# COMPLEMENTARY USE OF NPK FERTILIZER AND ZINC ON GROWTH AND YIELD OF COCOYAM IN AN ULTISOL OF SOUTHEASTERN NIGERIA

[1]Obasi, M. N., [2]Osodeke V E and [3]Asawalam D O
[1] National Root Crops Research Institute Umudike, PMB 7006, Umuahia, Abia State

E-mail: martinobasi@yahoo.com
[2 and 3] Department of Soil Science and Meteorology, Michael Okpara University of Agriculture, Umudike.

**ABSTRACT**
A study was carried out at the research farm, National Root Crops Research Institute, Sub-station Igbariam to determine the effect of NPK fertilizer and zinc on growth and yield of cocoyam. The study was a factorial type fitted into a randomized complete block design (RCBD) replicated three times. Five levels of NPK fertilizer (15:15:15) at 0, 150, 300, 450 and 600 kg $ha^{-1}$ in combination with zinc at five levels (0, 3, 6, 9 and 12 kg $ha^{-1}$) were applied as treatments. The test crop was cocoyam *Colocasia* variety (Ede ofe). Results showed that growth character such as plant height was influenced by the application of NPK fertilizer rate at 600 kg $ha^{-1}$. Application of NPK fertilizer at the rate of 450 to 600 kg $ha^{-1}$ appeared adequate for maximum tuber yield of cocoyam. Application at 600kg NPK $ha^{-1}$ and 6 kg Zn $ha^{-1}$ appeared adequate for maximum cocoyam production. However, application of NPK fertilizer rate should be based on soil test response. Integrated nutrient management strategy, using low input technology could raise the low nutrient status of the soil for sustainable cocoyam production. NPK fertilizer rate should be based on soil test response to alleviate the deleterious effect of chemical fertilizer arising from high fertilizer levels. With the application of NPK fertilizer balanced fertilizer with zinc should be adopted.

**INTRODUCTION**
Cocoyam (*Xanthosoma* sp, and *Colocasia* sp.) is an important staple food crop in the family *Araceae* cultivated in South-eastern and South-western parts of Nigeria (Ojiako *et al*., 2007). It is a food security crop variously grown by resource poor farmers, especially women who often intercrop it with yam, maize, plantain, banana, vegetables and rice (Ikwelle *et al*., 2003). Nigeria is the world largest producer with an average production figure of 5.06 mt, which accounts for about 37% of total world output (FAO 2007).

Recently, cocoyam has been brought into focus in view of its nutritive value which has increased its demand. Nutritionally, cocoyam is comparatively higher than those of other tuber crops. It has higher score for the dry matter content and total essential amino acids than other staple foods (Akomas *et al*, 1987). The starch granule of cocoyam is comparatively small and very digestible and are therefore, acclaimed total good carbohydrate source, for person with gastrointestinal disorder and diabetics (Eleje, 1987). Apart from its potential of being nutritive, cocoyam is one of the cheapest and handy carbohydrates sources that serves as a base for infant food (Ubalua and Chukwu 2008).

However, appraisal of the constraints in cocoyam production indicates that poor soil fertility management and other factors have greatly reduced the yield of this crop over the years. Moreso, soils of South Eastern Nigeria are low in organic matter and cannot sustain intensive production of cocoyam (MAFF 1990). Ano, (1998) reported that the soils are highly weathered and have low activity clays which have resulted in low crop yield. This makes the use of organic fertilizer almost mandatory to improve soil nutrient status and increase crop yield.

Previous studies show that the use of inorganic fertilizer recommendation of 60 kg N, 30 kg P and 50 kg K per hectare to achieve high cocoyam tuber yield in Nigeria farming systems has been found unstable (FFD, 2002, and Okwuowulu *et al*, 2000). Since, the application of inorganic fertilizer alone cannot sustain high crop yield, increasing interest is being directed towards the use of micronutrients (Zn in particular) as a means of increasing efficiency of crop production and improving return to the farmers. Therefore, zinc is an essential element needed in balanced amount for normal growth of plant. CIAT (1988) reported that zinc applied at 12.5 kg/ha as zinc sulphate with inorganic fertilizer increased the yield of cassava in laterite soils. While in Columbia, zinc sulphate applied at the rate of 20 kg/ha were required for maximum cassava growth and yield (Howeler *et al*., 1977).

