# EFFECTS OF POULTRY MANURE, URBAN WASTE COMPOST AND NPK-20-10-10 ON THE GROWTH, YIELD AND SHELF-LIFE OF TWO VARIETIES OF CUCUMBER (*Cucumis sativus* L.) IN THE WESTERN HIGHLANDS OF CAMEROON

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**ABSTRACT**

Organic and inorganic farm inputs in the form of fertilizers is a management practice to improve soil fertility for the growth and development of cultivated crops. A field experiment was conducted to evaluate the growth, yield and shelf-life response of cucumber (Classico F1 and Poinsett-76) to fertilizer applications. The experimental design was a randomized complete block in split plots with three repetitions of the treatments; Control (To: No fertilizer application), poultry manure (T1:20t $ha^{-1}$), urban waste compost (T2:20t $ha^{-1}$), NPK-20-10-10 (T3:0.7t $ha^{-1}$), poultry manure (10t $ha^{-1}$)+NPK-20-10-10 (0.35t $ha^{-1}$) (T4), poultry manure (10t $ha^{-1}$)+urban waste compost (10t $ha^{-1}$) (T5), urban waste compost (10t $ha^{-1}$)+NPK-20-10-10 (0.35t $ha^{-1}$) (T6). Collected data on growth and yield variables from emergence till harvest were analyzed for variation in R version 4.0.1. Results showed that variety and fertilizer had a significant effect ($P < 0.05$) on all growth variables with Classico F1 variety recording the highest mean values for all growth and yield variables. T1 recorded the highest in all growth variables (vine length, No. of leaves and stem diameter), except for the leaf area in T5 of Classico F1 (404.20$cm^2$) with the lowest in T0 of Poinsett-76 (87.87$cm^2$). Variety, fertilizer treatments and interactions showed significant effects ($P < 0.05$) on yield variables. Classico F1 was superior to Poinsett-76, yielding 31.91$tha^{-1}$ in T1 while Poinsett-76 produced 20.36$tha^{-1}$ in the same treatment. The lowest yield was recorded in the control treatments (4.45 $tha^{-1}$ for Poinsett-76 and 7.55 $tha^{-1}$ for Classico F1). Shelf-life evaluation showed the highest weight loss (20%) in fruits obtained in NPK-20-10-10 treatments within 21 days of storage. These results revealed that the integration of poultry manure or urban waste compost and chemical fertilizer (NPK-20-10-10) improves the growth and yield of cucumber as well as the shelf-life of harvested fruits in the western highlands of Cameroon.

*Keywords: poultry manure; urban waste compost; cucumber; fertilizer; shelf-life; growth; yield.*

## 1. INTRODUCTION

Cucumber *(Cucumis sativus* L.) is a herbaceous, annual creeping vegetable and a popular member of the Cucurbitaceae family [1]. It is the fourth most important vegetable crop after tomato, cabbage and onion in Asia, the second most important vegetable crop in Western Europe [2,3]. Cucurbitaceae crops form one of the largest vegetable groups worldwide due to their wide adaptation from acid to the humid tropical environments [4]. The benefits of cucumber range from health, economic to industrial levels in the society with the fruits containing water (95%) and it is an immediate and relative source of vitamins (A, B, C), minerals and about 2g of fiber which is an essential component of a healthy diet [5,6,7]. In addition, it contains chemical components such as flavonoids, indoles and isoflavones necessary for the human organism and useful in the prevention of several chronic diseases [8]. Fruits are sliced into pieces and served with vinegar or a salad dressing, on their own or mixed with other vegetables. Immature or ripe cucumber fruits are usually used as cooked vegetables [9].

Cucumber is a native of Asia and Africa, where it has been consumed for a long period of time. Production practices vary widely according to market type, profit margin, geographic region and cultivar. India has low labor costs, and has become a major producer for export to Europe, U.S., and Russia. It is adapted to a wide variety of soil types, but preferably in areas with good drainage, adequate soil water holding capacity and optimum pH of 5.5 – 7.0. According to [10], cucurbitaceae are harvested in the tropics, subtropics and milder regions of both hemispheres. Nevertheless, cucumbers adapt to various regions and are cultivated in zones up to 1,500m a.s.l. Cucumber can adapt to temperatures between 18 and 25ºC and it requires between 70 and 90% relative humidity. The growth and yield of cucumber greatly depends on soil and climatic conditions.

