International Journal of Agriculture Innovations and Research
Volume 1, Issue 6, ISSN (Online) 2319-1473

# Short-Term Response of Soil Chemical Properties and Leaf Nutrient Composition of Fluted Pumpkin to Organic and Inorganic Fertilizer Mixtures on an Ultisol in Southeastern Nigeria

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*Abstract* - **An investigation to evaluate the influence of sole organo-minerals and inorganic fertilizer and their mixtures on some selected soil chemical properties and leaf nutrient composition of fluted pumpkin (*Telfairia Occidentalis* Hook F), was carried out at Federal College of Agriculture, Ishiagu, Ebonyi State in 2011. The treatments (control, 10 t/ha RHD, 10 t/ha RHA, 10 t/ha PD, 0.375 t/ha NPK, 5 t/ha RHA + 5 t/ha PD, 5 t/ha RHD + 0.188 t/ha NPK, 5 t/ha RHA + 5 t/ha PD, 5 t/ha RHA + 0.188 t/ha NPK), were build into a randomized complete block design (RCBD) with three replications. Data were collected from both plant and soil parameters. Soil samples were collected before and at harvest from different plots for soil chemical analyses. The data collected were later subjected to statistical analysis using Genstat 3 7.2 Edition. Results obtained from this study showed that all the amended plots increased significantly (P<0.05) the soil pH, organic carbon, total nitrogen, available phosphorous and exchangeable potassium over the control. However, the results equally revealed that treatments application did statistically improve the leaf nutrient compositions. Generally, the results indicated that the integration of amendments significantly performed better in most soil and plant nutrient parameters than the sole and control plots.**

*Keywords* – **Amendments, Fluted Pumpkin, Nutrient Composition, Organo-Minerals, Soil Chemical Properties.**

## I. Introduction

Fluted pumpkin is a member of the family Cucurbitaceae and is a leafy green vegetable that has been widely accepted as a dietary constituent more popular in the south eastern states of Nigeria [1]. Among the important indigenous vegetables, telfairia seems to be widely eaten in Nigeria and cultivated for its edible succulent shoots and leaves as a backyard crop mainly by the Igbo tribe. With the spread of Igbos to other parts of Nigeria, *Telfairia* is now cultivated in almost all the parts of the country [2, 3]. In the middle belt, which is in the Guinea savanna region of Nigeria, *Telfairia* is now being cultivated not only as backyard crop but also as commercial crop during the wet and dry season. The tender leaves and vines are consumed as vegetables while the young seeds are eaten as food and snacks [4]. Oyolu [5] observed that vegetables will continue to remain the primary source of proteins, minerals and vitamins in African countries. He noted that leaves and edible shoots of fluted pumpkin together contain 85% moisture, while the dry portion of what is usually consumed contains 11% crude protein, 25% carbohydrate, 3% oil, 11% ash and as much as 700ppm iron. This level of iron seems to provide a basis for the folklore that fluted pumpkin leaf extract can be administered as a blood tonic to convalescent person. FAO [6] have reported the nutritional value of fluted pumpkin leaves as 86 ml water, 47 calories, 2.7 g protein, 1.8 g fat, 7.0 g carbohydrates and 1.7 g fibres.

Despite the nutritive values obtainable from fluted pumpkin, it is a common observation that the demands far exceed the supply of fluted pumpkin as a vegetable crop resulting in scarcity which increases cost. There is therefore, the need to increase the productivity of the crop by improving the soil condition upon which it is grown.

The constraints of small scale farmers in increasing crop yield in Nigeria include, small farm size and fertilizer supply [7]. Low soil fertility has also been recognized as one of the major production constraints affecting agriculture in the sub-Saharan Africa. According to Sanchez *et al.* [8], soil fertility depletion in small holder farm is the fundamental cause of declining per capita food production. Research result indicated that availability of fertilizer has direct effect on cost of fertilizer [9]. There is need for cheaper alternative that can make fertilizer more available to farmer. In most cases, Nigerian farmers' access to fertilizer in vegetable growing season is limited by fund [7]. Scarcity and late distribution are the major problems to the optimum production of vegetables. It is therefore necessary to source for locally available, cheap and environmental friendly materials that can be used solely or integrated for vegetable production. Organic materials have advantages of being environmental friendly as reported by Yusoff [10]. Organic materials are capable of promoting crop growth and increasing yield by improving soil physical, chemical and biological properties [11]. Organic fertilizers improve the physical properties of the soils, helps the soil to maintain better tilth and increase water holding capacity [12]. Organic fertilizer supplies both major and minor plant nutrients. The supplied nutrient can substitute for appreciate amounts of inorganic fertilizer [13].

