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Evaluation of seed of white yam (*Dioscorea rotundata* Poir) cultivars as influenced by minisett sizes in the Southern Guinea Savannah agro-ecological zone of Nigeria

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ABSTRACT

Enormous quantity of table-size yams that are capable of guaranteeing national food security are used as seeds in yam cultivation annually, which negatively impact yam availability for consumption. Hence, there is need for effective production of yam minisett, in order to reduce the dependence on wareyams for seeds, towards sustainable yam production necessary for food security. Therefore, field trials were carried out at two contrasting ecological zones during 2019 planting season at Teaching and Research Farm, Malete and Olla, both in Kwara State, Nigeria. The aim of the study was to evaluate the vegetative growth and tuber yield of white yam cultivars (*Dioscorea rotundata* Poir) as influenced by minisett size. Three commonly grown white yam cultivar [*O dara bi iyawo (ODA), Aamula (AMA), Omi-efun (OMF)*] and four minisett sizes (50, 100, 150 and 200 g) of each cultivar were factorially combined in a randomized complete block design (RCBD) using split-plot arrangement replicated three times. Significant variations were observed among the yam sett sizes and cultivars. Tuber yield also varied significantly with ODA>AMA>OMF regardless of location. The sizes of harvested minisett tubers increased in descending order (200>150>100>50). Although leaf production rate, vine length, leaf area index, and number of leaves per plant were poor for the 50 and 100 g minisett sizes, but tuber multiplication rate and tuber weight were higher in these minisett sizes than the other sizes. Particularly for cultivars ODA and AMA, the multiplication rate of 50 g size minisett was significantly higher than for the larger size minisetts. Based on the results obtained in this study, 50 - 100 g, 100 g, and 100 - 150 g minisett sizes for ODA, AMA and OMF, respectively, is found suitable for minisett production. In fact, further increase from 150 to 200 g minisett for the evaluated cultivars will produce wareyam above desired seed-yam size for commercial production.

Key Words : Ecological zone, minisett sizes, multiplication rate, tuber yield, yam

INTRODUCTION

Yam (*Dioscorea rotundata* Poir*)* is an important staple food across the length and breadth of West Africa. The crop plays important roles as source of dietary carbohydrate and providing income for millions of people in the region. Out of an estimated 58.7 million tonnes of yam produced annually worldwide, over 90 percent is from West Africa, with Nigeria ranking the largest producer (FAOSTAT, 2019). Asala and Ebukiba (2016) opined that propagating yam through seed yam is a major constraint to its production. The traditional methods of seed yam production by farmers involve double harvesting whereby an immature yam tuber, at about the middle of its growth cycle, is harvested and allowed to re-grow to produce seed yam. A second method involves sorting small size tubers out from the harvested wareyam tubers at the end of the growing season. These two methods are cumbersome, time consuming, and also reduce income of the farmers since the wareyam that could have served as food, as well as source of income, are used as planting material.

According to Iseki and Matsumoto

(2020) about 30 percent of harvested yam tubers are used as planting materials. Although, minisetts technology has been developed as a panacea to solve the problem of seed yam production, it has not been frequently adopted by majority of farmers possibly due to poor awareness and/or proper identification of appropriate minisetts size for each yam cultivar. According to Emokaro and Law-Ogbomo (2008) low sprouting rate and unstable tuber yield were major reasons why the technology is not adopted by farmers. Balogun et al. (2017) reported that higher sprouting rate in larger yam minisetts often result in higher tuber yield compared to smaller setts.

In addition, propagating yam through the minisett technology offers significantly more number of seed yams available for planting compared to the traditional methods. Several studies have been carried out on minisetts technology (Iseki and Matsumoto, 2020) and various minisetts sizes recommended for adoption. These studies, however, did not take into consideration the genetic variations that exist among yam cultivars. This research was therefore, carried out to investigate minisett sizes of commonly cultivated white yam (*Dioscorea rotundata* Poir*)* cultivars at two contrasting ecological zones in Kwara State, Nigeria, for meaningful recommendation and adoption.

