Effect of inorganic mineral nutrition on tuber yield of cassava (*Manihot esculenta* Crantz) on marginal ultisol of South Eastern Nigeria

Accepted 29th July, 2013

ABSTRACT

The paper examines the effect of Nitrogen, Phosphorus and Potassium (NPK) fertilizer treatment on tuber yield of cassava (*Manihot esculenta* Crantz), and attempts to develop optimum fertilizer rate for maximum yield to propel cassava from poverty alleviator to industrial crop and ensure sustainability in cassava production. The field trial was conducted at the research farm of the Botanical Garden, Abia State University, Uturu. Fertilizer was applied both in single application as well as, in combination. Cassava genotype of NR8082 was planted at the field density of 10,000 plants/ha and the rate of fertilizer application were 0, 200, 300, 400 kg/ha. The data obtained were subjected to Analyses of Variance (ANOVA) using the Genstat Discovery Edition 3. Level of significance was determined at 5% probability. The results showed that inorganic fertilizer significantly affected the tuber yield of cassava both in single application and in NPK fertilizer combination. The results also showed that inorganic fertilizer enhanced tuber yield as plots not treated with fertilizer produced lower tuber yield. Under high soil nutrient status, appreciable yield was obtained and the productivity of the system was high and encouraging to farmers. The most appreciable yield was obtained with 300 kgN/ha in single application and 300 kgN/400 kgP/200 kgK/ha in combination producing 39.5 t/ha. This implicates the importance of NPK fertilizer in enhancing tuber yield of cassava as plots not treated with fertilizer consistently produced lower tuber yield.

Key words: Treatment, fertilizer, tuber yield, productivity, rate.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is an important staple food for millions of people in the humid and sub-humid tropics, as it supplies about 70% of the daily calorie intake of over 50 million Nigerians in growing areas (Ugwu et al., 1990).

Cassava is the principal source of calories for more than 500 million people from mainly poor population of the tropical region (Henry, 1992). As a staple food, it is the sixth most important crop worldwide (Mann, 1997). Cassava plays an important role underpinning food and economic security in many of the world’s least developed and food deficient countries (Thro et al., 1999). In many cassava growing areas, its use as food helps to alleviate problems of hunger and carbohydrate intake deficiency. Thus, this underscores the importance of cassava in terms of food security in these areas.

Agriculture is expected to feed an increasing population forecasted to reach 8 billion by 2020 (Izquierdo, 2000), out of which 6.7 billion come from developing countries where the capacity of agricultural land has reached.

Nigeria is at present the largest producer of cassava in the world. The annual yield production per hectare increased in...
1978 from 12 to 33 million t/ha, ranking Nigeria first in the world production. Currently, the total harvested crop in 2003 was 21 million hectares with an average yield of about 11 t/ha. In 2006, its total production was about 34 million metric tonnes per hectare. In Nigeria, cassava production is far the largest in the world, a third more than production in Brazil and almost double the production in Indonesia and Thailand (FAO, 2002), with estimated production in Nigeria to be approximately 34 tonnes per hectare (FMARN, 2003).

In Nigeria, in spite of the abundance of natural resources and continued investment in development, rural poverty and food security have persistently affected more than 55% of the rural population. These elements established the magnitude of the poverty and food security to which research in agricultural production and application of research findings in mineral nutrition in agriculture has find a way to alleviate.

The single most important factor limiting yield in African agricultural system is the intrinsically low fertility of the soil (Dakora and Keya, 1979). The low fertility of soil has made it possible for food production to be at pace with the population growth in sub-Saharan Africa. Although, cassava adapts to low fertility of the soil, the soil is the most important limiting factor essential for agricultural production in the humid tropics (Okigbo, 1989). This is because the soil presents formidable problems to sustainable agricultural development due to its associated fertility constraints (Ezuma and Lawson, 1989).

