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Research Paper

Growth and yield response of cassava (*Manihot esculenta* Crantz) varieties to different spacing in Uyo, Southeastern Nigeria

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Abstract. A field study was conducted at the University of Uyo Teaching and Research Farm, Use-offot, Uyo, Southeastern Nigeria in 2008 and 2009 cropping seasons to evaluate the growth and yield of cassava varieties at different spacing. The experiment was laid out in a randomized complete block design, and replicated three times in split plot arrangement. The main treatments was three cassava varieties; TMS 30572, TMS 98/0505 and TME 419 while the sub-treatments was four intra row spacing; 1 m × 0.8 m, 1 m × 0.9 m, 1 m × 1 m and 1 m × 1.1 m. Data generated were subjected to analysis of variance. Significant means were compared with least significant difference (LSD) at 5% probability level. The study results indicated significant differences among the cassava varieties on number of leaves, leaf area, plant height, number of branches, number of storage root per stand and storage root yield in both cropping seasons. TMS 98/0505 had significant higher storage root yield of 33.47 t/ha and 31.15 t/ha in 2008 and 2009 cropping season, respectively. The least storage root yield; 23.33 t/ha and 26.09 t/ha was from TME 419. The influence of spacing on cassava showed significant differences on plant height, leaf area, number of leaves per plant, number of stems per stand, storage root length and storage root yield in both cropping seasons. The spacing of 1 m × 1.1 m produced the taller plants, higher number of leaves per plant, larger leaf area and storage root length while the spacing of 1 m × 0.8 m produced the significant higher number of stems per stand and storage root yields in TMS 30572 and TME 419, respectively. TMS 98/0505 produced the highest root yield at spacing of 1 m × 1 m. Based on the study findings, cassava farmers in Uyo, southeastern Nigeria were recommended to adopt 1 m × 1 m for TMS 98/0505 but those who wish to plant TMS 30572 and TME 419 varieties should adopt 0.8 m × 1 m for optimum storage root yield per hectare.

Keywords: Cassava, spacing, varieties, growth, yield.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is an important root crop in the farming systems of sub-Sahara Africa, Asia and Latin America. Cassava is referred to as African food security crop. Cock (1985) described cassava as an excellent source of dietary calorie equivalence of per capita consumption of about 238 kcal in Nigeria. The high consumption by the people in forms of garri, "*abacha*" fufu, cake/bread makes cassava strategic as an important food security crop in Nigeria (Ikeh, 2017). The crop is vital for food security and income generation in Nigeria (Ikeh *et al*., 2016). Storage roots of cassava are rich in carbohydrate. The fresh tuber consists of approxi-

mately 62% water, 20-25% starch, 1-2% protein and 1-2% fibre with traces of fat and minerals (Onwueme and Sinha, 1991). It plays an important role in food security, but also as a cash crop. Nigeria is the world largest producer of cassava with an annual output estimated at 49 million tonnes (FAO, 2015; James and Faleye, 2015). According to Ikeh (2017), cassava is typically perceived to be grown by poor resource smallholder farmers especially in many rural areas of rainforest and guinea savannah of Nigeria. The increase in production of cassava largely depends on the crop's low labour inputs requirement, the ability to produce good yield on degraded soils, drought tolerance and its resistance to pest and diseases.

Studies have reported variations in cassava storage root yield due to the differences in varieties, location and agronomic practices. The study of Akpan *et al*. (2013), Akata (2015) and Ikeh (2017) on different cassava genotypes grown in rainforest zone of Nigeria indicated significant variations in growth and yield of cassava. Ikeh (2017) reported variation yield and yield components of cassava genotypes at different time of harvesting. Spacing is one the agronomic practices that affect crop growth and yield. The literature with respect to optimum cassava spacing and cassava storage yield is still conflicting as a result of the differences in growth habits, morphological characteristics of the crop as well as environmental conditions which also influence cassava bulking ability and yield. Recommendation on spacing for one variety of cassava in a particular environment may not be appropriate elsewhere or within different varieties of cassava (Toro and Atlee, 1980).

