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TUBER PRODUCTION OF CASSAVA AT DIFFERENT PLANT SPACING AND SUBSEQUENT EFFECT ON SOIL PHYSICAL AND CHEMICAL PROPERTIES

Adeniyan, O. N.

Institute of Agricultural Research and Training, Obafemi Awolowo University, P. M. B. 5029, Moor Plantation, Ibadan.

adeniyantayo@yahoo.com

ABSTRACT

The study aimed at identifying the influence of different plant population (plant spacing) on cassava tuber yield and the cumulative residual effect on soil physical and chemical properties were carried out in two cropping seasons (2008/2009 and 2009/2010) at Orin Ekiti research station of the Institute of Agricultural Research and Training (IAR&T), Moor Plantation Ibadan. The highest percentage change (50.58%) for soil bulk density was recorded for cassava population at 17,689 plants per hectare (75 x 75 cm spacing) while the least value (13.95%) was recorded for cassava population at 10,000 per hectare (100 x 100 cm spacing). The highest percentage change (23.38%) of soil pH was recorded for cassava plant population at 17,689 plants per hectare while the lowest percentage change (0.77%) of soil pH was recorded for cassava plant population at 10,000 plants per hectare. There was reduction in organic C (-24.37%) at cassava plant population of 10,000 plants per hectare and -52.69% at plant population of 17,689 plants per hectare. Total soil N reduces from initial content before planting by -21.87% at plant population of 10,000 plants per hectare to -56.25% at plant population of 17,689 plants per hectare. Available P was generally increased with the corresponding increased in cassava plant population. The lowest percentage change (8.17%) was recorded for cassava population of 10,000 plants per hectare while the highest value (53.91%) was recorded for plant population at 17,689 plants per hectare. Exchangeable K was generally reduced after two years of putting the soil into cassava production at different plant population. The percentage changes of -31.59, -42.11, -57.89, -73.95, and -89.47% were recorded for 10,000, 12,321, 13,333, 14,763 and 17,689 plants per hectare respectively. There were no significant ($P < 0.05$) differences among the various cassava plant population for average number of tuber per plant, average tuber diameter, and average tuber weight in 2008 and 2009. In both years of experimentation, there were significant ($P < 0.05$) differences in fresh cassava tuber yield. The significantly highest fresh cassava tuber yields 32.4 and 27.3 t^{-1} for 2008 and 2009 respectively were obtained given by plant population at 17, 689 plants per hectare.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz*)* is an important root crop, providing food and income for over 700 million people in the tropics (FAO, 1999). In Africa, cassava is regarded as dual purpose crop, firstly as staple food and secondly as a source of income (IITA, 1990; Nweke, 1994). In Nigeria, cassava cultivation by resource poor farmers has increased tremendously in recent times due to its adaptation to shorter fallow periods, relative drought tolerance, ability to thrive well in soil of low fertility, its storage potentials in the soil, its ability to enhance export drive for increased foreign exchange and provision of employment opportunities (IITA, 1990; Aduramigba and Tijani-Eniola, 2001; Olojede, 2004).

Soil is a major component of the environmental system. It is a major resource of the earth with a lot of potential. Soil has been described as the basis of human civilization. This is because; soil supports plants, which provide nutrition for man and his livestock (Summer and Wilding, 2000). Soil is likely to show great variability in their physical, chemical, biological properties because the soil is a heterogeneous unit. Knowledge of variability of soil properties is very indispensable as this can affect crop yield. A study of the variability trends of soils is essential in order to highlight the soil potentials and enhance their management and productivity (Mahdi *et al*, 2006; Arnold, 1996).

In order to sustain the demand for cassava to meet both local and export needs of the nation, there is need to increase the present cassava plant population per hectare from the present 10,000 plants. Higher plant population of cassava per unit area of land will lead to removal of corresponding higher nutrients from the soil. According to Ekanayake *et al*; (1997) and Eke-Okoro *et al*; (1999) cassava impoverishes the soil rapidly, unless the absorbed or lost nutrients are replenished. Therefore, there is need to evaluate the influence of different cassava plant population on its tuber production and soil properties. Hence, this work presents the relationship between different cassava plant population density and soil properties in the study area.

