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Full Length Research Paper

Yield Performance of Five Cassava Genotypes under Different Fertilizer Rates

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Introduction of improved cassava varieties may require proper fertilizer management for increased and sustained root production. A factorial experiment involving five cassava genotypes and four levels of fertilizer with three replications was established at the Council for Scientific and Industrial Research (CSIR)-Crop Research Institute, Fumesua near Ejisu, Ghana (6^{0}43'00'N and 1^{0}28'0"W). The five cassava genotypes (Debor, Afisafi, Tuaka, Afebankye and Sisipi 290) were fertilized with NPK at the following rates:- F_0: 0 N – 0 P_2O_5 – 0 K_2O kg/ha (Control), F_1: 60N – 30 P_2O_5 – 90 K_2O kg/ha (Low), F_2: 120N – 60 P_2O_5 – 180 K_2O kg/ha (Medium) and F_3: 180N – 90 P_2O_5 – 270 K_2O kg/ha (High). The two trials were conducted from 9th September 2007 to 17th September 2008 and 22nd May 2009 to 22nd July 2010. Fertilizer significantly ($P < 0.05$) increased tuber yields. Fresh tuber yields of all the genotypes except Afisafi and Sisipe 290, generally, increased with increasing rates of fertilizer application. Whereas fresh root yields of Debor increased with increasing rates of the fertilizer up to the maximum rate (F_3), yield reductions of Tuaka, Afisafi and Sisipe also occurred at this rate. All the genotypes gave similar root yield except Sisipe 290 which produced significantly lower root yield. Interaction between genotypes and fertilizer was significant. Fresh root yields of Debor, Tuaka and Afebankye were significantly ($P <$ 5%) higher over the control at the lowest rate (F_1). The economic rate of fertilization for higher fresh root yield of all other genotypes except Debor is F_1. Sisipe 290 had the highest starch content at the F_1 fertilizer treatment. For higher fresh root yields, 60N – 30 P_2O_5 – 90 K_2O kg/ha (F_1), 120N – 60 P_2O_5 – 180 K_2O kg/ha (F_2) and 180N – 90 P_2O_5 – 270 K_2O kg/ha (F_3) are recommended for Afebankye and Tuaka, Afisafi and Debor respectively. With regards to starch content, 60N – 30 P_2O_5 – 90 K_2O kg/ha (F_1) rate is recommended for Debor, Afisafi and Sisipe 290, while F_2: 120N – 60 P_2O_5 – 180 K_2O kg/ha for Tuaka.

Key word: Cassava genotypes, fertilizer rates, fresh root yields, starch content

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is one of the important crops in Ghana. The importance of the crop to many in the country is epitomized in its Ewe name "*Agbele*", meaning "there is life'. The production and worldwide trend is positive over the years and its production level had increased by 12.5% between 1988 and 1990 with Nigeria the largest producer in the world (PPMED, MOFA, 1995).

Cassava occupies an important position in Ghana's agricultural economy and contributes about 46% of the agricultural GDP of the country. Cassava accounts for a daily calorie intake of 30% by Ghanaians and is grown by most farming family (PPMED, MOFA, 1995).

In terms of quantity, produced, cassava is the most important crop in Ghana followed by yams and cocoyams, ranking second to maize in terms of area of production (Al-Hassan, 1991). Yields of over 30t/ha is achievable in Ghana if recommended technologies for the crop is fully adopted (Issaka et al., 2007; MOFA, 2003).

Cassava is tolerant to long periods of drought and does well even on poor soils as well as low or unpredictable rainfall conditions. Fertilizer application is rarely done on the crop to replenish nutrients mined from the soil during

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cultivation. This is because farmers are content with their minimum yields obtained from using limited inputs or even from their infertile soil. The indifference towards low productivity can be attributed to the low and unstable prices of cassava tubers (Agbaje and Akinlosotu, 2004).

Research in Nigeria has shown that the crop yield can be increased and even maintained for many years with adequate fertilizers or manures. To achieve the yield potential of cassava, good soil fertility and adequate fertilization is essential (Gomez et al., 1980; Wilson and Ovid, 1994; Howler, 1996; Agbaje and Akinlosotu, 2004; Issaka et al., 2007).

