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## Effect of an organic amendment on the agromorphological performances, physicochemical properties and nutritional qualities of *Solanum aethiopicum* L. and *Solanum melongena* L. in Nzindong, West Cameroon

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### Abstract

In Cameroon, several varieties of eggplants used in the preparation of soups and broths, are disappearing from our markets. The aim of this study was to evaluate the effect of poultry manure-based amendments on the agromorphological parameters, physicochemical properties, and nutritional qualities of *Solanum aethiopicum* L. and *Solanum melongena* L. The experimental design was a split plot and the cultivation took place in Nzindong. We carried out 4 treatments for each plant (T0: no amendment/Control; T1: 1 kg/1.5 m<sup>2</sup> of poultry manure; T2: 2 kg/1.5 m<sup>2</sup> of poultry manure and T3: 2 kg/1.5 m<sup>2</sup> of poultry manure). The results obtained revealed that treatment T1 (*Solanum aethiopicum* L.) and T0 (*Solanum melongena* L.) gave the best production yields, estimated at 24.22 t/ha and 16.13 t/ha respectively. The physicochemical analyses showed that: for 100 g of dry matter of *Solanum aethiopicum* L., treatment T1 had the highest levels of lipids (0.27 g), proteins (4.37 g), fibers (6.32 g), Na (108.45 mg) and Zn (164.13 mg). For 100 g of dry matter of *Solanum melongena* L., treatment T0 had the highest levels of P (0.38 mg), Cu (60.42 mg), and Se (0.21 µg). These consumed fruit-vegetables could constitute an important dietary supplement for populations.

**Key words:** Culture, Poultry manure, *Solanum aethiopicum* L., *Solanum melongena* L., Cameroon

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## 1. Introduction

Eggplant is an annual crop with a fairly long production cycle and extensive harvests (J-François et al., 2001);

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eggplants have medicinal properties: these fruits are used in cases of obesity (Selena, 2008), possess antihypertensive (Mpondo et al., 2012), antidiabetic (Vandi et al., 2016); digestive (Mpondo et al., 2012), anticancer (Kahlon et al., 2008) and antioxidant (Nisha et al., 2009) activities thanks to the nutrients and bioactive compounds they contain, such as phenolic compounds (Boubekri, 2014; Mandal, 2010; Adegbindin, 2016; Eze and Kanu, 2014).

The strong agricultural and environmental pressures exerted on arable land led to a significant decline in soil fertility as well as production yields (Bado, 2002; Boga, 2007). Dietary habits influence the cultivation of a plant and can even cause the disappearance of some plants. However, the sustainability of plant cultivation is linked to the control of agroecological conditions and the maintenance of soil fertility (Rouanet, 1984) favored by the valorization of the products obtained. Given this trend of disappearance of several African foods, including certain eggplant varieties, it is therefore wise to choose an area suitable for cultivation, available and accessible amendments to maintain the plants' cultivation. Agroecological zone 3 in Cameroon, corresponding to the highlands, has been revealed as one of the agricultural production basins, specifically for vegetables, including eggplants. The locality of Nzindong (5° 34' North latitude, 10° 11' East longitude) in the Bamboutos Division (West Region), belonging to agroecological zone 3, is suitable for eggplant cultivation and is characterized by an average annual temperature that fluctuates around 20 °C and a relative humidity between 50% and 70% (Boudjeka, 2021; Christopher et al., 2022).

Among organic manures, there is poultry manure, which is highly valued in agriculture (Atidéglá, 2011). This manure is less expensive for vegetable growers compared to inorganic manures, which have many disastrous consequences and are also more expensive (Ullah et al., 2008). Moreover, in Ivory coast, work aimed at demonstrating the impact of organic amendments on the agromorphological parameters of an eggplant variety was carried out in 2018, thus revealing a scientific gap in the effects of organic amendments on the physicochemical and nutritional properties of eggplants.

The objective of this study is to evaluate the effect of the amendment on agromorphological performance and the physicochemical and nutritional properties of *Solanum aethiopicum* L. and *Solanum melongena* L. fruits in order to promote sustainable cultivation of these plants.

## 2. Materials

### 2.1. The study area

The study area was chosen based on data from an ethnonutritional survey (from September 1, 2021 to June 14, 2022) (Adriel et al., 2024) and a pilot cultivation study conducted jointly in Edéa (Littoral) and Nzindong (West) between June 30, 2022 and February 5, 2023. The ethnonutritional study revealed that West Cameroon is a production basin and, moreover, the pilot cultivation was found to be favorable in the West rather than the Littoral.

The actual cultivation was therefore carried out in the Bamboutos division (Batcham district; village: Nzindong; neighborhood: Balekeu at coordinates: 5° 34' North latitude, 10° 11' East longitude). The climate of Nzindong is Cameroonian, characterized by a long rainy season (mid-March to mid-November) and a short dry season (mid-November to mid-March). Average annual rainfall is between 1500 and 2000 mm, and the average annual temperature fluctuates around 20 °C (Boudjeka, 2021; Christopher et al., 2022).

### 2.2. Study duration

The study lasted 11 months and 10 days, from March 9, 2023, to February 19, 2024.

### 2.3. Study material

- **Plant material:** *Solanum aethiopicum* L. and *Solanum melongena* L.: The plant material used consisted of *Solanum aethiopicum* L. and *Solanum melongena* L. plants. The fruits were collected from farmers, and the seeds were extracted and dried beforehand for 1 week in the sun. These fruits were identified at the National Herbarium in Yaoundé.
  - *Solanum melongena* L.: Registered at the National Herbarium under No. 34757/HNC;

- *Solanum aethiopicum* L.: Registered at the National Herbarium under No. 43053/HNC.
- **Fertilizers:** The fertilizers used in our study consisted of poultry manure obtained from poultry manure dealer in the town of Mbouda.

For this study, we conducted four treatments:

- T0: no fertilizer (Control);
- T1 (1 kg/1.5 m<sup>2</sup>); T2 (2 kg/1.5 m<sup>2</sup>); and T3 (4 kg/1.5 m<sup>2</sup>): poultry manure.