MATERIALS AND METHODS

Study Locations and Planting Materials

The research was conducted during 2019 cropping season in two locations within Kwara State, Nigeria, namely, Malete (Latitude $8^0$71'N, Longitude 4^0 47'E) and Olla (Latitude 8^0 21'N, $5^0$18'E). The local climate in each location is characterized by distinct wet and dry seasons. The wet season commences in March or April and ends in October, with a dry spell in mid-July to mid-August. The dry season starts towards end of October and lasts till March or April. Meteorological data of the study locations during 2019 are presented in Table 1.

Disease-free ware yam tubers of three commonly grown white yam cultivars in Kwara State (*O dara bi iyawo (ODA)*, *Aamula (AMA)*, *Omi-efun (OMF)*), obtained from the local markets were selected for the research, each tuber weighing averagely 0.5 - 1.5 kg. The selected tubers of each cultivar were cut into four minisett sizes of 50 g, 100 g, 150 g, and 200 g each. The minisetts were treated by immersion for fifteen minutes in a solution of Chlorpyrifos 20% EC insecticide at the rate of 50 ml of the product to 20 litres of water. Treated minisetts were thereafter dusted with wood ash and subsequently spread out in a shaded but airy space for 24 hours.

Experimental Layout and Cultural Practices

Three commonly grown white yam cultivars in Kwara State and four minisett sizes (50, 100, 150 and 200 g) of each cultivar were evaluated in this study. The white yam cultivars were *O dara bi iyawo (ODA)*, *Aamula (AMA)*, and *Omi-efun (OMF)*. Thus, the trial was laid out in a 3 x 4 factorial experiment in a

Table 1. Meteorological data of the study locations in Nigeria

Months	Rainfall (mm)		Temperature (°C)		Relative Humidity (%)	
	Malete[1]	Olla[2]	Malete[1]	Olla[2]	Malete[1]	Olla[2]
April	23.5	96.26	25.95	24.86	75.61	85.2
May	104.3	214.88	23.71	24.07	77.46	87.5
June	48.1	228.60	24.15	23.32	75.85	90.2
July	59.6	160.02	24.39	22.51	75.04	92.7
August	40.7	92.25	24.11	22.18	77.21	92.7
September	150.2	248.66	25.50	22.75	76.00	91.3
October	28.1	195.07	28.50	23.60	75.00	88.4
November	0	19.55	26.25	24.92	55.00	76.4
December	0	0	31.00	24.30	55.00	47.1
Total	454.5	1,255.29	233.56	212.51	642.17	751.5
Mean	50.5	139.48	25.95	23.61	71.35	83.5

[1]Source: Lower Niger River Basin Development Authority (Hydrology Section), Ilorin, Nigeria.
[2]Source: Meteorological Unit, Teaching and Research Farm, Landmark University, Omu-Aran, Kwara State, Nigeria.

randomized complete block design, using split-plot arrangement and replicated three times. Each plot was 3.0 m × 3.0 m in size with 1.0 m alleys between the plots and the replicates, respectively. Yam cultivars were assigned to the main plots while minisett sizes were in the sub-plots.

The prepared minisetts were planted first in the nursery, in constructed shallow wooden boxes filled with sawdust as the sprouting medium to a depth of 20 cm and placed under shade. The sprouting medium was kept constantly moist and cut plant materials used for mulching in the boxes. At 3 weeks after planting in the nursery, sprouted minisetts were ready for transplanting to the field. The seedlings were carefully lifted from the sprouting medium ensuring minimum damage to the roots and transplanted to prepared mounds on the field spaced 1m x 1m inter and intra-row, which is the customary spacing for the yam crop in the growing areas. Poultry manure (Table 2) was applied mixed with each mound at the rate of 5 tonnes per hectare at two weeks before transplanting. The growing plants were staked at two weeks after transplanting and manual hoe-weeding done as frequently as it was necessary. Soil samples were collected from each location before planting using soil auger at a depth of 0 - 30 cm. The following soil parameters (Table 2) were determined from the samples: soil particle analyses, total nitrogen, available P, soil pH, total soil organic carbon and exchangeable bases (Ca, Mg, Na and K) using standard procedure.

