Growth and Yield of Cassava (*Manihot esculenta* Crantz) As Influenced By The Number Of Shoots Retained Per Stand On An Ultisol

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Abstract: A two-year (2008 and 2009) study was carried out at University of Uyo Teaching and Research Farm, Uyo to assess the effects of number of shoots retained per stand on growth and yield of cassava. A randomized complete block design with three replicates was used and the number of shoots retained per stand constituted the treatments. Results revealed significant differences in stem girth, height, leaf area and number of leaves per plant among the treatments in both years. However, increasing number of shoots beyond two per stand decreased all the growth and yield parameters, except number of storage roots per plant. Retention of five shoots per stand produced the highest number of storage roots per plant (7.33 and 7.83 in 2008 and 2009, respectively). The two shoots per stand treatment produced the highest storage root yield (25.76 and 23.62 t/ha in 2008 and 2009, respectively). Two shoots per stand out yielded other treatments by 18 – 31 % and 17-31% in 2008 and 2009, respectively. It therefore appears that retention of two shoots per stand is rewarding for increased cassava storage root yield.

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1. Introduction:

Cassava (*Manihot esculenta* Crantz) is one of the most important root crops in the tropic and was introduced to Africa in the 16th century, but it took until the 20th century for production to seriously take off (Hillocks 2002). Cassava constitutes a major food staple for over 50 million Nigerians, providing more than 70% of their daily energy requirements (]Nnodu et al 2006). It grows over a wide range of ecological conditions and is more tolerant to low soil fertility, drought, pest and disease (Udoh et. al 2005; Nnodu et al.2006).]. Cassava has advantage of being available all year round since it can be left in the ground after maturity for up to three years before harvesting without spoilage. It also has high productivity per unit area of land (30-40 tha-^{1}) with minimal inputs (Nnodu 1998; IITA 1993; Fermont 2009).

In the past five decades, total cassava production in Africa has almost quadrupled from 31 to 118 million tonnesper year (FAO 2009) and is frequently cultivated on marginal soils [Dixon et al 2007; Hillocks 2002; FAO 2004). Cassava is typically perceived to be grown by resource poor small farmers (Alves. 2002; FAO 2004; 2007) as it can be produced with family labour and basic inputs only and low production risk (Nweke 2005). According to FAO (2009), average cassava yield in Africa have gradually increased from 6 to10 tha^{-1} over the past five decades. However, at present the average African farmers harvest approximately 20% less cassava per hectare than the world average o 12.2 tha^{-1} (Fermont 2009). Nevertheless, there is a potential for higher yields in Africa as on-farm germplasm trials average yields of 15 to 40 tha^{-1} have been obtained (Fermont et al 2007 ;.2008)

Although there is a trend of increases in cassava production in the humid tropics (FAO 1993; 2009) management practices are variable and in most systems inappropriate for the expression of the yield potential of the improved cassava genotypes (Eke-Okoro et al 2001). One of which is the multi-shoot problem which has not been resolved and appears to constitute one of the major causes of low yield and yield variability in cassava. Enyi (1972) observed a reduction in growth rate and yield of multi-shoot plants because of competition for assimilate and diminished priority of storage roots in assimilate partitioning. In some agro-ecologies, Mandel et al (1973), Shanumugha and Srinivasan (1973), and Correa et al (1979) recommended retention of two shoots per stand as the best cultural practices for high cassava root yield.. Against these conflicting backgrounds, this study was conducted to assess the effects of varying number of shoots retained per stand on growth and storage root yield of cassava in Uyo, southeastern Nigeria.

2. Materials and Methods

The study was carried out in 2008 and 2009 cropping seasons at the University of Uyo Teaching and Research Farm located at Use Offot (Latitude $5^0$17' and $5^0$27'N, Longitude $7^0$27' and $7^0$58'E and altitude, 38.1m above sea level). This rainforest zone receives about 2500 mm rainfall annually. The rainfall pattern is bimodal, with long (March - July) and short (September - November) rainy seasons separated by a short dry spell of uncertain length, usually during the month of August. The mean relative humidity is 78%, atmospheric temperature is 30^0C and the mean sunshine hours is 12 (Peters et al 1989). A randomized complete block design with three replicates was used. A replicate measured 27 m x 4m while a plot size was 5 m x 4 m giving a total number of 15 plots. The inter -block and plot spacing was 2 and 1m, respectively. The number of shoots per stand (1, 2, 3, 4 and 5) constituted the treatments.

