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Effects of Planting Population, Planting Position and Number of Nodes per Cutting on Cassava (*Manihot esculenta* Crantz) Seed Yield

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ABSTRACT

A field study was conducted at National Cereals Research Institute, Uyo Out-Station in Akwa Ibom State in 2012 and 2013 to evaluate the effects of plant population, planting position, and the number of nodes per cutting on cassava seed yield. The experiment was laid out in a randomized complete block design, replicated thrice in 4 x 3 x 4 factorial arrangements. Factor A treatments were four plant populations per hectare (10,000, 12500, 16666.67, and 20,000). Factor B treatments were three planting positions: slanting, vertical, and horizontal while factor C treatments were a number of nodes per stem cutting (2, 3, 4, and 5). The result of the establishment percentage showed a significantly different ($p<0.05$) in the treatment of the number of nodes per cutting. Treatment of 5 nodes per plant had a significant establishment percentage (100%) in 2012 and 2013 while treatment of 2- nodes per plant had poor establishment percentages of 60.00 and 60.50 %, respectively. Treatment of 20,000 plant/hectare produced a significantly higher number of stem bundles/ha; 815.30 and 875.22 in 2012 and 2013. The 10, 000 plants/hectare, had the least number of stem bundles/ha; 306.00 and 309.33. Horizontal planting produced a significantly higher number of bundles/ha; 921.68 and 943.17 in both years, followed by 643.41 and 705.30 bundles recorded in a slant position. The least number of stem bundles; 314 and 330.66 was recorded in vertical position. Seed yield as influenced by the number of nodes per cutting also showed a significant difference ($p<0.05$). Treatment of 5 nodes had significant cassava seed yield of 745.34 and 722.12 bundles/ha while the least; 431.68 and 474.33 were recorded in the treatment of 2 nodes. The study also revealed that plant population per hectare, planting position and number of nodes per cutting influences cassava storage yielded. Farmers were advised to adopt a 20,000 plants population per hectare with 4 nodes per stem cutting and plant horizontal position for higher stem multiplication but if storage root is the sole target, farmers should plant at least 4 nodes per cutting, plant in horizontal position in plant population of 12,500 stands per hectare.

INTRODUCTION

Cassava is referred as food security crop in Nigeria. It is a major staple produced and consumed in the diets of so many Nigeria, particularly in rural areas. It is primarily cultivated as an annual crop in the humid tropics (Bellotti et al. 2011). In Africa, cassava is the single most important source of dietary energy for a large proportion of the population (Cock, 2011). Cassava is a major food crop in Nigeria and is strategically valued for its role in food security, poverty alleviation and as a source of raw material for agro-allied industries with huge potential for the export market (Egesi et al. 2006; Okpara et al. 2022). All parts of cassava plants are utilized for food and animal feed but storage roots are the most used part. The leaves are widely consumed in some regions in Africa, Asia and South America (Njoku et al. 2014) as a source of protein, minerals, vitamins, fiber and amino acids (Ceballos et al. 2008). In Nigeria, especially southeast region, cassava could be processed into different local diets such as gari, fufu or apu, abacha, akpu, mmiri etc. Cassava generates income for farmers and provides employment to the farmers, processors and traders.

Cassava starch is an important industrial raw material. Cassava starch is preferred in the laundry and textile industries. The blended flavor of cassava starch, its non-degradation tenderly and excellent freeze stability make it a favorite recommended as a diluent in chemical and drug manufacturing or as a carrier in cosmetics, pills and capsules (Kadere and Makhoha, 2007). It's used in manufacturing ethanol and demand for ethanol has increased dramatically in the world over the last few years. Many countries already have ethanol gasoline blend programs and the majority of these are ethanol importers. The use of cassava in producing ethanol contributed to meeting up ethanol demand as the world market potential for ethanol for 2012/2013 was estimated at 7 billion liters, 6 billion for ethanol- fuel and 1 billion for ethanol-no fuel (Marco and Mpoko, 2010).