Table 2. Physico-chemical compositions of the soils at two locations in Nigeria and the poultry manure used for fertilizing the yam crop

Parameters	Malete soil	Olla soil	Poultry manure
Physical properties			
Textural Class	Sandy loam	Sandy clay loam	-
Chemical Properties			
pH (H_2O)	6.15	7.25	10.47
Organic Carbon (%)	1.63	1.77	3.48
Available P (ppm)	4.85	49.35	941
N (%)	0.19	0.25	1.26
Exchangeable acidity (cmol/Kg)	0.152	0.144	0.136
CEC (cmol/Kg)	0.551	0.898	1.664
Base Saturation (%)	72.41	83.94	91.83
Organic Matter (%)	2.81	3.06	6.01
Exchangeable bases			
K (cmol/kg)	0.001	0.001	0.026
Na (cmol/kg)	0.028	0.028	0.557
Mg (cmol/kg)	0.085	0.055	0.090
Ca (cmol/kg)	0.285	0.670	0.855

Data Collection and Analysis

The plant growth and yield data taken were (1) Observed number of days when 50% of planted minisetts sprouted in the nursery, (2) Sprouting percentage calculated as the number of sprouted minisetts divided by the total number of miniset planted multiplied by hundred, (3) Vine length per plant in the nursery measured with a metre rule from ground level to the base of the last leaf, (4) Vine length per plant in the field measured with a metre rule from ground level to the base of the last leaf, (5) Leaf production rate calculated as the difference between the number of leaves produced at each of the sampling periods at 4, 6, 8, and 10 weeks after transplanting (WATP), (6) Leaf area index was estimated from three tagged plants in each plot. The products of the length and breadth of each of four leaves selected from the top, middle and upper vines, (7) Main vine girth at 4 WATP, measured with the aid of vernier caliper, (8) Tuber weight from each plot, taken and extrapolated as yield per hectare. Tubers were carefully harvested with a hoe when senescence had commenced, as indicated by the appearance of yellow leaves followed by withering and drying of the vines and (9) Tuber multiplication rate calculated as the ratio of the weight of harvested tubers to the weight of the minisetts in each treatment.

The data collected were subjected to two-way analysis of variance (ANOVA) and treatment means, where significant, were separated using Duncan's Multiple Range Test (DMRT) at 5% level of probability.

RESULTS AND DISCUSSION

Meteorological Information on Two Locations During the Period of Study

Rainfall, temperature and relative humidity observed during the period of the study (between April and December 2019) at the two study locations are presented in Table 1. The statistics presented were obtained from the hydrology section of Lower Niger River Basin Development Authority, Ilorin (a few kilometers from Malete study location) and

from the meteorology unit of the Landmark University's Teaching and Research Farm, Omu-Aran (a few kilometers from Olla study location). In both locations, both rainfall total and distribution pattern were adequate for yam cultivation. During the growing period, the highest monthly total rainfall (150.2 mm and 248.66 mm, respectively, for Malete and Olla locations) was recorded in the month of September. While average atmospheric temperature during the growing season at the Malete location (25.950°C) was higher than at Olla (23.610°C), the relative humidity at Olla (83.5%) was higher than at Malete (71.35%). Overall, air temperature during the period of the study in Malete ranged between 23.71 and 31.00 °C and relative humidity between 55.00 and 77.46%. In turn, the corresponding statistics for Olla were 22.18 and 24.92°C for air temperature and 47.1 and 92.7% for atmospheric relative humidity.

