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Effect of plant spacing and variety on weed and performance of orange-fleshed sweet potato in humid agro-ecological zone of Nigeria

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Abstract

Among the crops grown in the tropics, sweet potato ranks second after cassava. Field research was conducted at the National Root Crops Research Institute, Umudike, south-eastern Nigeria, to evaluate the response of orange-fleshed sweet potato varieties to intra-row spacing. Treatments included four varieties (*Umuspo* 1, *Umuspo* 3, *Ex-Igbariam* and *Ex-Oyunga*) and three intra – row spacings (20, 30 and 40 cm). Weed density and growth decreased, but sweetpotato leaf area index (LAI), fresh shoot biomass and storage root yield increased significantly (P<0.05) at the closer spacing (20 cm) than at the wider spacings (30 and 40 cm). *Umuspo* 1 had higher LAI and shoot biomass; and suppressed weeds more than other varieties. Also, storage root yield of *Umuspo* 1 (27.2t/ha) was significantly higher than that of Umuspo 3, Ex-Igbariam and Ex-Oyunga by 35, 103 and 325%, respectively.

Key words: Plant spacing, variety, yield, orange-fleshed, sweet potato, Nigeria

Introduction

Among the crops grown in the tropics, sweet potato ranks second after cassava (Ray and Ravi, 2005). Within sub-Saharan Africa, its ranks third after cassava and yam (Hahn and Hozyo, 1998). The orange-fleshed sweet potato (OFS) contains more beta carotene than the yellow or white types, and is very important in Africa where the deficiency of vitamin A is a serious health problem (FAO, 2011). The increasing potential of the crop in poverty alleviation and food security due to its higher productivity per area and time makes it a candidate crop for the survival of resource poor farmers especially in countries like Nigeria (NRCRI, 2005).

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Yield variables of crops are influenced by plant competition or by changes in plant population density. Plant spacin/g or density is, therefore, a major determinant of crop yields. Normally, yield per unit area tends to increase as plant density increases up to a point and then declines (Akintoye *et al.,* 2009). Although a closer spacing is recommended for sweet potato to achieve maximum yields, the determinants of optimum population density include soil fertility, cultivar and environment (Chambi and Taylor, 1986; Nedhnchezhiyan *et al*., 2012). While the recommended spacing for sweetpotato is 1m x 0.3m (Egeonu and Akoroda, 2009). This research examined the effect of intra-row spacing on weeds and on growth and yield of four orange-fleshed sweet potato varieties in south-eastern Nigeria.

Materials and methods

The experiment was conducted during the 2013 and 2014 cropping seasons at the National Root Crops Institute, Umudike farm south eastern Nigeria. Umudike is situated at latitude 05^0 29'N, longitude 07^0 33'E and altitude 122m. The soil is a sandy loam and had pH (H_20) = 4.7, organic matter = 1.59%, total N = 0.08%, P = 32.1mg/kg and K^+ = 0.35 cmol/kg) in 2013. In 2014, the soil had P^H 4.5, organic matter 2.22%, N 0.09%, N 0.09%, P 43.6 mg/kg and 0.20 cmol/kg.

Treatments were laid out as split-plot in randomised complete block design with three replications. The main plot treatments were four orange-fleshed sweet potato varieties (Umuspo 1, Umuspo 3, Ex-Oyunga and Ex-Igbariam). Storage root flesh colour is light orange for Umuspo 1, dark orange for Umuspo 3, orange for Ex-Oyunga and yellow for Ex-Igbariam. The sub-plot treatments were the intra-row spacings of 20, 30 and 40 cm along the crest of ridges, giving a plant population of 50,000, 33,333 and 25,000 plants/ha, respectively. Each sub plot measured 3 m x 2 m (6m^2) while the main plot measured 9m X 6m (54m^2)

The sweet potato vine cuttings were planted on 24 June, 2013 and on 17 May, 2014. Supply of vacant stands was done at 2 weeks after planting (WAP). NPK fertiliser (15:15:15) at 400kg/ha was applied 4WAP by band placement. Hoe-weeding was done at 8WAP and weeds were sampled using a 1 m x 1 m quadrat. The crop measurements were on leaf area index, fresh shoot biomass (t/ha), number of storage roots/plant, storage root weight (kg) and storage root yield (t/ha). Four plants from each sub plot were sampled for leaf area while all plants in the plot were sampled for shoot biomass and yield and yield components. Leaf area used for leaf area index determination was estimated by the disc method according to Kelm et al (2001) method. Leaf area index was calculated as L = LA/P, where L = leaf area index, LA = total leaf area per plant, P = land area occupied by the plant. The number of storage roots was counted while shoot biomass and storage roots were weighed. Shoot biomass and storage root yield were expressed in tons per hectare. The data were subjected to analysis of variance using GenStat (2007) statistical package.

