*Arachis hypogaea* L.). Academic Journal of Plant Science. 2(1):16-24.
14. Vimala, B. and Hariprakash, B. Evaluation of some promising sweet potato clones for early maturity. Electronic Journal of Plant Breeding. 2011;2:461-465.
15. Mbwaga Z. Quality and yield stability of orange-fleshed sweet potato (*Ipomoea batatas* (L.) Lam.) varieties in different agro-ecologies. M.Sc. Thesis. University of Zambia, Lusaka, Zambia. 2007;76.
16. Ogedengbe SA, Safwan I, Ajala BA. Effects of seed tuber size and NPK fertilizer on some yield components of coleus potato (*Solenostemon rotundifolius* (Poir) J.K. Morton). International Journal of Agriculture and Rural Development. 2015; 18(2): 2240-2245.
17. Nwankwo IIM, Afuape SO. Evaluation of high altitude orange-fleshed sweet potato (*Ipomoea batatas*) genotypes for adaptability and yield in Lowland rainforest ecology of Umudike, Southeastern Nigeria. IOSR Journal of Agriculture and Veterinary Science. 2013;5(6):77-81.
18. Masango S. Water use efficiency of orange-fleshed sweet potato. M.Sc. Thesis University of Pretoria, South Africa. 2014;112. Academic Publication. Available:http://www.repository.up.ac.za [Date assessed 2nd Feb. 2017]
19. Enyiukwu DN, Awurum AN, Nwaneri JA. Potentials of Hausa Potato (*Solenostemon rotundifolius* (Poir) J. K. Morton) and management of its tuber rot in Nigeria. Greener Journal of Agronomy, Forestry and Horticulture. 2014;2 (2):027–037.
20. Reddy PP. Plant protection in tropical root and tuber crops. Springer International Publishers, India. 2015;336 .

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