Cassava is one of the major crops in Nigeria and the crop responds favorably to applied nutrition (Kaenathuma et al., 1993). In traditional system, cassava is usually grown without the application of fertilizers. However, to produce high yield, the crop does require large supplies of nutrient, and this requirement can be met through the use of fertilizers as cultivation of cassava without fertilizer input in Vietnam reduced yield from 9 to 7 t/ha (Cong and Deluberk, 1998). This gradual decline was attributed to nutrient depletion of the soil. Cassava adjust its rate of growth to the nutrient supplying ability of the soil, maintaining a level of productivity that can be sustained by the nutrient supplying power of the soil (Fulton, 1996) as the fertility of the soil affects the yield levels obtained (Howler, 1985).

To advance to high level of production is a function of area and yield (FAO, 2004). Thus, an enormous intervention effort is required to propel cassava yield from current trend, hence, increasing yield is a significant challenge for researchers and push factor such as better nutritional package to increase yield is important. Thus, the proper level of fertilization and the correct balance of nutrient applied are of utmost importance if cassava is to be elevated from poverty alleviator to industrial crop.

Nutrient seldom reacts independently, interacting with each other instead (Howler et al., 1977). Thus, the proper level of fertilization and the correct balance of nutrient applied is of utmost importance to enhance yield if the crop is to fully benefit from major advances occurring in genomic era. As production has not been impressive, efforts aimed at exploiting and packaging better nutritional requirement that will enhance production and bring benefits to cassava producers is the focus of this research.

**MATERIALS AND METHODS**

The experiment was conducted at the Abia State University Botanical Garden, latitude 5° 45’N and longitude 7° 5’E. It situates between Okigwe and Isuikwuato and marginal ultisol is the predominate soil in the garden.

The planting material was improved cassava variety NR 8082 sourced from NRCRI, Umudike Umuahia, Abia State. Cassava stem six months old was used to enable vigorous sprouting. Land preparation was done by slash and burn; trashes were removed before ploughing into ridges (30 cm height) manually. The planting distance was 1 × 1 m apart and the plant population was 10,000 plants /ha. The plot was planted with 2/3 of stake buried in already prepared ridges with buds facing upwards.

The cassava was harvested at the 12th month after planting. Harvest was carried out when the soil was not too dry to avoid damage of roots. To harvest, the stem was cut 20 cm above the soil level and the soil was dug 60 cm × 60 cm depth to pull out the roots. The roots / tubers were detached and weighed using a weighing balance.

**Experimental design**

Experimental design incorporated Randomized Complete Block Design (RCBD) with three replications. The treatments are NPK single application in the rates of 0, 200 and 300 and 400 kg/ha and in combination of NPK. The data obtained were subjected to Analysis of Variance (ANOVA) to obtain the level of significance at p<0.05 using Genstat Discovery Edition 3 and least significant differences were obtained using Least Significant Difference (LSD) test.

**RESULTS**

Figure 1 shows the effect of nitrogen, phosphorus and potassium fertilizer treatment on tuber yield. Analyses of variance on the data obtained at p<0.05 showed significant treatment effect on tuber yield of cassava and significant differences between treatments were also obtained. The tuber yield of fertilizer rate of 300 kgN/ha was significantly different from those of 400 and 200 kgN/ha respectively as well as the control. At the end of the harvest period, tuber yield of plants of 300 kgN/ha has the highest tuber yield of (25.29 t/ha), while the control had the least (4.63 t/ha).

Effect of phosphorus fertilizer on tuber yield of cassava
also shows significant effect of treatment as well as, significant differences between treatments means. Tuber yield of plants treatment with phosphorous rate of 300 kgP/ha was significantly different from those of other treatments. At the end of the treatment, plots treated with phosphorous fertilizer treatment enhanced tuber yield as the fertilizer rates of 400 kgP/ha produced the highest (30.76 t/ha) while the control produced the least.

