Effects of Chicken Manure and Plantain Peel-Based Fertilization on Kalenda Eggplant (*Solanum melongena* L) Fruit Biochemical Parameters

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Authors' contributions

This work was carried out in collaboration among all authors. Author AKT designed the study, performed the statistical analysis, wrote the protocol, and drafted the first version of the manuscript. Authors AGM and BEL managed the analyses of the study. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Our study aims at improving the nutritional quality of eggplant fruits through application of organic fertilization. The study was conducted in Bingerville (located in the south of Côte d'Ivoire and west of Abidjan city), from April to August 2019.
The work consisted in assessing, in a randomized complete block design, the effects of five manures on the biochemical parameters of Kalenda eggplant (*Solanum melongena* L.) fruits. The manures studied were T1: chicken manure, T2: chicken manure + plantain peel compost, T3: chicken manure + plantain peel potash, T4: plantain peel compost, T0: no fertilizer, T5 (positive control): NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4).
The results showed that fiber, protein, lipid, sodium and iron contents were not influenced by the different treatments. However, treatments T5 (NPK (10 18 18) + Urea (46% N) + Potassium

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sulphate (K_2SO_4)), T4 (plantain peel compost), T3 (chicken manure + plantain peel potash) and T2 (chicken manure + plantain peel compost) induced the highest carbohydrate and energy content of fruits. With respect to phosphorus and potassium, treatments T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)), T4 (plantain peel compost) and T3 (chicken manure + plantain peel potash) had higher phosphorus values than those of other fertilizers T2 (chicken manure + plantain peel compost), T1 (chicken manure) with an average of 27; 26.58 and 25.491 mg per 100 g FM, respectively. Plants grown on the sites fertilized with chemical treatment T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)) produced the fruits richest in potassium with an average equal to 255.16 mg per 100 g FM, followed by treatment T3 (chicken manure + plantain peel potash) (245.5 mg/100g FM). For magnesium and calcium, treatments T3 (chicken manure + plantain peel potash) and T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)) were characterized by the lowest contents, thus reflecting an antagonism between potassium and these minerals.

From this study, it appears that plantain peel applied as an organic fertilizer on eggplant is a source of potassium, phosphorus, carbohydrates and energy for a good nutritional balance of the body.

1. INTRODUCTION

Eggplant (*Solanum melongena* L.) is a vegetable plant from the *Solanaceae* family. This plant is cultivated throughout tropical Africa for its fruits and leaves which are used in various culinary preparations [1]. The fruit is not only a good source of vitamins and minerals, but also contains many secondary metabolites including polyphenols. Its nutritional value is comparable to that of tomato [2]. There are a multitude of shapes and colors. Several edible species are cultivated in Côte d'Ivoire [3]. With an average national consumption of 3.7 kg of fresh fruit per inhabitant/year, eggplant is ranked second after okra (5.5 kg/inhabitant/year); and is one of the essential crops for ensuring food security [4]. Despite its very high consumption, eggplant cultivation faces many constraints, including soil poorness in terms of organic matter and mineral content (4). To remedy soil nutritional depletion, farmers apply chemical fertilizers to meet the nutrient requirements of cultivated plants [5]. However, due to their negative effects on the environment and the health of populations [6], chemical fertilizers are increasingly being abandoned in favor of organic fertilizers. Moreover, previous research works have shown that plant residues and animal droppings such as chicken droppings contribute to plant growth through their beneficial effects on the physicochemical and enhanced biological properties of soils and consequently on crop yields [7]. Recent work has shown that the combination of organic potash stemming from plantain peel and chicken manure have improved the agro morphological parameters of Kalenda eggplant crop [8].

These advantages classify soil amendment by composts of plant and animal wastes as an effective and competitive means of regenerating the fertility of degraded soils.