Analysis of the Soils and Poultry Manure Used in Two Locations of the Study

The physical and chemical properties of the soil samples collected at each of the two study locations and the poultry manure used for fertilizing the crop are presented in Table 2. While soil at the Malete location is slightly acidic (6.15) and sandy loam in texture, that at Olla is neutral in reaction (7.25) and sandy clay loam in texture. Although the organic matter content of both location soils can be described as medium, the percentage nitrogen of Malete soil is low while that of Olla is moderate. The low to moderate nitrogen contents of these soils could be attributed to the characteristic nature of tropical soils and a high uptake of this nutrient by the previous crop. The observed medium to low content of organic matter in both location soils may be attributed to the nature of their vegetation. For instance, the vegetation cover at the Olla location was denser than at Malete, and the more the vegetative cover, the more organic matter content formation in the soil. For both Malete and Olla location soils, respectively, the values of total nitrogen (0.19 and 0.25 mg/kg), available phosphorus (4.85 and 49.35 mg/kg), and potassium (0.001 and 0.001 mg/kg) were below the critical values for soils of the Guinea savanna (Olowoake and Ojo, 2014). The lower content of the major nutrients and organic matter content indicated in the results for both study location soils indicate the need for nutrient supplementation in order to achieve optimum plant performance (Azeez *et al.*, 2006; Lee and Dang, 2019).

In terms of the exchangeable bases, both location soils have relatively low to very low in contents. This situation may be due to the nature of the parent materials from which these soils were formed or climatic variations in each of the two locations. Generally, weathering is accompanied with high rate of erosion which leads to loss of exchangeable bases. The inherent poor fertility status of the Malete experimental site soils as observed in this study was earlier reported by Alabi *et al.* (2017). Malete study location soils are very low in available phosphorus compared the relatively high level at Olla (Enwezor *et al.*, 1989). Soils at the two locations are low in exchangeable calcium with very low exchangeable magnesium. Both soils are very low in exchangeable sodium, potassium and cation exchangeable capacity (USDA-SCS, 1974).

Poultry manure, in turn, is very strongly alkaline in nature with very high organic matter content and nitrogen. It is high in available phosphorus (Enwezor *et al.*, 1989), low to very low in exchangeable calcium and magnesium but moderate in exchangeable sodium.

Effects of White Yam Cultivars and Minisett Sizes on Percent Sprouting at Nursery

The significant interactive effects of white yam cultivars (*Dioscorea rotundata*, at different minisett sizes at the two locations on percent sprouting, number of vines and leaves per sprout at the nursery is presented in (Fig. 1). Except OMF at Malete location, significantly lower sprouting percentage was recorded for 50 g minisett sizes compared to other sizes. At Olla location, 150 and 200 g minisett sizes had significantly higher sprouting percentage than other sizes. Regardless of the location, 200 g of OMF had significantly more vines compared to other sizes. There were no significant differences between 50 and 100 g sizes of ODA and AMA at the two locations. The number of vines produced at the nursery by 100 g size of OMF was significantly higher than 50 g size. The number of leaves increased with the size of

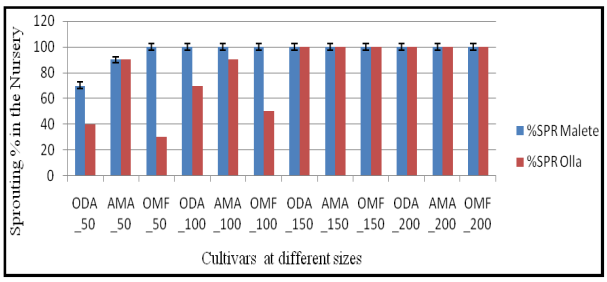


Fig. 1. Effects of white yam cultivars at different minisett sizes on sprouting in the nursery (ODA= Odara bi iyawo, AMA= Aamula, OMF= Omi efun; Cultivars sizes - 50,100, 150 and 200 g).

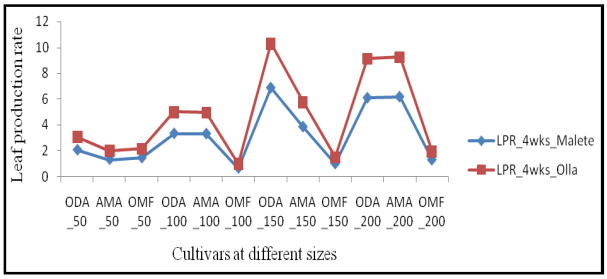


Fig. 2. Effects of white yam cultivars at different minisett sizes on leaf production rate per plant at 4 weeks after transplanting in Malete and Olla locations (ODA= Odara bi iyawo, AMA= Aamula, OMF= Omi efun; Cultivars sizes - 50,100, 150 and 200 g).