There are many varieties of cassava under cultivation in Nigeria. They could be distinguished by morphological characteristics such as leaf size, colour, shape, branching habit, plant height, colour of stem/petiole, storage root shape/colour, and time to maturity and yield (Ikeh, 2017). In a cassava trial by Cock and Howeler (1978), five varieties were planted in a systemic density experiment which showed that optimum plant density for root yield changes with plant age. Some varieties showed a pronounced optimum plant growth while others showed a flat topped response curve. Yield of over 50 tonnes per hectare were obtained with some varieties that respond to close spacing. Cassava population density is one of the factors that affect the yield of cassava (Udoh and Ndon, 2016). Enyi (1972) reported that no spacing has been found to be universally applicable because it varies with cassava variety, the rate of development of leaf cover, branching habits, dominant weed and soil moisture conditions. Center for International Tropical Agriculture (CIAT, 1979) reported no significant yield differences either in total or in commercial root production when three varieties were grown at a standard 10,000 plant per hectare density in spatial arrangements with 1-2 stakes per planting site ranging from the quadratic 1 m × 1 m to a strongly square pattern of 2 m × 0.5 m. Cock and Howler (1978) quoted in Hillocks *et al.* (2002) while testing mechanical harvesters found out that the standard spacing of 1 m × 1 m was for centrally mounted harvester. At this spacing, two rows had to be harvested simultaneously to prevent tract or wheels running over the untargeted crops.

Daniel and Gobeze (2007) reported that no significant storage root yield from different spacing. The yield obtained from spacing of 1 m × 1 m was compared to 1 m × 1. 2 m. Rodriguez *et al*. (1966) recommended much higher populations of 13,300 to 20,000 plants/ha. Gurnah (1973) obtained the best yield of roots at population of 18,500 plants/ha planted at 60 cm × 60 cm and observed that spacing above or below 60 cm × 60 cm reduced root yield in the forest zone of Ghana. Takyi (1972) observed that spacing of 90 cm × 90 cm on sandy loam in *ochrosol* at Kwadaso, Ghana gave significantly higher yields than spacing of 90 cm × 120 cm in experiments on cassava in Sierra Leone.

Since many authors had reported differences in yield of cassava at different spacing (Plant population) in cassava varieties at different locations, ecologies and soil types, there is need to identify the optimum spacing for the most adopted improved cassava varieties in Uyo, Southeastern Nigeria. The objectives of this study were to determine the appropriate plant spacing that would enhance high storage yield in different cassava varieties. The result would be of guide to farmers in selecting cassava varieties and appropriate row spacing for each of the variety

MATERIALS AND METHODS

This experiment was conducted at the University of Uyo Teaching and Research Farm, Use-Offot, Uyo, Akwa Ibom State of Nigeria in 2008 and 2009. The site is located at Latitude 5°17′ and 5°27′N, Longitude 7°27′ and 7°58′E and on altitude of 38.1 m above sea level. This rainforest zone receives about 2500 mm rainfall annually. The rainfall pattern is bimodal, with long (March to July) and short (September to November) rainy seasons separated by a short dry spell of uncertain length usually during the month of August. The mean relative humidity is 78% and the atmospheric temperature is 30°C. The mean sunshine hours is 12 (Peters *et al.*, 1989).

The cassava varieties (TME 419, TMS 30572 and TMS 0505) were obtained from National Root Crops Research Institute Umudike, Umuahia, Abia State, Nigeria. The experimental site was manually cleared and tilled in both cropping seasons. The experiment was laid out in randomized complete block design, replicated three times with split plot arrangement. The main plot size was 24 m × 8 m while sub-plot size was 4 m × 8 m. The main treatment was cassava varieties TME 419, TMS 0505 and TMS 30572 while spacing (m) of 1 m × 0.8 m, 0.9 m × 1 m, 1 m × 1 m and 1.1 m × 1 m constituted the sub-

Table 1. Number of leaves per plant as influenced by cassava varieties and spacing.