However, complementary use of organic and inorganic fertilizers has been reported to be a sound soil fertility management strategy for crop production [14]. Stephen [15] obtained high and sustained yield of fluted pumpkin with the use of organic manure in combination with inorganic fertilizer. Makinde *et al*. [16] reported significant increase in melon yield with combined application of inorganic and organic fertilizers. Makinde *et al*. [11], also reported that combined application of organic and inorganic fertilizer significantly increased the uptake of N, Ca and Mg by amaranthus in a research conducted in Lagos, Nigeria.

Huang and Lin, [18] noted enhanced soil fertility status when inorganic fertilizer was applied in combination with organic manure. Zang and Fang [19] reported that combined application of inorganic and organic manure can correct nutrient deficits associated with application of either of the sources alone. As reported by Ossom *et al*. [20], a combined application of inorganic and organic manure is needed for increased leaf yield and growth of fluted pumpkin. Commercial and subsistence farming has been and is still relying on the use of inorganic fertilizers for growing crops, [21]. This is because they are easy to use, quickly absorbed and utilized by crops. However, these fertilizers are believed to contribute substantially to human, animal food intoxication and environmental instability/degradation.

Therefore, the study aimed at investigating the effects of sole organo-minerals, inorganic fertilizer and their mixtures on the soil chemical improvement and leaf nutrient composition of fluted pumpkin.

## II. Materials and Methods

### *2.1 Experimental Site:*

The experiment was conducted in 2011 at the Research Farm of Federal College of Agriculture, Ishiagu. The area lies within latitude 05°56´N and longitude 07°41´E in the Derived Savannah Zone of Southeastern Nigeria. The mean annual rainfall for the area is 1350 mm, spread from April to October with average air temperature being 29°C. The underlying geological material is Shale formation with sand intrusions locally classified as the 'Asu River' group. The soil is hydromorphic and belongs to the order Ultisol. It has been classified as Typic Haplustult [22]. Using a composite sample from the top-(0-20 cm) soil region at the study site, the soil was characterized before land preparation. The soil is sandy loam with moderate soil organic carbon (OC) content, low in pH and cation exchange capacity (CEC), with dominance of the exchange complex site by calcium and magnesium (Table 1).

The soil amendments comprised partially burnt rice-mill wastes (rice husk ash) and fresh rice-mill wastes (rice husk dust) all found in abundant and collected respectively from a rice-mill industry; all within the vicinity of the study site. Others included NPK 15:15:15 and poultry droppings.

Chemical analysis of the organic materials showed that (Table 2), poultry manure had the highest values of N and Ca nutrients. The RHD had the highest OC values and the highest C:N ratio of 48.21 compared to others, while RHA produced the highest K and Mg nutrients with the least C:N ratio of 6.71.

### *2.2 Field study:*

The experiment was carried out in 2011 cropping season. The treatments were laid into randomized complete block design (RCBD) with three replications. Nine treatments of single and their mixture as soil amendments including the control were used. The soil amendments were different manure sources and their mixtures, applied at different rates and these included: $\mathbf{T_1}$ = Control; $\mathbf{T_2}$ = 10 t/ha of rice-husk dust; $\mathbf{T_3}$ = 10 t/ha rice husk ash; $\mathbf{T_4}$ = 10 t/ha poultry droppings; $\mathbf{T_5}$ = 0.375 t/ha of NPK fertilizer 15:15:15; $\mathbf{T_6}$ = 5 t/ha of rice husk dust + 5 t/ha of poultry dropping; $\mathbf{T_7}$ = 5 t/ha of rice husk dust + 0.188 t/ha NPK 15: 15: 15; $\mathbf{T_8}$ = 5 t/ha poultry dropping + 5 t/ha of rice husk ash; $\mathbf{T_9}$ = 5 t/ha rice husk ash + 0.188 t/ha of NPK 15:15:15