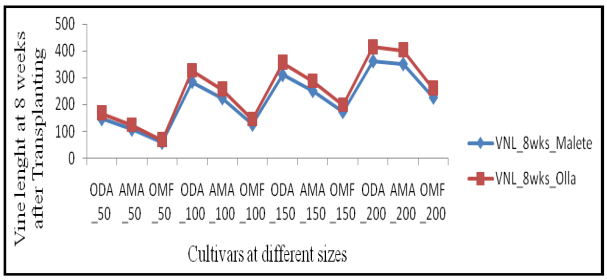


Fig. 3. Effects of white yam cultivars at different minisett sizes on vine length at 8 weeks after transplanting at Malete and Olla locations. (ODA= Odara bi iyawo, AMA= Aamula, OMF= Omi efun; Cultivars sizes - 50,100, 150 and 200 g).

the minisett, irrespective of the yam cultivar although for all the cultivars the 50 g size had significantly fewer number of leaves compared to other sizes at the two locations. Generally, the sprouting percentage, vine length, number of vines, number of leaves, leaf production rate, number of tubers, tuber weight and final tuber yield increased with the minisett size (that is, from 50 to 200 g sizes) regardless of the cultivar and location. The variables measured were also found to be better in Olla location than Malete and this can probably be attributed to differences in climate and soil between the two locations.

Early sprouting and higher sprouting percentage as observed in the larger minisett sizes (100 - 200 g) in the two locations indicate that initiation of cell growth is faster in larger minisetts. This observation agreed with the earlier reported work of Iseki and Matsumoto (2020). Notwithstanding, the sprouting percentage, vine length, leaf area, tuber weight and tuber yield in 50 g setts were significantly lower compared to other sett sizes as against the non-significant differences among the minisett sizes as reported in an earlier study by Iseki and Matsumoto (2020). The significant difference in the present study between 50 g and other sizes could be due to genetic variations among the yam genotypes. A similar difference in sprouting percentage among yam genotypes was reported by Balogun *et al.* (2017).

Interactive effects of white yam cultivars at different minisett sizes on number of leaves and leaf production rate per plant and vine length at 8 WAT are presented in Figs. 2 and 3, respectively. Regardless of minisett size, ODA cultivar had significantly longer vines than AMA and OMF at the two locations. Among the cultivars, 50 g minisett size had significantly shorter vines compared to the other sizes. There was no significant different in the vine length between 100 and 150 g minisett size for ODA and AMA cultivars. Amongst the cultivars, 200 g minisett size produced longer vines than other sizes. Regardless of the location, the rate of leaf production was lower in OMF cultivar than ODA and AMA. There was no significant different in the rate of leaf production between 100 and 150 g minisett sizes for AMA and OMF cultivars. Rate of leaf production between ODA and AMA cultivars at 200 g minisett size was not significant. The rate of leaf production between AMA and OMF at 100 and 150 g minisett size was not significant.

Effects of Cultivar and Minisett Size on Leaf Area Index, Number of Tubers Per Plant and Weight (Yield) of Tubers

Interactive effects of white yam cultivars at different minisett sizes on leaf area index, number of tubers per plant and the weight of the tubers are presented in Figs. 4, 5 and 6, respectively.