Results

The total weed density increased significantly with increase in intra-row spacing up to 40 cm (Table 1). Among the varieties, Ex-Oyunga had the highest number of weeds, followed by Umuspo 3 and Ex-Igbariam; while Umuspo 1 had the lowest weed density in 2014. In both years,

Table 1. Effect of plant spacing and variety on weed density (no/m^2) at 8WAP in 2013 and 2014

Variety	Plant spacing (cm)			
	2013			
	20	30	40	Mean
Umuspo 3	18.50	29.50	32.83	26.94
Umuspo 1	23.83	18.67	35.83	26.11
Ex-Oyunga	17.67	26.50	36.50	26.89
Ex-Igbariam	18.33	18.80	37.67	24.93
Mean	19.58	23.37	27.21	26.22
	2014			
Umuspo 3	25.50	45.80	73.70	48.33
Umuspo 1	20.50	33.70	45.50	33.23
Ex-Oyunga	36.20	62.00	90.20	62.80
Ex-Igbariam	27.50	44.50	70.20	47.40
Mean	27.43	46.50	69.90	47.94
			2013	2014
LSD (0.05) for spacing (S) Mean		=	3.02	3.5
LSD (0.05) for variety (V) Mean		=	NS	9.0
LSD (0.05) for S x V Mean		=	NS	NS

NS = Not significant at P<0.05

there was no plant spacing by variety interaction (P>0.05) for weed density.

Similarly, weed dry matter progressively increased significantly with wider spacings in 2014 (Table 2). Weed biomass at the closer spacing (20 cm) was lower than the values (30 and 40 cm) intra-row spacing by 57 and 68%, respectively. Umuspo 1 and Umuspo 3 varieties had significantly lower weed dry matter than Ex-Igbariam, which also had lower weed biomass than Ex-Oyunga. Interactions of planting spacing and variety did not produce significant effects (P>0.05) on weed dry weight.

In both years, LAI was significantly higher at the narrow spacing of 20 cm than at the wider spacings (Table 3). Also, orange fleshed sweetpotato Umuspo 1 consistently had higher LAI than other varieties. Interactions were significant in 2014, with highest LAI of 8.4 produced in Umuspo 1 at the closer spacing (20 cm).

Fresh shoot biomass of the orange fleshed sweetpotato was not affected by spacing in 2013, but in 2014, the narrow intra-row spacing of 20 cm had significantly higher fresh top yield than the wider spacings (Table 4). Shoot yield of 20 cm spacing in 2014 was 46 and 87%

Table 2. Effect of plant spacing and variety on weed dry matter (g/m²) at 8WAP in 2014

Variety	Plant spacing (cm)			
		2013		
	20	30	40	Mean
Umuspo 3	24.5	64.0	38.6	42.4
Umuspo 1	28.0	22.8	30.8	27.2
Ex-Oyunga	40.2	22.8	28.9	30.6
Ex-Igbariam	17.8	21.6	30.1	23.2
Mean	27.6	32.8	32.1	
		2014		
Umuspo 3	6.30	9.40	24.50	13.4
Umuspo 1	4.00	15.80	18.00	12.6
Ex-Oyunga	15.00	29.70	41.80	28.8
Ex-Igbariam	9.00	25.20	21.60	18.6
Mean	8.58	20.03	26.48	
		2013	2014	
LSD $_{(0.05)}$ for spacing (S) Mean		=	3.00	
LSD $_{(0.05)}$ for variety (V) Mean		=	5.40	
LSD $_{(0.05)}$ for S x V Mean		=	NS	

NS = Not significant at P<0.05

higher than those of the wider spacings of 30 and 40 cm, respectively. Variety Umuspo 1 produced shoot yield that was on average higher by 233, 228 and 53% than those of Umuspo 3, Ex-Oyunga and Ex-Igbariam, respectively. Spacing X variety interactions were not significant (P>0.05) on above ground biomass accumulation..