The objectives of the study were to assess influence of different plant population on cassava tuber yield and the residual effect of cassava different plant population on soil physical and chemical properties.

MATERIALS AND METHODS

The experiment was carried out in two cropping seasons (2008/2009 and 2009/2010) at Orin Ekiti research station of the Institute of Agricultural Research and Training (IAR&T), Moor Plantation Ibadan. Pre-planting and post-planting soil samples laboratory analyses were carried out. Twenty-five core pre-planting soil samples were collected randomly from 0-15cm depth on the experimental site using soil auger, mixed thoroughly and bulked. While five core post-planting soil samples were collected randomly from 0-15cm depth on the plots based on the treatments from each of the replications, mixed thoroughly and bulked on treatment basis. The soil samples were taken to the laboratory, air dried and sieved to pass through a 2mm sieve for chemical analysis.

Particle size was determined by the hydrometer method. Soils reaction (pH) was determine in 1:2 soil/water ratio by use of glass electrode pH metre. Organic Carbon was determined by the Walkley and Black (1934) method while total nitrogen was by the Kjeldahl digestion method. Available phosphorus was determined by the Bray and Kurtz No. 1 method. Exchangeable (bases) cations were extracted with IN NH4OAC (pH7); Calcium (Ca) and Magnesium (Mg) were determined by the EDTA titration method while potassium (K) was determined with flame photometer. The bulk density was also determined by the core method using a core sampler.

The experimental field was cleared, ploughed, harrowed, ridged and was laid out in plots. The plot size was 6m x 6m ($36m^2$) each. There were six spacing treatments; 100 x 100cm, (10,000 plants/ ha), 100 x 90cm (11,110 plant/ha), 90 x 90cm (12,321 plant/ha), 90 x

75cm (14,689 plant/ha) and 75 x 75cm (17,689 plants/ha) with three replications and arranged in a randomized complete block design (RCBD). A spacing treatment of 100 x 100cm which was conventionally used by farmers served as the control treatment. Planting of viable cassava stem cuttings of NR8082 variety of branching type into different plots based on the above mentioned spacing started between May 2008 and April 2009 and was repeated between May 2009 and April 2010. The crops received 400kg/ha NPK (20: 10: 10) 21 days after planting (DAP). A second application of the same fertilizer mixture at 200 kg/ha was applied to the cassava crop 4 months after planting (MAP) to boost the fertility of the soil in both cropping seasons. At 12 months after planting, harvesting was carried out in the two years of experimentation and data were collected on number of tubers per plant, tuber diameter (cm), average tuber weight (g) and fresh tuber yield per hectare (t/ha). The data were analyzed and subjected to analysis of variance (ANOVA) F-test and their means were separated using Least Significant Difference (LSD) at 5% level of significance.

RESULTS AND DISCUSSION

Pre-planting soil physical and chemical properties

Table 1 shows the pre-planting physical and chemical properties of the soil of the study area. The texture of the soil was sandy loamy with high sand fraction, with silt content of 18.1% and clay content of 9.8%. The bulk density was 1.72 MgM^{-3}. The soil P^H was 5.22 and according to Enwezor *et al;* (1981) the soil reaction was acid. Such P^H condition of the soil could be attributed to the high rainfall peculiarity of the rainforest agro-ecological zone, which could leach out basic cations from the soil in the study area (Table 1). Organic carbon was 5.58 g Kg^{-1} such level of organic C could translate to correspondence low organic matter content but could sustain cassava production. This low organic C might be attributed to intensive land use in the study area. Total N content was low (0.96 g Kg^{-1}), the available phosphorus was moderate (5.75 Mg Kg^{-1}) and exchangeable bases were generally low with the following values K (0.19 Cmol Kg^{-1}), Ca (1.17 Cmol Kg^{-1}) and Mg (0.08 Cmol Kg^{-1}) (Table 1).