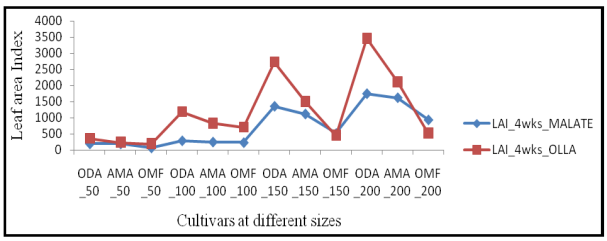


Fig. 4. Effects of white yam cultivars at different minisett sizes on: (a) Leaf Production Rate (LPR) and (b) Leaf Area index (LAI) at 4 weeks after transplanting at Malete and Olla locations (ODA= Odara bi iyawo, AMA= Aamula, OMF= Omi efun; Cultivars sizes - 50,100, 150 and 200 g).

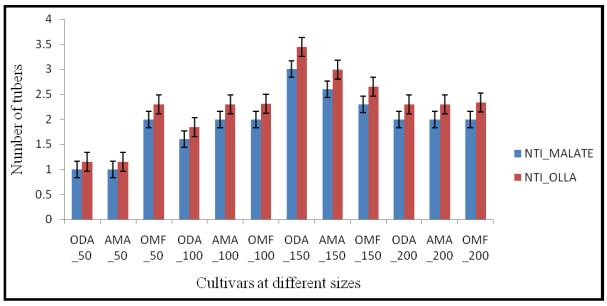


Fig. 5. Effects of white yam cultivars at different minisett sizes on number of tubers per plant (ODA= Odara bi iyawo, AMA= Aamula, OMF= Omi efun; Cultivars sizes - 50,100, 150 and 200 g).

The leaf area index, number of tubers, tuber weight and yield were significantly influenced by cultivars and minisett sizes at the two locations. The highest leaf area 3,462 and 1,752 cm for Olla and Malete, respectively was obtained at 200 g sizes of ODA. This value was found to be significantly higher than other leaf areas. Except in Malete location, 50 g minisett set size significantly had lower leaf area compared to other sizes. The leaf area recorded in ODA for all the sizes were higher than AMA and OMF. The number of tubers produced varied significantly for the varieties as well as the sizes. The highest number of tubers was recorded at 150 g minisett size for ODA variety. Irrespective of the size, OMF produced similar number of tubers. There was no significant difference between 50 and 100 g minisett sizes in the number of tubers produced for ODA and OMF at the two locations. ODA at 200 g minisett size significantly had more tuber weight than other sizes at the two locations. Regardless of variety, and location, significantly lower tuber weight was recorded at 50 g minisett size. Except OMF, there was no significant different in tuber weight between 100 and 150 g minisett sizes. The weight of tuber produced at 150 and 200 g size for OMF variety was not significant. The interactive effect on multiplication ratio is inconsistence and varied significantly among yam cultivars regardless of location. 150 g size of ODA and AMA significantly had lower multiplication ratio compared to other sizes. There were no significant differences between 50, 100 and 150 g of OMF with respect to multiplication ratio.

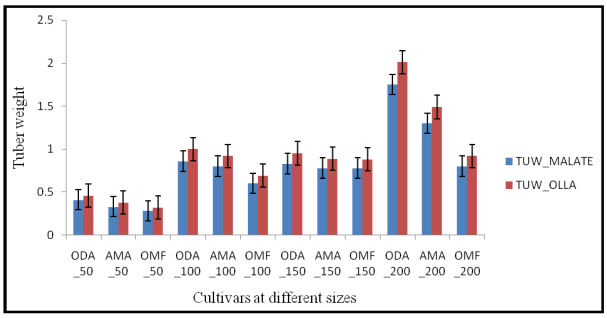


Fig. 6. Effects of white yam cultivars at different minisett sizes on tuber yield (weight) per plant at Malete and Olla locations (ODA= Odara bi iyawo, AMA= Aamula, OMF= Omi efun; Cultivars sizes - 50,100, 150 and 200 g).

Effects of White Yam Cultivars and Minisett Sizes on Tuber Yield and Yield Components

Interactive effects of white yam cultivars at different minisett sizes on tuber yield and yield components are shown in Fig. 5a, Fig. 5b and Fig. 5c. Tuber yield varied significantly with ODA > AMA > OMF and the sizes increased in descending order (200 > 150 > 100 > 50 g minisetts). Within the three cultivars, 50 g minisett size gave similar tuber yield. There was no significant difference in tuber yield between 100 and 150 g minisett sizes for ODA and AMA cultivars. The difference in tuber yield between 150 and 200 g minisett sizes in OMF was also not significant. 200 g size of ODA significantly out yielded AMA and OMF. Tuber yield at Olla was higher than Malete location for all the sizes.