The scarcity of planting materials in all the cassava-growing states of Nigeria is a major challenge in the expansion of cassava farms. The major target of farmers is cassava with high storage root yield during maturation, without thinking about how to generate more stem cutting or seed. The only ultimate way to reduce the scarcity of cassava stem cutting is to adopt better agronomic practices that could lead to high storage root and seed yields. The choice of which enterprise to engage depends on the individual farmer. Some farmers prefer the production and marketing of cassava seed while most of the prefer storage root production and further processing of the roots into different cassava produce. Plant population probably influences crop vegetative and yield traits. In cassava, space between plant rows influences plant height, stem diameter, number of leaves, and storage root yields of different cassava varieties (Akpan and Ikeh, 2018). Several studies have been conducted with cassava, at plant populations that ranged from 6,666 plants ha-1 (Rojas et al. 2007) to 27,777 plants ha-1 (Guerra et al. 2003). Larger populations (of up to 50,000 plants ha-1) have been tested to determine their effects on the above-ground part of the plant (Lima et al. 2002). Akpan and Ikeh (2018) have demonstrated that different intra-row spacing had a significant effect on cassava growth and yield, but the response is on a varietal basis. In other words, an increase in row spacing may increases, reduces, or maintains cassava storage root and seed yields, based on the cassava varietal differences with respect to their growing habits or morphology.

Cassava cutting may be planted horizontally, vertically, or in an inclined position. The position of cassava varies depending on the plant variety, soil characteristics, ease of operation, tradition, and climatic conditions (Chantaprasan and Wanapat, 2003). The studies of Crawford (2005) in Jamaica concluded that horizontal planting of 25 cm stakes is best if soil moisture is limited at planting time. Similarly, Chan (1990) found a significant difference in cassava tuber yield among horizontal, vertical, and inclined positions of 15cm stakes. Krochmal (2009) studies on Virgin Islands reported that it would be better to plant 20 or 25-cm stakes with three buds horizontally at 5-10 cm under the soil surface than planting them in a horizontal method. Harper (1993) studies in Thailand found that planting position depends on soil and climatic conditions. Narmilan and Puvanitha (2020) reported that planting methods of cuttings and varietal characters had a profound influence on the growth and root yield of cassava cultivars in Sir Lanka. Chew (1994) reported no significant difference between the three planting positions in Malaysia. Different authors at different location reported differences in storage root yields at different planting orientation but no literature have ever reported on stem multiplication.

Considering that improved cassava planting is scarce in Nigeria, one of the ways of making adequate improved planting materials available to farmers is to embark on large-scale field multiplication of cassava stems through different conventional and non-conventional methods. A lot of work has been done on the agronomic aspect of cassava improvement in Nigeria but the issue of meeting the increasing demand for improved cassava variety planting materials in Nigeria has not been addressed. Recently, training of cassava farmers on seed production (Seed multiplication) by the National Root Crop Research Institute (NRCRI), International Institute for Tropical Agriculture in collaboration with the National Seed Council of Nigeria has thrown more light on possible ways of reducing the challenges of inadequate cassava planting material in Nigeria and to ensure that farmers produce clean and quality planting materials through cassava seed entrepreneurs (CSCs) programme. Therefore, this study was carried out to evaluate the influence of cassava plant population, planting position, and number of nodes per stem cutting on cassava seed yield as well as storage root yields.

MATERIALS AND METHOD

The trail was conducted at the research farm of the National Cereals Research Institute (NCRI) Uyo out station located at Owot Uta Ibesikpo/Asutan local Government Area of Akwa Ibom State during the 2012 and 2013 cropping seasons. Ibesikpo/Asutan lies at latitude 0405N, longitude 07056, and altitude 38m above sea level. Ibesikpo/Asutan has an annual rainfall of 2500mm and monthly sunshine of 3.14 hours and a mean annual temperature of 28^0C with an annual relative humidity of 79% and evaporation rate of 2.6cm2. The rainfall pattern of the location is bimodal. Rainfall usually starts in March and ends in November with a short period of relative moisture stress in August, traditionally referred to as 'August Break" (Peters et al. 1989). The soil physicochemical properties of the experimental site before planting were as follows; pH5.7, organic matter 1.67%, available P, 88.24mg/kg, total Nitrogen, 0.06%. The particle size analysis indicated 90.40% sand, 3.30% silt, and 6.30% of clay.