However, most studies have very often been limited to showing the favorable effects of fertilizers on crop agronomic parameters without considering the impact of fertilizers on fruit nutritional quality. Furthermore, the work of [9] has shown an increase of almost 30.8% of Ca, 24.4% of Mg and 0.66% of P in tomato fruits, of the same family as eggplant, after organic fertilization application. This suggests that the increase in organic matter might largely lead to an improvement in the mineral quality of crops and, therefore, of food. It is therefore important to wisely select fertilizers so as to improve the quality performance of eggplant fruits. The main objective of this study is to evaluate the contribution of organic fertilizers on the nutritional value of Kalenda eggplant fruits. More specifically, it will be a question of determining the biochemical compositions and the major mineral contents of these fruits resulting from mineral and organic fertilization.

2. MATERIALS AND METHODS

2.1 Materials

2.1.1 Study location

The study was conducted in Bingerville, located in the south of Côte d'Ivoire and west of Abidjan city (003°53'16" west longitude and 05°22'44" north latitude). The municipality is located in the Guinean area with an equatorial climate [10].

2.1.2 Plant material

The plant material consisted of eggplant powder of the Kalenda variety (*Solanum mélongena* L.). The powder was obtained by placing three eggplant fruits in an oven at 105°C for 48 hours. The dry sample was then removed, cooled in a desiccator and crushed in a grinder to collect the powder.

2.2 Methods

2.2.1 Site preparation

The preparation of the land consisted in clearing the pre-existing vegetation cover, ploughing and loosening the soil surface with a hoe. Then, a plate of dimensions 6 m x 1 m was made in order to install the nursery. The planting area was also cleared and burned. We made a staking to materialize the location of the future plants.

2.2.2 Implementation of trials

The total area of the experimental plot is 325 m^2 (25 m x 13 m). The distance between two blocks is 4 m and between two elementary plots (treatment) is 1 m. Eggplant plants were transplanted (spacing 1 m x 0.5 m) in the field after a stay of forty days after sowing in nurser. Maintenance of the plot consisted in ridging, weeding, phytosanitary treatment and fertilization. Fertilizer treatments were carried out with a frequency of three applications (30, 60 and 90 days after transplanting).

2.2.3 Experimental design

The experimental design was a randomized complete block with six treatments and three repetitions. Only one factor was studied: treatment with six levels, namely:

T0 (negative control): no fertilizer
T1: chicken manure
T2: chicken manure + plantain peel compost
T3: chicken manure + plantain peel potash
T4: plantain peel compost
T5 (positive control): NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K$_2$SO$_4$).

The quantities of fertilizers applied are:

T1: 2 kg of chicken droppings
T2: 2 kg of chicken droppings + 2 kg of compost from banana peel
T3: 2 kg of chicken droppings + 20 g of potash from banana peel

T4: 2 kg of compost from banana peel
T5: 30 g of NPK 10-18-18 + 10 g of urea + 20 g of Potassium sulfate.

Treatment T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K$_2$SO$_4$)) is the one popularized by research organizations in Côte d'Ivoire. The trial comprised 18 elementary plots corresponding to the six treatments. The number of plants per elementary plot and per block was 12 and 72 plants respectively, that is, a total of 216 plants on the experimental plot. This design made it possible to study the effects of fertilizing treatments on fruit biochemical characteristics.

2.2.4 Assessment of fruit biochemical parameters

2.2.4.1 Fruit water and dry matter contents

For sampling, three fruits were taken at random per treatment at each block. Fruit water contents were obtained by steaming the crucibles containing the samples. Thus, in a previously weighed crucible (m$_0$), 5 g of the eggplant fruit sample was weighed (m$_1$) and placed in an oven (Memmert UL 30, Germany), at 105 °C for 24 hours. The dry sample was then removed, cooled in a desiccator and weighed (m$_2$).

The difference in weight before and after desiccation of each sample gave the moisture content [11] according to the following formulas:

$$\text{Water contents} = \frac{m_1 - m_2}{m_1 - m_0} \times 100 \quad (1)$$

$$\text{Dry matter contents} = 100 - \% \text{ water} \quad (2)$$

With:

m$_0$: mass of empty crucible; m$_1$: mass of empty crucible + sample; m$_2$: mass of empty crucible + sample after drying

2.2.4.2 Fruit ash contents

A total of three fruits were taken at random per treatment at each block. Ash contents were obtained by incineration of the sample at 550°C for 4 h [12]. The eggplant powder sample weighing 5g (mass of the sample) was placed in a porcelain crucible, weighed beforehand (mass of the empty crucible), then incinerated in a muffle furnace (Nabertherm B 180, Germany) at 550°C for 4 hours. After this time period, the crucible containing the ashes was removed from

the oven, cooled in a desiccator for 30 minutes and reweighed (mass of the crucible + ash). Ash content was obtained by the following formula:

Ash contents = $\frac{\text{(Mass of crucible+ashes)-Mass of empty crucible}}{\text{Mass of the sample}}$ x100   (3)

The final value was expressed in g per 100 g of fresh matter.

