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Research Article
Assessment of Root and Vine Yields of Sweet Potato (*Ipomoea batatas* (L.) Lam) Landraces as Influenced by Plant Population Density in Jos-Plateau, Nigeria

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Abstract

Objective: An investigation was conducted in Kuru (Latitude 09°44'N, longitude 08°47'E and altitude 1350 m a.s.l.) on the Jos-Plateau, Nigeria to assess the root and vine yields of three landraces and one elite variety of sweet potato (*Ipomoea batatas* (L.) Lam) as influenced by plant population density and genotype. **Materials and Methods:** Sweet potato cultivars (Landraces) sourced from both local farmers and the National Roots Crops Research Institute (NRCRI), Umudike, Abia state, Nigeria included Kunkudu, Katsina and Dunku, while TIS.2532.OP.1.13 (An elite variety) served as the check to ensure the purity of the planting material. The parameters tested were the root and top yields, while the plant population densities under investigation consisted of 50,000, 40,000, 33,333 and 28,570 plants ha^{-1} based on past literature and concurrent studies. These were laid out in a Randomized Complete Block Design (RCBD) consisting of 16 treatments with 3 replications. Data collected were subjected to analysis of variances (ANOVA) according to Snedecor and Cochran, while the Duncan's new multiple-range test was used to compare the treatment means. **Results:** Results obtained indicated that the highest and lowest mean root yields were observed in Katsina at 33,333 plants ha^{-1} (47.89 t ha^{-1}) and Dunku (8.25 t ha^{-1}) landraces, respectively. TIS.2532.OP.1.13 ranked 2nd after Katsina but the difference ($p>0.05$) was not significant with respect to 50,000 plant population density but showed significant difference ($p<0.05$) with respect to the other three plant population densities. The mean vine yield showed that landrace Dunku had the highest at 33,333 (59.83 t ha^{-1}) plants ha^{-1}, while the lowest was observed in landrace Katsina (25.22 t ha^{-1}). **Conclusion:** The study has shown that the optimum plant population density with the most influence on yield parameters was 33,333 plants ha^{-1} and therefore should guide farmers in making the right choice for maximum yield and breeding potentials either for forage or root production.

Key words: *Ipomoea batatas* (L.) Lam, genotype, planting material, inbreeding, plant density, breeding, replication

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Sweet potato (*Ipomoea batatas* (L.) Lam) is an important root crop which is extensively cultivated in tropical and sub-tropical zones[1]. It is one of the world's most important food crops due to its high yield and nutritive value[2]. The high nutritive value and performance under resource poor conditions makes it attractive to farmers and households. Sweet potato is mainly propagated by vine-cuttings, planted on mounds and ridges and in single or double rows[3]. New shoots and roots arise from the nodes of the vine-cuttings[4]. Despite the high potentials of the crop as a short duration crop (3-4 months) that could be cropped more than once a year, its production is faced with constraints such as low yielding varieties, difficulty in maintaining the vines (planting material) during the dry season when water is scarce, scarcity of vines as planting material, inbreeding depression as a result of continuous use of vines as planting material which is characterized by decrease in vigour and yield[5].

African survey reports, Nigeria ranked 2nd in production of sweet potato in Africa with an annual production output of 2.6 million metric tons, while the global survey reports, Nigeria ranked 3rd followed by Uganda (2.5 million metric tons) in global sweet potato production output[6]. These figures have changed in the last decade. Presently, Nigeria is the first largest producer of sweet potato in Africa with 3.46 million metric tons annually. Globally, Nigeria is now the second largest sweet potato producer after China at the top of the list with 106 million metric tons[7]. The crop ranks 7th among the world's major food crops. In Nigeria, sweet potato is produced virtually in every part of the country but predominantly in the Northern Guinea Savannah where many landraces abound. In the North Central part of the country large quantities of sweet potato are produced by small scale farmers but the yields realized are low due to the use of low yielding varieties and poor agronomic practices. However, this trend could change if appropriate agronomic practices and utilization of improved varieties are adopted[8-10].

Household income is supplemented by sales of the roots in local markets and to urban dwellers. Its importance in starch, alcohol, livestock, pharmaceutical and textile industries cannot be over emphasized[11]. The orange-fleshed varieties with high B-carotene content have been fortified with vitamin A to reduce its deficiency especially in children.

Several researchers have reported on plant population density as an index of yield in: Sweet potato[12], maize[13] and sesame[14]. Therefore, the objective of this study was to determine the most appropriate plant population density for maximum root and vine yields and breeding potentials in the test landraces and to also determine the performance of an elite variety, TIS.2532.OP.1.13 when compared with the test landraces.

MATERIALS AND METHODS

The experiment was carried out in Kuru (Latitude 09°44'N, longitude 08°47'E and altitude 1350 m a.s.l.) on the Jos-Plateau, Nigeria to investigate root and vine yields of three local cultivars and one elite variety of sweet potato (*Ipomoea batatas* (L.) Lam) as influenced by plant population density in Jos-Plateau, Nigeria.