The number of storage roots was not affected by spacing in both the years (Table 5). The varieties, however, varied significantly in number of storage roots per plant. Overall, Umuspo 1 variety gave the highest number of storage roots; while Ex-Oyunga had the least.

Unlike number of storage roots per plant, storage root yield of the orange fleshed sweetpotato increased significantly at the closer spacing (20 cm) than at the wider spacings (30 and 40 cm) by 52 and 108%, respectively, (Table 6). Across the two cropping seasons, root yield was 23.5 t/ha at the intra-row spacing of 20cm. Average storage root yield obtained from Umuspo 1 variety was 27.2t/ha and this was significantly the highest, followed by Umuspo 3; while Ex-

Table 3. Effect of plant spacing and variety on leaf area index of orange-fleshed sweetpotato at 12 WAP in 2013 and 2014

Variety	Plant spacing (cm)			
		2013		
	20	30	40	Mean
Umuspo 3	3.03	0.52	0.46	1.34
Umuspo 1	7.05	4.32	3.90	5.09
Ex-Oyunga	4.14	2.11	1.30	2.52
Ex-Igbariam	4.85	2.80	1.55	3.07
Mean	4.77	2.44	1.80	3.01
		2014		
Umuspo 3	1.80	0.87	0.79	1.15
Umuspo 1	8.42	4.52	2.69	5.21
Ex-Oyunga	4.47	2.69	1.32	2.83
Ex-Igbariam	5.26	2.94	1.49	3.23
Mean	4.99	2.76	1.57	3.11
		2013	2014	
LSD $_{(0.05)}$ for spacing (S) Mean	=	0.77	0.80	
LSD $_{(0.05)}$ for variety (V) Mean	=	0.76	0.75	
LSD $_{(0.05)}$ for S x V Mean	=	NS	1.27	

NS = Not significant at P<0.05

Oyunga had the lowest yield. Interactions were significant in 2014, with Umuspo 1 at the narrow spacing of 20cm producing the highest yield of 56.3t/ha, followed by Umuspo 3 while Ex-Oyunga had the lowest yields at the wider spacings of 30 and 40 cm.

Top and storage root yields were negatively and significantly correlated with inter-row spacing in 2014 (Table 7). Shoot biomass and storage root yields were negatively but not significantly correlated with spacing in 2013.

Discussion

Weed density and growth were dependent on plant spacing, showing a decline at narrow spacing until intra-row spacing was 20 cm (Tables 1 and 2). As a planophile, the orange-fleshed sweet potato at the narrow intra-row spacing of 20 cm had a high LAI of 5.0. at 12WAP, which gave good ground cover and suppressed weeds. The 40 cm wider spacing had lower LAI of 1.7, but higher weed population (Table 3). This result

Table 4. Effect of plant spacing and variety on biomass (t/ha) of orange fleshed sweet potato at 16WAP in 2013 and 2014

Variety	Plant spacing (cm)			
	2013			
	20	30	40	Mean
Umuspo 3	5.67	4.11	3.42	4.40
Umuspo 1	12.00	15.00	12.42	13.14
Ex-Oyunga	6.50	5.78	3.75	5.34
Ex-Igbariam	10.42	7.89	8.08	8.80
Mean	8.65	8.20	6.92	7.92
	2014			
Umuspo 3	15.20	8.40	7.00	10.20
Umuspo 1	45.30	34.40	26.80	35.50
Ex-Oyunga	13.00	8.60	6.80	9.47
Ex-Igbariam	32.00	20.90	15.80	22.90
Mean	26.38	18.08	14.10	19.52
		2013	2014	
LSD $_{(0.05)}$ for spacing (S) Mean		=	NS	
LSD $_{(0.05)}$ for variety (V) Mean		=	5.54	
LSD $_{(0.05)}$ for S x V Mean		=	NS	

NS = Not significant at P<0.05

agrees with the findings of O'Donovan (1994) and Njoku *et al.* (2009) that the competitive effect of weeds was reduced when the seeding rate increased from low density (wider spacing) to a higher density (closer spacing). Evidently, crop canopy closure developed much earlier in plots where the orange fleshed sweetpotato was planted at the closer spacing of 20cm resulting in shading that reduced weed density and dry matter.