2.2.4.3 Fruit total fiber contents

The crude fiber contents of eggplant powder were determined by the Van Soest method described by [13]. Three samples of 1g eggplant powder (m) per treatment were placed in an empty crucible weighed beforehand (m_0) then brought to the boil in 100 ml of an acid detergent solution (20 g of cethylammonium bromide + 28.2 ml sulfuric acid for 1 L) for 1 hour. The resulting residues were dried at 105 °C for 12 h (m_1).

The total crude fiber (F_b) contents were reported in g per 100 g of fresh matter by the formula:

$$F_b = \frac{m_1 - m_0}{m} \times 100 \qquad (4)$$

2.2.4.4 Fruit lipid contents

Lipid contents were determined by hexane extraction in a soxhlet extractor (SYSTEM HT2 1045, UNID TECATOR, SWEDEN). The hexane was then evaporated to determine the lipid content [14]. Three samples of 5g dry matter sample (m) per treatment were taken from an empty, pre-weighed Wathman cartridge. The cartridge was put into the soxhlet extractor, to which a pre-weighed 500-ml flask (m1) was connected. A quantity of 250 ml of hexane was then added. The refrigerant water supply was turned on and the flask heater was turned on while avoiding overheating. After 6 hours of operation, the soxhlet was turned off and cooled. The system was disassembled, the flask containing the mixture (solvent / oil) was carefully removed as well as the cartridge containing the powder. Evaporation of the solvent was carried out on a rotary evaporator (Rotavapor). The traces of solvent in the oil sample were subsequently evaporated in an oven at 105 °C for 1 hour. Removed from the oven, the flask was immediately cooled in a desiccator for 30 min and then weighed (m_2).

The mass of the oil was calculated by the difference: m_2 - m_1

The lipid level in the eggplant sample was determined after five repetitions according to the following formula :

Lipid contents = $\frac{m_2 - m_1}{m}$ x100   (5)

m_2: mass of the flask + oil deposit; m_1: mass of the empty flask; m: mass of the sample

The final values were expressed in g per 100 g of fresh matter.

2.2.4.5 Fruit crude protein contents

Protein contents (N x 6.25) of the samples were determined by the Kjedahl method described by [14]. In order to measure the nitrogen level, 1 g of eggplant fruit powder was introduced into a matrass and mineralized in the presence of 20 ml of concentrated sulfuric acid (H_2SO_4) (95-98%) and 0.5 g of catalyst (copper sulfate + potassium sulfate). The mineralization was carried out hot (around 400 °C) for 2 hours on a mineralization ramp. The mineralizate was then cooled. A volume of 80-ml distilled water was added to each matrass. Distillation was carried out with 10 ml of mineralizate + 10 ml of 40% NaOH to obtain ammoniacal nitrogen. 175 ml of distillate was collected in a 500-ml Erlenmeyer flask previously containing 25 ml of boric acid (2%) and three drops of the mixed indicator (methyl red-methyl blue). The distillate obtained was subsequently titrated under stirring with a 0.1N HCl solution until the color turned from pink to green, marking the end of the assay. The volume of HCl poured in was noted (V_{HCl}). A blank containing all the reagents, with the exception of the sample, was carried out under the same analytical conditions. The nitrogen levels were calculated by the following formula:

$$\% N = \frac{(V_{HCl} - V_{blank}) \times N_{HCl} \times M (N)}{m} \times 10 \qquad (6)$$

M (N): Molar mass of nitrogen: 14.01 g.mole^{-1}; N_{HCl}: HCl normality: 0.1 eq g.l^{-1}; m: mass of the sample analyzed in g. The values of N obtained were assigned coefficient 6.25 to determine the protein contents according to the following expression:

% Proteins = N x 6.25 (7)   With, 6.25: Nitrogen-to-protein conversion factor

The latter were finally reported in g per 100 g of fresh matter.