### 3. Methods

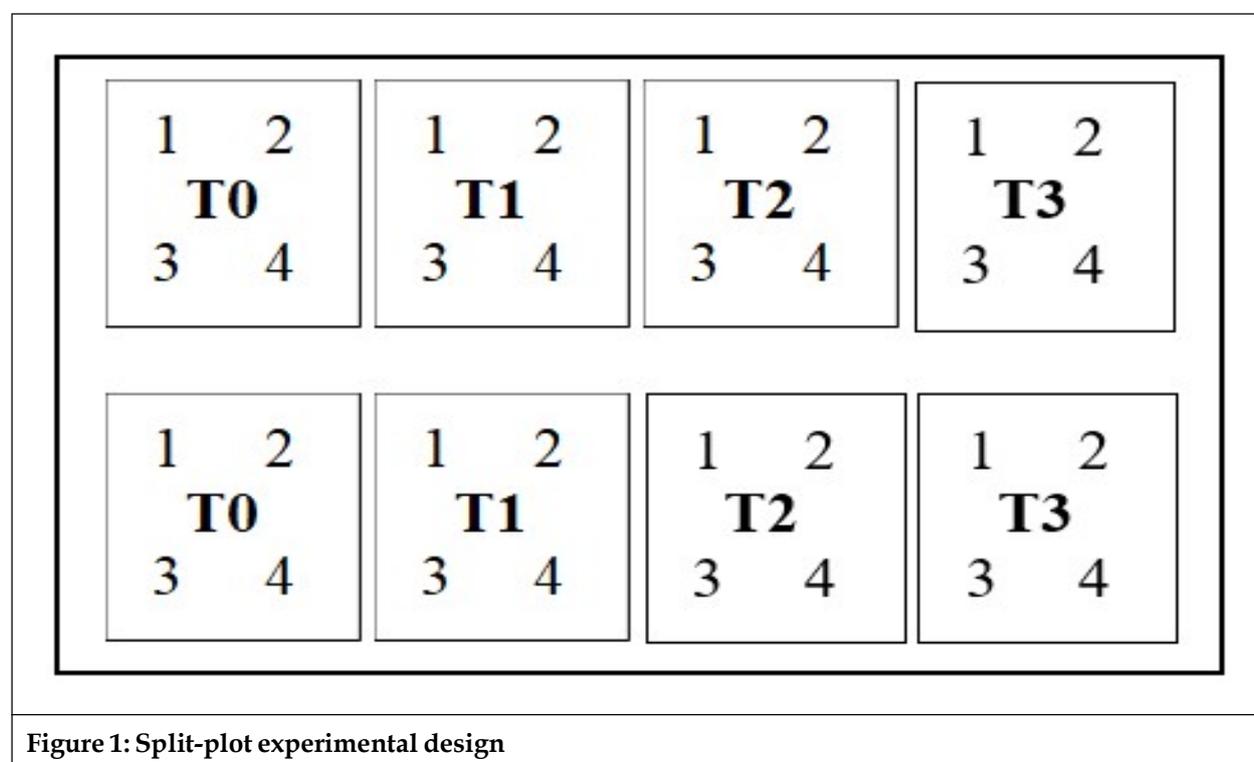
#### 3.1. Procedures

##### 3.1.1. Soil and poultry manure characterization

Three 200 g samples (one from the center and two from the edges of the experimental area) were collected and mixed to obtain a homogeneous soil sample. 500 g of soil and 500 g of poultry manure were collected and transported in polyethylene bags to the Soil Analysis and Environmental Chemistry Research Unit of the Faculty of Agronomy and Agricultural Sciences (FAAS) at the University of Dschang for physicochemical analyses. These analyses included pH measurements and determination of the following element contents: total Organic Carbon (OC), Organic Matter (OM), total Nitrogen (N), total Phosphorus (P), Calcium (Ca), Potassium (K), and Magnesium (Mg). In addition, the texture, available phosphorus, Cation Exchange Capacity (CEC), and exchangeable bases of the soil were determined (Alla Kouadio et al., 2018; Pauwels et al., 1992).

##### 3.1.2. Experimental crop design

The split-plot experimental design, as shown in Figure 1, was applied for this study (Letourmy, 1999); it consisted of a non-random distribution of treatments. To achieve this, we successively planted and transplanted the plants across all experimental units.



**Figure 1: Split-plot experimental design**

- **Nursery setup:** The nursery began on March 9, 2023, by bagging the soil clods followed by regular watering every three days. The seeds collected (previously dried for 1 week in the sun) from the fruits were placed in bags on March 29, 2023, spacing them 2 to 3 cm apart. The seeds were then pushed in 2 or 3 mm, then covered and sprayed with water. To ensure proper seedling emergence, the nursery stage lasted 65 days until transplanting.

- **Transplanting the seedlings into the ground:** Soil preparation began on May 15, 2023. It consisted of clearing the approximately 100 m<sup>2</sup> plot, plowing, and loosening the soil surface using a machete, rake, and hoe. The seedlings were transplanted into the open field on July 6, 2023. Puddles 5 to 10 cm deep and at a planting density of 4 plants/1.5 m<sup>2</sup> were created.
- **Plant fertilization and crop maintenance:** Ridging was carried out 14 days after transplanting the seedlings into the field, followed by weeding and hoeing for crop maintenance following grassing. Fertilizer treatments (T1, T2, T3) were carried out at a frequency of four applications (1 basal fertilization and 3 maintenance fertilizations). For each treatment, the first application consisted of basal fertilization and was applied during soil preparation. The other three supplementary applications consisted of maintenance fertilizations. They were carried out respectively 30, 60, and 90 days after transplanting, as shown in Table 1. During cultivation, the plants were not pruned, and crop maintenance was carried out until harvest. Note that insecticides and antifungals were used to prevent infections approximately 60 days after transplanting; Pyriforce 600 (emulsifiable concentrate); Penncozeb (Dispersible Granule).

**Table 1: Poultry manure fertilization plan**

Treatments	Bottom fertilizer	Maintainance fertilizers		
		30 days	60 days	90 days
T0 (Control)	Without fertilizer	Without fertilizer	Without fertilizer	Without fertilizer
T1	1 kg/1,5 m <sup>2</sup> Poultry manure			
T2	2 kg/1,5 m <sup>2</sup> Poultry manure			
T3	4 kg/1,5 m <sup>2</sup> Poultry manure			