Plants in the narrow row spacing yielded more than those in the wider row spacings (Table 6). Storage root yield increased as population increased with the highest yield, occurring at the narrow row spacing (20 cm), which was the highest population of 50,000 plants/ha. The narrow spacing (20 cm) consistently out-yielded the wider row spacings of 30 and 40 cm by 52 and 108%, respectively on average. The storage root yield of 23.5 t/ha was obtained at the narrow row (20 cm), which also produced the highest shoot biomass of 17.6t/ha.

Storage root yield correlated negatively (r = -0.566**) and significantly with intra-row spacing. The total yields increased at

Table 5. Effect of plant spacing and variety on number of storage roots/plant of orange fleshed sweet potato in 2013 and 2014 at 16WAP in 2013 and 2014

Variety	Plant spacing (cm)			
	2013			
	20	30	40	Mean
Umuspo 3	1.63	1.43	1.27	1.44
Umuspo 1	1.97	2.07	2.26	2.10
Ex-Oyunga	0.55	0.84	0.47	0.62
Ex-Igbariam	1.36	1.16	1.38	1.30
Mean	1.38	1.38	1.35	1.37
	2014			
Umuspo 3	2.30	2.20	2.20	2.23
Umuspo 1	2.40	2.50	2.50	2.47
Ex-Oyunga	1.10	1.10	1.00	1.07
Ex-Igbariam	2.10	2.50	2.60	2.40
Mean	1.98	2.08	2.08	2.04
			2013	2014
LSD (0.05) for spacing (S) Mean		=	NS	NS
LSD (0.05) for variety (V) Mean		=	0.40	0.30
LSD (0.05) for S x V Mean		=	NS	

NS = Not significant at P<0.05

the closer spacing probably due to increase in the number of plants per unit area, which contributed to the production of extra yield (Law-Ogbomo and Egharevba, 2009). Similar observations were reported on yams (Okpara *et al*., 2013; Ikoro *et al*., 2014). The wider intra-row spacings of 30 and 40 cm did not produce high number of storage roots that could compensate for the reduced number of plants per unit area, compared to the narrow row of 20 cm. Consequently, planting the orange fleshed sweetpotato at the narrow row (20 cm) favoured the plants and resulted in greater yield because there was enough space for the plants to express full potential and intercept more solar energy. The increase in the number of plants per unit area contributed more yield per unit area.

For the cultivars, Umuspo 1 produced higher shoot biomass, suppressed weeds more effectively and out-yielded other varieties, indicating better adaptation to Umudike conditions in the humid environment of south eastern Nigeria. Umuspo 1 produced the highest storage

Table 6. Effect of plant spacing and variety on storage root yield (t/ha) of orange fleshed sweet potato in 2013 and 2014

Variety	Plant spacing (cm)			
	2013			
	20	30	40	Mean
Umuspo 3	14.56	10.39	7.96	10.97
Umuspo 1	18.75	13.35	15.88	15.99
Ex-Oyunga	3.05	1.98	1.66	2.23
Ex-Igbariam	4.48	4.40	4.27	4.38
Mean	10.21	7.53	7.44	8.39
	2014			
Umuspo 3	46.30	24.50	16.50	29.10
Umuspo 1	56.30	36.80	22.00	38.37
Ex-Oyunga	15.20	9.60	6.60	10.47
Ex-Igbariam	28.60	23.20	15.10	22.30
Mean	36.60	23.53	15.05	25.06
			2013	2014
LSD (0.05) for spacing (S) Mean		=	1.42	4.20
LSD (0.05) for variety (V) Mean		=	5.40	4.50
LSD (0.05) for S x V Mean		=	NS	7.50

NS = Not significant at P<0.05

Table 7. Correlation between spacing and yield of orange-fleshed sweetpotato in 2013 and 2014

	Correlation with	
	Root yield (t/ha)	Shoot biomass (t/ha)
	2013	
Spacing	-0.149ns	-0.123ns
	2014	
Spacing	-0.566**	-0.397*

* Significant at 5% probability level, ** significant at 1% probability level, NS = Not significant at P<0.05

root yield (27.2t/ha), followed by Umuspo 3 (20.0t/ha); while Ex-Oyunga had the lowest yield (6.4t/ha). The yield differences were probably due to the tendency to have a strong ability to accommodate more assimilates in the storage root by the high yielders. Interactions were significant for storage root yield in 2014, with Umuspo 1 producing the highest yield at the narrow row (20cm); followed closely by Umuspo 3. The poor performance of Ex-Oyunga could be attributed to its poor adaptation to the humid environment of south eastern Nigeria, since the cultivar was introduced from CIP, Nairobi Kenya.