The major nutrients required by cassava for optimum top growth and tuber yields are nitrogen (N) and potassium K (Ogbigbesan and Fayemi1976, Howler, 1991). Soils that have low N (< 0.10% total N) and K (< 0.15 meq/100g) will require an additional fertilizer for optimum tuber yield (Kang and Okeke, 1991). Adequate K levels in soil stimulate response to N fertilizers but excess amount of both nutrients leads to luxuriant growth at the expense of tuber formation (Sanchez 1976, Onwueme and Charles 1994, Wilson and Ovid 1994)

The introduction of improved cultivar for both domestic and industrial purposes is one of the most effective and cost-efficient means of enhancing crop productivity and farmers' incomes (Kueneman, 2002). However, ensuring sustainability of production of improved cultivar in farmers' field requires agronomic packages based on sound scientific principles. Soil fertility management on small farms in the tropics has become a major crop production issues, as a result of continued land degradation and rapid population growth (FAO, 1981). External nutrient inputs are essential to improve and sustain crop production of these soils (Hossner and Juo, 1999).

Ghanaian soils are inherently low in fertility and their restoration over the years after long periods of exhaustion is by bush fallowing for 10 or more years. With the rising growth in population and its associated pressure on land resources, cropping systems have become both permanent and continuous (Asamoah 1990). The introduction of high yielding varieties with higher demand for plant nutrients will aggravate the soil fertility problems. As to whether these newly introduced varieties will respond to the current fertilizer levels and cropping system is unknown. Hence, the need to upgrade the existing fertilizer recommendations in the country is imperative. However, judicious fertilizer use with minimum polluting effects on the environment must be the major rule. Sarfo et al., (1998) noted that, for most crops, the best fertilizer types, rates and time of application are not known and that this constitutes a major constraint to fertilizer use in the country. They also noted that mineral fertilizers are scarcely used because of their prohibitive high prices.

It is therefore the objectives of this study to 1) evaluate the yield performances of five cassava genotypes under four rates of mineral fertilizers and 2) establish the optimum rate of fertilizer application for these genotypes.

MATERIALS AND METHODS

A factorial experiment comprising two factors, Fertilization (4 levels) and Genotypes (5 types) arranged in a Randomized Complete Block Design (RCBD) with 3 replications was used. The trial was installed at the Council for Scientific and Industrial Research (CSIR)-Crops Research Institute, Fumesua, near Ejisu-Kumasi ($6^0$43'00'N and $1^0$28'0"W), Ghana. Two trials were conducted from 9^{th} September 2007 to 17^{th} September 2008 and 22^{nd} May 2009 to 22nd July 2010. The four fertilizer rates were (viz F_0: 0 N – 0 P_2O_5 – 0 K_2O kg/ha(Control), F_1: 60N – 30 P_2O_5 – 90 K_2O kg/ha - Low, F_2: 120N – 60 P_2O_5 – 180 K_2O kg/ha - Medium and F_3: 180N – 90 P_2O_5 – 270 K_2O kg/ha – High) were applied to the following 5 genotypes: Debor (G_1), Afisiafi (G_2), Tuaka (G_3), Afebankye (G_4) and Sisipe (G_5).

Bankye wura (23 – 17 - 16) a fertilizer formulated by WIENCO Ghana Limited was used as basal and top dressed with Urea, Triple Superphosphate and Muriate of potash.

A plot size measuring 5.0 m x 4.0m was adopted for each treatment. First fertilizer application was done at 5 weeks after planting (WAP) followed by a top dressing at 5 months after planting (MAP).

Soils samples were taken from depths of 0 – 20 cm before fertilizer application and also at harvest for routine analysis. Statistical analysis was done using StatView 5.0.1 soft ware.

RESULTS AND DISCUSSION

Soil Properties

Interpreted physico-chemical property data of soil at the experimental site as contained in Table 1 revealed that the soil has sandy loam texture and moderately acidic. Although these two properties are suitable for the growth of the cassava crop, all other major chemical properties analyzed for, such as total nitrogen (N), available P and K and organic carbon are low (Anonymous, 2010). This is an indication of low fertility and therefore the crop is likely to respond to fertilizer application as reported by Kang and Okeke (1991). Though differences in these soil fertility parameters were observed between the two cropping cycles, the results were not significantly different. This suggests that soil nutrient mining by the crop was minimal.