But in the humid tropics more especially in South Eastern Nigeria, the effect of zinc in combination with inorganic fertilizer has not been investigated. Therefore, the present investigation sought to determine the effectiveness of combined use of NPK fertilizer and zinc in soils of South Eastern Nigeria using cocoyam as a test crop. Hence, the objective of this study is to determine the combine effect of inorganic fertilizer and zinc on growth and yield of cocoyam.

**MATERIALS AND METHODS**

The field experiment was conducted in 2007 and 2008 cropping seasons at the research farm of the National Root Crops Research Institute Sub-station Igbariam (Longitude $60^0$ $31^1$ N and $70^0$ $21^1$ E and Latitude $50^0$ $38^1$ E and $60^0$ $47^1$ N). The experimental site for 2007 was on an area left to fallow for two years while that of 2008 was on an area where maize was planted in 2007.

The experiment was a factorial type fitted into a randomized complete block design (RCBD) with twenty-five treatment combinations replicated three times. The treatments were NPK fertilizer (15:15:15) at 0, 150, 300, 450 and 600 kg/ha. While zinc was at 0, 3, 6, 9 and 12 kg/ha. High yielding cocoyam *colocasia* variety (Ede ofe) was used as the test crop.

The NPK and zinc fertilizer treatments were applied to the crops eight weeks after planting (8 WAP) using band application method. All growth and yield parameters were measured. These include; plant height, number of leaves, number of corms and cormels and total yield. Prior to this, pre-cropping surface soil sample was randomly collected at 0 to 20 cm depth pooled as a composite sample and allowed to dry for three days. The dry soil was sieved with 2 mm sieve. The samples were than analyzed for texture, clay, pH, organic matter, calcium, magnesium, potassium, phosphorus, nitrogen and zinc.

**RESULTS AND DISCUSSION**

The physical and chemical properties of soils used for NPK fertilizer and zinc response studies are shown in Table 1. The pH values of the soils were low and vary from moderately acidic to strongly acidic. Values decreased slightly at harvest for both years. Soil nitrogen was low and ranged from 0.05 to 0.07% with a mean of 0.06%. The available phosphorus were low (< 6.13 mg $kg^{-1}$ ) and it ranges from 5.21 to 6.13 mg $kg^{-1}$ with a mean value of 5.49 mg $kg^{-1}$. The available P-values were less than the critical level of 10-16 mg $kg^{-1}$ (Adeoye and Agboola, 1985). Exchangeable calcium dominated the other exchangeable cations in the soils in both years of cropping. Exchangeable calcium content ranged from 1.52 to 2.80 cmol $kg^{-1}$ in the soils and decreased slightly at harvest in both years of cropping. The slight decrease may be attributed to the minimal leaching process as a result of the clay particle content in the soil Adeboye *et al* (2009). The exchangeable magnesium and potassium (<0.80 cmol $kg^{-1}$ and (< 0.12 cmol $kg^{-1}$) respectively were low. The low exchangeable bases are an indication of soil loss through erosion which has been reported to result in deficiencies of exchangeable bases in the soil (Mbagwu, 1988). The effective cation exchange capacity of the soils were generally low (<5.34 cmol $kg^{-1}$). The low effective cation exchange capacity reported suggests that the soils would be prone to leaching of nutrient (Adeboye *et al* 2009).