Sweet potato cultivars (Landraces) sourced from both local farmers and the National Roots Crops Research Institute (NRCRI), Umudike, Abia state, Nigeria included Kunkudu, Katsina and Dunku, while TIS.2532.OP.1.13 (An elite variety) served as the check to ensure the purity of the planting material. The parameters tested were the root and vine yields, while the plant population densities under investigation consisted of 50,000, 40,000, 33,333 and 28,570 plants ha^{-1}. The experiment was laid out in a Randomized Complete Block Design (RCBD) consisting of 16 treatments and 3 replications. The agronomic characteristics of some elite varieties are shown in Table 1.

Land preparation was done manually. The net plot, which measured 3×3 m, consisted of 3 rows, each measuring 3 ×1 m. Vine-cuttings of about 20 cm long were planted on each row at 30 cm (within row) and 100 cm (between rows).

The plots were first weeded manually at 40 Days after Planting (40 DAP). At 41 DAP the plots received a blanket application of fertilizer NPK (15:15:15) at the rate of 60 kg ha^{-1} each of nitrogen, phosphorus and potassium, which was equivalent to 360 g plot^{-1}.

Field sampling: Field observations began at 40 DAP and continued until 140 DAP. The total root yield from 10 sampled

Table 1: Agronomic characteristics of some elite sweet potato varieties

Elite variety	Plant population density (plants ha^{-1})	No. of days to maturity (WAP)	Average yield (t ha^{-1})	No. of days to 50% flowering (WAP)
TIS.2532.OP.1.13	33,333	16	10.45	5
TIS.8164	33,333	16	9.58	6
TIS.87/0087	33,333	16	11.65	6
CIPM 3	33,333	16	9.79	6
CIPM 31	33,333	16	1.30	10

Source: National Roots Crops Research Institute (NRCRI) Umudike, Nigeria plants in each plot was used in the analysis of variance to determine the mean root yield for each landrace. Similarly, the total vine yield from 10 sampled plants in each plot was used in the analysis of variance to determine the mean vine yield for each landrace and the check.

Statistical data analysis: Data collected were subjected to analysis of variances (ANOVA) according to Snedecor and Cochran[15]. Duncan's new multiple-range test was used to compare between means of treatments according to Duncan[16] at probability of 5% (Duncan's new multiple-range test).

RESULTS

Mean root yield (t ha^{-1}): The results showed that the influence of genotype (Landrace) at 50,000 plants ha^{-1} population density on mean root yield was highest and lowest in Katsina (39.96 t ha^{-1}) and Kunkudu (11.10 t ha^{-1}), respectively. TIS.2532.OP.1.13 ranked 2nd after Katsina and the difference (p>0.05) was not significant (Table 2). However, it showed significant difference (p<0.05) when compared with Dunku in the 3rd position at 40,000 plant population (Table 2). The influence of genotype (Landrace) at 40,000 plants ha^{-1} population density indicated that the highest and lowest mean root yields were recorded in Katsina (41.22 t ha^{-1}) and Dunku (8.83 t ha^{-1}), respectively. Similarly, TIS.2532.OP.1.13 ranked 2nd after Katsina but this time showed significant difference (p<0.05) with both Dunku and Kunkudu in the 3rd position (Table 2). The influence of genotype and 33,333 plants ha^{-1} population density on mean root yield showed that the highest and lowest mean root yields were observed in Katsina (47.89 t ha^{-1}) and Dunku (8.25 t ha^{-1}), respectively. TIS.2532.OP.1.13 maintained the 2nd spot showing significant difference (p<0.05) amongst the landraces (Table 2). The influence of genotype and 28,570 plants ha^{-1} population density showed that the highest and lowest were observed in Katsina (40.00 t ha^{-1}) and Dunku (8.70 t ha^{-1}), respectively with TIS.2532.OP.1.13 in the 2nd position showing significant difference (p<0.05) with the others.

Mean vine yield (t ha^{-1}): The influence of genotype and 50,000 plants ha^{-1} population density on vine yield indicated that the highest and lowest mean vine yields were observed in Dunku (58.91 t ha^{-1}) and Katsina (25.22 t ha^{-1}), respectively. TIS.2532.OP.1.13 ranked 2nd after Dunku and the difference was not significant (p>0.05) but showed significant difference (p<0.05) with both Katsina and Kunkudu (Table 3). Genotype

Table 2: Mean root yield (t ha^{-1}) of sweet potato landraces as influenced by population density