2.2.4.6 Fruit total carbohydrate contents

Total carbohydrate content was calculated according to [15]. To this end, the other constituents contained in the food; namely proteins, lipids, ashes and fibers were determined, separately, added and subtracted from the total weight of the dry sample. Determination of the digestible carbohydrate content was obtained by the following formula:

GT = 100 – [proteins (%) + lipids (%) + moisture (%) + ashes (%)]   (8)

The values finally obtained were expressed in g per 100 g of fresh matter.

2.2.4.7 Fruit energy value

The theoretical energy value of powders was calculated using specific coefficients for proteins, lipids and total carbohydrates (including crude fibers) [16]:

E = (4 × % proteins) + (4 × % total carbohydrates) + (9 × % lipids)   (9)

The results were reported in Kcal per 100 g of fresh matter.

2.2.4.8 Fruit main mineral contents

Mineral composition was determined on ashes with a scanning electron microscope coupled on to an energy scattering spectrometer (Supra 40 VP Zeiss, Germany). A quantity of 10 mg of ash was taken and spread over the pad primed with double-sided adhesive carbon. The pad was attached to the slide of the scanning electron microscope coupled to an energy scattering spectrometer. Finally, the ready sample slide was mounted on the scanning electron microscope chamber stage for microanalysis of X-ray energy scattering spectrometer. The X-rays emitted depended on the nature of the sample. The assays focused on sodium, phosphorus, calcium, magnesium, potassium and iron contents. In order to identify the mineral composition of the sample, the device measured electron transition energy at the electron clouds of the K, L, and M series of atoms in the sample. The contents obtained were expressed in mg per 100 g FM.

2.3 Data Statistical Analyses

The data collected was subjected to statistical tests using STATISTICA 7.1 software. An analysis of variance (main effects) was used to assess the effects of fertilizer treatments on fruit biochemical parameters. In the event of a significant difference between the treatments, the Newman-keuls multiple comparison test at 5% threshold was used to classify them into homogeneous groups. Furthermore, a Principal Component Analysis (PCA) was used to select the different fertilizer treatments for which the plants showed the best biochemical characteristics.

3. RESULTS

3.1 Effects of Fertilizers on Fruit Biochemical Properties

3.1.1 Moisture, dry matter, ash and fiber levels

The values of all the parameters presented varied significantly depending on the fertilizer treatments applied, with the exception of fiber level ones (Table 1). Thus, the highest average water contents in fruits were due to treatments T0 (no fertilizer), T1 (chicken manure), T2 (chicken manure + plantain peel compost) and T4 (plantain peel compost), and the lowest ones were due to T3 (chicken manure + plantain peel potash) and T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)). The opposite trends were noted with respect to dry matter levels. For this parameter, application of treatments T3 (chicken manure + plantain peel potash) and T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)) induced the highest values (9.45 and 9.37% FM, respectively). The lowest average levels were statistically evenly inherent in treatments T0 (no fertilizer), T1 (chicken manure), T2 (chicken manure + plantain peel compost) and T4 (plantain peel compost). On average, the biofertilizers, as well as the control treatment, induced statistically equal ash levels but lower than the one that resulted from T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)), the value of which was the highest. Furthermore, the fiber levels did not vary significantly depending on the treatments performed. Fertilizers had no effect on this parameter. The average value recorded was equal to 4.32% of fresh matter.

3.1.2 Lipid, protein, carbohydrate and energy value contents

There was no significant difference between fertilizers for lipid and protein contents (P > 0.05).

The effects of fertilizer treatments on fruit carbohydrate and energy contents were classified into two distinct groups. The first group represented by treatments T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)), T4 (plantain peel compost), T3 (chicken manure + plantain peel potash) and T2 (chicken manure + plantain peel compost) induced the highest carbohydrate contents and the best fruit energy values. The second group with the lowest carbohydrate and energy contents were represented by treatments T0 (no fertilizer) and T1 (chicken manure) (Table 2).