**Table 1: Some Physical and chemical properties of the soil before planting and after planting**

| Soil Properties | 2007 Planting | | 2008 Planting | |
|---|---|---|---|---|
| | Before | After | Before | After |
| | Harvest | | Harvest | |
| Sand (%) | 64.60 | 64.40 | 70.0 | 70.0 |
| Silt (%) | 28.70 | 27.60 | 17.0 | 14.0 |
| Clay (%) | 6.70 | 8.00 | 13.0 | 16.0 |
| pH ($H_20$) | 5.20 | 5.10 | 5.6 | 5.0 |
| Soil class | Sandy loam | Sandy loam | Sandy loam | Sandy loam |
| Organic (%) | 0.57 | 0.48 | 0.74 | 0.61 |
| Total N (%) | 0.07 | 0.06 | 0.06 | 0.05 |
| Available P (mg/kg) | 5.24 | 6.13 | 5.21 | 5.41 |
| Ca (cmol $kg^{-1}$) | 2.80 | 2.71 | 1.53 | 1.52 |
| Mg (cmol $kg^{-1}$) | 0.08 | 0.80 | 0.96 | 0.94 |
| K (cmol $kg^{-1}$) | 0.12 | 0.16 | 0.26 | 0.28 |
| Na (comol $kg^{-1}$) | 0.36 | 0.34 | 0.09 | 0.08 |
| ECEC (cmol $kg^{-1}$) | 5.34 | 5.21 | 2.87 | 2.88 |

**Effect of NPK fertilizer and zinc on planting height (cm) of cocoyam**

The height of plant is an important growth character directly linked with the production potential of plant in terms of fodder, grain and fruit yield. NPK fertilizer application had a significant effect ($P>0.05$) on plant height of cocoyam in both years (Table. 2). Mean plant height increased significantly with incremental application of NPK fertilizer up to 600 kg NPK $ha^{-1}$ in both years. These were 15 and 27 percent higher than the absolute control in 2007 and 2008 respectivel. The effect of zinc applied on plant height had no significant effect on cocoyam. Cocoyam plants attended mean height of 76.1 cm in 2007 and 103.2 cm in 2008, when zinc was applied at 12 kg Zn $ha^{-1}$ and 6 kg Zn $ha^{-1}$ respectively. There were no significant effect of NPK fertilizer x zinc interaction on plant height of cocoyam in the two years of cropping. However, plant height of cocoyam 90.4cm and 128.4cm were obtained with a combination of 600 kg NPK $ha^{-1}$ and 12 kg Zn $ha^{-1}$ in 2007, 600 kg NPK $ha^{-1}$ and 6 kg Zn $ha^{-1}$ in 2008 respectively. Fertilizer application is an important option for farmers in order to improve crop yields in most soils of Southeastern Nigeria, particularly because of the increase intensity of land use (Ikeorgu, 1999). Therefore, the findings of this study showed that for optimum performance of cocoyam higher does of NPK are required while, lower dose of zinc is required for optimum plant height.

**Table 2: Effect of NPK fertilizer and zinc on plant height (cm) of cocoyam during the 2007 and 2008 cropping seasons**

| NPK rates | 2007 Zinc rates (kg $ha^{-1}$) | | | | | | 2008 Zinc rates (kg $ha^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (kg/ha) | 0 | 3 | 6 | 9 | 12 | mean | 0 | 3 | 6 | 9 | 12 | mean |
| 0 | 67.4 | 63.7 | 60.4 | 58.5 | 58.0 | 61.6 | 73.3 | 68.5 | 77.0 | 91.6 | 77.3 | 77.6 |
| 150 | 72.8 | 68.7 | 64.0 | 67.2 | 69.4 | 68.4 | 93.0 | 93.5 | 99.5 | 102.4 | 95.7 | 96.8 |
| 300 | 83.2 | 70.4 | 73.6 | 74.1 | 75.1 | 75.2 | 110.2 | 105.4 | 99.4 | 95.5 | 115.0 | 105.2 |
| 450 | 79.8 | 87.8 | 82.2 | 87.6 | 87.8 | 85.0 | 102.5 | 106.1 | 11.7 | 109.5 | 107.8 | 107.9 |
| 400 | 84.2 | 89.0 | 89.4 | 87.8 | 90.4 | 88.2 | 109.9 | 113.1 | 128.4 | 115.0 | 101.5 | 113.6 |
| Mean | 77.5 | 75.9 | 73.9 | 75.0 | 76.1 | | 98.3 | 97.3 | 103.2 | 10.2 | 102.8 | |