### *2.3 Field preparation, data collection and analysis*

The experimental site was cleared, ploughed, harrowed and made into seed beds. The treatments were allocated into the plots and incorporated into 0-5 cm soil depth before planting except treatment 5 (NPK fertilizer). The rice husk dust and poultry dropping amendments were applied into the soil two weeks before planting, while the rice husk ash was applied two days before planting. Planting of the test crop, fluted pumpkin (*Telfairia*) seeds were done one seed per hole at the depth of 2.5cm and planting distance of 1 x 1m apart.

### *2.4 Leaf Analysis*

Fluted pumpkin (Telfairia) vegetative samples were collected from all the plots at **8**$^{th}$ week after planting and subjected to chemical analysis to determine their Nutrient composition (Proximate analysis). Leaf samples were oven dried at 60$^0$C to constant weight. Dried samples were ground and passed through 2.00 mm sieve. The ash, crude fibre, moisture content and dry matter content were determined as described by [23]; while the Calcium, phosphorous and vitamins were determined as described by [24].

### *2.5 Soil sample collection and laboratory analysis*

A composite topsoil sample from different representative locations was collected from the experimental site after site clearing with soil auger to a depth of 0-20cm for initial soil characteristics.

At harvest, another soil samples were collected from all the plots for chemical analyses to determine the changes that occurred due to treatments application.

The soil samples were air-dried and sieved with 2 mm sieve, and analysis done using the soil fractions less than 2 mm. Soil pH was measured in a 1:2.5 (soil:0.1 M KCl) suspensions. The soil OC was determined by the Walkley and Black method as described by Nelson and Sommers, [25]. The total nitrogen was determined by the method described by Bremner and Mulvancy, [26]. Exchangeable bases were determined by the method of Thomas, [27]. Available phosphorus was measured by the Bray II method [28].

Statistical analysis of all the data was performed using **GENSTAT** 3 7.2 Edition. Significant treatment means was separated and compared using Least Significant

Difference (LSD), standard errors of means and standard errors of differences of means; and all inferences were made at 5% Levels of probability.

## III. Results and Discussion

### *3.1 Effects of soil amendments on soil pH, organic carbon (OC), total nitrogen (TN), available phosphorous (Avail. P) and exchangeable potassium (K+) (0-20cm) soil depth*

The results on the effects of soil amendments on the soil pH, OC, total nitrogen, available phosphorous and exchangeable potassium were shown on Table 3. The results showed that the amended plots significantly differ ($p<0.05$) in the improvement of soil pH over the control plots. It was obtained that a statistical improvement in pH was obtained from plots amended with 0.188 t/ha NPK + 5 t/ha RHA and 10 t/ha RHA compared to plots amended with other treatments. The increase in pH in RHA amended plots and its additives relative to other treatments could be due to its higher contents of Ca, Mg and K in the material compared to other amendments which are the basic elements for lowering acidity level of a medium. It has been shown that the oxides and hydroxides of Ca, Mg and K contained in ash from plant residues makes its mode of actions similar to that of burnt or hydrated lime [29, 30]. The result also agreed with the findings of Nwite *et al.* [31], in a work carried out in the same location on maize, where rice husk ash was reported to have significantly increased the soil pH of the studied area.

The soil organic carbon was significantly ($p<0.05$) improved in all amended plots compared to the control plots. Generally, the organic carbon contents of the amended soils in most plots were very low relative to its initial values in the soil. The low percent of organic carbon could be related to losses through crop removal. This agrees with Biederbeck *et al.* [32], who had reported losses in surface soil organic carbon levels through burning and removal of crop residue. Consequently, it was observed that the mixtures of the amendments including RHD and PD improved OC higher than the sole NPK 15:15:15. This is in agreement with Obi and Ofoduru, [33] who reported that the use of mineral fertilizers such as NPK, Urea and Ammonium sulphate led to degradation of physical and chemical qualities of soils caused by low organic matter levels. This was supported by Zake[34], who stated that a single heavy dose of soluble fertilizers might not work in the low activity clay soils, and they required an organic matter to impart appropriate chemical, physical and biological properties.