The land was plowed, harrowed, and ridged. The experiment design used was 4 x 3 x 4 factorial. Factor A treatments were four plant populations per hectare (10,000, 12500, 16666.67, and 20,000) while Factor B treatments were three planting positions: slanting, vertical and horizontal while factor C treatments were a number of nodes per stem cutting (2, 3, 4 and 5). Each plot size was 6m x 6m with inter and intra-block spacing of 1.5m paths, respectively. Planting was done in May, 2012 and 2013. The Cassava variety used was TME 419. Weeding was done at 4 and 12 weeks after planting (WAP), followed by slashing at 8 months after planting (MAP). The inorganic fertilizer (NPK-15:15:15) at a rate of 400kg/ha was applied on the blanket recommendation two months after planting.

The following parameters were assessed during the trial; establishment percentage, number of sprouted shoots, number of branches per plant, plant height, number of stem bundles per hectare, number of storage roots per plant, and storage tuber yield in tons per hectare. All the data collected were subjected to analysis of variance. Significant means were compared with the least significant difference at 5 percent probability.

RESULTS

The result of the establishment percentage showed a significantly different (p<0.05) in the treatment of the number of nodes per cutting (Table 1). Treatment of 5 nodes per plant had a significant establishment percentage (100%) in 2012 and 2013 while treatment of 2- nodes per plant had poor establishment percentages of 60.00 and 60.50 %, respectively.

The effect of plant population on cassava height at harvest indicated a significant difference (P<0.05) among the spacing treatments. Spacing of 10,000 plant population per hectare (p/ha) had the tallest cassava of 198.68 and 203.40 cm in the 2012 and 2013 cropping seasons, respectively whereas the shortest was 177.55 and185.30 cm respectively observed in 20,000p/hectare treatment (Table 2). Cassava height as influenced by planting orientation y differed significantly with the vertical position having the tallest (209.34 and199.34 cm) while the shortest (163.11 and 173.43 cm) was observed in the horizontal position. Cassava height as influenced by the number of nodes per stem cutting showed no significant difference among the treatments (Table 2).

The number of stems per stand at harvest as influenced by plant population, planting position and number of nodes per stem cuttings were significantly different (Table 2). A plant population of 20,000 per hectare had a significantly higher number of stems per plant (2.93 and 3.38) in 2012 and 2013, respectively. The least number of stems per stand at harvest (1.53 and 1.48) respectively was recorded in the spacing of 10,000 p/hectare. Among the planting positions, the horizontal position produced a significantly higher number of stems per stand at harvest (4.89 and 4.55) in both cropping seasons while the least number of stems per stand (1.33 and 1.09) was recorded in the vertical position. Treatment of 5 nodes per stem cutting had a significantly higher number of stems per stand (3.79 and 3.46) in the 2012 and 2013 trials, respectively. The least number of stems per stand was recorded in the treatment of 2 nodes per stand (1.34 and 1.34) respectively.

Table 1: Establishment Percentage and Number of Shoots per Stand

Treatments	**Establishment (%)**		**Number of Shoots per Stand**	
Plant population/ha	2012 4WAP	2013 4WAP	2012 4WAP	**2013 4WAP**
10,000	99.00	100.00	2.31	**2.51**
12,500	100.00	100.00	2.11	**3.81**
16666.67	99.00	100.00	2.51	**3.60**
20,000	100.00	100.00	3.06	**2.75**
LSD (P<0.05)	NS	NS	NS	**NS**
Planting Position (P)				
Slant	99.00	98.50	2.75	**2.66**
Vertical	95.50	99.50	1.82	**1.53**
Horizontal	100.00	100.00	4.32	**4.81**
LSD (P<0.05)	**NS**	**NS**	**1.45**	1.55
Number of Nodes (N)				
2	60.00	60.50	1.01	**1.12**
3	70.00	70.00	1.83	**1.75**
4	100.00	95.00	2.41	**2.39**
5	100.00	100.00	3.95	**3.84**
LSD (P<0.05)	**7.05**	**6.81**	**1.03**	1.12
Interactions				
S x P	**NS**	**NS**	**NS**	NS
S x N	**NS**	**NS**	**NS**	NS
P x N	**NS**	**NS**	**0.78**	0.46
S x P x N	NS	NS	NS	NS

*NS= not significant

The effect of plant population, planting position, and number of nodes per stem cutting on cassava stem girth at harvest showed no significant difference in all the treatment factors in both cropping seasons (Table 2). Cassava stems girth as influenced by plant population treatments ranged from 7.33 - 7.60 cm and 7.82 -8.45 in the 2012 and 2013 cropping seasons, respectively. In the treatment of planting position, it ranged from 6.68-7.78 cm and 7.33-8.01 cm in both cropping seasons. In a number of node treatments, cassava stems girth ranged from 6.85-7.85 cm and 7.43-7.85 cm in both cropping seasons.