According to [11], total world production of Cucumber as of 2017 was 83 753, 861 tons with China producing 77% of the world total. Cucumber is grown in all countries of tropical Africa, but not in large scale and international trade from African countries is modest and unrecorded [12]. According to [13], Africa produced 107,000 tons on 25, 000 ha, accounting for just less than 1.5% of production. Egypt is the highest producer of cucumber in Africa (591, 858 tons as of 2017).

Food security is a major issue in developing countries due to unreliable rainfall, marginal soil fertility and low input levels causing a decline in crop yield [14]. Major factors that constrain tropical soil fertility and sustainable agriculture include low nutrient, capital, moisture stress, erosion, high P fixation, high acidity with aluminum toxicity and low soil biodiversity [15].

Cameroon has a myriad of agro-ecological zones and a single variety may not be suitable for all the agro-climatic regions. Hence, suitable varieties have to be identified for specific regions. Amongst the agricultural practices, plant nutrition is one of the main factors that affects the growth, yield and shelf-life of cucumber. Nutritional requirement of cucumber also varies with soil type, soil fertility, agro-climatic conditions and the cultivated variety [10]. Thus, the production of cucumber requires optimum fertilization through organic and mineral sources as well as adapted varieties.

Increase in agricultural production is required to meet the needs of the growing population through various types of cultivation practices, including the type and method of fertilization. Such increment could be achieved by increasing production per unit area through appropriate mineral fertilization that plays a major role in compensating the necessary elements for plant growth. Appropriate fertilization systems that ensures the availability of nutrients at sufficient quantities is of significance to obtain high and quality production. Moreover, safe or effective fertilization methods that are low cost and eco-friendly are also necessary. However, the use of mineral fertilizer in intensive agriculture has registered some shortcomings; its high cost and it is often associated with reduced crop yield, soil degradation, nutrient imbalance and acidity [16,17]. [18] outlined that the use of organic manure to supplement soil nutrients is a better option compared to chemical fertilizers due to the fact that it is cheap, eco-friendly and not easily leached.

Due to its high economic importance and short life cycle, cucumber is often grown in sequence on the same piece of land for between two and four times a year especially where irrigation is practiced during the off-season [19]. Farmers involved in cucumber cultivation in the western highlands mostly rely on mineral fertilizers (NPK 20:10:10 and NPK 12:6:20) to improve yield in order to meet up with demand [20]. Constant application of mineral fertilizers on the same piece of land in an attempt to make more profit through improved yield, has resulted to negative nutrient balances [19]. This has resulted to soil degradation leading to high cost of production, soil, water and fruit pollution, thus causing health complications such as kidney failures, joints and spine pains, lungs and liver problems, cancer and loss of biodiversity [21]. Thus, a need to evaluate alternative sources of fertilizers that are eco-friendly such as poultry manure and urban waste in cucumber production.

The short cycle of cucumber (50-70 days) depending on the cultivar indicates that it is an important and a potential source of income for smallholders. Its nutritional value (protein, fat, carbohydrates, dietary fiber) indicates its role in the digestive system. In Cameroon, there is need to increase production in other to satisfy the demand and improve the dietary requirements of the fast-growing population. The aim of this study was to evaluate the agronomic performance and the post-harvest shelf-life of two cucumber varieties under different fertilizer sources in the western highlands of Cameroon.

## 2. MATERIALS AND METHODS

### 2.1 Study Site

The experiment was carried out in the Research and Application Farm of the Faculty of Agronomy and Agricultural Sciences of the University of Dschang located in Menoua Division, West region of Cameroon. The farm lies along latitude 5° 26' 28.29'' North and longitude 10° 4' 11.95'' East in the western highlands [22].

The site has been a fallow for almost a year, dominated by grasses, prior to the experimental setup. The dominant vegetation in the study site consisted of *Tithonia diversifolia, Mimosa pudica, Ageratum conyzoides, Ageratum haustonianum, Cyperus esculentus, Bidens pilosa,* and *Penissetum purpureum* [23]. The previous crop before the fallow was a mono-cropping of maize (*Zea mays*).

The soil type is Oxisols (according to USD Soil Classification) or red ferralitic soil with complex profiles, moderate fertility with potential phosphorus deficiencies. The soil is highly weathered and contains high amounts of Fe and Al oxides with kaolinit clay. The site falls under the Western highlands agro-ecological zone with an elevation ranging from 1500m to 2500m, with a mean annual temperature of about 21°c and annual rainfall of 1800mm-2400mm. The climate is of the tropical monsoon type (equatorial fresh and wet climate), with a dry season that lasts for 4 months (mid-November to mid-March), and a long rainy season (mid-March to mid-November) [24].