	Population density (plants ha^{-1})			
Sweet potato landrace	50,000	40,000	33,333	28,570
Kunkudu	11.10^{c}	15.46^{c}	11.62^{c}	12.34^{c}
Katsina	39.96^{a}	41.22^{a}	47.89^{a}	40.00^{a}
Dunku	21.74^{b}	8.83^{d}	8.25^{d}	8.70^{d}
TIS.2532.OP.1.13	39.11^{a}	37.80^{b}	37.53^{b}	30.99^{b}
CV (%)	6.74	14.45	12.54	12.27

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)

Table 3: Mean vine yield (t ha^{-1}) of sweet potato landraces as influenced by population density

	Population density (plants ha^{-1})			
Sweet potato landrace	50,000	40,000	33,333	28,570
Kunkudu	33.55^{b}	33.24^{b}	26.21^{c}	37.44^{b}
Katsina	25.22^{c}	31.11^{c}	40.16^{b}	25.41^{d}
Dunku	58.91^{a}	34.67^{b}	59.83^{a}	31.06^{c}
TIS.2532.OP.1.13	55.32^{a}	45.33^{a}	41.95^{b}	42.82^{a}
CV (%)	2.72	2.47	4.63	16.24

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)

and 40,000 plants ha^{-1} population density influence showed that the highest and lowest mean vine yields were recorded in TIS.2532.OP.1.13 (45.33 t ha^{-1}) and Katsina (31.11t ha^{-1}), respectively, Dunku and Kunkudu ranked 3rd and 4th, respectively with no significant difference (p>0.05) between them (Table 3). The highest and lowest mean vine yields with respect to genotype and 33,333 plants ha^{-1} population density were observed in Dunku (59.83 t ha^{-1}) and Kunkudu (26.21 t ha^{-1}), respectively. TIS.2532.OP.1.13 ranked 2nd after Dunku and showed significant difference (p<0.05) with both Dunku and Kunkudu but did not differ significantly (p>0.05) with Katsina (Table 3). The influence of genotype and 28, 570 plants ha^{-1} population density revealed that the highest and lowest were recorded in TIS.2532.OP.1.13 (42.82 t ha^{-1}) and Katsina (25.41 t ha^{-1}), respectively with Kunkudu and Dunku ranking 2nd and 3rd showing significant difference (p<0.05) amongst all the landraces (Table 3).

DISCUSSION

Variation in the mean root and vine yields could be attributed to both genotype and environmental influences. The variation in root and vine yields within and between landraces attributable to genotype could be due to planting densities and genotype respectively. Similarly, variation within and between planting densities attributable to genotype could be due to genotype and planting densities. The variation in the mean root and vine yields among landraces and planting densities could be largely due to genotype even when the difference (p>0.05) is not significant. A similar observation has been reported by Tewe *et al.*[17]. Landrace Katsina had the highest mean root yield but also had the least vine yield, whereas the landrace Dunku which had the least mean root yield ended up with the highest mean vine yield. This suggests an interplay of a negative correlation existing among the landraces with respect to root and vine yield parameters. Some researchers have reported a negative relationship existing in the sweet potato landraces in which they showed that clones which have a prolonged vegetative phase tend to have a low root-top ratio since most of the assimilates produced will be used in leaf and stem growth instead of tuber growth or flower production[18]. Several other researchers including Ifenkew *et al.*[19] have also reported on this type of relationship.

The study has shown that different planting densities and genotypes favour different yield parameters among the landraces tested. This is an indication that farmers' desire and needs should guide their choice of genotypes and planting density rates to be utilized in order to realize maximum yields from their harvest. For example, one may want to consider the landrace Katsina which had the highest root yield in all planting densities and may be recommended for root production (Table 2), whereas Dunku the planting density of 33,333 and 50,000 plants ha^{-1} may be more advantageous if the purpose is vine yield in the event of scarcity of planting material and it may also be recommended for forage production (Table 3). In this study TIS.2532.OP.1.13 ranked 2nd in all yield parameters and population densities suggesting that it is an improved variety. However, Iwama *et al.*[20] have discouraged its production if the aim is industrial processing because of the low dry matter content of its tubers.

CONCLUSION

In conclusion, one may want to consider the landrace Katsina because it did well in all the planting densities if the purpose is root yield, whereas Dunku the planting densities of 33,333 and 50,000 plants ha^{-1} may be more advantageous if the purpose is vine yield. Thus, it can be concluded from this study that landraces and planting densities have played a lot of influence on root and vine yields exploitable potentials of the sweet potato through breeding that can enhance the production of this crop in the Jos-Plateau agro-ecological zone of Nigeria.

SIGNIFICANCE STATEMENT

- Plant population density and genotype should serve as a guide for farmers in making the right choices to meet specific needs for maximum yield and breeding potentials
- The production of TIS. 2532.OP.1.13 (An elite variety) may not be advantageous if the aim is for industrial processing because of the low dry matter content of its tubers, it may however be profitable if the aim is for consumption as food because of its average root and vine yields

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