The number of cassava branches per plant as influenced by plant population, planting position and the number of nodes per stem cutting differs significantly (P<0.05) in both cropping seasons (Table 3). The effect of plant population on the number of branches per plant varied significantly different (p<0.05) in both cropping seasons (Table 3).

Table 2: Cassava Height (cm), Number of Stems per Stand and Stem Girth (m) at Harvest as Influenced by Spacing, Planting Orientation, and Number of Nodes per Stem Cutting.

Treatments	**Plant height (cm) at harvest**		**Number of Stems per stand at harvest**		**Stem Girth (m) at Harvest**	
Plant population/ha	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
10,000	198.68	203.40	1.53	1.48	7.33	8.45
12,500	180.68	193.40	1.98	2.01	7.60	7.99
16666.67	179.75	192.33	2.48	3.11	7.55	7.82
20,000	177.55	185.30	2.93	3.38	7.51	7.82
LSD (P<0.05)	**3.90**	**4.68**	**1.15**	**1.54**	**NS**	NS
Planting Position (P)						
Slant	176.78	183.40	2.41	2.33	7.78	8.01
Vertical	209.34	199.34	1.33	1.09	7.33	7.59
Horizontal	163.11	173.43	4.89	4.55	6.68	7.33
LSD (P<0.05)	**5.67**	**2.46**	**2.55**	**1.96**	**Ns**	Ns
Number of Nodes (N)						
2	193.33	185.31	1.34	1.34	6.84	7.85
3	191.34	194.34	2.33	2.40	7.75	7.56
4	189.45	179.36	3.43	3.75	7.81	7.44
5	173.45	173.04	3.79	3.46	7.85	7.43
LSD (P<0.05)	**NS**	**NS**	**1.13**	**1.11**	**NS**	NS
Interactions						
S x P	**NS**	**NS**	**NS**	**0.35**	**NS**	NS
S x N	**NS**	**NS**	**NS**	**0.67**	**NS**	NS
P x N	**NS**	**NS**	**0.55**	**0.41**	**NS**	NS
S x P x N	NS	NS	NS	NS	NS	NS

A pant population of 10,000 /ha had a significantly higher number of branches per plant (16.33 and 13.42) in the 2012 and 2013 cropping seasons, respectively. The least number of branches per plant (6.41 and 5.45), respectively was recorded in a plant population of 20,000/ha. Among the planting positions, vertical planting produced a significantly higher number of branches per plant (15.84 and 12.35) in the 2012 and 2013 cropping seasons, respectively. The least number of branches per plant (9.01 and 8.55), respectively, was observed in the horizontal planting position. The 5 nodes per stem cutting had a significantly higher number of branches per plant (13.81 and 14.29) in the 2012 and 2013 cropping seasons, respectively. The treatment of 2 nodes per stem cutting had the least number of branches per plant (4.45 and 3.39), respectively.

The number of storage roots per plant as influenced by plant population, planting position, and number of nodes per cutting varied significantly (P<0.05) in both cropping seasons (Table 3). Planting at a population of 20,000/ha had the significantly highest number of storage roots per stand (10.45 and 9.66) in the 2012 and 2013 cropping seasons, respectively while the least (4.99 and 5.31) was obtained from a plant population of 10,000/ha. Among the planting positions, results showed a significant difference (p<0.05) in the number of storage roots per plant (Table 3). Horizontal planting treatment had a significantly higher number of storage roots per stand (10.40 and 10.35) compared to the least number of storage roots (5.16 and 5.19) recorded from the vertical planting position. The result of nodes per cutting differed significantly different in both cropping years. They showed a significant increase in the number of storage roots per stand with the increase in the number of storage roots per plant. Stem cutting of 5 nodes per cutting had 8.14 and 8.63 storage roots per stand in both cropping seasons while treatment of 2 nodes per stem cutting has an average of 3.34 and 3.40 storage roots per stand in 2012 and 2013, respectively. The result further showed no significant difference (p>0.05) when the mean number of storage roots from 5 nodes was as compared to 4 nodes per plant, in both cropping seasons.