Post-planting soil physical and chemical properties

Changes in soil physical and chemical properties after two years as influenced by cumulative effect of cassava production under different plant population (plant spacing) are presented in table 2. Generally, the values of the bulk density were reduced after two years of putting the soil into cassava cultivation. This indicates that increase in cassava tuber formation due to increase in plant population leads to a corresponding decrease in soil bulk density in the study area. However, the highest percentage change (50.58%) for soil bulk density was recorded for cassava population at 17,689 plants per hectare (75 x 75 cm spacing) while the least value (13.95%) was recorded for cassava population at 10,000 plants per hectare (100 x 100 cm spacing). It could be deduced that the more the cassava plants per unit area of land the more the tuber formation the less the soil compact and the lower the corresponding bulk density (Table 2). There was increase in soil pH values as corresponding cassava plant population increases (Table 2). The highest percentage change (23.38%) of soil pH was recorded for cassava plant population at 17,689 plants per hectare while the lowest percentage change (0.77%) of soil pH was recorded for cassava plant population at 10,000 plants per hectare. Implication of this was that increase in cassava plant population per unit area of land leads to increase in cassava tuber formation with increase in mineralization of soil nutrients. However, the corresponding increase in microorganisms' activities in decomposing and releasing of nutrients back to the soil from plant parts could increase soil pH.

The organic carbon at the start of the study was 5.58 gKg^{-1}in 2008 (Table 1) this reduced to 4.22, 4.18, 4.07, 4.54, 3.14 and 2.64 gKg^{-1} respectively for 10,000, 11,100, 12,321, 13,333, 14,763 and 17,698 plants per hectare in 2010 (Table 2). The reduction in organic C (-24.37%) for cassava plant population of 10,000 plants per hectare and -52.69% for plant population of 17,689 plants per hectare) could be attributed to mineralization of organic matter to supply nutrients for plant uptake for growth and development (Ayanaba et al; 1976). Observations by Ayanaba et al. (1976) and Zingore et al. (2005) that organic matter content of tropical soils decline rapidly confirms the observed reduction in the organic carbon content of the soil. Total soil N was reduced from initial amount of 0.96 gKg^{-1} at the start of the study in 2008 (Table 1) to 0.75, 0.68, 0.64, 0.57, 0.51 and 0.42 gKg^{-1} respectively for 10,000, 11,100, 12,321, 13,333, 14,763 and 17,698 plants per hectare in 2010 (Table 2). Total soil N reduces from initial content before planting by -21.87% for plant population of 10,000 plants per hectare to -56.25% for plant population of 17,689 plants per hectare. The rapid decline in the soil N content in this study, confirms CIAT (1982) report that cassava depletes a large amount of N for root yield formation.

Soil available P was increased from initial amount of 5.75 $mgKg^{-1}$ at the start of the study in 2008 (Table 1) to 6.22, 6.75, 6.92, 7.54, 8.03 and 8.85 $mgKg^{-1}$ respectively for 10,000, 11,100, 12,321, 13,333, 14,763 and 17,698 plants per hectare in 2010 (Table 2). Available P was generally increased with the corresponding increased in cassava plant population. The lowest percentage change (8.17%) was recorded for cassava population of 10,000 plants per hectare while the highest value (53.91%) was recorded for plant population at 17,689 plants per hectare. Although mycorrhizal associations were not studied in this experiment, studies have shown that cassava roots form an association with mycorrhiza which allows for an increased surface area through which diffusion of P into the roots could take place (Howeler, 2001; Howeler and Sieverding, 1983). Exchangeable K was generally reduced from initial amount of 0.19 $cmolKg^{-1}$ at the start of the study in 2008 (Table 1) to 0.13, 0.11, 0.08, 0.05, 0.04 and 0.02 $cmolKg^{-1}$ respectively for 10,000, 11,100, 12,321, 13,333, 14,763 and 17,698 plants per hectare in 2010 (Table 2). Exchangeable K was generally reduced after two years of putting the soil into cassava production under different plant population. The percentage changes of -31.59, -42.11, --57.89, -73.95, -78.95 and -89.47% were recorded for 10,000, 11,110, 12,321, 13,333, 14,763 and 17,689 plants per hectare respectively. Howeler and Cadavid (1983) reported of similar significant reduction in soil exchangeable K after 12 months of crop growth and attributed it to plant uptake as well as to leaching and soil erosion. Ca and Mg contents were increased after two years of putting the soil into cassava production under different plant population (Tables 1 and 2). The observed general increase in the Mg status of the soil could be attributed to release of Ca and Mg from the cassava leave litter that was deposited on the soil surface (Pellet and El-Sharkawy, 1997).