Cassava varieties	Spacing (m)	2008 Months after planting			2009 Months after planting		
		2	4	6	2	4	6
	0.8 × 1	155.33	199.45	83.62	129.33	163.41	97.41
	0. 9 × 1	163.43	225.62	92.75	163.45	205.33	100.43
TMS 30572	1 × 1	182.51	230.33	92.65	162.20	216.40	105.03
	1.1 × 1	186.75	230.49	83.72	153.11	222.33	106.11
	Mean	172.23	221.47	88.19	153.77	201.87	102.25
	0.8 × 1	137.61	295.51	125.61	267.33	249.20	132.12
	0.9 × 1	183.25	305.31	128.33	296.43	286.71	148.06
TMS98/ 0505	1 × 1	196.75	349.25	139.62	325.63	299.72	149.25
	1.1 × 1	196.83	355.62	138.75	363.41	363.75	156.12
	Mean	178.50	326.42	133.08	313.20	294.85	146.39
	0.8 × 1	106.30	135.62	69.66	112.33	143.41	63.61
	0.9 × 1	113.75	149.25	70.55	121.42	145.61	71.42
TME 419	1 × 1	123.62	153.75	74.76	124.13	168.43	82.11
	1.1 × 1	126.36	157.02	73.92	128.03	173.73	83.05
	Mean	117.50	148.91	72.22	121.48	162.80	75.05
LSD ($p < 0.05$)							
Varieties (v)		7.95	25.16	16.75	36.70	41.07	19.18
Spacing (s)		Ns	6.25	Ns	7.02	9.25	N
V x S interaction		Ns	1.31	Ns	2.61	3.71	Ns

ns = not significant

treatment. Planting in both years was done in April while harvesting was done in February of the subsequent year of each of the year. The following growth parameters were collected from ten (10) sample plants in net plot. Plant height was measured with metre rule from the base to the terminal bud of each sample plant. Leaf area was determined by measuring the leaf length and width of the sample plants and multiplied by a correction factor of 0.7 provided by Hammer (1980). Number of branches per plant was determined by counting the branches in each sample plant. Number of leaves per plant was obtained by counting the functional leaves per plant. Cassava stem girths were measured with the aid of a vennier caliper (Model: Helios Extra, Stainless Steel Mitutoyo 530-312. Made in Japan). Number of stems per stand were counted and recorded on treatment basis. The following yield and yield components were also assessed; number of storage roots per stand by counting all the storage roots. Length of storage roots were measured with metre rule while storage root circumference was determined with the aid of a vennier caliper (Model: Helios Extra, Stainless Steel Mitutoyo 530-312. Made in Japan). The storage roots weight were determined with the aid of a top load weighing balance and later converted the weight in kilogramme to tones per hectare.

All the data collected in both cropping seasons were analyzed with analysis of variance, means that showed significant difference were separated using least significant difference (LSD) at 5% probability level.

RESULTS

The number of leaves per plant as influenced by cassava cultivars and spacing is shown in Table 1. The results showed significant ($p < 0.05$) difference among the cassava varieties in both planting seasons. The TMS 05050 variety had the highest number of leaves per plant; 278.61, 326.42 and 133.08 in 2008 and 313.20, 294.85 and 146.39 in 2009 at 2, 4 and 6 months after planting (MAP) respectively. This was followed by 172.23, 221.47 and 88.19 in 2008 and 153.77, 201.87 and 102.25 in 2009 at 2, 4 and 6 MAP respectively from TMS 30572 variety. The least number of leaves per plant was from TME 419 variety; 117.50, 148.91 and 72.22 in 2008 and 121.48, 162.80 and 75.05 in 2009 at 2, 4 and 6 MAP respectively. The TMS 0505 cultivar produced 38 to 58%, 32 to 54% and 34 to 46% more number of leaves above other variety at 2 and 6 MAP respectively in 2008 and 51

Table 2. Plant height (cm) as influenced by cassava varieties and spacing.