Soil total nitrogen differed significantly ($p<0.05$) among the treatments, with each of the amended plots showing higher value than the control. This improvement in the soil total nitrogen was higher in plots treated with 5 t/ha RHA + 0.188t/ha NPK than others. The overall low magnitude in the enhancement of nitrogen by the amendments in some amended plots compared to initial N value in the soil suggests high level of topsoil N volatilization and de-nitrification [35].

Soil available P increased significantly ($p<0.05$) due to the applied amendments. The results show that the highest available P was obtained in 5t/ha RHA + 0.188/ha NPK treated plots and was followed by 10t/ha PD treated plots. The increased available P in amended soils could be attributed to the improvement made on soil pH which might have influenced the release of the available P from the exchange complex site. Also, the higher improvement in the available P in plots treated with RHA + NPK might have been necessitated by high content of P in the materials used.

Exchangeable potassium ($K^+$) was increased significantly ($p<0.05$) in the amended plots relative to the control plots. The results showed that the 10t/ha RHA amended plots gave the highest soil exchangeable $K^+$. This was followed by plots treated with 10 t/ha of poultry droppings and mixture of 5 t/ha of RHA and 5 t/ha of poultry dropping. The best performance put up by plots treated with rice husk ash could be attributed to the high content of phosphorous in the material used for amendment, which when applied released the element to the soil.

### *3.2 Proximate analysis:*

#### *3.2.1 Effects of soil amendments on proximate analysis (leaf Nutrient composition) of the fluted pumpkin (Fibre, Ash, Moisture content, Dry matter, Phosphorous and Calcium) %.*

Proximate analysis of *Telfairia* leaves as affected by the soil amendments application is presented in Table 4. The result showed that sole poultry droppings (PD) and NPK fertilizer significantly reduced the crude fibre in fluted pumpkin. It was also recorded that the integration of all the amendments (organic and inorganic fertilizers) statistically reduced crude fibre relative to the control. The result is in agreement with the report of Makinde *et al.* [36], that the integration or combination of kola pod husk or poultry waste with NPK fertilizer significantly reduced crude fibre of amaranthus in a research conducted in Lagos. However, inability of rice husk dust to significantly reduce the crude fibre over the control could be attributed to the fact that nutrients in organic materials which could have boost the protein content of the plant are less easily available since the materials have to be decomposed and organic nutrients mineralized.

Generally, the soil amendments in their sole form and mixtures relatively increased the ash contents of the fluted pumpkin leaves, except sole rice husk ash, which its inability to increase the ash content of the plant leaf might be due to the ease with which the nutrients in ash material were lost by leaching.

Table 4 equally indicated that amended plots recorded significant effect on the moisture, dry matter and calcium contents of fluted pumpkin leaves. Generally, the quality and mineral element contents in the leaves and stems of fluted pumpkin were significantly improved with both application of sole inorganic and organic fertilizers and their mixtures. This result equally agreed with the findings of Olaniyi and Akanbi, [37], that the integration of N-fertilizer and organic fertilizer; and their sole application relatively improved moisture, fibre, crude protein, dry matter, fat and Ca contents of fluted pumpkin. It was obtained from the result that the amendments did not significantly increase phosphorous content of the fluted pumpkin leaves.

*3.2.2 Effects of soil amendments on Proximate analysis (leaf Nutrient composition) of the fluted pumpkin (Vitamin C, Thiamine, Riboflavin and Niacin) mg/100g.*

The result of Table (5) indicated that vitamin C was significantly improved upon by both the sole amendments and their integrations. It was also recorded that the highest vitamin C content in fluted pumpkin leaf was obtained from sole poultry dropping amendment with 18.60 mg/100g; while rice husk dust mixed with poultry dropping amendment yielded the best improvement on vitamin C content among the amendments mixtures.

It was also obtained that Thiamine, Riboflavin and Niacin were equally increased significantly by the soil amendments including their mixtures.