Table 3: Number of Stems per Plant, Number of Tubers per Plant and Tuber Yields as Influenced

Treatments	**Number of branches/Stand**		**Number of Storage Root/Plant**	**Storage Root Yield (t/ha)**		**Number of Stem Bundles/ha**		
Plant Population/ha	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	2013
10,000	16.33	4.99	5.31	8.76	28.34	29.06	306.00	**309.33**
12,500	11.40	6.16	6.38	6.55	33.45	34.06	681.45	**631.43**
16666.67	9.34	9.01	9.75	12.39	28.74	31.43	725.14	**753.11**
20,000	6.41	10.45	9.66	10.14	18.44	18.38	815.30	**875.22**
LSD (P<0.05)	**2.11**	**2.16**	**1.76**	**2.01**	**3.17**	**3.73**	**13.56**	15.98
Planting orientation (P)								
Slant	15.84	12.35	8.11	8.42	29.38	28.61	643.41	**705.30**
Vertical	12.83	12.30	5.16	5.19	28.95	26.75	314.32	**330.66**
Horizontal	9.01	8.55	10.40	10.35	30.34	31.41	921.68	**943.17**
LSD (P<0.05)	**2.12**	**1.86**	**2.08**	**2.65**	**NS**	**2.01**	**18.77**	18.45
Number of Nodes (N)								
2	4.53	3.39	3.34	3.40	18.75	18.07	431.68	**474.33**
3	9.69	7.43	4.34	4.39	28.34	27.45	582.71	**586.30**
4	12.75	10.81	7.40	8.09	29.88	30.07	731.14	**716.30**
5	13.81	14.29	8.14	8.63	30.05	31.22	745.34	**722.12**
LSD (P<0.05)	**3.67**	**3.81**	**1.55**	**1.92**	**2.44**	**2.85**	**12.90**	11.78
Interactions								
S x P	**0.98**	**0.56**	**1.01**	**0.72**	**NS**	**NS**	**3.10**	2.98
S x N	**0.16**	**0.23**	**NS**	**NS**	**NS**	**NS**	**NS**	NS
P x N	**0.12**	**0.17**	**0.43**	**0.55**	**NS**	**NS**	**0.12**	0.09
S x P x N	0.08	0.03	NS	NS	NS	NS	NS	NS

Cassava storage root yield per hectare as influenced by plant population, planting position, and number of nodes per cutting varied significantly (P<0.05) in both cropping seasons (Table 3). The plant population of 125000 stands per hectare produced significant storage root yield; 33.45 and 34.06 t/ha in the 2012 and 2013 cropping seasons, respectively. This was followed by 28.74 and 31.43 t/ha respectively harvested from a plant population of 16666.67 stands/hectare. The least storage root yield (25.66 and 28.08 t/ha) was harvested from a plant population of 20,000 stands/hectares in the 2012 and 2013 cropping seasons, respectively. Cassava storage root yield as influenced by planting position varied significantly different (Table, 3). Horizontal planting position produced significantly higher storage root yield (30.34 and 31.41 t/ha) in the 2012 and 2013 cropping seasons. This was followed by 29.38 and 28.61 t/ha, respectively recorded in slant (inclined) planting position. The least storage root yield (28.95 and 26.75 t/ha) in both cropping seasons was recorded in the vertical planting position. Cassava storage root yield as influenced by the number of nodes per cutting showed a significant difference (p<0.05) in both cropping seasons. Treatment of 5 nodes produced a significantly larger storage root yield (30.05 and 31.22 t/ha) in both cropping seasons. The treatment of 4 nodes per stem cutting had storage root yields of 29.88 and 30.17 t/ha in the 2012 and 2013 cropping seasons, respectively. Treatment of 2 nodes per stem cutting, produce the least storage root yield (18.75 and 18.07 t/ha) in the 2012 and 2013 cropping seasons, respectively.