Cassava varieties	Spacing (m)	2008 Months after planting			2009 Months after planting		
		2	4	6	2	4	6
	0.8 × 1	102.33	163.52	169.41	90.61	125.61	139.33
	0. 9 × 1	123.11	173.60	185.31	118.33	162.11	176.51
TMS 30572	1 × 1	129.13	182.03	191.07	120.61	172.33	182.60
	1.1 × 1	132.25	187.40	195.11	125.33	181.22	189.70
	Mean	121.71	176.64	185.22	113.72	160.57	172.04
	0.8 × 1	83.63	108.33	112.31	98.41	111.83	122.61
	0.9 × 1	94.71	112.52	122.41	102.31	119.63	126.30
TMS98/ 0505	1 × 1	99.35	135.71	142.11	109.42	153.40	139.33
	1.1 × 1	99.37	145.60	151.30	113.25	163.50	163.60
	Mean	94.27	125.54	132,03	105.85	137.09	137.96
	0.8 × 1	139.85	213.06	220.20	123.71	226.60	240.33
	0.9 × 1	148.03	219.31	225.13	152.11	231.75	239.62
TME 419	1 × 1	152.41	225.40	243.16	156.33	233.03	248.11
	1.1 × 1	154.31	232.33	249.33	156.93	239.93	252.12
	Mean	148.65	222.53	234.46	147.27	232.83	245.05
LSD ($p < 0.05$)							
Varieties (v)		7.39	10.68	12.13	6.11	18.09	26.32
Spacing (s)		Ns	2.86	5.62	3.07	11.22	18.15
V × S		Ns	0.55	1.04	Ns	3.31	5.77

ns = not significant

to 61%, 32 to 45% and 30 to 49% at 2, 4 and 6 MAP respectively in 2009.

The results also showed significant ($p < 0.05$) difference among the spacing, at 4 MAP in 2009 and at 2 and 4 MAP in 2010. The interaction effect between varieties and spacing maintain similar pattern in spacing. The 1.1 × 1m spacing produced highest number of leaves per plant irrespective of variety, followed by 1 × 1 m spacing.

Table 2 shows plant height (cm) as influenced by cassava varieties and spacing. The results showed significant ($p < 0.05$) effect among the varieties, in both cropping seasons. The TME 419 produced tallest plant on average; 148.65, 222.53 and 234.46 cm at 2, 4 and 6 MAP in 2008 and 147.27, 232.83 and 245.05 cm at 2, 4 and 6 MAP respectively in 2009, followed by TMS 30572 variety; 121.71, 176.64 and 185.22 cm at 2, 4 and 6 MAP respectively in 2008 and 113.72, 160.57 and 172.04 cm at 2, 4 and 6 MAP respectively in 2009. The shortest stem on average was recorded in TMS 0505; 94.27, 125.54 and 132.03 cm in 2008 and 105.85, 137.09 and 137.96 cm in 2009 at 2, 4 and 6 MAP respectively. The TME 419 was 18 to 37%, 21 to 44% and 21 to 45% taller than other varieties at 2, 4 and 6 MAP in 2008 and 23 to 28%, 31 to 41 and 30 to 44% taller respectively in 2009. The effect of spacing on plant height varied significantly at 4 and 6 MAP in 2008 and at 2, 4 and 6 MAP in 2009. The tallest plants were from the spacing of 1.1 × 1 m in both cropping seasons. The interaction effect between cassava varieties and spacing were significantly different at 4 and 6 MAP in both cropping seasons.

The leaf area as influenced by cassava varieties showed significant ($p < 0.05$) differences in all the months under observation (Table 3). The TMS 0505 produced the largest leaf area per plant; 450.19, 467.74 and 373.69 cm^2 in 2008 and 410.74, 420.28 and 362.78 cm^2 in 2009 at 2, 4 and 6 MAP, respectively. TME 419 produced the least leaf area of 318.23, 336.99 and 256.28 cm^2 in 2008 and 304.44, 346.15 and 261.99 cm^2 in 2009 at 2, 4 and 6 MAP, respectively. The TMS 0505 variety had larger leaf area of 21 to 29%, 18 to 28% and 21-31% more than other varieties at 2, 4 and 6 MAP respectively in 2008 and 21 to 26%, 13 to 18% and 28 to 39% percentage difference at 2, 4 and 6 MAP respectively in 2009. The result also showed significant ($p < 0.05$) effect on spacing at 4 and 6 MAP in both cropping season. The result indicated an increase in leaf area with increase in spacing.