Generally, the results indicated that while PD at 10 t/ha recorded the highest value of vitamin C and niacin, RHA at 10 t/ha equally gave the highest level of thiamine with a value of 0.57 mg/100g. Consequently, the highest value of riboflavin was obtained from plots treated with mixtures of RHA at 5 t/ha + 5t/ha of PD.

## IV. Conclusion

Results from the study have indicated that the application of organo-minerals and inorganic fertilizer in their both sole and mixture forms can adequately improve soil chemical properties and nutrient composition of fluted pumpkin.

However, since poultry droppings (PD) may not be much available in large quantities required for application by farmers and NPK fertilizers are scarce and /or costly, farmers are by the results of this study advised to use rice husk dust (RHD) and rice husk ash (RHA) that are so abound in the area with the integration of the PD or NPK. The use of these cheap and available wastes with little mixtures of PD or NPK by the poor resource farmers in the area regarded as food belt of Southeastern Nigeria, will not only improve the soil properties, but enhance vegetable nutrient composition on long term basis.

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Table 1: Some properties of the topsoil (0-20cm) before amendments (pre-planting)

| **Soil property** | **Value** |
|---|---|
| Clay (%) | 18.7 |
| Silt (%) | 15.1 |
| Total sand (%) | 66.2 |
| Textural class | sandy loam |
| Organic carbon (%) | 0.97 |
| Total nitrogen (N) (%) | 0.084 |
| pH | 4.91 |
| Exchangeable bases (cmolkg-1) | |
| Sodium (Na) | 0.17 |
| Potassium (K) | 0.10 |
| Calcium (Ca) | 2.00 |
| Magnesium (Mg) | 1.60 |
| Cation exchange capacity (CEC) | 7.14 |
| Exchangeable acidity (EA) | 2.1 |
| Available phosphorus (mg/kg) | 10.2 |

Table 2: Nutrient compositions (%) in the amendments

| **Property** | **Amendment** | | |
|---|---|---|---|
| | **Poultry Dropping (PD)** | **Rice Husk Dust (RHD)** | **Rice Husk Ash (RHA)** |
| OC | 16.52 | 33.75 | 3.89 |
| N | 2.10 | 0.70 | 0.056 |
| Na | 0.34 | 0.22 | 0.33 |
| K | 0.48 | 0.11 | 1.77 |
| Ca | 14.4 | 0.36 | 1.4 |
| Mg | 1.2 | 0.38 | 5.0 |
| P | 2.55 | 0.49 | 11.94 |
| C:N | 7.87 | 48.21 | 6.71 |

Table 3: Effects of soil amendments on soil pH, organic carbon, total nitrogen, available phosphorous and exchangeable potassium (0-20 cm) soil depth

| **Treatment** | **Soil pH ($H_20$)** | **Organic Carbon (%)** | **Total Nitrogen (%)** | **Avai. P mg/kg** | **Exch. K $cmolkg^{-1}$** |
|---|---|---|---|---|---|
| **$T_1$** = Control | 5.0 | 0.65 | 0.059 | 13.87 | 0.07 |
| **$T_2$** = 10 t/ha RHD | 5.6 | 1.12 | 0.076 | 18.02 | 0.08 |
| **$T_3$** = 10 t/ha RHA | 5.9 | 0.71 | 0.063 | 24.79 | 0.13 |
| **$T_4$** = 10 t/ha PD | 5.7 | 0.76 | 0.073 | 16.72 | 0.11 |

| | | | | | |
|---|---|---|---|---|---|
| $T_5$ = 0.375 t/ha NPK | 5.5 | 0.73 | 0.089 | 18.94 | 0.09 |
| $T_6$ = 5 t/ha RHD | | | | | |
| + 5 t/ha PD | 5.5 | 0.97 | 0.085 | 19.99 | 0.08 |
| $T_7$ = 5 t/ha RHD | | | | | |
| + 0.188 t/ha NPK | 5.6 | 0.95 | 0.080 | 20.57 | 0.08 |
| $T_8$ = 5 t/ha RHA | | | | | |
| +5 t/ha PD | 5.7 | 0.80 | 0.108 | 19.55 | 0.11 |
| $T_9$ = 5 t/ha RHA | | | | | |
| + 0.38 t/ha NPK | 5.6 | 1.14 | 0.115 | 25.67 | 0.07 |
| **LSD at 0.05** | **0.1252** | **0.0189** | **0.0035** | **0.4279** | **0.01092** |