In both years, planting was done in June using stem cuttings with 8 nodes at a spacing of 1m x 1m. Horizontal method was used in order to encourage sprouting and the emergence of up to five shoots per stand. One stem cutting was planted per stand giving a population of 10,000 stands per hectare. A popular cassava cultivar in Uyo (TMS 30572) was used. The number of shoots per stand was pruned from one week after sprouting to achieve the respective number of shoots per stand in the treatments. Fields were inspected regularly to maintain the right number of shoots per stand. Weeding was carried out manually at 1, 2, and 5 months after planting. A compound fertilizer (NPK-15:15:15) was applied once, using ring method, at the rate of 400kg per hectare at 6 weeks after sprouting. Ten plants were randomly tagged per plots for height, stem girth, leaf area, number of leaves per plant, number of storage roots per plant and tubers yield (tha^{-1}) determination. Data collected were subjected to analysis of variance procedure and treatment means that indicated significant differences were separated using the Least Significance Difference at 5 percent level of probability (Gomez and Gomez 1984).

3. Results

Cassava stem girth, leaf area, height, number of leaves per plant as affected by number of shoots per stand are presented in Tables 1 and 2 for 2008 and 2009, respectively. Stem girth, leaf area, height and number of leaves per plant differed significantly in both years. Plants with one shoot produced the biggest stem girth (8.75, 9.82 and 12.15 cm in 2008 and 8.15, 9.34 and 12.81cm in 2009, respectively followed by two shoots per stand (8.35, 9.77 and 12.03 cm and 7.15, 8.32 and 13.00 cm at 2, 4, and 6 MAP in 2008 and 2009, respectively). The smallest stem girths were recorded in five shoots per stand treatment (3.10, 4.74 and 8.15cm and 5.33, 5.80 and 9.00cm at 2, 4, and 6 MAP in 2008 and 2009, respectively).

One shoot per stand produced the tallest plants (38.33, 90.33 and 139.33 cm in 2008) and 51.12, 81.56 and 130.30 cm in 2009 at 2,4, and 6 MAP, respectively), followed by two shoots per stand (38.11, 79.33, and 136.11cm in 2008 and 50.98, 79.55 and 127.90 cm in 2009 at 2,4, and 6 MAP, respectively). The shortest plants were recorded when five shoots were retained per stand (30.51, 40.83 and 80.52cm in 2008 and 39.12, 63.30 and 88.25cm in 2009 at 2, 4, and 6 MAP, respectively). One shoot per stand produced the widest leaf area (103. 71, 121.61and 90.65 cm^2 in 2008 and 113.12, 116.38 and 65.31cm^2 in 2009 at 2, 4, and 6 MAP, respectively), followed by two shoots per stand (103.33, 119.12 and 90.31 cm^2 in 2008 and 105.63, 110.13, and 63.83cm^2 in 2009). Plants with five shoots per stand had the smallest leaf area (78.51, 87.31 and 55.20cm^2 in 2008 and 99.71, 90.71 and 52,51cm^2 in 2009 at 2, 4, and 6 MAP, respectively). The number of leaves per plant was highest in one shoot per stand treatment (59.51, 121.11 and 68.82 in 2008 and 64.33, 139.11 and 99.25 in 2009), followed by two shoots per stand (57.70, 118.61 and 63.11 in 2008 and 63.51, 136.12 and 89.31 in 2009 at 2, 4, and 6 MAP, respectively). The least number of leaves per plant was obtained in the five shoots per stand treatment (46.11, 78.12 and 53.85 in 2008 and 58.33, 109.31 and 57.60 in 2009 at 2, 4, and 6 MAP, respectively).

The number of storage roots per plant and storage root yield per hectare differed significantly in both years (Tables 1 and 2). The highest number of storage roots per plant was recorded in the five shoots per stand treatment (7.33 and 7.83 in 2008 and 2009, respectively) followed by the four shoots per stand treatment (6.13 and 6.33 in 2008 and 2009, respectively). The least number of storage roots per plant was recorded in the one shoot per stand plots (3.38 and 4.33 in 2008 and 2009, respectively). The five shoots per stand produced 16 - 54 and 19 - 45% more number of storage roots than other treatments in 2008 and 2009, respectively.