Soil properties to cassava yield parameters

There were no significant ($P < 0.05$) differences among the various cassava plant population for average number of tuber per plant, average tuber diameter, and average tuber weight in 2008 and 2009 (Tables 3 and 4). In both years of experimentation, there were significant ($P < 0.05$) differences in fresh cassava tuber yield. The fresh cassava tuber yield of 22.3, 23.8, 24.2, 25.2, 27.6 and 32.4 tha^{-1} respectively for 10,000, 11,100, 12,321, 13,333, 14,763 and 17,698 plants per hectare in 2008 (Table 3) and 19.2, 20.4, 21.4, 23.0, 25.7 and 27.3 tha^{-1} respectively for 10,000, 11,100, 12,321, 13,333, 14,763 and 17,698 plants per hectare in 2009 (Table 4) were recorded. The significantly highest fresh cassava tuber yields 32.4 and 27.3 t^{-1} for 2008 and 2009 respectively were obtained given by plant population under 17, 689 plants per hectare.

The negative and significant relationship between soil bulk density of the soil of the study area indicates that increases cassava tuber formation leads to a corresponding decrease in bulk density. However, the negative correlation of bulk density to tuber yield indicates that the more the tuber formation the less compact the soil becomes (Table 5). Similar result was obtained by Gbadegesin (1996) who worked on soils of savanna belt of South-Western Nigeria using maize yield parameters. The positive and significant correlation between soil pH and the tuber suggests the increase of cassava tuber formation due to plant population increases the soil pH. The implication of this relationship is that at low pH values, there is tendency to have low tuber yield occasioned by low mineralization. Organic C, total N and exchangeable K positively and significantly correlated with tuber yield, as increase in tuber formation exert proportional increase in uptake of these minerals from the soil. A number of studies have reported similar results see for instance studies by Gbadegesin (1996) and Odjugo (2007) similar results relating cassava tuber in savanna belt of South-western Nigeria and some oil producing communities in Delta Sate and its environs.

CONCLUSION AND RECOMMENDATION

The study reveals that variation in cassava plant population (plant spacing) influenced soil properties and cassava tuber yield. The reduction in the nutrient content of the soil cannot exclude the possibility of putting the soil into maximum use for cassava production. The soil could be made productive in terms of crop cultivation if proper management systems such as application of organic and inorganic fertilizers could be adopted. Hence, from this experiment, the spacing treatment for cassava at 75 x 75 cm (17,689 plants per hectare) gave the significantly higher tuber yield than the conventional spacing 100 x 100cm (10,000 plants per hectare). The recommendation is that farmers who are interested in commercial cassava tuber production should adopt 75 x75 cm spacing.

Table 1: Initial soil chemical and physical characteristics of the 0 – 20 cm layer of the soil before planting the cassava in 2009.

Parameters	Orin Ekiti Pre-planting
Physical parameters	
Sand (%)	72.1
Silt (%)	18.1
Clay (%)	9.8
Bulk Density (mg/m^{-1})	1.72
Chemical properties	
pH (H20)	5.22
Org. C (g/kg^{-1})	5.58
Total N (g/kg^{-1})	0.96
Avail. P. (Mg/kg^{-1})	5.75
Exchangeable Bases (cmol kg^{-1})	
K	0.19
Ca	1.17
Mg	0.08

Table 2: Changes in soil chemical characteristics as influenced by cassava population density at Orin Ekiti