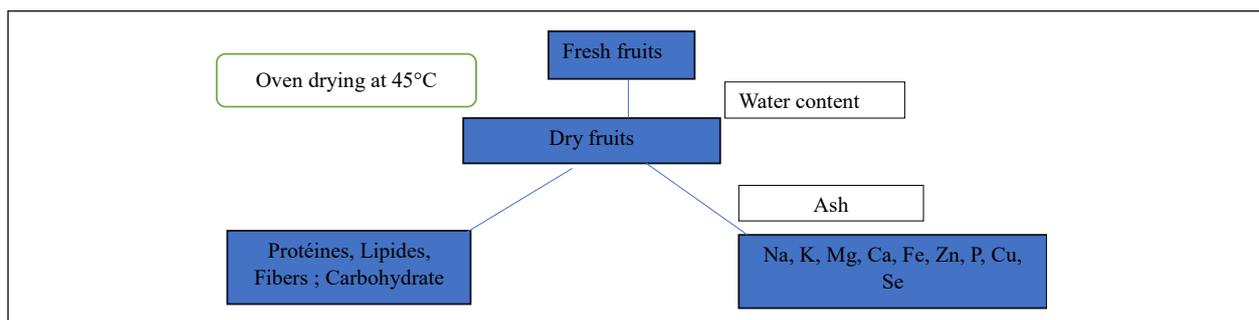
3.1.3. Assessment of agromorphological parameters

The effect of the amendment was observed on growth and production parameters. For plant height growth, measurements were taken using a tape measure from the root collar to the apical bud. The diameter at the root collar was measured 2 cm above the ground using a caliper. The number of live leaves, the number of branches, and the number of fruits present on the plants were also determined by counting. All these growth parameters were assessed 150 days after transplanting.

Regarding production, measurements included the number and average diameter of fruits, the average length and mass of fruits, and the yield in tons per hectare at harvest. Fruits were counted at harvest. Fruit length and diameter were measured using a caliper. The average fruit mass was calculated by dividing the total fruit mass by the number of fruits harvested in the elementary plot. The yield was calculated by considering the total fruit mass harvested per treatment followed by extrapolation to the hectare.

3.1.4. Evaluation of physicochemical properties

Nutrients were measured using the methods of Pauwels *et al.* (1992) as shown in Figure 2.



**Figure 2: Flowchart of physicochemical analyses**

### 3.2. Statistical data analysis

Tests were performed in triplicate, and the collected data were saved in Excel and subjected to statistical tests using XLSTAT 2014.5.03 software. An analysis of variance was used to assess the effects of fertilizer treatments on agromorphological parameters. The assumption of equality of means was evaluated at a risk of  $\alpha = 5\%$  (Treatment/Fisher (LSD)/Analysis of differences between modalities with a 95% confidence interval).

## 4. Results

### 4.1. Physicochemical characterization of the soil and fertilizers

The soil analysis presented in Table 2 reveals that its texture corresponds to a clay-loam soil type.

<b>Table 2: Physicochemical analysis of the soil</b>	
<b>Color</b>	<b>Black</b>
<b>Particle size</b>	
Clay% (C%)	31.50 ± 0.71
Silt% (S%)	39.25 ± 0.35
Sand% (S%)	29.00 ± 0.71
<b>Acidity</b>	
pH-water	5.25 ± 0.71
pH-KCl	4.45 ± 0.71
<b>Organique profile</b>	
Organic carbon (OC)%	5.76 ± 0.01
Total organic matter (OM)%	9.93 ± 0.03
Total nitrogen N (%)	0.41 ± 0.007
C/N ratio	14.22 ± 0.21
<b>Mineral state (meq/100 g)</b>	
Calcium	4.32 ± 0.007
Magnesium	1.43 ± 0.01
Potassium	0.47 ± 0.01
Sodium	0.22 ± 0.01
Sum of exchangeable bases	6.43 ± 0.05
<b>Cation exchange capacity (meq/100 g)</b>	
CEC	20.9 ± 0.03
V%	30.79 ± 0.03
<b>Assimilable phosphorus</b>	
P (mg/kg)	34.92 ± 0.03

The analysis of the Poultry Manure presented in Table 3 reveals that it has a slightly alkaline pH. This Poultry Manure is rich in organic matter and very low in mineral elements.

Table 3: Physicochemical analysis of poultry manure	
<b>Acidity</b>	
pH	7.45 ± 0.07
<b>Organic profile</b>	
OC (%)	30.14 ± 0.05
OM (%)	60.28 ± 0.09
N (%)	1.95 ± 0.01
C/N	15.46 ± 0.09
<b>Mineral state</b>	
Ca (%)	0.42 ± 0.007
Mg (%)	0.16 ± 0.007
Na (%)	0.00
K (%)	0.21 ± 0.007
P (%)	0.03 ± 0.007

#### 4.2. Effects of the amendment on growth parameters

Table 4 above shows the growth parameters 150 days after transplanting according to the plant species.

For *Solanum aethiopicum* L., treatment T3 had the highest values for leaf number (461 ± 6.36), branch number (42 ± 2.12), and fruit number (67 ± 12.73). Treatment T2 had the greatest plant height (54 ± 1.41) and the largest crown diameter (20.55 ± 2.19 mm). For *Solanum melongena* L., treatment T0 had the highest values for leaf number (399 ± 10.7), branch number (36 ± 9.2), and crown diameter (23.45 ± 1.06 mm). Treatment T1 had the greatest plant height (83 ± 14.14 cm). Treatment T2 had the highest fruit number (66 ± 14.85).

Table 4: Effects of the amendment on growth parameters						
Species	Treatments	Number of leaves	Number of branch	Height (cm)	Collar diameter (mm)	Number of fruits
<i>Solanum aethiopicum</i> L.	T0	299 ± 82.73 <sup>b</sup>	15 ± 7.07 <sup>b</sup>	42 ± 2.83 <sup>b</sup>	16.95 ± 3.04 <sup>b</sup>	38 ± 14.85 <sup>b</sup>
	T1	320 ± 0.71 <sup>b</sup>	22 ± 6.36 <sup>a,b</sup>	43 ± 7.07 <sup>b</sup>	22.4 ± 0.98 <sup>a</sup>	54 ± 13.44 <sup>a,b</sup>
	T2	364 ± 1.41 <sup>b</sup>	29 ± 19.8 <sup>a,b</sup>	54 ± 1.41 <sup>a,b</sup>	20.55 ± 2.19 <sup>a,b</sup>	48 ± 4.24 <sup>a,b</sup>
	T3	461 ± 6.36 <sup>a</sup>	42 ± 2.12 <sup>a</sup>	46.5 ± 4.95 <sup>a</sup>	19.5 ± 0.14 <sup>a, b</sup>	67 ± 12.73 <sup>a</sup>
<i>Solanum melongena</i> L.	T0	399 ± 10.7 <sup>a</sup>	36 ± 9.2 <sup>a</sup>	78 ± 5.65 <sup>a</sup>	23.45 ± 1.06 <sup>a</sup>	57 ± 7.07 <sup>a</sup>
	T1	262 ± 2.83 <sup>b</sup>	22 ± 5.65 <sup>a,b</sup>	83 ± 14.14 <sup>a</sup>	19.05 ± 3.04 <sup>b</sup>	38 ± 7.78 <sup>a,b</sup>
	T2	320 ± 29.7 <sup>b</sup>	31 ± 2.82 <sup>a,b</sup>	77.5 ± 6.36 <sup>a</sup>	20.95 ± 4.03 <sup>b</sup>	66 ± 14.85 <sup>a,b</sup>
	T3	277 ± 1.41 <sup>b</sup>	26 ± 1.41 <sup>a,b</sup>	80.5 ± 0.7 <sup>a</sup>	19.75 ± 0.78 <sup>a,b</sup>	48 ± 16.26 <sup>a</sup>