Fresh root yield

Significant differences ($p < 0.05$) in fresh root yields were observed between genotypes with Afebankye giving the highest fresh root yield and Sisipe 290 the lowest (Table 2). The root yields observed for Debor, Afisafi, Tuaka, Afebankye were not significantly ($p > 0.05$) different, but were all significantly ($p < 0.05$) higher than in Sisipe 290. Fertilization resulted in higher root yields in the fertilized plots than the control. This observation supports the

Table 1: Changes in physico-chemical properties of soil from 0-20cm depths.

Soil Properties	Cycle 1		Cycle 2		Rating
	Initial	Harvest	Initial	Harvest	
Sand (%)	73	74	75	75	Sandy loam
Silt (%)	13	14	12	14	
Clay (%)	14	12	13	11	
pH	6.49	6.44	6.44	6.47	Moderately acid
EC (dS/m)	0.07	0.06	0.06	0.04	Non-saline
Total N (%)	0.08	0.07	0.07	0.05	Very low
Available P (mg/kg)	1.71	1.65	1.62	1.6	Very low
Available K (mg/kg)	69.66	71.22	69.7	70.7	Low
Organic carbon (%)	1.17	1.04	1.04	0.93	Low

Table 2: Yield and yield components of cassava genotypes as influenced by fertilizer rates.

Genotypes	Root yield (t/ha)	Root No./plt (n)	Mean Tuber wt (kg)	Stover weight (t/ha)	% Root Rot	Starch Content (%)
Debor	**41.78**	**6.99**	**0.73**	**56.39**	**6.57**	**21.61**
Afisafi	**39.29**	**6.75**	**0.67**	**54.28**	**12.19**	**24.10**
Tuaka	**41.71**	**6.25**	**0.64**	**62.39**	**7.63**	**22.70**
Afebankye	**44.20**	**6.67**	**0.61**	**53.49**	**8.00**	**22.08**
Sisipe 290	**30.00**	**6.75**	**0.71**	**61.62**	**20.83**	**24.66**
Fertilizer rates						
F0	**31.46**	**5.5**	**0.63**	**45.83**	**8.39**	**21.74**
F1	**39.89**	**7.1**	**0.69**	**55.54**	**9.79**	**23.28**
F2	**43.39**	**6.8**	**0.69**	**61.54**	**11.20**	**23.69**
F3	**42.83**	**7.3**	**0.66**	**67.35**	**14.79**	**22.59**
Lsd=0.05						
Genotype (G) =	**6.31**	**NS**	**NS**	**6.26**	**13.35**	**1.67**
Fertilizer (F)	**5.64**	**0.86**	**NS**	**6.99**	**NS**	**1.5**

findings of many authors (Gomez et al., 1980; Wilson and Ovid, 1994; Howler, 1996; Agbaje and Akinlosotu, 2004; Issaka et al., 2007) who obtained higher root yield when fertilizer was applied. Interactions between genotypes and fertilizer rates are presented in Figure 1. Fresh tuber yields generally, increased in all genotypes with increasing rates of fertilizer application up to F_2 (120N – 60 P_2O_5 – 180 K_2O kg/ha), and thereafter declined for Tuaka, Afisan and Sisie 290. However, yields of Debor and Afebankye increased linearly up to the highest rate of fertilization F_3 (180N – 90 P_2O_5 – 270 K_2O kg/ha). . The yield reductions observed were 7.0%, 8.1% and 34.9% for Afisafi, Tuaka and Sisipe 290 respectively. However, the economic rate of the fertilizer application (Figure 2) for all genotypes was 60N – 30 P_2O_5 – 90 K_2O kg/ha (F_1).