3.1.3 Mineral element contents

Statistical analyses showed, for microelement contents, expressed in mg per 100 g of fresh matter, that there was no significant difference between applied treatments ($P > 0.05$) for sodium and iron. The average values were equal to 6.44 and 0.26 mg per 100 g MF, respectively (Table 3).

Regarding phosphorus, the results showed a significant difference between treatments. Fruits from treatments T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)) and T4 (plantain peel compost) have had higher values than those of other fertilizers with on average 27.001 and 26,580 mg per 100 g MF, respectively. The fruits stemming from the control treatment had the lowest phosphorus value. Moreover, plants grown on fertilized sites with treatment T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)) produced the potassium-richest fruits with an average equal to 255.166 mg per 100 g FM.

Concerning calcium content, the Newman-Keuls test made it possible to classify the treatments into two homogeneous groups. The first group

formed by treatments T0 (no fertilizer), T1 (chicken manure), T2 (chicken manure + plantain peel compost) and T4 (plantain peel compost) induced the largest values. While the group formed by treatments T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)) and T3 (chicken manure + plantain peel potash) had the lowest values.

As for magnesium, a significant difference was observed between the average values depending on the treatments, with constitution of three distinct groups. The best group was formed by treatments T1 (chicken manure) and T4 (plantain peel compost) which induced the highest magnesium contents with respective averages of 14.443 and 14.528 mg per 100 g FM. The second group formed essentially by treatments T0 (no fertilizer) and T2 (chicken manure + plantain peel compost), had intermediate values respectively equal to 12.973 and 12.995 mg per 100 g FM. The third group formed by treatments T3: (chicken manure + plantain peel potash) and T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)) was characterized by the lowest contents (11.375 and 11.215 mg per 100 g FM, respectively).

3.2 Main Component Analysis of Fruit Biochemical Properties

Main Component Analysis made it possible to screen the fertilizer treatments studied basing on the biochemical properties of eggplant fruits. Axes 1 and 2 have characterized the assessed treatments. These axes contributed 81.44% to the variation observed regarding fruits. Main Component Analysis, made from data relating to moisture, dry matter, ash and fiber levels on the one hand, and nutrients (lipids, proteins, carbohydrates and energy values), in minerals

Table 1. Moisture, dry matter, ash and fiber levels of Kalenda eggplant fruit fibers depending on fertilizer treatments

Treatments	Moisture (% FM)	Dry matter (% FM)	Ash (% FM.10^3)	Fibers (% FM)
T0	91.086±0.08 a	8.913±0.08 b	0.602±0.00 b	4.326±0.00 a
T1	91.074±0.07 a	8.925±0.07 b	0.602±0.00 b	4.327±0.02 a
T2	91.010±0.04 a	8.989±0.04 b	0.603±0.00 b	4.326±0.00 a
T3	90.548±0.14 b	9.451±0.14 a	0.604±0.00 b	4.325±0.00 a
T4	90.950±0.01 a	9.049±0.14 b	0.604±0.00 b	4.333±0.00 a
T5	90.630±0.09 b	9.370±0.09 a	0.609±0.00 a	4.332±0.00 a
MG	90.88	9.12	0.60	4.32
CV (%)	0.27	2.73	0.28	0.14
p	0.001	0.002	0.000	0.087

* In the same column, the values assigned the same letter are not significantly different at 5% threshold (Newman-Keuls test); T0: Control; T1: Chicken manure; T2: Chicken manure + Compost; T3: chicken manure + Potash; T4: Compost; T5: NPK + N + K2SO4; MG: General Average, CV: Coefficient of Variation corresponding to the last residual error; P: probability

Table 2. Lipid, protein, carbohydrate and energy contents per 100 g of fresh matter in Kalenda eggplant fruits depending on the fertilizing treatments