**Note:** Treatment/Fisher (LSD)/Analysis of differences between methods with a 95% confidence interval. T0: Control without fertilizer (Control); T1: 1 kg/1.5 m<sup>2</sup>; T2: 2 kg/1.5 m<sup>2</sup>; T3: 4 kg/1.5 m<sup>2</sup>. \* The comparison is made for each species according to the associated treatments. *Solanum aethiopicum* L. (T0; T1; T2 and T3) and *Solanum melongena* L. (T0; T1; T2 and T3). \* Column numbers with the same superscript letters are not significantly different at the 5% level.

### 4.3. Effects of the amendment on production parameters

Table 5 above shows the production parameters of the two species according to the treatments.

For *Solanum aethiopicum* L., treatment T3 had the highest number of fruits ( $100 \pm 1.41$ ) and the highest yield of 27.39 t/ha; Treatment T1 had the highest values for mean fruit length ( $58.16 \pm 7.63$  mm), mean diameter ( $29.82 \pm 4.14$  mm), and mean mass ( $23.44 \pm 7.85$  g).

Species	Treatments	Number of fruits	Fruits length (mm)	Fruits diameter (mm)	Fruits mass (g)	Yields (t/ha)
<i>Solanum aethiopicum</i> L.	T0	$50 \pm 2.21^b$	$51.6 \pm 8.01^c$	$29.46 \pm 4.17^a$	$20.14 \pm 7.74^b$	$11.49 \pm 0.08^b$
	T1	$78 \pm 3.54^b$	$58.16 \pm 7.63^a$	$29.82 \pm 4.14^a$	$23.44 \pm 7.85^a$	$24.22 \pm 0.1^a$
	T2	$83 \pm 2.12^b$	$53.48 \pm 9.11^c$	$28.49 \pm 4.5^b$	$20.83 \pm 8.73^b$	$24.67 \pm 0.12^a$
	T3	$100 \pm 1.41^a$	$55.89 \pm 8.8^b$	$28.17 \pm 2.89^b$	$20.53 \pm 6.39^b$	$27.39 \pm 0.08^a$
<i>Solanum melongena</i> L.	T0	$267 \pm 4.24^a$	$28.07 \pm 4.3^a$	$17.83 \pm 2.59^c$	$4.54 \pm 1.89^c$	$16.13 \pm 0.02^a$
	T1	$222 \pm 0.71^b$	$28.45 \pm 4.1^a$	$17.79 \pm 2.27^c$	$4.5 \pm 1.6^c$	$13.12 \pm 0.02^b$
	T2	$221 \pm 8.49^b$	$28.34 \pm 3.88^a$	$18.21 \pm 2.27^b$	$4.78 \pm 1.79^b$	$13.49 \pm 0.02^b$
	T3	$193 \pm 1.41^c$	$28.35 \pm 4.59^a$	$18.92 \pm 2.6^a$	$5.08 \pm 1.82^a$	$13.07 \pm 0.02^b$

**Note:** Treatment/Fisher (LSD)/Analysis of differences between methods with a 95% confidence interval. T0: Control without fertilizer (Control); T1: 1 kg/1.5 m<sup>2</sup>; T2: 2 kg/1.5 m<sup>2</sup>; T3: 4 kg/1.5 m<sup>2</sup>. \* The comparison is made for each species according to the corresponding treatments: *Solanum aethiopicum* L. (T0; T1; T2 and T3) and *Solanum melongena* L. (T0; T1; T2 and T3). \* Column figures with the same superscript letters are not significantly different at the 5% threshold.

For *Solanum melongena* L., treatment T2 had the greatest mean fruit length ( $28.34 \pm 3.88$  mm); treatment T3 had the highest values for mean diameter ( $18.92 \pm 2.6$  mm) and mean mass ( $5.08 \pm 1.82$  g). Treatment T0 had the highest number of harvested fruits ( $267 \pm 4.24$ ) and yield of  $16.13 \pm 0.02$  t/ha.

### 4.4. Physicochemical characteristics

Table 6 shows that for 100 g of dried *Solanum aethiopicum* L. fruits, the water content of the fruits of the different

Fruits	Treatments	Macronutriments (g/100 g)					Carbohydrate
		Water content	Lipid	Protein	Fiber	Ash	
<i>Solanum aethiopicum</i> L.	T0	$79.53 \pm 0.23^a$	$0.2 \pm 0.01^d$	$3.62 \pm 0.11^e$	$6.2 \pm 0.52^{ab}$	4 <sup>a</sup>	$6.45 \pm 0.44^a$
	T1	79.28 <sup>ab</sup>	$0.27 \pm 0.01^a$	$4.37 \pm 0.05^a$	$6.32 \pm 0.52^{ab}$	$3.66 \pm 0.58^a$	$6.08 \pm 0.10^a$
	T2	$79.57 \pm 0.58^a$	$0.22 \pm 0.013^{cd}$	$3.93 \pm 0.17^{cde}$	$6.11 \pm 0.14^b$	$3.66 \pm 0.58^a$	$6.50 \pm 0.68^a$
	T3	79.5 <sup>a</sup>	$0.24 \pm 0.02^{bc}$	$3.93 \pm 0.69^{cde}$	$6.25 \pm 0.06^{ab}$	4 <sup>a</sup>	$6.08 \pm 0.71^a$
<i>Solanum melongena</i> L.	T0	$79.22 \pm 0.53^{ab}$	$0.22 \pm 0.01^{cd}$	$4.16 \pm 0.05^e$	$6.7 \pm 0.5^{ab}$	$3.33 \pm 0.58^a$	$6.36 \pm 0.23^{abc}$
	T1	$79.27 \pm 0.58^{ab}$	$0.25 \pm 0.02^{ab}$	$3.71 \pm 0.11^e$	$6.59 \pm 0.24^{ab}$	$3.66 \pm 0.57^a$	$6.51 \pm 0.25^{ab}$
	T2	$78.88 \pm 1^{ab}$	$0.26 \pm 0.01^{ab}$	$4.29 \pm 0.05^{abc}$	$6.34 \pm 0.5^{ab}$	$3.66 \pm 0.57^a$	$6.55 \pm 0.20^a$
	T3	$78.99 \pm 0.58^{ab}$	$0.26 \pm 0.01^{ab}$	$4.16 \pm 0.05^{abcd}$	$6.72 \pm 0.006^{ab}$	$3.66 \pm 0.58^a$	$6.21 \pm 0.05^{bc}$