Results on effects of potassium treatment on tuber yield of cassava analyzed at p<0.05 indicated that there was significant effect of potassium fertilizer on tuber yield after treatment. Tuber yield of plots treated with potassium rate of 300 kgK/ha was significantly different from those of other treatments. Although, tuber yield of plots treated with fertilizer rate of 300 kgK/ha and 400 kgP/ha did not differ significantly, but they differed significantly from the control 0kg/ha. At the end of the treatment, plots treated with fertilizer rate of 300 kgK/ha produced the highest (19.58 t/ha), while the least was observed for the control 0 kg/ha (2.26 t/ha).

Evaluation of NP fertilizer treatment combination is shown in Figure 2. Significant effect of treatment on tuber yield was obtained as well as, significant differences between treatments. Tuber yield of plots of fertilizer rate of 200 kgN/400 kgP/ha was significantly different from those of 400 kgN/200 kgP/ha. Plants of fertilizer rate of 300 kgN/300 kgP/ha produced the highest tuber yield of 37.49 t/ha, while the control had the least (2.26 t/ha). Also, results of treatment effect of NK fertilizer treatment combinations showed significant treatment effect on tuber yield of cassava and significant differences between treatments were also obtained (Figure 3). Tuber yield of plants of fertilizer rate of 300 kgN/200 kgK/ha differed significantly from those of 400 kgN/200 kgK/ha and those of 400 kgN/300 kgK/ha. Tuber yield of plants treated with fertilizer rate of 300 kgN/400 kgP/ha produced the highest (30.31 t/ha), while the control produced the least (2.26 t/ha).

Statistical analyses of the data obtained at p<0.05 on the effect of PK treatment combinations on tuber yield is shown in Figure 4. Significant differences between treatments were also obtained. Tuber yield of plants of fertilizer rate of 400 kgP/300 kgK/ha was significantly different from those of fertilizer treatment of 200 kgP/300 kgK/ha, while tuber yield of plants of fertilizer rate of 400 kgP/400 kgK/ha was significantly different from those of 400 kgP/200 kgK/ha. At the end of the growth period, plants treated with fertilizer rate of 300 kgP/400 kgK/ha produced the highest
tuber yield of 31.09 t/ha, while the control had the least (4.82 t/ha).

Evaluation of the result at p<0.05 showed significant treatment interaction of NPK fertilizer on tuber yield of cassava. Significant differences between treatments were also obtained. Tuber yield of plants of fertilizer rate of 200 kgN/400 kgP/200 kgK/ha was significantly different from those of fertilizer rate of 200 kgN/300 kgP/400 kgK/ha, while tuber yield of fertilizer rate of 200 kgN/300 kgP/200 kgK/ha was not significantly different from those of fertilizer rate of 200 kgN/200 kgP/400 kgK/ha. Tuber yield of plots of fertilizer rate of 300 kgN/400 kgP/200 kgK/ha produced the highest (39.50 t/ha) while the control was the least (2.66 t/ha) (Figure 5).

**DISCUSSION**

Cassava is one of the most important crops in Africa as its starchy thickened tuberous roots are a valuable source of cheap calories especially in developing countries where calories are deficient and malnutrition are widespread.
Figure 4. Effect of Pk fertilizer application on tuber yield of cassava (*Manihot esculenta* Crantz).

Figure 5. Effect of NPK fertilizer application on tuber yield of cassava (*Manihot esculenta* Crantz).
The performance of any crop is usually affected by the properties of the soil in which the crop is grown and this is consistent with the result of this experiment, as the performance of the cassava plants were enhanced by soils that were enriched by fertilizer treatment.

The result of the effect of nitrogen fertilizer on tuber yield showed that N fertilization significantly enhanced tuber yield and plots not treated with N fertilizer performed poorly. This result is consistent with the result of Obigbesan (1980) who showed that nitrogen fertilizer increased the photosynthetic apparatus of the leaves and thereby, enhanced root yield. There was a gradual increase in tuber yield as N fertilizer application increased.

However, there was a negative response of cassava to high N fertilizer application as the tuber yield decreased with higher application of N fertilizer (400 kgN/ha). This result corroborates with the findings of Ngongi (1976) who reported a negative response of cassava to high N application as the plant produced excessive foliage and little roots. The investigation revealed that excessive nitrogen inhibits tuber yield in cassava.