Treatments	Lipids	Proteins	Carbohydrates	Energies
T0	0.175±0.00 a	1.238±0.01 a	7.501±0.01 b	36.526±0.04 b
T1	0.175±0.00 a	1.248±0.00 a	7.502±0.00 b	36.579±0.01 b
T2	0.175±0.00 a	1.236±0.01 a	7.578±0.01 a	36.830±0.02 a
T3	0.174±0.00 a	1.240±0.00 a	8.038±0.00 a	38.678±0.02 a
T4	0.173±0.00 a	1.259±0.01 a	7.617±0.00 a	37.065±0.01 a
T5	0.175±0.00 a	1.253±0.01 a	7.943±0.00 a	37.519±0.02 a
MG	0.17	1.25	7.696	37.366
CV (%)	1.16	1.84	0.75	0.51
P	0.860	0.180	0.000	0.000

* In the same column, the values assigned the same letter are not significantly different at 5% threshold (Newman-Keuls test); T0: Control; T1: Chicken manure; T2: Chicken manure + Compost; T3: chicken manure + Potash; T4: Compost; T5: NPK + N + K_2SO_4; MG: General Average, CV: Coefficient of Variation corresponding to the last residual error, P : probability

Table 3. Mineral contents (in mg per 100 FM) of Kalenda eggplant fruits depending on fertilizer treatments

Treat	Phosphorus	Potassium	Sodium	Calcium	Magnesium	Iron
T0	19.908±0.22 d	205.666± 2.41 d	6.460±0.05 a	18.176±0.86 a	12.973±0.07 b	0.235±0.01 a
T1	24.731±0.21 c	208.333± 4.04 d	6.395±0.07 a	18.371±0.50 a	14.443±0.17 a	0.248±0.01 a
T2	25.153±0.15 bc	222.666± 1.26 c	6.336±0.05 a	17.718±0.80 a	12.995±0.12 b	0.243±0.01 a
T3	25.490±0.18 b	245.500± 4.33 b	6.391±0.02 a	13.231±0.27 b	11.375±0.18 c	0.268±0.01 a
T4	26.580±0.33 a	225.333± 2.29 c	6.530±0.07 a	18.388±0.59 a	14.528±0.17 a	0.271±0.01 a
T5	27.001±0.16 a	255.166± 1.92 a	6.553±0.07 a	13.401±0.15 b	11.215±0.14 c	0.266±0.00 a
MG	24.81	227.11	6.44	16.55	12.92	0.26
CV (%)	1.72	3.13	2.38	8.23	2.55	11.06
P	0.000	0.000	0.137	0.000	0.000	0.019

* In the same column, the values assigned the same letter are not significantly different at 5% threshold (Newman-Keuls test);T0: Control; T1: Chicken manure; T2: Chicken manure + Compost; T3: chicken manure + Potash; T4: Compost; T5: NPK + N + K_2SO_4; MG: General Average, CV: Coefficient of Variation corresponding to the last residual error, P : probability, Treat: Treatment
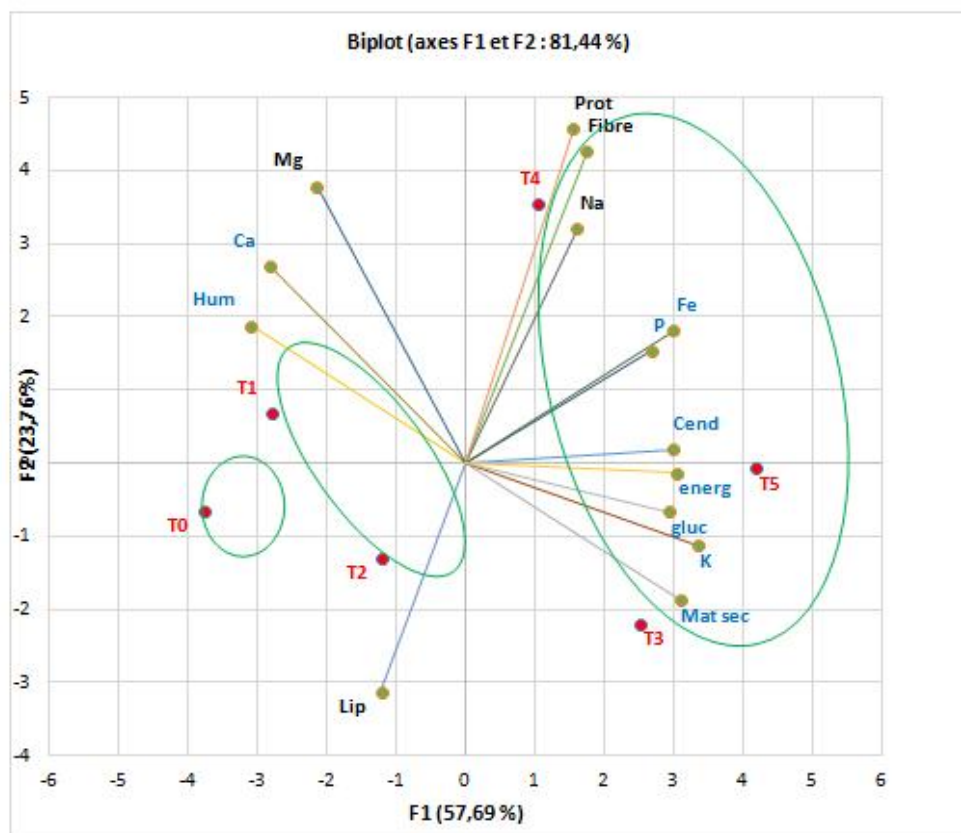
Fig. 1. Distribution of fertilizers depending on fruit biochemical properties along axis 1 and 2 of a Main component analysis