Parameters	100cm x 100cm (10,000 pits/ha)		100cm x 90cm (11,110 pits/ha)		90cm x 90cm (12,321 pits/ha)		100cm x 75cm (13,333 pits/ha)		90cm x 75cm (14,763 pits/ha)		75cm x 75cm (17,689 pits/ha)	
	Post plant analysis	***Change in soil chemical status (%)**	**Post plant analysis**	***Change in soil chemical status (%)**	**Post plant analysis**	***Change in soil chemical status (%)**	**Post plant analysis**	***Change in soil chemical status (%)**	**Post plant analysis**	***Change in soil chemical status (%)**	**Post plant analysis**	***Change in soil chemical status (%)**
Bulk Density (mg/m^{-1})	1.48	13.95	1.42	17.44	1.35	21.51	1.12	34.88	1.02	40.69	0.85	50.58
pH (H20)	5.18	-0.77	5.13	-1.72	5.88	0.66	6.35	21.65	6.48	24.14	6.44	23.38
Org. C (g/kg^{-1})	4.22	-24.37	4.18	-25.09	4.07	-27.06	3.54	-36.56	3.14	-43.73	2.64	-52.69
Total N (g/kg^{-1})	0.75	-21.87	0.68	-29.17	0.64	-33.33	0.57	-40.62	0.51	-46.87	0.42	-56.25
Avail. P (Mg/kg^{-1})	0.22	8.17	6.75	17.39	0.92	20.35	7.54	31.13	8.03	39.65	8.85	53.91
K ($cmol/kg^{-1}$)	0.13	-31.58	0.11	-42.11	0.08	-57.89	0.05	-73.68	0.04	-78.95	0.02	-89.47
Ca ($cmol/kg^{-1}$)	2.06	76.06	2.34	100	2.44	108.54	2.43	107.69	2.77	136.75	2.95	152.99
Mg ($cmol/kg^{-1}$)	1.12	3.70	1.18	9.26	1.24	14.81	1.67	54.62	1.72	59.26	1.87	73.15

* = Final – Initial soil property x 100%.

Table 3: Yield and yield components of Cassava as influenced by population density at Orin Ekiti in 2008

Plant spacing (cm)	Estimated plant population density per hectare	Average number of tubers per plant	Average tuber diameter (cm)	Average tuber weight (g)	Fresh tuber weight per hectare (t/ha)
100 X 100	10,000	5.54	5.7	611.5	23.8
100 X 90	11,110	5.45	5.1	687.6	23.5
90 X 90	12,321	5.28	5.2	625.6	24.2
100 X 75	13,333	5.22	5.2	667.3	25.2
90 X 75	14,763	5.64	5.7	625.1	27.6
75 X 75	17,689	5.11	5.3	666.7	32.4
	LSD (0.05)	NS	NS	NS	3.7

NS= Non Significant

Table 4: Yield and yield components of Cassava as influenced by population density at Orin Ekiti in 2009

Plant spacing (cm)	Estimated plant population density per hectare	Average number of tubers per plant	Average tuber diameter (cm)	Average tuber weight (g)	Fresh tuber weight per hectare (t/ha)
100 X 100	10,000	5.20	4.4	508.7	21.9
100 X 90	11,110	5.45	4.8	578.5	20.4
90 X 90	12,321	5.68	5.9	521.3	21.4
100 X 75	13,333	5.82	4.9	562.5	23.0
90 X 75	14,763	5.39	4.5	523.5	25.7
75 X 75	17,689	5.11	4.3	592.5	27.3
	LSD (0.05)	NS	NS	NS	1.2

NS= Non Significant

Table 5: Summary of multiple regression results with cassava tuber yield as dependent variable in Orin Ekiti in 2008 and 2009.

Independable variables	Regression coefficient	Standard error of coefficient	Correlation coefficient (R)
Bulk density	-68.45	55.24	-0.67*
pH	142.17	253.33	0.53*
Organic C	22.64	43.64	0.51*
Total N	-3.76	4.44	-0.51
Available P			
Exchangeable K	525.24	923.22	0.56*
Mg	-1,24	3.76	-0.64
Ca	-0.62	0.65	0.83*

*= 5% level (95 percent)

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