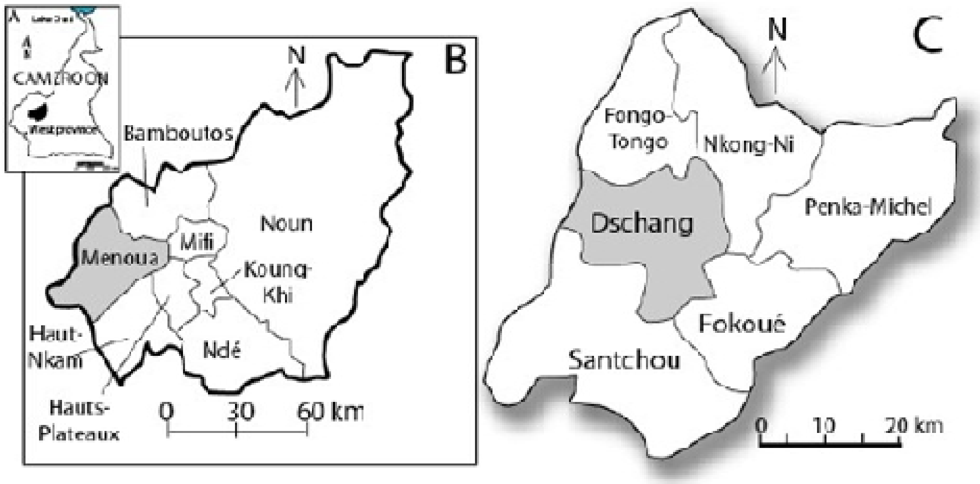


Figure 1: Localisation of the study site [25].

**2.2 Plant Material**

Cucumber varieties used in this experiment were “Poinsett” and “Classico F1” obtained from SEMAGRI store, in Dschang. The “Poinsett” variety is a monoecious slicing cucumber type with excellent uniform dark green color and Classico F1” is a hybrid that grows into dark-green, cylindrical and uniform fruits. The characteristics of the two varieties are shown on Table 1. These varieties were chosen because they are amongst the most cultivated varieties in Menoua Division due to their yield potential and nutritional content.

**Table 1. Cucumber varieties used in the study.**

| Variety | Cycle (DAS) | Potential yield (t ha$^{-1}$) | Disease resistance |
|---|---|---|---|
| Poinsett-76 | 55-70 | 15-22 | Powdery mildew and anthracnose |
| Classico F1 | 45-50 | 30-50 | Downy and powdery mildews<br>Cucumber mosaic virus (CMV) |

**DAS:** Days After Sowing.

**2.3 Fertilizer Application**

In this study, two types of fertilizers were used; commonly used inorganic fertilizer (NPK: 20-10-10) and organic fertilizers (poultry manure and urban waste compost) as shown in Table 2. Poultry manure and urban waste compost were applied once (one weeks) before planting. Composite samples of poultry manure and urban waste compost were collected before application for chemical analysis.

Split application of NPK chemical fertilizer (20-10-10) was done at two weeks after germination and at flowering. According to the experimental treatments, NPK was applied at 17.5g plant$^{-1}$ and the organic manures at 250g plant$^{-1}$.

**Table 2. Fertilizer type and dose used in the study.**

| Type | Name | Quantity (t $ha^{-1}$) |
|---|---|---|
| Organic | Poultry manure | 20 |
| | Urban waste | 20 |
| Inorganic | NPK (20-10-10) | 0.7 |

### 2.4 Phytosanitary Treatment

Two fungicides (systemic and contact) of large spectrum (preventive and curative measures) against several diseases of food crops, market garden, cucurbit downy mildew and vegetable blight were used in the field experiment (FUNGICHAMP 720 WP that contains 720g/l of Cymoxamil (80g/l) + Mancozebe and FLASH ONE 36 WP which contains 36g/l of Chlorothalonil (30%) + Cymoxanil (6%)). An insecticide (OPTIMAL 20 SP) with acetamiprid 200g/l as active ingredient against insects was applied according to the manufacturer's recommendations.

### 2.5 Methodology

#### 2.5.1 Evaluation of seed viability

Seed viability tests were carried out to determine the emergence/germination rate. Uniform and healthy seeds were selected prior to this test and seed germination was conducted in a bucket filled with topsoil treated with 40g of pencozebe and 30 ml of pyriforce in 11L of water. 24 hours later, 20 selected seeds of cucumber were planted at equidistance inside the bucket and the setup was watered daily. Four days later, the emerged plants were counted and expressed in percentage.