| | | 2007 | 2008 |
|---|---|---|---|
| LSD (0.05) NPK | = | 6.338 | 8.83 |
| LSD (0.05) Zn | = | ns | ns |
| LSD (0.05) NPK X Zn | = | ns | ns |
| ns | = | Not significant at 5% probability level | |

**Effect of NPK fertilizer and zinc on number of cormels of cocoyam**

Table 3 show that the effect of NPK fertilizer and zinc on number of cormels of cocoyam NPK fertilizer application had a significant (P>0.05) effect on the number of cormels of cocoyam on both years. As the levels of NPK fertilizer increased, there were significant increases in the mean number of cormel from 324 to 511 and 368 to 758 in 2007 and 2008 respectively. Mean number of cormel produced at 600 kg $ha^{-1}$ was higher by 19.7% in 2008, compared with the number obtained at the same rate in 2007. The result also revealed that there was no significant (P<.05) effect of zinc in the number of cormels produced. NPK fertilizer x zinc interaction had no significant (P<0.05) effect in cormel production. The low potassium status before and after planting as shown in Table 1 might explain the differential in the number of cormels. Also, the failure of zinc applied to influence cormel production in acid tropical soils such as soils of Southeastern Nigeria may be related to the risk of phosphorus – induced zinc deficiency which occurs when zinc is applied in combination with phosphorus fertilizer. Furthermore, the lack of interaction could be better explained that cocoyam grows better in a high moisture regime. Therefore, fertilizer applied is subject to leaching. Onwueme (1978) suggested that application of fertilizer to cocoyam to enhanced growth and yield should be applied in split doses, stressing that the first application is made at planting and the second is made four months after planning just as corm enlargement is commencing.

**Table 3: Effect of NPK fertilizer and zinc on number of cormel of cocoyam during 2007 and 2008 cropping season**

| NPK rate | **2007** Zinc rates kg $ha^{-1}$ | | | | | | **2008** Zinc rates kg $ha^{-1}$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (kg/ha) | 0 | 3 | 6 | 9 | 12 | Mean | 0 | 3 | 6 | 9 | 12 | Mean |
| 0 | 437 | 354 | 278 | 216 | 293 | 324 | 395 | 290 | 415 | 337 | 374 | 368 |
| 150 | 386 | 385 | 373 | 362 | 357 | 373 | 458 | 401 | 617 | 522 | 469 | 493 |
| 300 | 477 | 407 | 370 | 415 | 444 | 423 | 617 | 612 | 570 | 553 | 535 | 577 |
| 450 | 413 | 417 | 469 | 495 | 528 | 465 | 653 | 721 | 628 | 609 | 618 | 646 |
| 600 | 481 | 521 | 529 | 514 | 509 | 511 | 800 | 812 | 762 | 701 | 716 | 758 |
| Mean | 440 | 417 | 408 | 400 | 446 | | 584 | 567 | 598 | 551 | 542 | |

| | | | 2007 | 2008 |
|---|---|---|---|---|
| LSD (0.05) | NPK | = | 64.2 | 75.6 |
| LSD (0.05) | Zn | = | ns | ns |
| LSD (0.05) | NPK x Zn | = | ns | ns |