The number of stems per stand at 6 MAP as influenced by cassava varieties showed no significant difference

Table 3. Leaf area (cm^2) as influenced by cassava varieties and spacing.

Cassava varieties	Spacing (m)	2008 Months after planting			2009 Months after planting		
		2	4	6	2	4	6
	0.8 × 1	326.91	349.33	280.81	289.63	338.21	239.33
	0. 9 × 1	368.22	388.63	296.33	325.60	359.62	242.11
TMS 30572	1 × 1	368.53	396.71	296.71	345.33	376.71	256.09
	1.1 × 1	369.51	396.80	309.60	343.71	381.18	297.13
	Mean	356.30	382.87	295.86	326.07	363.93	258.67
	0.8 × 1	385.71	397.36	321.33	376.11	376.17	343.10
	0.9 × 1	467.11	483.07	384.11	396.25	396.15	363.67
TMS 98/ 0505	1 × 1	469.22	494.33	393.12	431.20	425.18	371.17
	1.1 × 1	478.71	496.18	396.18	439.40	483.60	373.16
	Mean	450.19	467.74	373.69	410.74	420.28	362.78
	0.8 × 1	305.33	321.81	234.52	299.31	336.09	253.71
	0.9 × 1	316.17	323.15	259.33	302.12	333.22	256.82
TME 419	1 × 1	320.33	344.31	263.14	304.16	352.11	266.61
	1.1 × 1	331.10	348.70	268.11	312.18	363.17	270.80
	Mean	318.23	336.99	256.28	304.44	346.15	261.99
LSD (p <0.05)							
Varieties (v)		39.22	42.08	22.18	25.14	28.06	30.62
Spacing (s)		ns	7.50	9.25	ns	18.25	17.17
V × S		ns	2.11	2.71	ns	1.66	5.65

ns = not significant.

(Table 4); however TME 419 produced highest number of stem of 2.18 per stand, followed by TMS 0505 at 2.04. The least number of stem per stand (1.86) was from TMS 30572. The effect of spacing on number of stems per stand varied significantly in both cropping seasons. Planting at 0.8 m × 1 m produced highest number of stems per stand irrespective of cassava variety.

Number of branches per plant varied significantly among the cassava varieties (Table 4). The TMS 0505 had the highest number of branches at 6 MAP as 5.87 and 6.73 in 2008 and 2009 respectively, followed by 1.35 and 1.15 in 2008 and 2009 respectively, recorded from TMS30572 variety. The TME 419 had no branch at 6 MAP in 2008 and 0.11 branches in 2009. The TMS 0505 variety had 77 to 100% and 83 to 98% of more number of branches per plant than other cassava varieties in 2008 and 2009 cropping seasons respectively. The results of number of branches per plant further indicated decrease in number of branches per plant with increase in spacing in TMS 30572 and 0505 varieties in both cropping seasons. The stem girth per plant as affected by cassava varieties also was not significantly different in both cropping seasons. The TME 419 variety had the biggest stem girth of 14.26 cm in 2008 while TMS 0505 was the biggest (15.66 cm) in 2009. The smallest stem (13.60 cm) and (14.48 cm) in 2008 and 2009 was from TMS 30572. The TME 419 and TMS 98/0505 varieties had 2 to 6% and 4 to 8% of bigger stems in 2008 and 2009 respectively. The interaction effect between cassava varieties and spacing on stem girth was significantly different ($P < 0.05$) in both cropping seasons (Table 4). The results showed increase in spacing with significant increase in stem girth, irrespective of cropping season. In all the cassava varieties, the biggest stem girth was at spacing of 1.1 m × 1m.