The highest storage root yield was obtained from the two shoots per stand treatment (25.76 and 23.62, tha^{-1} in 2008 and 2009, respectively), followed by the one shoot per stands,(23.63 and 22.85 tha^{-1}), three shoots per stand (21.77 and 19.70 tha^{-1}), and four shoots per stand (20.10 and 18.33 tha^{-1}) while the least tuber yield was obtained from five shoots per stand (19.85 and 16.67 tha^{-1}) in 2008 and 2009, respectively. Retention of two shoots per stand out-yielded other treatments by 18 - 31 and 17 - 31 % in 2008 and 2009, respectively.

Table 1: Stem girth, plant height, leaf area, number of leaves, and number of tubers per plant and tuber yield (tha^{-1}) as influenced by number of shoots at 2008.

Number of shoots per stand	Stem girth(cm)			Height (cm)			Leaf area(cm^2)			Number of leaves per plant			Number of tuber per plant	Tuber yield (tha^{-1})
	2	**4**	**6**	**2**	**4**	**6**	**2**	**4**	**6**	**2**	**4**	**6**		
1	8.75	9.82	12.15	38.33	90.33	139.33	103.71	121.61	90.65	59.51	121.11	68.82	3.38	23.63
2	8.35	9.77	12.03	38.11	79.33	136.11	103.33	119.12	90.31	57.70	118.61	63.11	5.14	25.76
3	5.33	6.11	9.75	37.63	68.13	120.53	98.81	101.73	84.12	57.17	105.15	60.63	6.17	21.77
4	4.14	4.86	9.33	36.33	65.81	100.33	88.31	93.03	78.36	47.31	80.25	58.30	6.13	20.10
5	3.10	4.74	8.15	30.51	40.83	80.52	78.51	87.31	55.20	46.11	78.12	53.85	7.33	19.85
LSD ($p<0.05$)	**1.02**	**2.11**	**ns**	**ns**	**5.10**	**4.31**	**10.21**	**9.33**	**6.41**	**ns**	**8.31**	**5.88**	**2.55**	**4.31**

ns=not significant

Table 2: Stem girth, plant height, leaf area, number of leaves, and number of tubers per plant and tuber yield (tha^{-1}) as influenced by number of shoots in 2009.

Number of shoots per stand	Stem girth(cm)			Height (cm)			Leaf area(cm^2)			Number of leaves per plant			Number of tubers per plant	Tuber yield (tha^{-1})
	2	4	6	2	4	6	2	4	6	2	4	6		
1	8.15	9.34	12.81	51.12	81.56	130.30	113.12	116.38	65.31	64.33	139.11	99.25	4.33	22.85
2	7.15	8.33	13.00	50.98	79.55	127.90	105.63	110.13	63.83	63.51	136.12	89.31	5.33	23.62
3	5.70	6.18	10.33	46.33	70.17	121.61	103.81	106.01	63.60	59.51	129.33	78.18	6.31	18.70
4	5.45	6.15	10.13	45.01	69.81	105.33	103.71	93.11	60.22	59.12	113.31	68.16	6.33	18.33
5	5.33	5.80	9.00	39.12	63.30	88.25	99.71	90.71	52.51	58.33	109.31	57.60	7.83	16.67
LSD ($p<0.05$)	**ns**	**1.16**	**2.34**	**7.33**	**10.04**	**12.30**	**6.75**	**11.08**	**2.77**	**ns**	**8.61**	**11.18**	**2.61**	**2.07**

ns = not significant

4. Discussions

Increasing the number of shoots per stand decreased the crop growth and yield. Increasing shoot number from two to three per stand decreased stem girth, height, leaf area, and number of leaves per plant and storage root yield. Competition for nutrients and other growth resources between shoots in plants with more than two shoots could be responsible for this. (Enyi 1972; Elsharkawy 2004; El-Sharkawy, 2007) observed a reduction in the growth rate and yield of multi-shoot plants due to competition for assimilates.

Storage root tuber yield seem to be dependent on the number of shoots per plant. Retaining number of shoots per plant beyond two decreased storage root yield. Shanumugha and Srinivasan (1973); Correa et al 1979; Eke-Okoro et al (2001) made similar observations. Retention of two shoots per stand has been reported to be the best cultural practice for cassava production (Correa et al 1979; Mandel et al 1973; Eke-Okoro et al 2001).

5. Conclusion

This study shows that number of shoots per stand influenced the growth and yield of cassava. This investigation suggests that root yield of cassava could be enhanced by maintaining two shoots per stand in cassava production if root tuber production is the target. On the other hand, farmers interested in stem multiplication could maintain up to five shoots per stand.

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