RHD = Rice Husk Dust, RHA = Rice Husk Ash, PD = Poultry dropping, NPK = Nitrogen. Phosphorus. Potassium fertilizer (15:15:15), LSD = Least significant difference

Table 4: Effects of soil amendments on proximate analysis (leaf Nutrient composition) of the fluted pumpkin (Fibre, Ash, Moisture content, Dry matter, Phosphorous and Calcium) %.

| Treatment | Fibre | Ash | Moisture Cont. (MC) | Dry Matter (DM) | Phosphorous | Calcium |
|---|---|---|---|---|---|---|
| $T_1$ = Control | 14.07 | 4.74 | 10.05 | 88.32 | 293 | 165.37 |
| $T_2$ = 10 t/ha RHD | 13.93 | 5.0 | 10.69 | 89.73 | 483 | 186.30 |
| $T_3$ = 10 t/ha RHA | 13.83 | 4.94 | 11.02 | 89.17 | 530 | 181.27 |
| $T_4$ = 10 t/ha PD | 11.41 | 5.69 | 11.15 | 89.24 | 501 | 170.37 |
| $T_5$ = 0.375 t/ha NPK | 12.65 | 5.97 | 11.07 | 89.44 | 539 | 178.20 |
| $T_6$ = 5 t/ha RHD | | | | | | |
| + 5 t/ha PD | 12.37 | 4.98 | 10.95 | 89.25 | 495 | 180.47 |
| $T_7$ = 5 t/ha RHD | | | | | | |
| + 0.188 t/ha NPK | 12.60 | 5.77 | 11.41 | 89.11 | 532 | 189.37 |
| $T_8$ = 5 t/ha RHA | | | | | | |
| +5 t/ha PD | 12.88 | 5.47 | 10.74 | 89.76 | 495 | 178.60 |
| $T_9$ = 5 t/ha RHA | | | | | | |
| + 0.188 t/ha NPK | 12.73 | 5.74 | 10.77 | 89.49 | 506 | 178.67 |
| **LSD at 0.05** | **0.594** | **0.173** | **0.577** | **0.638** | **NS** | **7.241** |

RHD = Rice Husk Dust, RHA = Rice Husk Ash, PD = Poultry dropping, NPK = Nitrogen phosphorus potassium, LSD = Least significant difference, NS = Not significant

Table 5: Effects of soil amendments on Proximate analysis (leaf Nutrient composition) of the fluted pumpkin (Vitamin C, Thiamine, Riboflavin and Niacin) mg/100g.

| Treatment | Vitamin C | Thiamine | Riboflavin | Niacin |
|---|---|---|---|---|
| $T_1$ = Control | 12.63 | 0.037 | 0.020 | 0.40 |
| $T_2$ = 10 t/ha RHD | 14.17 | 0.047 | 0.047 | 0.48 |
| $T_3$ = 10 t/ha RHA | 15.13 | 0.057 | 0.027 | 0.47 |
| $T_4$ = 10 t/ha PD | 18.60 | 0.053 | 0.060 | 0.59 |
| $T_5$ = 0.375 t/ha NPK | 14.73 | 0.033 | 0.057 | 0.51 |
| $T_6$ = 5 t/ha RHD | | | | |
| + 5 t/ha PD | 16.97 | 0.047 | 0.047 | 0.57 |
| $T_7$ = 5 t/ha RHD | | | | |
| + 0.188 t/ha NPK | 15.43 | 0.043 | 0.053 | 0.47 |
| $T_8$ = 5 t/ha RHA | | | | |
| +5 t/ha PD | 16.07 | 0.040 | 0.063 | 0.51 |
| $T_9$ = 5 t/ha RHA | | | | |
| + 0.38 t/ha NPK | 14.53 | 0.047 | 0.060 | 0.49 |
| **LSD at 0.05** | **1.102** | **0.0088** | **0.00971** | **0.0425** |

RHD = Rice Husk Dust, RHA = Rice Husk Ash, PD = Poultry dropping, NPK = Nitrogen phosphorus potassium LSD = Least significant difference