The yield and yield components of cassava as influenced by varieties and spacing is presented in Table 5. The number of storage root as affected by varieties was not significantly different ($P > 0.05$) in both cropping seasons. The TME 419 variety had the highest number of storage roots per stand of 8.26 and 7.77 in 2008 and 2009, respectively. The TMS 98/0505 had 7.78 and 6.99 storage roots per stand while TMS 30572 variety had 7.28 and 6.90 storage roots per stand in 2008 and 2009 respectively. The effect of cassava spacing on number of storage roots per stand showed no significant ($p > 0.05$) difference in both cropping seasons (Table 5), although spacing of 0.8 m × 1 m produced the highest number of storage roots per stand which was not statistically significant when compared to other spacing treatments.

Table 4. Number of stems per stand, branches and stem girth (cm) at 6 MAP.

Cassava varieties	Spacing (m)	2008			2009		
		Number of stem/ stand	Number of branches / plant	Stem girth (cm)/plant	Number of stem/Stand	Number of branches / plant	Stem girth (cm)/plant
	0.8 × 1	3.00	1.63	11.31	2.93	1.33	12.18
	0. 9 × 1	2.13	1.33	13.75	2.03	1.25	14.25
TMS 30572	1 × 1	1.10	1.31	14.38	1.33	1.00	15.71
	1.1 × 1	1.10	1.11	14.93	1.33	1.00	15.77
	Mean	1.86	1.35	13.60	1.91	1.15	14.48
	0.8 × 1	3.33	8.75	9.36	4.31	7.31	13.31
	0.9 × 1	2.83	6.25	11.33	2.75	6.75	15.30
TMS 98/ 0505	1 × 1	1.01	5.13	16.75	1.37	6.33	16.71
	1.1 × 1	1.00	3.33	18.63	1.33	6.52	17.30
	Mean	2.04	5.87	14.02	2.44	6.73	15.66
	0.8 × 1	2.38	0.00	12.13	2.25	0.33	12.25
	0.9 × 1	2.13	0.00	13.71	2.06	0.10	14.11
TME 419	1 × 1	2.10	0.00	15.32	2.03	0.00	16.71
	1.1 × 1	2.10	0.00	15.86	1.93	0.00	16.85
	Mean	2.18	0.00	14.26	2.07	0.11	14.98
LSD (p <0.05)							
Varieties (v)		ns	1.25	Ns	Ns	1.85	Ns
Spacing (s)		0.59	Ns	Ns	0.78	Ns	Ns
V × S		ns	Ns	Ns	Ns	Ns	Ns

ns = not significant

The interaction effect between cassava varieties and spacing on number of storage root yields was not significantly different (P > 0.05) in both cropping seasons (Table 5). The length of storage roots as influenced by cassava varieties was significantly different (P < 0.05) in 2008 and 2009 cropping seasons (Table 5). The TME 419 had the longest storage root of 43.50 and 43.56 in 2008 and 2009, respectively. The TME 419 had 11 to 30% and 9 to 36% longer storage root length compared to TMS 30572 and TMS 98/0505 varieties. The effect of spacing showed significant differences on storage root length (Table 5). The result indicated a significant increase in storage root length with increase in spacing. The spacing of 1 m × 1.1 m had the longest storage root in all the cassava varieties while the shortest was from spacing of 1 m × 0.8 m. Cassava storage root circumference as influenced by varieties differed significantly in both cropping seasons (Table 5).

TMS 98/0505 had the largest circumference of 23.18 cm and 23.84 cm in 2008 and 2009 cropping seasons, respectively. TMS30572 had the smallest storage root circumference of 14.51 cm and 18.55 cm, respectively. The effect of spacing on cassava storage root circumference was not significantly different (p > 0.05) in both cropping seasons.

Cassava storage root yield as influenced by varieties differed significantly in both cropping seasons (Table 5). Among the cassava varieties, TMS 98/0505 had the significant higher storage root yield of 33.47 t/ha and 31.15 t/ha in 2008 and 2009 cropping seasons respectively. TMS 30572 had 28.96 t/ha and 29.63 t/ha storage root yields in 2008 and 2009 cropping seasons respectively. The least storage root yield of 23.33 t/ha and 26.09 t/ha, respectively was from TME 419. The TMS98/0505 variety had 13 to 30% and 13 to 23% of higher storage root yield more than other cassava varieties in 2008 and 2009 cropping seasons respectively. The effect of spacing on cassava storage root yield was also significantly different (P < 0.05) in both cropping seasons. The TMS 30572 and TME 419 had significant storage root yield at spacing of 1 m × 0.8 m while TMS 98/0505 had higher storage root yield at spacing of 1 m × 1 m.