The tuber yield increased in ascending order from 50 to 200 g regardless of cultivars and locations. The yield varied significantly among yam cultivars at various minisett sizes. The observed higher yield at higher minisett sizes matches with the findings of Iseki and Matsumoto (2020). The higher yield could be attributed to high growth rate (vine length,

number of leaves, leaf area, leaf production rate). The early production of leaves accompanied with longer vines length at high minisett sizes gave them the opportunity of early staking which further increased the well being of yam plant. Staking exposes the leaves to increase the photosynthetic activities. This agronomical practice was found to increase the number of leaves, longer vine length and tuber yield in intercropping involving yam/pepper. According to Orkwor *et al.* (2010), staking is essential for optimum development increased plant height by the plant which further enhances photosynthetic and biological efficiency of the crops. Degrass (2005) reported that staking increased light capture and enhances photosynthetic efficiency of yam leaves.

Although, leaf production rate, vine length, leaf area index, number of leaves were poor for 50 and 100 g minisett sizes. This effect was not manifested in tuber multiplication rate as higher and significant multiplication rate and tuber weight were observed in these sizes. Indeed, the multiplication rate was significantly higher than minisett of larger sizes particularly, ODA and AMA. The implication of this is that with good agronomic practices, these sizes (50 and 100 g setts) could be adopted by farmers to produce minisetts. In fact, increasing minisett size to 200 for ODA and AMA is a waste of ware yam as these sizes produce sellable Yam/Wareyam. In the earlier study, Iseki and Matsumoto (2020) also observed similar results.

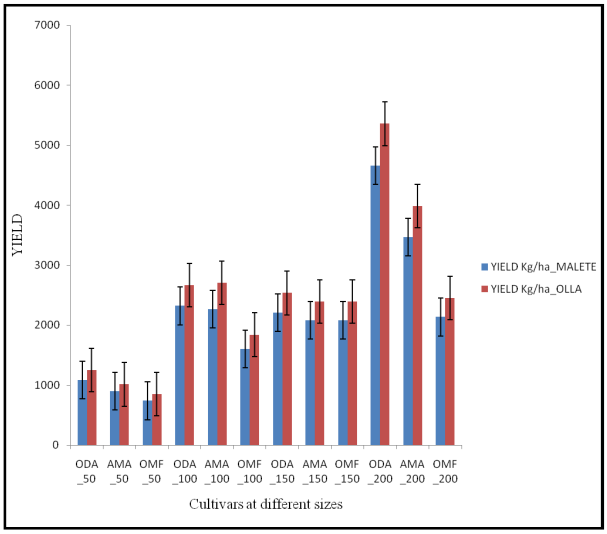


Fig. 7. Effects of white yam cultivar at different minisett sizes on tuber yield at Malete and Olla locations (ODA= Odara bi iyawo, AMA= Aamula, OMF= Omi efun; Cultivars sizes - 50,100, 150 and 200 g).

Overall, the growth and yield at Olla location was better than Malete (Fig. 7). The differences could be attributed to variation in textural class of the soil and variation in weather conditions during the growing period. The soil textural class at Olla was sandy clay loam while Malete was sandy loam. This high clay content is suitable for yam production since it will enhance water and nutrient holding capacity as well as lowering the soil temperature. Furthermore, the rainfall amount and distribution during the growing period was suitable for yam production in Olla than Malete. At Olla location, the rainfall received was 228.60, 160.02, 92.25 and 248.66 mm in June, July, August and September, respectively, which were higher compared to Malete location during the same months.. These periods also coincided with early growth, tuber initiation and tuberization as the yam setts were transplanted in June. In fact, the moisture content at Malete during these periods was accompanied with higher temperature especially in June taking into consideration the sandy nature of the soil gave the poor establishment of the yam setts. The heavy down pour in September came at the period when tuberization was almost completed.