Seed emergence was also evaluated at the level of the field for all experimental treatments (fertilizer sources and cucumber variety) and the emergence rate was calculated according to [26];

Germination rate (%) = *No. of emerged seeds /total number of seeds sown)* x 100 (1)

#### 2.5.2 Experimental design and land preparation

The experimental design was a complete randomized block arranged in split plots with three repetitions. The main factor was the fertilizer treatments (7) and the secondary factor was the cucumber varieties (Poinsett-76 and Classico F1). Each block consisted of 7 plots that were further divided into 14 sub-plots (7units per sub-block), with each unit measuring 1.5$m^2$ giving a total of 42 experimental units occupying 166.63$m^2$. The gap separating the blocks was 1m, 0.25m between the sub-blocks and 0.5m between experimental units. The treatments were randomly attributed to the various units. The fertilizer treatments (T) were:T0 : Control (no fertilizer application), T1 : Poultry manure (20t $ha^{-1}$), T2 : Urban waste compost (20t $ha^{-1}$), T3 : Chemical fertilizer (0.7t $ha^{-1}$ NPK-20-10-10), T4 : Poultry manure (10t $ha^{-1}$) + chemical fertilizer (0.35t $ha^{-1}$ NPK-20-10-10), T5 : Poultry manure (10t $ha^{-1}$) + urban waste compost (10t $ha^{-1}$), T6 : Urban waste compost (10t $ha^{-1}$) + chemical fertilizer (0.35t $ha^{-1}$ NPK-20-10-10).

Land preparation began on the 6th of January 2022 by manual clearing of the experimental site with a machete. A total of 166.63m$^2$ area was manually tilled to the depth of 20-25cm with hand-held tools. Open holes of 20cm deep and 25cm wide respecting the planting distance were created in the experimental units. 75% (v/v) of the holes were filled with top soil and the rest with organic manures used (poultry droppings and urban waste) for units that received these treatments. The top soil and organic manures were mixed thoroughly and watered twice daily for a week before planting.

**2.5.3 Sowing and field management**

Three seeds were sown directly in each hole at a uniform depth of 1-2cm on the 1st of February 2022. Seeds of the two varieties were sown at 50cm between the plants and 100cm between the lines giving a planting density of 20,000 plants ha$^{-1}$. Plants were thinned to two plants per hole two weeks after sowing resulting to 8 plants per experimental unit, 336 plants for the experiment and a planting density of 40 000 plants ha$^{-1}$. Phytosanitary treatments (fungicides and insecticides) were applied at two weeks interval throughout the experiment. Organic fertilizer treatments (poultry and urban waste compost) were applied prior to sowing according to the experimental treatments.

**2.5.4 Data collection**

**2.5.4.1 Growth and yield variables**

Data collection on growth variables were conducted on four randomly selected and labelled plants on each experimental unit. Data collection started three weeks after sowing (WAS) and was done weekly before fruit maturity. Growth variables (germination rate, number of leaves, plant height, stem diameter, leaf length and leaf width) and yield variables (number of fruits, fruit length, fruit diameter and fruit weight) were measured accordingly to evaluate the agronomic performance of the two cucumber varieties under different fertilizer treatments.

The number of leaves per plant were counted manually while plant height, stem diameter, leaf length and leaf width were measured using a graduated ruler and a measuring tape. The germination rate was determined three WAS. Leaf surface area of plants was determined using the measured leaf length and width according to [27];

$$LA = 0.88LW - 4.27 \qquad (2)$$

where LA is leaf area, L is the leaf length and W is leaf width.

The number of fruits for each variety were counted manually at maturity indicated by a bright-medium-to-dark-green coloured and firm fruits with a hardened epidermis. The variety Poinsett-76 matured earlier (59 DAS) than the hybrid Classico-F1 (66 DAS). Matured fruits were harvested three times (weekly) in a cold dry weather and taken to the laboratory where fruit length and diameter were measured and the fruits weight obtained with an electronic scale.

**2.5.4.2 Fruit shelf-life**

Fruit shelf-life for all the experimental treatments were determined through weight loss under ambient temperature. Fruits with consistent maturity and appearance, free of any mechanical and biological damage were sampled to determine the shelf-life for each treatment. Fruit weight loss (%) was determine weekly by using the initial and final weight of the fruits according to [28].

#### 2.5.5 Data analysis

Data collected on growth and yield variables were compiled and organized in Microsoft Excel software 2016 while statistical analyses were done using R version 4.0.1 at $P$ = 0.05. Analysis of variance was run using the general linear model and means were separated using the least significant difference (LSD) test.