The interaction effect between cassava varieties and spacing on storage root yield was significantly different (P < 0.05) in both cropping seasons (Table 6). The result showed significant decrease in storage root yield with increase in spacing in TMS 30572 and TME 419 while TMS 98/0505 variety had significant storage root yield at 1 m x 1 m spacing with low storage root yield at 1 m × 1.1 m spacing

Table 5. Yield and yield components of cassava as influenced by varieties and spacing.

Varieties	Spacing (m)	2008				2009			
		Number of storage roots/stand	Storage root length (cm)	Storage root circumference (cm)	Storage root yield (t/ha)	Number of storage roots/stand	Storage root length (cm)	Storage root circumference (cm)	Storage root yield (t/ha)
	0.8 ×1	8.35	30.22	14.14	31.33	9.31	35.10	18.11	30.58
	0. 9 × 1	7.23	40.10	14.33	29.15	6.16	39.34	18.60	30.41
TMS 30572	1 × 1	6.82	42.12	14.75	28.60	6.12	41.81	18.70	29.11
	1.1 × 1	6.71	42.60	14.82	26.75	6.01	42.71	18.80	28.40
	Mean	7.28	38.76	14.51	28.96	6.90	39.74	18.55	29.63
	0.8 × 1	8.53	21.40	18.33	31.18	7.40	38.60	21.30	31.12
	0.9 × 1	8.33	23.10	21.60	33.11	7.10	38.75	23.71	35.60
TMS 98/ 0505	1 × 1	7.13	38.71	26.33	36.18	6.75	38.60	25.11	37.71
	1.1 × 1	7.11	38.10	26.45	33.40	6.70	39.45	25.25	31.15
	Mean	7.78	30.33	23.18	33.47	6.99	38.85	23.84	33.90
	0.8 × 1	8.30	39.25	15.33	27.81	8.10	40.65	19.03	32.62
	0.9 × 1	8.25	44.25	17.33	23.88	7.73	43.11	19.45	28.51
TME 419	1 × 1	8.25	35.21	15.45	22.82	7.64	45.25	19.65	23.02
	1.1 × 1	8.22	45.28	19.03	18.80	7.61	45.61	19.20	20.21
	Mean	8.26	43.50	17.29	23.33	7.77	43.56	19.33	26.09
LSD (p <0.05)									
Varieties (v)		Ns	1.99	2.16	3.61	Ns	3.01	2.14	4.02
Spacing (s)		*Ns	3.11	Ns	2.55	Ns	1.83	Ns	2.17
V x S		Ns	Ns	Ns	1.21	Ns	Ns	Ns	1.02

DISCUSSION

The result of growth and yield of cassava as influenced by varieties varied significantly ($p < 0.05$) in both cropping seasons. TMS 98/0505 had significant number of leaves per plant while TME 419 had the least. TME 419 was the tallest variety while TMS 98/0505 was the shortest variety. TMS98/0505 had the largest leaf area compared to the other varieties. The differences observed could be attributed to the inherent varietal characteristics of different cassava varieties. IITA (1990), Akata (2015) and Ikeh (2017) reported that many cassava cultivars or varieties could be distinguished by such morphological characteristics such as leaf size, colour and shape, branching habit, plant height, colour of stem and petiole, storage root shape and colour, time to maturity and yield. The reduction in number of leaves per plant and leaf area at 6 MAP in both cropping seasons could be as a result of vulgar of weather at month of December which is the peak of dry season in the study area. This observation agrees with the reports of IITA (1990) and Ikeh *et al.* (2013) who reported that leaf size of cassava is considerably reduced under adverse environmental conditions, such as water stress. The TMS 98/0505 had significant highest storage root yield compare to TMS 419 and TMS 30572 varieties. This could be due to its high rate of new leaves formation, size of leaves and longevity of leaves compared to other varieties. This finding agrees with Ikeh (2017) who reported that higher leaf area index, longevity of leaves and Leaf area duration is the major determinant of storage root yield in many cassava varieties. This result also agreed with the findings of Ikeh (2017) who reported significant higher storage root yields from the cassava varieties with longer leaf area duration and higher leaf area.