It was surprising to observe that even though application of N fertilizer enhanced tuber yield, plots treated with 300 kgN/ha produced the highest tuber yield of 25.29 t/ha in single application while plots treated with 400 kgN/ha yielded (16.43 t/ha) having a lower value than the plots treated with 300 kgN/ha. It was also observed that even though plots treated with 400 kgN/ha had higher nitrogen, it did not record higher yield. This could be as a result of immediate mineralization of nitrogen after application which leads to excessive shoot growth and little yield (Ngongi, 1976).

Furthermore, the investigations showed that enrichment of the soil with nitrogen enhances tuber yield as plots treated with nitrogen fertilizer application yielded better than plots not treated with N fertilizer suggesting the importance of nitrogen in tuber yield as the total amount of roots harvested were relatively low when plants were not fertilized 4.63 t/ha, suggesting the importance of nitrogen in tuber productivity.

Higher tuber yield due to nitrogen fertilizer could be attributed to favorable changes in soil which enabled better root formation. Adequate biomass production and better nutrient uptake might have resulted in higher tuber yield consequent upon application of N fertilizer. Although, it has been generally reported that cassava respond negatively to high nitrogen fertilization, the result of this work shows that nitrogen nutrient is still one major factor limiting crop yield. This lends its credence to the work of Zhao et al. (2004).

Depending on soil N fertility, adequate supply of N to cassava is fundamental to optimizing crop yield. Although, mismanagement of N such as excessive N application can result in negative response of the crop to tuber yield as observed in this work. Therefore, N fertilizer management are essential in balancing the factors in the soil so as to obtain maximum yield in cassava plants.

Phosphorus is central to yield of cassava as the rate of growth, development and tuber yield is controlled by soil nutrients such as phosphorus. The effect of phosphorus fertilizer on tuber yield of cassava showed significant effect of P treatment. This result is in line with the findings of Krochuna and Samuels (1970) who obtained significant P treatment on tuber yield of cassava. It was observed that application of phosphorus up to 400 kgP/ha increased yield up to 30.76 t/ha, while at low rates of applied phosphorus, 200 kgP/ha yield declined to 14.50 t/ha.

However, in all, the plots treated with P produced the highest yield of cassava tubers while plot not treated with phosphorus produced lower yield of 2.26 t/ha. The result shows that lack of P in marginal ultisol was the main limiting factor for cassava yield as non-application results in low yield (Normanha, 1960; Numes et al., 1974; Siqueiro, 1973; Santana and Carvaiho, 1979). Nair et al. (1988) found that P was the main limiting nutrient for cassava yield. It was found that maximum yield was obtained with 400 kgP/ha in single although, Dicks et al. (1991) obtained maximum yield with 120 kgP/ha in a yellow podzolic soil.

On interaction, the study showed a high significant interaction of NK, PK, NP and NPK on tuber yield of cassava. This result is consistent with the findings of Fulton (1996) who showed significant yield response of cassava to NK application. It was also observed that yield increased with addition of NPK fertilizer and declined gradually without NPK fertilizer application and when NPK were applied at sufficiently high rates of applied P, the plots treated with 400 kgN/400 kgP/200 kgK/ha very high yield of 39.50 t/ha was obtained. It was also observed from the study that high application of P increased yield while yield decreased at high application of nitrogen. This effect of P has also been recorded by Schmidt et al. (1990) and Centre Tuber Crops Research Institute, CTCRI (1975), showing the importance of phosphorus in limiting tuber yield of cassava.

Potassium is essential for carbohydrate translocation from top to the roots and inadequate supply of K for cassava will thus, lead to excessive top and little root production (Obigbesan, 1976). Effect of potassium treatment on cassava yield showed a significant effect of treatment. This result agrees with the works of Bahia (1979), Numes et al. (1974), Ngongi (1976) and CIAT (1977), although, Obigbesan (1977) failed to obtain a significant response of cassava yield to application of K. Furthermore, significant differences between treatment means were also obtained. Potassium treatment enhanced cassava yield in all the treatments with the plots treated with potassium rate of 300 kgK/ha having the highest 19.58 t/ha. However, the plots not treated with K fertilizer performed poorly (2.26 t/ha).