Number of root per plant

Number of roots per plant (Table 2) was not significantly

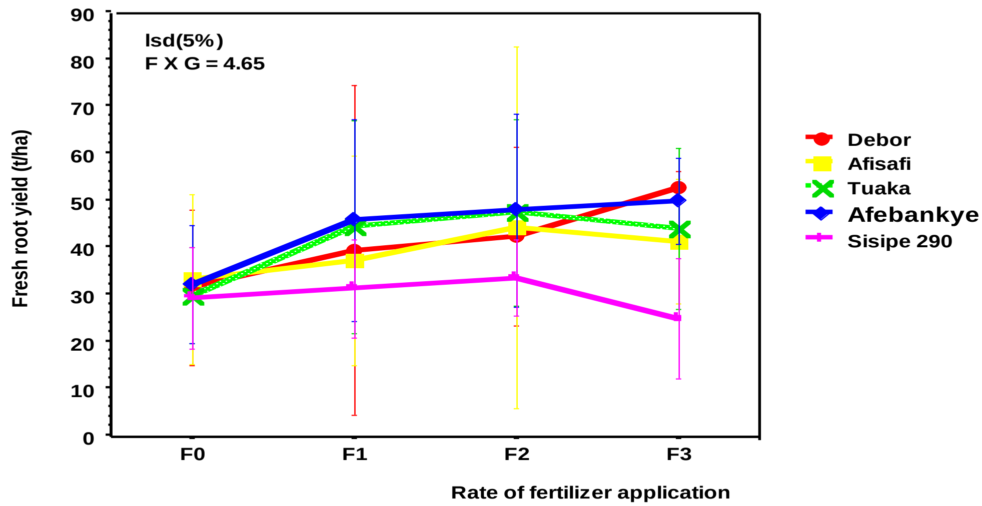

Fig. 1: Fresh root yield of genotypes as influenced by different rates of fertilizer.

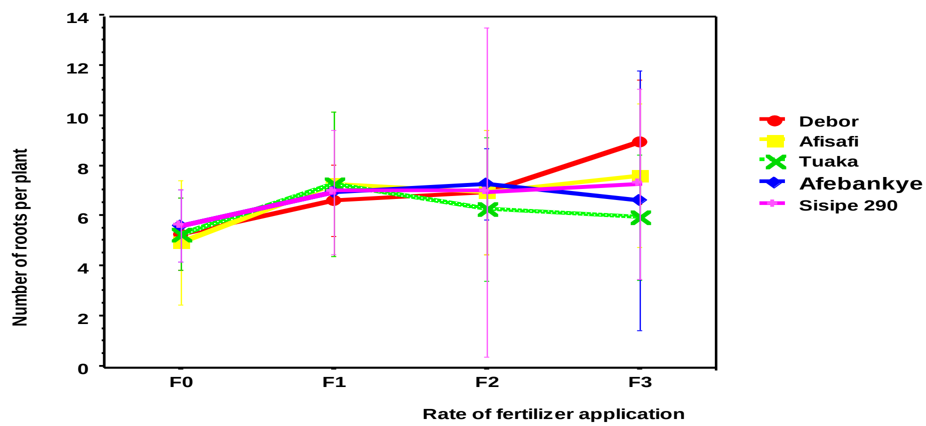

Fig. 2: Number of roots per plant of genotypes as influenced by different rates of fertilizer.

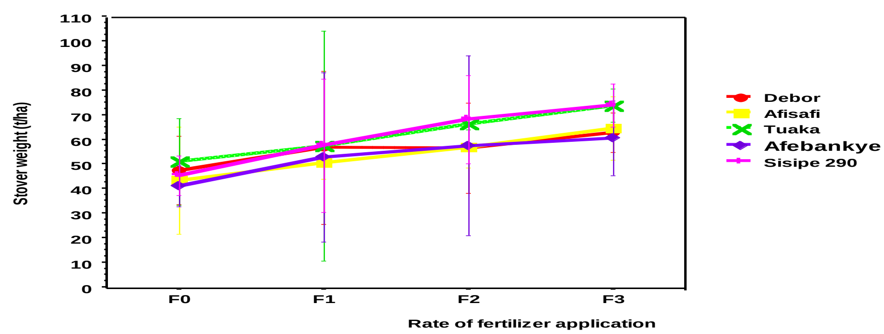

Fig. 3: Stover weight of genotypes as influenced by different rates of fertilizer.