The effect of spacing on growth and yield of cassava were significantly different in both cropping seasons. The tallest plants, higher number of leaves per plant and leaf area were recorded from 1m × 1.1 m spacing (9090.91 cassava stands/ha). The tallest plants, higher number of leaves per plant and larger leaf area observed from the spacing of 1 m × 1.1 m could be due to low competition for nutrients, water and space in wider spacing compared to the close spacing of 1 m × 0.8 m (12,500 cassava stands/ha) were there is greater competition for nutrients, water and space. In closed spaced plants, there could be also excessive shading of the leaves therefore reducing the interception of solar radiation. The lower storage root

Table 6. The interaction between cassava varieties and spacing on storage root yield in 2008 and 2009 cropping season.

Treatment	2008				2009			
	Spacing				Spacing			
Cassava varieties	1 m × 0.8 m	1 m × 0.9 m	1 m × 1 m	1 m × 1.1 m	1 m × 0.8 m	1 m × 0.9 m	1 m × 1 m	1 m × 1.1 m
TMS30572	31.33	29.15	28.60	26.75	30.58	30.41	29.11	28.40
TMS98/0505	31.18	33.11	36.18	33.40	31.12	35.60	37.71	31.15
TME 419	30.58	30.41	29.11	28.40	32.62	28.51	23.02	20.21
LSD (P < 0.05)	1.21				1.02			

yield observed from TMS98/0505 at 1 m × 0.8 m compared to significant higher storage root yield obtained at 1 m × 1 m (10,000 cassava stands/ha) could be attributed to higher shading of the leaves at spacing of 1 m × 0.8 m. The 1 m × 1 m spacing resulted to a significant storage root yield in TMS 30572 and TME 419 varieties which also produced significant higher storage root yields at 1 m × 0.8 m spacing. Both varieties were tall and had lesser number of branches per plant compared to TMS98/0505 variety that branched profusely. The higher yield obtained from both varieties could be due to higher number stands per hectare which invariably resulted to more number of storage roots and yield in each plot. The TMS 98/0505 produced the highest storage yield in spacing of 1 m × 1 m, and this could be due to its branching type which could prefer wider spacing. The result agrees with the findings of Calderon (1972) that yield of some cassava varieties increase with increase in population. CIAT (1975) also agrees that optimum density in cassava changes with varieties. The decreases in storage root yield at wider spacing could be due to a fewer number of storage root per plot from 9090.91 cassava population per hectare compared to the higher number of storage roots from 12500 cassava stands per hectare. Cock and Howeler (1978) reported that reduction in yield at wider more than 1 m × 1 m spacing the optimum was due to a reduced harvest index. The study showed that 1 m × 0.8 m was optimum for TMS 30572 and TME 419, while 1 m × 1 m spacing was better for TMS 98/0505. The observations were in line with IITA (1990), whose report suggests the use of 10,000 to 15,000 plant populations at intra-row spacing of 0.8 m to 1.0 m for mono cropped cassava stand.

CONCLUSION

The result of this study shows that yield of cassava varies according to varieties and spacing. The yield obtained at spacing of 1 m × 0.8 m (12500 cassava stands/ha) was significantly higher in TMS 30572 and TME 419 varieties, while the highest storage root yield in TMS98/0505 was at 1 m × 1 m spacing. Based on the study findings, cassava farmers within Uyo in southeastern agroecology of Nigeria were recommended to adopt 1 m × 1 m spacing for TMS 98/0505 but those who wish to plant TMS 30572 and TME 419 varieties, should adopt 1 m × 0.8 m for optimum storage root yield.

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