Since cassava roots removed more potassium than any other element, K deficiency can be commonly expected in most soils. Therefore, adequate amount of K should be
applied to sustain yield. With K application even without phosphorus, yields could be maintained since K is the most crucial nutrient for maintaining long-term productivity in cassava soils. The importance of K application to cassava for maintenance of productivity has also been observed in Vietnam (Nguyen et al., 1998), and in China (Zhang et al., 1998). The study has shown that K is still one major factor limiting crop yield, and enrichment of soil with K can increase yield. This has also been obtained by Chadha (1958) who obtained yield increases up to 75%.

Treatment of cassava with PK fertilizer treatments significantly enhanced tuber yield during this investigation as plots not treated with PK fertilizer consistently showed lower yield, implicating PK as one of the most important factor in yield of cassava.

In general, the present investigation highlights the importance of nutrition in tuber yield of cassava. Since cassava is generally grown in infertile soils in southeastern Nigeria, and has a medium to high external nutritional requirements, it is clear that the application of fertilizer is essential to obtain maximum yield. Non application of fertilizer resulted in very low yield; there is need for application of adequate NPK to meet the requirement of cassava crop at critical stages of its development.

Nitrogen balance revealed that there was increasingly positive response of cassava yield to high application of NPK fertilizer. Balance of NPK application fertilizer with the application of high levels of recommended NPK of 300 kgN/400P/400 kgK/ha in different cassava based cropping systems to enhance yield lend support to the present result since low rates of NPK fertilizers resulted in low yields of 2.26 t/ha. This provided no incentive for the commercial production of cassava, hence, a comprehensive assessment of the nutrient required to produce maximum tuber yield was required for cassava grown in marginal ultisol.

The results of the investigation indicated that to increase the yield potentials of cassava, the crop responds to good soil fertility and adequate fertilizer treatment combination is required (Gomez et al., 1998; Wilson and Ovid, 1994; Howler, 1996).

**Conclusion**

Rapid improvement of cassava to meet its expanding role in developing economies will depend on better understanding of its nutritional need underlying important economic trait for which this crop is known for food security and industrial use. Development and deployment of enhanced nutrition and package therefore, remains the most important method of ensuring improved production and increase yield.

Most cassava farmers are resource poor, lacking the ability to purchase and apply agrochemicals on a regular basis. Cassava responds positively to NPK fertilizer, therefore, balanced application remains the most important method of ensuring cassava production. To enhance production, the application of mineral salts on farmer preferred cultivars is therefore highly attractive.

To increase this low cost, staple food supplies to urban consumers assuming regular source of income as well as, cheap carbohydrate to rural household who engage in agriculture and increase cassava production in marginal soil of southeastern Nigeria. Cassava farmers should apply inorganic fertilizer as it is central to yield of cassava as the rate of growth, development and tuber yield is controlled by soil nutrients and the maximize yield, hence, fertilizer rate of 300 kgN/400 kgP/200 kgK/ha is recommended.

**ACKNOWLEDGEMENTS**

Our profound gratitude must first go to the Almighty God for His grace and infinite mercies that saw us through the period of this research project. We are also grateful to Prof. (Mrs.) N. B. Onyike for her contributions to the success of this research work and also very grateful to our both families for their steadfast support during the course of this study. We cannot, but remain grateful to all my friends and well-wishers.

**REFERENCES**


Thollapilly G, Monti LM, Mohan Raj DR, Moore AW (1992). Biotechnology: Enhancing Research on Tropical Crops in Africa Technical Centre for Agricultural and Rural Cooperation (CTA) and international institute...

Cite this article as:
Submit your manuscript at http://www.academiapublishing.org/journals/ajar