T0: Witness without fertilization; T1: Chicken manure; T2: Chicken manure + plantain peel compost;
T3: Chicken manure + plantain peel potash; T4: Plantain peel compost; T5: NPK + Nitrogen (N) + potassium
sulfate (K_2SO_4); Hum: Moisture; Mat sec: Dry matter; Cen: Ash; P: Phosphorus; K: potassium; Na: Sodium; Ca:
calcium; Mg: magnesium; Fe: iron; Li: lipid; Pro: Protein; Glu: carbohydrate; Energ: Energy

(phosphorus, potassium, sodium, calcium, magnesium and iron) on the other hand, showed that axes 1 and 2 were sufficient to characterize the applied manures. Ash, dry matter, carbohydrate, energy, phosphorus, potassium and iron contents were strongly and positively correlated with axis 1 while those of calcium, magnesium and moisture were negatively correlated (Fig. 1). Thus, axis 1 has helped distribute the treatments into three groups. Treatments T3 (chicken manure + plantain peel potash), T4 (plantain peel compost) and T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)) form the same group, the one of manures that favored a better mineral transfer. The second group, consisting of treatments T1 (chicken manure) and T2 (chicken manure + plantain peel compost), was characterized by average values. The negative control T0 (no fertilizer)

which constituted the last group, induced the lowest mineral export regarding fruits.

4. DISCUSSION

In this study, chemical treatment T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)) and organic treatment T3 (chicken manure + plantain peel potash) induced higher dry matter than T1 (chicken manure), T2 (chicken manure + plantain peel compost) and T4 (plantain peel compost) fertilizers. These high levels denote good mineral (P, K, Na, Ca, Mg, Fe) nutrition of plants and their accumulation in fruits stemming from these treatments T3 (chicken manure + plantain peel potash), T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)). The low mineral concentrations of the fruits stemming from organic treatments T1 (chicken manure), T2

(chicken manure + plantain peel compost) and T4 (plantain peel compost) would be justified by the fact that these included organic fertilizers that have slow and progressive mineralization, unlike T3 (chicken manure + organic potash) which behaved like a mineral fertilizer. As a result, plants could not use the maximum nutrient on time for better mineral export. Indeed, it would seem that these nutrients are not always available for plants at the right time, following the slow decomposition of organic matter. Our results align with [17] findings that showed a significant and positive correlation between dry matter and nutrient concentrations in carrot and onion.