The official recommendation in Nigeria for spacing in sweetpotato at the time of initiation of this experiment was 1 m x 30 cm, with 33,300 plants/ha (Egeonu and Akoroda, 2009). However, the results of the present study showed that intra-row spacing could be further reduced to 20 cm to give higher leaf area index and biomass, suppress weeds and produce higher storage root yield in orange-fleshed sweetpotato. Increasing spacing from 20 to 40 cm reduced yield from 23.5 to 11.3 t/ha on average, giving 52% yield reduction at 40 cm intra-row spacing. The closer intra-row spacing of 20 cm was therefore sufficient to enhance yield and is recommended. Umuspo 1 was more efficient in suppressing weeds and produced the highest storage root yield, followed by Umuspo 3. Yields were generally higher in 2014, in which planting was done earlier in May and viral infection was low due to the use of clean or healthy vines.

References

Akintoye, H.A., Kintomo, A.A. and Adekunle, A.A. 2009. Yield and fruit quality of water melon in response to plant population. *International Journal of Vegetable Science* 15:369-380.

Carmer, S.G. and Swanson, M.R. 1971. Detection of differences between means. A monte Carlo study of five pair wise multiple comparison procedures. *Agronomy Journal* 63: 940-945.

Food and Agricultural Organization (FAO), 2011. Faostat annual report Fao(1) Http//es.wikipedia the encyclopaedia

Egeonu, I.N. and Akoroda, M.O. 2009. Missing stands in sweet potato field trials. In: Sweet potato in Nigeria (eds. Malachy Akoroda and Ijeoma Egeonu). Proceedings of the first National Sweet potato Conference held during 16-18 September, 2008 at Ibadan, Nigeria.

GenStat, 2007. GenStat Discovery Edition 3. Lawes Agricultural Trust (Rothamsted Experimental Station), UK.

Hahn, S.K. and Hozyo, Y. 1998. Sweet potato reprint series, International Institute of Tropical Agriculture (IITA), Ibadan and Agricultural Research Centre, Yatabe Tsukebe 305 Japan.

Ikoro, A.I., Okpara, D.A. and Ikeogu, J. 2014. Effects of nodes per vine and planting density on leaves and yield of water yam in south eastern Nigeria. *Journal of Applied Agricultural Research* 6: 219 -226.

Kelm, m., Bruck, H., Hermann, M. and Sattelmacher, B. 2001. Plant productivity and water use efficiency of sweet potato (*Ipomea batatas*) as affected by nitrogen supply. CIP Program Report 1999-2000. http://www.cipotato.org/market/pgmrprts/pr99-00/34waternpdf.

Law-Ogbomo, K. and Egharevba, E. 2009. Effect of planting density and NPK fertilizer application on yield and yield components of tomato in forest location. *World Journal of Agricultural Science* 5: 152-158.

National Root Crops Research Institute (NRCRI), 2005. National Root Crops Research Institute, Umudike Annual Report.

Nedunchezhiyan, M., Byju, G. and Jata, S.K. 2012. Sweet potato Agronomy, Regional Centre of Central Tuber Crops Research Institute, Bhubaneswar – 751019, India.

Njoku, J.C., Muoneke, C.O., Okocha, P.I. and Ekeleme, F. 2009. Effect of propagule size and intra-row spacing on the growth and yield of sweet potato in a humid agro ecological zone. *Nigerian Agricultural Journal* 40:115-124.

O'Donovan, J.T. 1994. Conola (*Brassica rapa*) plant density influence Tartary Buck wheat (*Fagoprum tataricum*) interference, biomass and seed yield. *Weed Science* 42:385-389.

Okpara, D.A., Ikoro, A.I. and Ojikpong, T.O 2013. Water yam microsett responses to plant density and mulching in southeastern Nigeria. *African Journal of Root and Tuber Crops* 10:55-60.

Ray, R.C. and Ravi, V. 2005. Post harvest spoilage of sweet potato and its control measures. *Critical Review of Food Science and Nutrition* 35:623-644.