CONCLUSION

In this study, significant variations exist among the white yam cultivars and minisett sizes evaluated. Minisett sizes of 50-100, 100 and 100-150 g for ODA (*O dara bi iyawo*), AMA (*Aamula*) and OMF (*Omi-efun*), respectively were found to be suitable for seed yam production from their minisetts. Furthermore, it was observed that increase from minisett sizes beyond 200 g produced wareyam or sellable yam tubers. Conclusively, the study clearly showed the need to evaluate appropriate minisett sizes for each yam cultivar in the yam producing areas due to variations that may be exhibited among yam cultivars or genotypes. On the basis of this study, it is recommended that (1) 50-100 g sizes are suitable for production of minisettts in ODA cultivar, (2) 100-150 g sizes are appropriate for minisetts production in AMA cultivar and (3)

150-200 g sizes are suitable for production of minisetts production in OMF cultivars.

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REFERENCES

Alabi, K. O., Wahab, A. A., Lawal, O. O., Aderolu, I. A. and Senjobi, B. A. (2017). Characterization and classification of soils of Kwara State University Teaching and Research Farm, Malete, Nigeria. *J. Sci. Technol. Math. Edu.* **13** : 100-06.

Asala, S. W. and Ebukiba, E. S. (2016). Profitability of yam production in Southern Guinea Savanna zone of Nigeria. *Net J. Agric. Sci.* **4** : 9-14.

Azeez, J. O., Adetunji, M. T. and Lagoke, S. T. O. (2006). Response of low-nitrogen tolerant maize genotypes to nitrogen application in a tropical Alfisol in Northern Nigeria. *Soil Till. Res.* **91** :181-85.

Balogun, M., Maroya, N., Taiwo, J., Chukwunalu, O., Ajayi, A., Kumar, P. L., Pelemo, O., Aighewi, B. and Asiedu, R. (2017). Clean breeder seed yam tuber production using temporary immersion bioreactors. IITA Ibadan, Nigeria.

Degras, L. (2005). Produccion de name clon Criollo a partir de bulbillos aereos. *Agron. Mesoam.* **29** : https://www.redalyc.org/articulo.oa?id=43754020007.

Emokaro, C. O., and Law-Ogbomo, K. E. (2008). The influence of minisett size on the profitability of yam production in Edo state, Nigeria. *Res. J. Agric. Biol. Sci.* **4** : 672-75.

Enwezor, W. O. E., Udo, J. and Ajotade, K. A. (1989). Fertilizer procurement and distribution. Fertilizer use and management practice for crops in Nigeria. Savenda Publishers, Nsukka, Nigeria. pp. 25-28.

FAOSTAT (2019). Food and Agricultural Organization of the United Nations. Rome, Italy. www.fao.org/statistics/en.

Iseki, K. and Matsumoto, R. (2020) Effect of seed sett size on sprouting, shoot growth, and tuber yield of white guinea yam (*Dioscorea rotundata*). *Plant Prod. Sci.* **23** : 75-80.

Lee, S. K. and Dang, T. A. (2019). Assessment of AquaCrop Model applicability for estimating cassava yield in the Son Hoa planting region of Phu Yen Province, Vietnam. *Res. Crops* **20** : 438-44.

Olowoake, A. A. and Ojo, J. A. (2014). Effect of fertilizer types on the growth and yield of *Amaranthus caudatus* in Ilorin, Southern Guinea, Savanna Zone of Nigeria. *Adv. Agric.* **2** : 1-6.

Orkwor, G. C., Asiedu, R. and Ekanayake, I. J. (2010). Food yams: Advances in Research. IITA, Ibadan and NRCRI, Umudike, Nigeria. pp. 249.

USDA-SCS (1974). Field Book for describing and sampling soils (Version 3.0). National Soil Survey Center Natural Resources Conservation Service, U.S. Department of Agriculture, U.S.A.