## 3. RESULTS AND DISCUSSION

### 3.1 Soil Fertility Status and Nutrient Composition of Organic Fertilizers Used

Table 3 shows the soil physical and chemical properties of the experimental site obtained from standard laboratory analyses. The soil is slightly acidic ($pH_{water}$ = 6.3) according to [29], hence facilitated nutrient uptake by the plant's roots and $pH_{KCl}$ of 4.8 which is an acidic soil according to soil acidity (4.0-5.3) classes. Soil texture is sandy loam with low organic matter content (2.21%) with a good moisture retaining properties that favours root development and permits water and air circulation. In addition, exchangeable cations of the nutrients in this soil were below the critical level, indicating the need for application of soil amendment in form of inorganic and organic fertilizers.

Laboratory analysis on Table 4 show that OC (%), OM (%), N (mg $kg^{-1}$) and P (mg $kg^{-1}$) in poultry manure is higher than in urban waste compost, while urban waste has the a higher Ca, Na, and K (mg $kg^{-1}$) content indicating poultry manure to be relatively a better nutrient amendment.

### 3.2 Growth and Yield Variables

#### 3.2.1 Growth variables

#### 3.2.1.1 Germination/emergence rate (GR %)

The first seed germination is observed 3 DAS for all fertilizer treatments, rated at 85% and increased progressively up to the 5th DAS. The highest germination rate is observed at poultry manure (100%), NPK (100%), poultry manure + NPK (100%), poultry manure + urban waste compost (100%), and urban waste compost + NPK (100%) for both cucumber varieties (Figure 2). The lowest germination rate is observed for the control treatment of Poinsett-76 (96%), control of Classico F1 (99%) and urban waste of Poinsett-76 (97%). From figure 2, the rate of germination in all treatments was far above 95%. However, there is no significant difference in the germination percentage among the treatments and varieties ($P > 0.05$) with lowest germination rate observed in urban waste treatments. Also, Classico F1 show a better germination rate than Poinsett-76 and this may be due to the fact that it is a hybrid of F1 generation with improved growth characteristics.

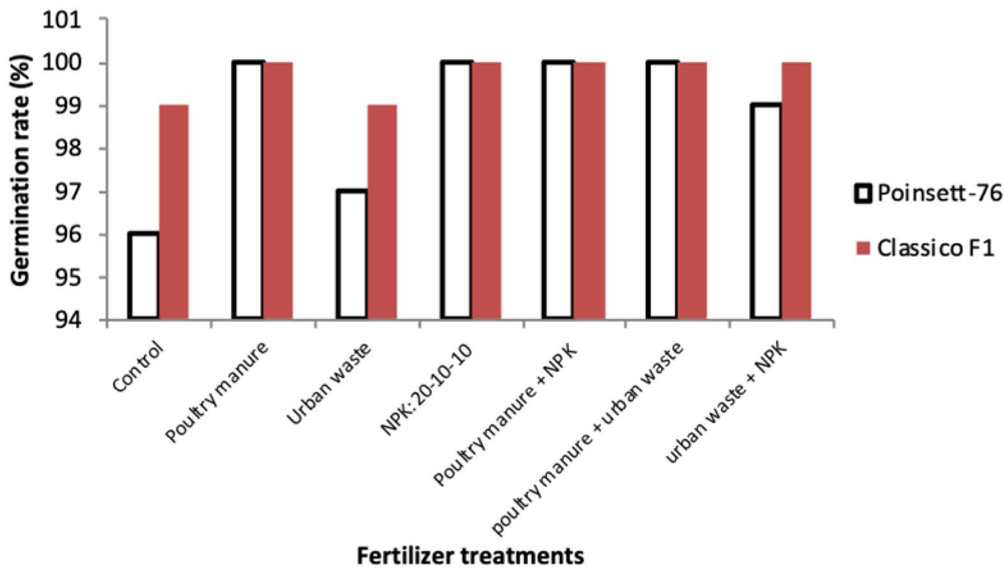


Figure 2: Effects of varieties and fertilizers on germination/emergence rates

### 3.2.1.3 Vine length and stem diameter, Number of leaves and leaf surface area

Generally, the fertilizer treatments significantly influence the growth variables and there is a significant interaction ($P < 0.05$) between the variety and fertilizer treatments applied at 7 WAS (Table 5). Thus, interaction effect of variety and different fertilizers is significant for vine length, vine diameter, number of leaves and leaf surface area significantly under the present study (Table 5).