ns = Not significant at 5% probability level

**Effect of NPK fertilizer and zinc on total tuber yield of cocoyam**

Result obtained for total tuber yield (t/ha) of cocoyam with different rates of NPK fertilizer for 2007 are shown in Table 4 which indicate a significant positive (>0.05) response to the applied fertilizer. A steady increase in the mean total tuber yield was obtained with NPK fertilizer rate up to 450 kg ha$^{-1}$. In 2008 the response to cocoyam to applied NPK fertilizer was not significant. But there was a steady increase in the mean total tuber yield of cocoyam from 0 kg ha$^{-1}$ to 300 kg ha$^{-1}$ after which mean total tuber yield depressed. The results also revealed that highest mean total tuber yield of 13.9 and 11.8 t/ha were obtained with 600 kg NPK ha$^{-1}$ for 2007 and 2008 respectively, mean total tuber yield in 2007 was higher by 7.8 percent to that of 2008. The mean yield result suggest that the highest NPK fertilizer rate 600 kg ha$^{-1}$ may not be the optimum rate since the yield values obtained in the two years of study for 450 kg ha$^{-1}$ and 600 kg ha$^{-1}$ rates were not significantly ($P<0.05$) different. The mean yield results indicated that the optimum rate of NPK fertilizer (15:15:15) for cocoyam production in the study area may lie between 450 kg ha$^{-1}$ to 600 kg ha$^{-1}$.

The effect of zinc rates on total tuber yields (t/ha) of cocoyam are presented in Table 4. In both years the effect of zinc on total tuber yield was not significant. However, in 2007, highest mean total tuber yield of 11.4 t/ha was obtained with the control (0 kg Zn ha$^{-1}$. This value was slightly less compared with the mean value of 11.8 t/ha obtained with 3 kg Zn ha$^{-1}$. But in the two years of study zinc rate at 6 kg ha$^{-1}$ gave the highest total tuber yield of 14.6 t/ha and 15.0 t/ha respectively.

**Table 4: Effect of NPK fertilizer and zinc on total tuber yield (t/ha) of cocoyam**

| NPK rates | 2007 Zinc rates kg ha$^{-1}$ | | | | | | 2008 Zinc rates kg ha$^{-1}$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(kg/ha)** | **0** | **3** | **6** | **9** | **12** | **Mean** | **0** | **3** | **6** | **9** | **12** | **Mean** |
| 0 | 10.43 | 6.97 | 5.80 | 6.13 | 6.40 | 7.14 | 4.97 | 15.30 | 5.37 | 5.90 | 5.03 | 7.31 |
| 150 | 9.10 | 9.90 | 8.03 | 9.40 | 8.47 | 8.98 | 8.03 | 7.63 | 10.10 | 9.00 | 8.30 | 8.61 |
| 300 | 13.37 | 10.80 | 8.07 | 9.27 | 10.53 | 10.41 | 10.60 | 11.27 | 8.80 | 9 .03 | 9.03 | 9.80 |
| 450 | 10.10 | 1 2.90 | 12.60 | 12.17 | 13.9 | 12.33 | 10.87 | 12.07 | 11.50 | 0.63 | 7.30 | 10.55 |
| 600 | 13.83 | 13.57 | 14.63 | 14.40 | 13.8 | 14.05 | 12.90 | 12.07 | 15.03 | 12.30 | 11.8 | 12.82 |
| Mean | 11.37 | 10.83 | 9.83 | 10.27 | 10.62 | | 9.47 | 11.67 | 10.16 | 9.37 | 8.43 | |

| | | | | |
|---|---|---|---|---|
| LSD (0.05) | NPK | = | 1.93 | ns |
| LSD (0.05) | Zn | = | ns | ns |
| LSD(0.05) | NPK x Zn | | ns | ns |
| ns | = | Not significant at 5% at p ha level | | |

**CONCLUSION**

Application of NPK fertilizer at the rate of 600 kg ha$^{-1}$ enhanced plant height in both years. Application of NPK fertilizer at the rate of 450 to 600 kg ha$^{-1}$ appeared adequate for maximum tuber yield of cocoyam. This study confirms that NPK fertilizer and zinc applied to cocoyam is necessary for improving cocoyam productivity. Application at 600 kg NPK ha$^{-1}$ and 6 kg Zn ha$^{-1}$ appeared adequate for maximum cocoyam production**.**

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