influenced by the genotype but by the fertilizer rates with all rates of fertilizer applied treatments significantly ($p < 0.05$) out numbering the control (F_0: 0-0-0 kg/ha). Number of roots per plant of all genotypes (Fig. 2) increased significantly with the lowest rate of fertilizer (F_1: 60N – 30 P_2O_5 – 90 K_2O kg/ha) over the control. With the exception of Tuaka which showed decreasing number of roots after this rate up to the F_3 (180N – 90 P_2O_5 – 270 K_2O kg/ha), all other genotypes had theirs slightly increasing up to F_2. While number of root per plant of Debor, Afisafi and

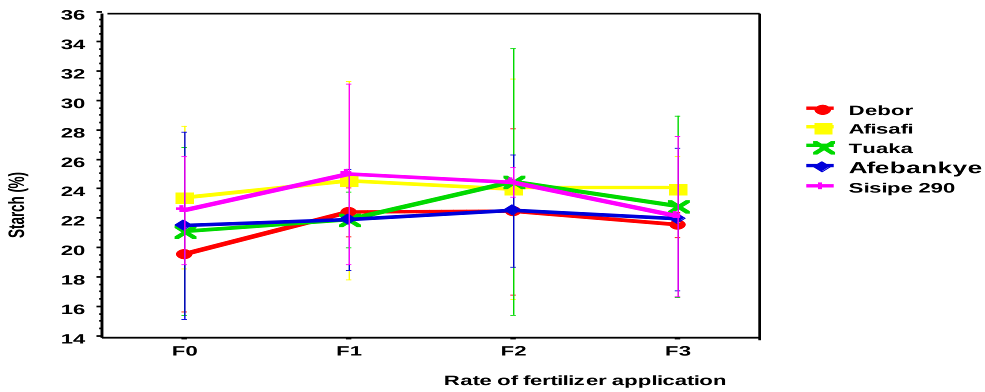

Fig. 4: Percent starch of varieties as influenced by different rates of fertilizer.

Sisipe 290 increased by 22.2%, 8.7% 4.5% respectively, at F_3, those of Tuaka and Afebankye decreased by 5.5% and 9.9% respectively.

Mean root weight

Neither genotype nor fertilizer application significantly influenced mean root weight of the crop (Table 2), suggesting that mean root weight under the fertilizer regimes had no influence on the fresh root yields of the genotypes.

Stover weight

Stover weight was significantly influenced by both genotype and fertilizer rates, with Tuaka being the highest and Sisipe, Debor, Afisafi and Afebankye following in that order. Fertilizer application also significantly increased stover yields as compared to tuber yield of Tuaka and Sisipe indicating that there was luxuriant top at the expense of tuber growth (Table 2 and Figure. 3). This findings thus corroborate that of Sanchez (1976) and Agbaje and Akinlosotu (2004).

Percent root rot

Across genotypes, the highest and lowest root rot were observed in Sisipe 290 (20.8%) and Debor (6.4) respectively (Table 2). Fertilizer application did not significantly influenced root rot of the genotypes. The low root rot observed in Debor s attributable to its high root yield while the high rot in Sisipe 290 is due to its low root yield as reported by Agbaje and Akinlosotu (2004).

Percent starch content

Significant differences in starch content were observed between the various genotypes and fertilizer rates over the control (F_0: 0-0-0 kg/ha) with Sisipe 290 showing the highest and Debor the lowest (Table 2). The highest starch content observed among the genotypes was in Sisipe 290 and this occurred at the F1 fertilizer treatment**.** Furthermore, the optimum fertilizer rate for higher starch production for Debor, Afisafi, Afebankye and Sispe 290 was 60N – 30 P_2O_5 – 90 K_2O kg/ha (F_1) fertilization. On the other hand, 120N – 60 P_2O_5 – 180 K_2O kg/ha (F_2) was the optimum rate of fertilizer application for higher percent starch content for Tuaka and Afebankye (Figure. 4). In conclusion, the study revealed that the economic rate of fertilization for higher fresh root yield for all the genotypes except Debor (120N – 60 P_2O_5 – 180 K_2O kg/ha (F_2) was F_1 (60N – 30 P_2O_5 – 90 K_2O kg/ha). For higher percent starch yield, 60N – 30 P_2O_5 – 90 K_2O kg/ha (F_1) is recommended for Debor, Afisafi and Sisipe 290, while 120N – 60 P_2O_5 – 180 K_2O kg/ha (F_2) is recommended for Tuaka and Afebankye.

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