**Note:** Treatment/Fisher (LSD)/Analysis of differences between methods with a 95% confidence interval. T0: Control without fertilizer (Control); T1: 1 kg/1.5 m<sup>2</sup>; T2: 2 kg/1.5 m<sup>2</sup>; T3: 4 kg/1.5 m<sup>2</sup>. \* The comparison is made for each species according to the corresponding treatments; *Solanum aethiopicum* L. (T0; T1; T2 and T3) and *Solanum melongena* L. (T0; T1; T2 and T3). \* Column figures with the same superscript letters are not significantly different at the 5% level.

treatments is between 79.28% and  $79.57 \pm 0.58\%$ ; the lipid content is less than 0.3% (between  $0.20 \pm 0.01\%$  and  $0.27 \pm 0.01\%$ ); the protein content is between  $3.62 \pm 0.11\%$  and  $4.37 \pm 0.05\%$ ; the fiber content is between  $6.11 \pm 0.14\%$  and  $6.32 \pm 0.52\%$ , and the ash content is between  $3.66 \pm 0.58\%$  and 4%.

For 100 g of dried *Solanum melongena* L. fruits, the water content of the fruits of the different treatments is between  $78.88 \pm 1\%$  and  $79.27 \pm 0.58\%$ . The lipid content is less than 0.3% (between  $0.22 \pm 0.01\%$  and  $0.26 \pm 0.01\%$ ); the protein content is between 3.71% and 4.29%. The fiber content is between  $6.34 \pm 0.5\%$  and  $6.72 \pm 0.006\%$ , and the ash content is between  $3.33 \pm 0.58\%$  and  $3.66 \pm 0.57\%$ .

Table 7 presents the micro and trace nutrients of the fruits of *Solanum aethiopicum* L. and *Solanum melongena* L. according to the amendment.

We observe that for *Solanum aethiopicum* L., the Na content ranges from  $86.78 \pm 0.11$  mg to  $108.45 \pm 0.06$  mg; the K content is between  $721.39 \pm 0.1$  mg and  $1010.39 \pm 0.12$  mg; the Ca content is between  $585.43 \pm 0.06$  mg and  $857.74 \pm 0.12$  mg; the Mg content is between  $297.97 \pm 0.06$  mg and  $667.94 \pm 0.12$  mg; the P content is between  $0.24 \pm 1.21$  mg and  $0.48 \pm 1.18$  mg; the Fe content is between  $7.28 \pm 0.0007$  mg and  $12.51 \pm 0.0007$  mg; the Cu content is between  $35.42 \pm 0.004$  mg and  $60.42 \pm 0.004$  mg; the Zn content is between  $115.51 \pm 0.69$  mg and  $164.13 \pm 0.69$  mg and the Se content is between  $0.21 \pm 0.007$  µg and  $0.25 \pm 0.07$  µg.

For *Solanum melongena* L., the Na content ranges from  $85.05 \pm 0.06$  mg to  $135.16 \pm 0.06$  mg; the K content is between  $726.84 \pm 0.06$  mg and  $944.98 \pm 0.06$  mg; the Ca content is between  $583.94 \pm 0.1$  mg and  $806.73 \pm 0.06$  mg; the Mg content is between  $295.97 \pm 0.06$  mg and  $679.97 \pm 0.06$  mg; the P content is between  $0.29 \pm 1.21$  mg and  $0.38 \pm 0.61$  mg; the Fe content is between  $10.25 \pm 0.0007$  mg and  $20.04 \pm 0.0007$  mg; the Cu content is between  $23.75 \pm 0.589$  mg and  $42.08 \pm 0.589$  mg;

The Zn content is between  $194.27 \pm 0.69$  mg and  $271.07 \pm 0.69$  mg and the Se content is between  $0.12 \pm 0.014$  µg and  $0.21 \pm 0.007$  µg.

**Table 7: Effects of the amendment on micro and trace nutrients according to treatment**

Fruits	Treatments	Micro and trace nutrients								
		Na (mg/100 g)	K (mg/100 g)	Ca (mg/100 g)	Mg (mg/100 g)	P (mg/100 g)	Fe (mg/100 g)	Cu (mg/100 g)	Zn (mg/100 g)	Se (µg/100 g)
<i>Solanum aethiopicum</i> L.	T0	$86.78 \pm 0.11^f$	$721.39 \pm 0.1^h$	$783.15 \pm 0.11^c$	$465.93 \pm 0.1^f$	$0.48 \pm 1.18^a$	$7.52 \pm 0.0007^i$	$37.92 \pm 0.004^d$	$144.68 \pm 0.69^g$	$0.24 \pm 0.014^{ab}$
	T1	$108.45 \pm 0.06^e$	$862.23 \pm 0.06^d$	$585.43 \pm 0.06^g$	$297.97 \pm 0.06^g$	$0.3 \pm 0.6^b$	$7.40 \pm 0.0007^g$	$35.42 \pm 0.004^e$	$164.13 \pm 0.69^e$	$0.22 \pm 0.0071^{abc}$
	T2	$108.39 \pm 0.18^e$	$853.98 \pm 0.18^f$	$608.34 \pm 0.18^e$	$655.9 \pm 0.18^c$	$0.27 \pm 1.78^c$	$12.51 \pm 0.0007^c$	$39.58 \pm 0.004^c$	$115.51 \pm 0.69^b$	$0.25 \pm 0.07^a$
	T3	$101.46 \pm 0.12^a$	$1010.39 \pm 0.12^a$	$857.74 \pm 0.12^a$	$667.94 \pm 0.12^b$	$0.24 \pm 1.21^d$	$7.28 \pm 0.0007^h$	$60.42 \pm 0.004^a$	$151.49 \pm 0.69^f$	$0.21 \pm 0.007^{bc}$
<i>Solanum melongena</i> L.	T0	$85.05 \pm 0.06^g$	$726.84 \pm 0.06^g$	$775.97 \pm 0.06^d$	$568.59 \pm 0.06^d$	$0.38 \pm 0.61^a$	$10.25 \pm 0.0007^d$	$42.08 \pm 0.589^b$	$222.46 \pm 0.69^c$	$0.21 \pm 0.007^{bc}$
	T1	$101.72 \pm 0.12^d$	$857.69 \pm 0.12^e$	$583.94 \pm 0.1^b$	$466.5 \pm 0.12^e$	$0.29 \pm 1.21^b$	$10.13 \pm 0.0007^e$	$23.75 \pm 0.589^g$	$194.27 \pm 0.69^d$	$0.12 \pm 0.014^e$
	T2	$101.75 \pm 0.06^d$	$879.54 \pm 0.06^c$	$607.47 \pm 0.06^f$	$295.97 \pm 0.06^h$	$0.36 \pm 0.61^c$	$12.92 \pm 0.0007^b$	$36.25 \pm 0.589^e$	$271.07 \pm 0.69^a$	$0.20 \pm 0.0071^c$
	T3	$135.16 \pm 0.06^b$	$944.98 \pm 0.06^b$	$806.73 \pm 0.06^b$	$679.97 \pm 0.06^a$	$0.33 \pm 0.61^d$	$20.04 \pm 0.0007^a$	$27.08 \pm 0.589^f$	$266.21 \pm 0.69^b$	$0.16 \pm 0.014^d$