The number of cassava stem bundles per hectare as influenced by plant population, planting position and the number of nodes per stem cutting varied significantly (P<0.05) in both cropping seasons (Table 3). Plant population of 20,000 stands per hectare produced significantly higher stem bundles per hectare; 815.30 bundles in 2012 and 875.22 bundles in 2013. This was followed by 725.14 and 753.11 bundles per hectare respectively, recorded from a plant population of 16666.67 stands per hectare. The least number of stem bundles per hectare (306 and 309.33) was recorded in a plant population of 10,000 stands per hectare. Comparing the planting positions, horizontal planting produced the highest stem bundles per hectare; 921.68 in 2012 and 943.17 in 2013. Inclined (slant) planting positions produced 643.41 and 705.30 bundles in the 2012 and 2013 cropping seasons, respectively. The least number of bundles; 314.32 and 330.66, respectively, was recorded in the vertical planting position. Comparing the treatments of the number of nodes per stem cutting, the result showed a significant increase in the number of stem bundles from 2 to 5 nodes per stem cutting. Planting of 5 nodes per stem cutting produced the highest number of stem bundles per hectare; 745.34 and 722.12 per hectare in the 2012 and 2013 cropping seasons, respectively. The results showed no significant difference between the number of stem bundles per hectare recorded in 5 nodes and (731.14 and 716.30) recorded in 4 nodes per stem cutting. The least number of stem bundles per hectare; 431.68 and 474.33 in the 2012 and 2013 cropping seasons respectively were recorded in 2 nodes per stem cutting.

DISCUSSION

The establishment percentage of cassava as influenced by spacing and planting orientation showed no significant difference ($P<0.05$) in both cropping seasons. The higher establishment percentage achieved in the study could be due to the high moisture content of the soil. The experiment was conducted during raining season. Adequate soil moisture is one of the factors that enhanced early germination and establishment of seeds. This observation agreed with the findings of Ikeh et al. (2012) that provided that soil moisture is sufficient, cassava can sprout and grow all year round. Ikeh (2017) also reported that relatively adequate soil moisture content and viable cassava planting material significantly influenced cassava sprouting and establishment percentage. The effect of the number of nodes per stem cutting on establishment percentage varied significantly different in both the 2012 and 2013 cropping seasons. The treatment of 5 nodes per stem cutting had the highest sprouting percentage while the least establishment percentage was recorded in 2 nodes per stem cutting. The result indicated an increase in the number of nodes per stem cutting with the increase in establishment percentage. The lower establishment percentage recorded in the number of 2 and 3 nodes agrees with the findings of IITA (1990) and Ikeh (2017) that cutting with few buds are more likely to lose the viability of their buds during propagation due to lower food reserves and more susceptible to pathogen attack and rapid dehydration. The low sprouting percentage recorded in the 2 nodes per cutting also agrees with the report of El-Sharkawy (2004) that sprout emergence and early growth of the plants from stem depends on endogenous nutrients stored in the stems and the adaptability to the local climate or the environment rather than on soil nutrients,

The variations in the number of sprouted shoots, number of stems per stand, number of stem bundles per hectare, number of tuber of stem bundles and tuber yield among all the treatments in each factor showed that plant population, planting position and number of nodes per cutting had effect in stem multiplication and tuber yield. The study agreed with the findings of IITA (1990); Chew (1994) that planting position of the cutting influences several growth characteristics of the plant. The significant effect of the number of nodes per cutting is in line with the finding of Udoh et al (2021) that longer stem cuttings have been reported to give higher yields than short ones, although no significant storage root yield was recorded between cassava stakes of 5 nodes and 7 nodes, irrespective of cassava varieties. The interaction result showed that planting position and the number of stem cuttings had a significant effect on the number of stems per stand and the number of stem bundles per hectare. The high storage root yield recorded in a plant population of 12500 could be due to an increase in plant population per hectare (12,500 plants) with less competition for light, nutrients, and space compared to 20,000 stands per hectare where competition for nutrients, space, and light may be more compared to 12,500 plant population. This could be one of the factors that resulted in to decrease in storage root yield in the plant population of 20,000 stands per hectare. The high number of stem bundles recorded horizontally could be due to the higher number of stems per stand observed in the treatment compared to vertical and slant planting positions.

CONCLUSION

The study showed that cassava plant population, planting position, and the number of nodes per stem cuttings were among the cultural practices that influenced the number of cassava seeds and storage root yield. Cassava farmers in Uyo agro-ecology were advised to adopt a 20,000 plants population per hectare with 4 nodes per stem cutting and plant horizontal position for higher stem multiplication but if storage root is the sole target, farmers should plant at least 4 nodes per cutting, plant in the horizontal position in plant population of 12,500 stands per hectare.

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