Irrespective of the fertilizer treatments, the hybrid Classico F1 produced longer and thicker vines, higher number of leaves and broader leaf surface area compared to Poinsett-76 in this study. For the Classico F1 variety, highest vine length (211 cm) and stem diameter (1.35 cm) and number of leaves (18) was observed for the poultry manure treatment (Table 5). These results are similar to the findings of [18] who applied $40tha^{-1}$ in an acidic soil of a forest agro-ecological zone of Nigeria. Also, [30] obtained similar results while applying $20tha^{-1}$ in a similar agro-ecological zone of Cameroon.

The largest leaf surface area (404 $cm^2$) was observed in the Poultry manure + urban waste compost treatment for the same variety. This may be due to the fact that Classico F1 generation is an improved hybrid and poultry manure according to the laboratory analysis is richer in available nutrients compared to the urban waste compost. In addition, the organic manure (poultry) amends other soil physical and chemical properties compared to urban waste compost and chemical fertilizer applied solely.

On the other hand, the lowest vine length (49 cm) at 7WAS was observed for the control treatment of Poinsett-76 which was statistically similar to Poinsett-76 (NPK-20-10-10) (72 cm).

**Table 3. Soil physical and chemical properties of the study site.**

| Soil properties | Values |
|---|---|
| **pH$_{-water}$** | 6.3 |
| **pH-KCl** | 4.8 |
| **Clay%** | 30.5 |
| **Sand%** | 45.5 |
| **Silt %** | 24 |
| **Textural class** | **Sandy loam** |
| **%N** | 0.112 |
| **%OC** | 1.28 |
| **%OM** | 2.21 |
| **C/N** | 11.46 |
| **Ca (cmol(+) kg$^{-1}$)** | 4.36 |
| **Mg (cmol(+) kg$^{-1}$)** | 1.56 |
| **K (cmol(+) kg$^{-1}$)** | 0.50 |
| **Na (cmol(+) kg$^{-1}$)** | 0.03 |
| **ESB (cmol(+) kg$^{-1}$)** | 6.45 |
| **CEC (cmol(+) kg$^{-1}$)** | 14.08 |
| **P (cmol(+) kg$^{-1}$)** | 52.86 |

**CEC:** Cation exchange capacity, **OM:** Organic matter, **N:** Nitrogen, **C/N:** Carbon/Nitrogen ratio, **P**: Phosphorus, **K**: Potassium, **ESB**: Exchangeable saturation base.

**Table 4. Chemical composition of poultry manure and urban waste compost.**

| Characteristics | Poultry Manure | Urban waste | Mineral fertilizer (%) |
|---|---|---|---|
| **$pH_{water}$** | 8.20 | 8.90 | / |
| **OC (%)** | 29.50 | 16.50 | / |
| **OM (%)** | 51.38 | 28.74 | / |
| **Na (mg $kg^{-1}$)** | 3.78 | 2.07 | / |
| **Ca (mg $kg^{-1}$)** | 3.52 | 4.80 | / |
| **Mg (mg $kg^{-1}$)** | 1.75 | 2.06 | / |
| **N (mg $kg^{-1}$)** | 0.043 | 0.032 | 20 |
| **P (mg $kg^{-1}$)** | 3.96 | 3.29 | 10 |
| **K (mg $kg^{-1}$)** | 14.61 | 20.49 | 10 |

**CEC:** Cation exchange capacity, **OM:** Organic matter, **N:** Nitrogen, **C/N:** Carbon/Nitrogen ratio, **P**: Phosphorus, **K**: Potassium.

**Table 5. Effects of fertilizer treatments on the growth variables at 7 WAS.**

| Variety | Fertilizer treatment | Vine length (cm) | No. of leaves | Leaf area ($cm^2$) | Stem diameter (cm) |
|---|---|---|---|---|---|
| **Poinsett-76** | Control | $49.36 \pm 6.05^{h}$ | $9 \pm 1^{e}$ | $87.87 \pm 7.08^{g}$ | $0.77 \pm 0.02^{e}$ |