**Note:** Treatment/Fisher (LSD)/Analysis of differences between methods with a 95% confidence interval. T0: Control without fertilizer (Control); T1: 1 kg/1.5 m<sup>2</sup>; T2: 2 kg/1.5 m<sup>2</sup>; T3: 4 kg/1.5 m<sup>2</sup>. \* The comparison is made for each species according to the relevant treatments: *Solanum aethiopicum* L. (T0; T1; T2 and T3) and *Solanum melongena* L. (T0; T1; T2 and T3). \* Column numbers with the same superscript letters are not significantly different at the 5% threshold.

## 5. Discussion

### 5.1. Physicochemical characterization of soil and fertilizers

The results of soil analysis of the cultivated plot in Balekeu (31.50% Clay, 39.25% Silt and 29% Sand) following the Texture Triangle, it shows that this experimental soil is of the Silt-clay type. Soils rich in silt are favorable for the cultivation of eggplants ([Agriculture biologique: Aubergine, 2010](#)). This silt-containing soil tends to have good stability: The stability of the soil structure results from weak bonds between soil particles thanks to organic matter from amendments (humus, debris), and from soil life (biological, root exudates). The presence of clay in this soil promotes its structural stability, particularly when it is amended with organic matter

contributing to the formation of the clay-humic complex. This combination of clay and organic matter, thanks to a bivalent cation, most often  $\text{Ca}^{2+}$  or  $\text{Mg}^{2+}$ , forms a matrix, which thus stabilizes the soil clods. The structure of silt and clay soils is easily improved by amendments. Thus, a stable soil will be more resistant to erosion from rain and wind (Tosello, 2018).

Soil stability also helps resist soil-borne diseases: Indeed, a biologically active, structured, and stable soil is more conducive to healthy plant growth. They are in an environment unfavorable to pathogens and have the ability to better defend themselves against attacks. However, the more soil stability deteriorates, the more soils have recurring problems with diseases or soil pests. The use of fermentable organic matter promotes the development of non-pathogenic flora, which limits the development of pathogens through spatial and trophic competition (Noble and Coventry, 2005). In addition, soil stability also depends on its biological activity: aerated soil is favorable to the development of microorganisms that participate in soil structuring, promoting the formation of soil aggregates, particularly through the production of polysaccharides (Acton et al., 1962). High biological activity thus confers greater stability to a soil.

This soil has an acidic pH-water of 5.25; soil with a slight risk of toxicity due to excess aluminum or manganese (Boudjeka, 2021). Indeed, soil acidity impacts the proper development of crops and yields. This is the case for certain soluble forms of aluminum, which can become toxic when the pH is below 5.5. This phenomenon is called aluminum toxicity and is the main cause of yield loss in acidic soils. In acidic soil, vegetation is less vigorous; soils with high salinity are unfavorable for growing eggplants, although it is the least demanding in terms of soil type; pHs close to neutral are preferable and for this, an addition of amendments rich in bases or calcium amendments is necessary if we want to improve the soil reaction (Boudjeka, 2021).

The organic profile of the experimental soil of Balekeu showed an Organic Carbon (OC) content of 5.76%, a total Organic Matter (OM) content of 9.93%, a total Nitrogen (N) content of 0.41% and a C/N ratio of 14.22. According to Beernaert and Bitondo (1992), the total Organic Matter (OM) rate of the Balekeu soil is very high ( $6 < \text{OM}$ ), with a poor organic matter (C/N) quality (Beernaert and Bitondo, 1992), reflecting that the nitrogen mineralization of this soil is slow with a need for amendment thus allowing a fairly rapid nitrogen supply for the crop thanks to easy degradation of the materials by microorganisms (Tosello, 2018). This soil is rich in organic matter (humus), which is a key element for obtaining a fertile and productive soil; OM affects many soil properties and increases biological activity by making soil nutrients available to the plant and maintaining the stability of soil pH (Maria, 2019). According to Euroconsult (1989), the mineral status of the Balekeu soil showed low values for Calcium (4.32 meq/100 g), Magnesium (1.44 meq/100 g) and Sodium (0.23 meq/100 g); average values for Potassium (0.48 meq/100 g) and Available Phosphorus (34.94 mg/Kg) (Euroconsult, 1989). This soil therefore has a moderate sum of exchangeable bases of 6.43, a moderate cation exchange capacity of 20.9 and a low saturation of 30.79%. A compensation of these minerals can be done delicately because the contribution of salts (calcium or sodium) impacts the pH of the soil. This moderate CEC indicates fertility and an intermediate nutrient retention capacity for the soil. CEC is influenced by the quality of organic matter and soil clay, allowing for a gradual release of nutrients.

Physicochemical analysis of Poultry Manure showed a slightly alkaline pH of 7.5, with the following organic profile: a high Organic Carbon (OC) content of 30.14%, a high total Organic Matter (OM) content of 60.28%, an average total Nitrogen (N) content of 1.95%, and a C/N ratio of 15.46, reflecting slow nitrogen mineralization. Our C/N results corroborate the data presented by (Anne and Jean, 2009).