In general, the plants that received mineral fertilizer T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)) as treatment have exported more major elements including potassium and phosphorus as well as carbohydrates. These were followed by those treated with the combination of chicken manure-organic potash T3 (chicken manure + plantain peel potash). Indeed, the quick release of nutrients followed by their absorption by plant roots, explain this preference. Referring to the total exports of minerals in fruits, it follows that the export order is such that K>P>Mg>Ca>Na>Fe. Our results obtained are similar to those of [18] on exports and use of mineral elements in corn cultivation. According to [19], the strong absorption of potassium is favored by the need of the crop in this element. Indeed, potassium participates in many decisive metabolic processes for fruit yield and quality. It improves water regulation in the plant, performance of assimilation and fruiting [20].

According to [21], the high nutritional value of fruits stemming from treatments T3 (chicken manure + plantain peel potash) and T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)) in minerals, especially in potassium, phosphorus and carbohydrate would be due to an indirect effect of nitrogen which, by stimulating photosynthesis, might increase the production of soluble sugars. The same authors report that high nutrient values could also be explained by the decrease in the osmotic pressure of the soil solution (i.e. more strongly negative) when it is more concentrated in nutrients (increased the electrical conductivity of the soil), which would induce a decrease in water intake to fruits and therefore a concentration of higher solutes inside the latter.

The main component analysis (MCA) of fruit biochemical properties has shown that T3 (chicken manure + plantain peel potash) and T4 (plantain peel compost) organic fertilizer-based treatments have had an export of minerals similar to that of the chemical fertilizer T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)). However, treatment T3 (chicken manure + plantain peel potash) has significantly distinguished itself from treatment T4 (plantain peel compost) with higher fruit contents.

This result suggests that this fertilizer has favored a good synthesis and a good transfer of minerals regarding fruits. This performance of treatment T3 (chicken manure + plantain peel potash) lies in the fact that the potash contained in this fertilizer might bring potassium easily absorbed by plants. Indeed, [22] showed that 36 to 49% of the total potassium contained in potash is soluble in water. [23] also reported an efficiency of potassium contained in potash equivalent to that of chemical potassium fertilizers.

Mineral and organic fertilizers in this study have had an impact on Ca and Mg levels in fruits. Eggplants from potassium-based fertilization T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K_2SO_4)) and T3 (chicken manure + plantain peel potash) have had fruits with lower Ca and Mg contents. Calcium contents have dropped considerably in the presence of high organic potassium content provided by these fertilizers. This increase in potassium content might limit calcium assimilation behind the observed results. With regard to magnesium, the contents observed in the different fruits were quite homogeneous but remained weak. Potassium might seem to hinder the absorption and assimilation of calcium and magnesium in Kalenda eggplant variety [24]. These findings highlight K-Ca, K-Mg antagonisms shown by many authors [25].

5. CONCLUSION

The objective of our study was to improve the nutritional quality of eggplant fruits by organic fertilization. The results showed that fiber, protein, lipid, sodium and iron contents were not influenced by the different competing fertilizers. However, the chemical treatments T5 (NPK (10 18 18) + Urea (46% N) + Potassium sulphate (K2SO4)) and T3 (chicken manure + plantain peel potash) induced the highest levels of potassium, phosphorus, carbohydrates and

significantly improved the energy value of the fruits. However, these two treatments had the lowest levels of magnesium and calcium, reflecting an antagonism between potassium and these minerals. The lowest carbohydrate and energy contents were found in the T0 (no fertilizer) and T1 (chicken manure) treatments.

Of all the organic treatments tested, the combination of chicken droppings with banana peel potash, thanks to a synergistic effect of the two types of fertilizer, proved to be the most effective in terms of mineralization, assimilate transport and mineral export.

The results show that eggplant (*Solanum melongena*) fertilized with organic potash combined with chicken droppings has a good nutritional value comparable to chemical fertilizer because of its high content of macro-nutrients essential for the body's good balance.

Thus, the use of this organic fertilizer could be an interesting alternative to the application of chemical fertilizers, particularly potassium sulphate and nitrogen, which would be a danger to the environment and human health. This technical itinerary based on the valorization of livestock by-products (chicken droppings) and crops (banana peel), which are local natural resources at a lower cost and ecologically sustainable, could contribute to reduce the expenses of the market gardener, to preserve the environment, to sustainably manage soil fertility and to guarantee the quality of the harvested products.

CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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