| | | | | | |
|---|---|---|---|---|---|
| | Poultry manure | 123.20±6.39$^{cde}$ | 14±1$^{b}$ | 142.00±13.06$^{ef}$ | 1.24±0.23$^{ab}$ |
| | Urban waste | 64.10±20.87$^{gh}$ | 10±2$^{de}$ | 99.92±7.00f$^{g}$ | 0.85±0.06$^{e}$ |
| | NPK-20-10-10 | 72.58±8.38$^{fgh}$ | 10±1$^{de}$ | 99.92±7.00f$^{g}$ | 0.90±0.06$^{de}$ |
| | Poultry manure+ NPK | 132.41±10.65$^{bcd}$ | 14±1$^{b}$ | 141.70±14.21$^{ef}$ | 1.10±0.02$^{bc}$ |
| | poultry manure + urban waste | 92.66±8.38e$^{fg}$ | 11±1$^{cd}$ | 134.5±15.65$^{efg}$ | 1.02±0.04$^{cd}$ |
| | urban waste + NPK | 70.66±14.95$^{fgh}$ | 10±2$^{de}$ | 109.35±11.66$^{fg}$ | 0.80±0.02$^{e}$ |
| **Classico F1** | Control | 84.25±4.57$^{efgh}$ | 10±1$^{de}$ | 167.7±31.59$^{de}$ | 1.05±0.05$^{cd}$ |
| | Poultry manure | 211.08±59.43$^{a}$ | 18±3$^{a}$ | 399.5±23.66$^{a}$ | 1.35±0.17$^{a}$ |
| | Urban waste | 139.65±11.32$^{bcd}$ | 13±0$^{bc}$ | 281.18±20.24$^{b}$ | 1.14±0.08$^{bc}$ |
| | NPK-20-10-10 | 84.05±12.5$^{fgh}$ | 10±1$^{de}$ | 205.16±24.65$^{cd}$ | 1.10±0.12$^{bc}$ |
| | Poultry manure+ NPK | 151.92±26.13$^{bc}$ | 14±2$^{b}$ | 346.66±59.57$^{a}$ | 1.18±0.12$^{abc}$ |
| | poultry manure + urban waste | 170.54±9.03$^{b}$ | 17±2$^{a}$ | 404.2±23.69$^{a}$ | 1.25±0.05$^{ab}$ |
| | urban waste + NPK | 106.44±39.71$^{def}$ | 11±3$^{cd}$ | 239.36±101.29$^{b}$ c | 1.03±0.13$^{cd}$ |
| **Significance** | Variety | s | ns | s | ns |
| | Fertilizer treatment | s | s | s | s |
| | Variety * Fertilizer treatment | s | s | s | s |

**WAS:** weeks after sowing, **s:** significant, **ns:** not significant. Values (mean ± standard deviation) within the same column with different superscript are statistically significantly different at a probability threshold of 5% according to LSD.

#### 3.2.1.4 Yield and yield attributes

Table 6 shows that both variety and fertilizer treatments significantly influenced the number of harvested fruits for first, second and third harvests. But the interaction effect between variety and fertilizer was only significant ($P < 0.05$) for the first and the second harvest. Generally, Classico F1 produced more fruits than Poinsett-76. For both varieties, the highest number of fruits was recorded in the poultry manure treatment (6 and 4 for Classico F1 and Poinsett-76, respectively). In addition, the number of fruits produced by Classico F1 for all fertilizer treatments decrease with time (first harvest>second harvest>third harvest) contrary to Poinsett-76 (Table 6). For both variety, poultry manure treatment produced the highest number of fruits and this may be due to the fact that poultry manure exhibited the best growth and thus a better photosynthetic activity fruit fruit growth and development.

Similarly, Table 7 below shows that Classico F1 (poultry manure) recorded the longest fruits with mean length of 24.85 cm, followed by Classico F1 (poultry manure + urban waste). Both variety and fertilizer treatments significantly ($P < 0.05$) influenced fruit length (Table 7). The lowest fruit length was recorded under the control treatments for both varieties. The results are similar to the findings of [30] with the diameter of fruits slightly higher than the results they obtained in an acidic, sandy clayey loamy soil with high in the north west region of Cameroon.

Contrarily, fertilizer treatments in this study did not influenced fruit diameter for both species. For the same treatment fruits of comparable diameter were harvested for both varieties irrespective of the time of harvest with the fertilizer treatments producing fruits with significantly large diameter compared to the control (Table 8). [18] obtained three times the number of fruits and yield with similar fruit length after applying 40tha$^{-1}$ of poultry manure.

In terms of yield, the hybrid variety Classico F1 performed than Pointsett-76 and yield was highest during the first harvest compared to the second and the third. For the first harvest, poultry manure applied solely produced the highest yield (15.95t ha$^{-1}$ and 6.94t ha$^{-1}$ for Classico F1 and Poinsett, respectively) compared to the other fertilizer treatments (Table 9). The lowest yield was obtained in the control treatments for both varieties. Interestingly, yield for fertilizer treatments in which poultry manure was used were almost stable from the first to the third harvest whereas yield for the NPK solely, urban waste compost and combined showed a drop during the third harvest. The best agronomic and yield performance were obtained with the hybrid Classico F1 confirming [31] who regarded the potential and quality of seeds as the most important input in agriculture.