The mineral status showed the following mineral elements: Calcium: 0.42%; Magnesium: 0.17%; Potassium: 0.21%; Sodium: 0%, and phosphorus of 0.04%. The results of Poultry Manure analysis were different from those obtained by Théodore et al. (2018), who had presented a basic pH of 8.3, an organic carbon content of 25.25%, a nitrogen content of 2.38%; Calcium: 0.02%; Magnesium: 2.35%; Potassium: 0.85%; Sodium: 0.026% and assimilable phosphorus of 0.85% (Alla Kouadio et al., 2018). This difference in the composition of manure may be due to the treatment processes undergone by manure because organic amendments and fertilizers are materials containing more or less nitrogen depending on their origin and manufacturing process. These are rather complex materials that are degraded into increasingly simple molecules by soil life, before being absorbed by plants (Tosello, 2018) while allowing them to develop their roots well to access nutrients and also aiming to improve soil structure and boost production yield (Jeanne, 2021).

## 5.2. Agromorphological parameters

The cultivation of these wild eggplants in Balekeu is quite practicable and complies with the crops found in agroecological zone No. 3 corresponding to the highlands of West Cameroon, in which market gardening is practiced (Keudem, 2016).

The taking of the parameters, carried out during the cultivation revealed according to the species *Solanum aethiopicum* L. that, the T3 treatment has the high vegetative growth parameters unlike the other treatments according to the number of leaves ( $461 \pm 6.36$ ), the number of branches ( $42 \pm 2.12$ ) and the number of fruits ( $67 \pm 12.73$ ) at 150 days after transplanting and the T3 treatment has the highest average number of fruits harvested ( $100 \pm 1.41$ ) with a higher production yield estimated at 27.39 t/ha. The T1 treatment has the highest values according to the average length ( $58.16 \pm 7.63$  mm), the average diameter ( $29.82 \pm 4.14$  mm), the average mass ( $23.44 \pm 7.85$  g) of the fruits. This significant growth and yield of the T3 treatment would be due to the high nitrogen content provided, on the other hand the high potassium content of this treatment does not prove beneficial for the ripening and quality of the fruits observed. Therefore, according to our study, the T1 treatment is the one which would have an optimal potassium intake.

Treatment T1 doubled the estimated yield from  $11.49 \pm 0.08$  t/ha for (T0) to  $24.22 \pm 0.1$  t/ha for (T1). The lack of linearity in the production yields of the species *Solanum aethiopicum* L. could reflect a saturation of the plant's OM requirements and the optimal manure dosage for this crop would be 10 t/ha, unlike Omary Mbwanbo and Fekadu Fufa Dinssa who recommended a dosage of 15-20 t/ha to obtain a good yield (Omary and Fekadu, 2012). For the cultivation of the species *Solanum melongena* L., treatment T0 gave high results unlike other treatments (T1, T2 and T3) in vegetative growth parameters according to the number of leaves ( $399 \pm 10.7$ ), the number of branches ( $36 \pm 9.2$  mm) and the collar diameter ( $23.45 \pm 1.06$  mm) at 150 days after transplanting and the greatest number of fruits harvested ( $267 \pm 4.24$ ) with high yield estimated at  $16.13 \pm 0.02$  t/ha. The production of the species *Solanum melongena* L. on this plot of Balekeu does not require a need for organic amendment according to the results obtained. The low parameters (growth and production) observed in treatments T1, T2 and T3 compared to T0 would reflect a slowdown in plant growth and development because treatment T0 (Control) which did not receive any amendment produced high parameters (growth and production) compared to the other treatments. This low vegetative growth would reflect that this amendment is not beneficial for the crop on this plot of Balekeu which has sufficient organic matter and an additional amendment causes an adverse effect. Among the factors that could explain the decline in crop yield are the limitations imposed by the soils. Knowledge of limiting factors is an important prerequisite in agricultural research (Awono et al., 2003). Note that according to Konaté et al. (2022), fertilization must be measured and limited to avoid excess nutrients, which will ultimately be unusable by the plant because excessive nitrogen input can lead to a decrease in yield, due to increased stem development at the expense of leaves (Konate et al., 2022).

The lack of beneficial effects of amendments for the species *Solanum melongena* L. could be justified by the history of the plot, which is a parameter to be taken into consideration for crops with the corollary of plot heterogeneity; this can be improved by the practice of experimental crop rotation (Letourmy, 1999).

Furthermore, for this crop, Latin square designs could be applied as a device: because it allows for a double control of heterogeneity. In a Latin square, it is required, on the one hand that the number of repetitions be equal to the number of treatments and, on the other hand, that each treatment be placed once in each row and in each column. The randomization procedure is as follows: we begin by constructing an arbitrary Latin square, then randomize the rows, and finally randomize the columns to obtain the final design. Furthermore, without repeating each treatment on several units, it is impossible to distinguish the effect due to the treatment from experimental error (Letourmy, 1999).

## 5.3. Physicochemical characteristics

In 100 g of dried *Solanum aethiopicum* L. fruit, we have:

- The water content of fruits of the different treatments ranged between 79.28% and 79.57%. These contents obtained are consistent with several studies, whose contents were actually between 65% and 94% (Oyen and Lemmens, 2002; Affiong et al., 2021). However, according to the work of Koua (2016), the water content was higher and ranged between 90% and 92% (Koua, 2016).

- The lipid content of fruits of the different treatments ranged between 0.2% and 0.27%. These lipid contents obtained are higher than those presented by the work of Koua (2016) and according to Oyen and Lemmens (2002) and whose contents were respectively between 0.1% and 1%. Furthermore, other works have shown that these fruits have a lipid content higher than 0.3% (Oyen and Lemmens, 2002; Affiong et al., 2021; Koua, 2016; Tchatchambe, 2015).
- The protein content of fruits of the different treatments between 3.6% and 4.37%. These contents are higher than those presented by several other works and whose contents were lower than 3% (Oyen and Lemmens, 2002; Affiong et al., 2021; Koua, 2016). In addition, Tchatchambe (2015) obtained 5.2% of proteins (Tchatchambe, 2015).
- The fiber content of the fruits of different treatments between 6.11% and 6.32%. These contents are higher than those of several works and which were respectively lower than 3% (Oyen and Lemmens, 2002; Affiong et al., 2021; Koua, 2016; Tchatchambe, 2015).
- The ash content of fruits of the different treatments ranged from 3.66% to 4%. Several authors have obtained contents below 1% (Oyen and Lemmens, 2002; Affiong et al., 2021; Koua, 2016). Furthermore, the work of Tchatchambe (2015) presented a very high content of 10.68% (Tchatchambe, 2015).
- The carbohydrate content of the fruits of the different treatments was between 6.08% and 6.50%, much higher than the content obtained by the work of affion et al. (2021) which was 4.14% (Affiong et al., 2021).

In 100 g of *Solanum melongena* L. fruit and according to the different treatments we have:

- The water content of fruits of the different treatments was between 78.88% and 79.27%. Previous studies have presented contents between 92% and 94% (Affiong et al., 2021; Koua, 2016). However, according to the work of Agoreyo et al. (2012), this content was between 72.93% and 78.44% (Agoreyo et al., 2012).
- The lipid content of fruits of the different treatments was less than 0.3% and between 0.22% and 0.26%. However, according to Koua (2016), the lipid content was 0.1% and according to several other studies this content was between 1.65% and 2.13% (Affiong et al., 2021; Agoreyo et al., 2012). In addition, according to the work of Tchiegang and Mbougoueng (2005), the lipid content was approximately 9% (Tchiegang and Mbougoueng, 2005).
- The protein content of the fruits of the different treatments was between 3.71% and 4.29%. According to several studies, this content ranged from 0.8% to 1.3% (Affiong et al., 2021; Koua, 2016). On the other hand, according to Agoreyo et al. (2012), this content was between 4.58% and 5.79%, and it was around 13% according to Tchiegang and Mbougoueng (2005) (Agoreyo et al., 2012; Tchiegang and Mbougoueng, 2005).
- The fiber content of fruits of the different treatments was between 6.34% and 6.72%, unlike several studies by Koua (2016), which presented contents lower than 4.2% (Affiong et al., 2021; Koua, 2016; Agoreyo et al., 2012). Furthermore, according to Tchiegang and Mbougoueng (2005), the fiber content was 32.46% (Tchiegang and Mbougoueng, 2005).
- The ash content of fruits of the different treatments was between 3.33% and 3.66, and higher than that of several studies (Affiong et al., 2021; Koua, 2016; Agoreyo et al., 2012). These fiber contents obtained in our study are lower than that of the work of Tchiegang and Mbougoueng (2005) which was 5.52% (Tchiegang and Mbougoueng, 2005).
- The carbohydrate content of the different treatments is between 6.21% and 6.55%, much higher than the content obtained by the work of affion et al. (2021) which was 2.42% (Affiong et al., 2021).

In 100 g of *Solanum aethiopicum* L. fruits, we observed, depending on the different treatments, that:

- The Na content varies from 86.78 mg to 108.45 mg, and this content is higher than that of several studies (Eze and Kanu, 2014; Koua, 2016). On the other hand, the work of affion et al. (2021) presented a content of 147.32 mg (Affiong et al., 2021).
- The K content is between 721.39 mg and 1010.39 mg. The work of Eze and Kanu (2014) obtained 4250 mg (Eze and Kanu, 2014). Moreover, several other studies have presented contents lower than 250 mg (Affiong et al., 2021; Koua, 2016).

- The Ca content is between 585.43 mg and 857.74 mg. Unlike similar studies which presented contents lower than 150 mg (Eze and Kanu, 2014; Oyen and Lemmens, 2002; Affiong et al., 2021; Koua, 2016; Tchatchambe, 2015).
- The Mg content is between 297.97 mg and 667.94 mg. On the other hand, similar studies presented contents lower than 2 mg (Eze and Kanu, 2014; Affiong et al., 2021; Tchatchambe, 2015).
- The P content is between 0.24 mg and 0.48 mg. This P content is lower than those presented by several studies (Eze and Kanu, 2014; Oyen and Lemmens, 2002; Affiong et al., 2021; Koua, 2016).
- The Fe content is between 7.28 mg and 12.51 mg. This content is higher than that of similar studies (Eze and Kanu, 2014; Oyen and Lemmens, 2002; Affiong et al., 2021; Tchatchambe, 2015).
- The Cu content is between 35.42 mg and 60.42 mg. The Zn content is between 115.51 mg and 164.13 mg; these two contents are higher than those obtained by several studies on these same species (Eze and Kanu, 2014; Affiong et al., 2021).
- The Se content is between 0.21 µg and 0.25 µg. This content is lower compared to that of other studies on the same species (Eze and Kanu, 2014; Affiong et al., 2021).

In 100 g of *Solanum melongena* L. fruits, we observe, depending on the different treatments, that:

- The Na content varies from 85.05 mg to 135.16 mg. This content is lower than that obtained by the work of Affiong et al. (2021), which was 160.12 mg (Affiong et al., 2021).
- The K content is between 726.84 mg and 944.98 mg. This content is higher than that presented by similar works and between 238.10 mg and 245.37 mg (Affiong et al., 2021; Koua, 2016; Agoreyo et al., 2012).
- The Ca content is between 583.94 mg and 679.97 mg. This content is higher than that presented by several works on the same species (Affiong et al., 2021; Koua, 2016; Agoreyo et al., 2012; Tchiegang and Mbougoung, 2005).
- The Mg content is between 295.97 mg and 679.97 mg. This content is lower than that presented by the work of Tchiegang and Mbougoung (2005), which was 808.99 mg (Tchiegang and Mbougoung, 2005).
- The P content is between 0.29 mg and 0.38 mg. This content is lower than that presented by the works of Koua (2016), Agoreyo et al. (2012) and Tchiegang and Mbougoung (2005). These contents were respectively: 21 mg, between 3.72 mg and 5.23 mg and 8.20 mg (Koua, 2016; Agoreyo et al., 2012; Tchiegang and Mbougoung, 2005).
- The Fe content is between 10.25 mg and 20.04 mg. This content was higher than that of similar works (Affiong et al., 2021; Agoreyo et al., 2012; Tchiegang and Mbougoung, 2005). These Fe contents were between 1.96 mg and 7.07 mg.
- The Zn content is between 194.27 mg and 271.07 mg. This content was higher than that of similar studies and was 0.25 mg (Affiong et al., 2021; Agoreyo et al., 2012).

Any differences observed between the nutrients of the different treatments demonstrate the effect of the amendment. Moreover, according to Amiot-Carlin and Stéphane (2020), cultural practices, and in particular irrigation and fertilization practices, affect the nutritional content of fruits and vegetables (Amiot-Carlin and Georgé, 2020). Moreover, fruits and vegetables are an excellent source of fiber and many minerals.

## 6. Conclusion

The present study revealed that the addition of poultry manure could double the production of the *Solanum aethiopicum* L. crop in Balekeu with a dosage of 10 t/ha. On the other hand, the addition of amendments for the cultivation of *Solanum melongena* L. is not necessary for production in view of the growth and production parameters obtained. Physicochemical analyses have shown that these fruits are an important source of nutrients. Furthermore, the significant variations in nutrient content indicate that the use of chicken droppings-based amendments for growing eggplants must be carried out with great care to obtain fruits with high yields and good nutritional quality.

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