**Table 6. Effects of fertilizer treatments on the number of harvested fruits.**

| | | **No. of fruits** | | |
|---|---|---|---|---|
| **Varieties** | **Fertilizer treatment** | **1$^{st}$ harvest** | **2$^{nd}$ harvest** | **3$^{rd}$ harvest** |
| **Poinsett-76** | Control | $1±0^{j}$ | $2±0^{ef}$ | $1±0^{f}$ |
| | Poultry manure | $4±1^{cd}$ | $3±0^{bc}$ | $6±0^{a}$ |
| | Urban waste | $1±1^{hi}$ | $1±0^{f}$ | $1±0^{ef}$ |
| | NPK-20-10-10 | $1±0^{ij}$ | $1±1^{ef}$ | $1±0^{cde}$ |
| | Poultry manure+ NPK | $2±1^{fg}$ | $2±1^{def}$ | $2±1^{bcd}$ |
| | poultry manure + urban waste | $2±1^{gh}$ | $1±0^{ef}$ | $2±0^{b}$ |
| | Urban waste + NPK | $1±1^{ij}$ | $1±0^{f}$ | $2±0^{bcd}$ |
| **Classico F1** | Control | $1±0^{ij}$ | $2±0^{ef}$ | $1±0^{ef}$ |
| | Poultry manure | $6±0^{a}$ | $6±0^{ab}$ | $3±0^{a}$ |
| | Urban waste | $3±0^{ef}$ | $2±1^{def}$ | $1±0^{def}$ |
| | NPK-20-10-10 | $3±0^{ef}$ | $2±1^{cde}$ | $2±1^{bcd}$ |
| | Poultry manure+ NPK | $5±1^{b}$ | $3±1^{cd}$ | $2±0^{bc}$ |
| | poultry manure + urban waste | $4±0^{c}$ | $4±0^{a}$ | $3±1^{a}$ |
| | Urban waste + NPK | $3±1^{de}$ | $2±0^{cde}$ | $1±0^{bcde}$ |
| **Significance** | Variety | s | s | s |

| | | | | |
|---|---|---|---|---|
| | Fertilizer treatment | s | s | s |
| | Variety * Fertilizer treatment | s | s | ns |

**s:** significant, **ns:** not significant. Values (mean ± standard deviation) within the same column with different superscript are statistically significantly different at a probability threshold of 5% according to LSD.

**Table 7. Effects of fertilizer treatments on fruit length.**

| Varieties | Fertilizer treatment | Fruit length (cm) | | |
|---|---|---|---|---|
| | | 1$^{st}$ harvest | 2$^{nd}$ harvest | 3$^{rd}$ harvest |
| **Poinsett-76** | Control | 4.22±0.28$^{f}$ | 14.91±1.15e | 4.76±3.71d |
| | Poultry manure | 23.54±0.86$^{ab}$ | 23.60±1.39ab | 22.21±0.60a |
| | Urban waste | 8.35±4.15$^{e}$ | 16.81±0.88de | 9.65±2.49c |
| | NPK-20-10-10 | 10.30±2.81$^{e}$ | 18.51±0.40d | 16.71±2.27b |
| | Poultry manure+ NPK | 22.30±1.50$^{abc}$ | 21.18±0.28bc | 19.85±0.52ab |
| | poultry manure + urban waste | 18.29±3.11$^{d}$ | 18.70±0.63cd | 18.94±0.96ab |
| | Urban waste + NPK | 9.83±2.30$^{e}$ | 17.58±0.85d | 16.78±0.12b |
| **Classico F1** | Control | 10.98±2.81$^{e}$ | 18.2±1.8d | 8.88±6.06cd |
| | Poultry manure | 25.95±0.10$^{a}$ | 24.85±1.04a | 21.6±2.00a |
| | Urban waste | 19.75±2.26$^{bcd}$ | 24.00±1.90a | 20.11±3.82ab |
| | NPK-20-10-10 | 19.25±1.44$^{cd}$ | 21.29±1.59b | 18.90±2.03ab |
| | Poultry manure+ NPK | 23.08±0.98$^{abc}$ | 23.28±1.52ab | 23.05±2.21a |
| | poultry manure + urban waste | 21.95±0.93$^{bcd}$ | 23.88±1.15a | 22.40±0.69a |
| | Urban waste + NPK | 21.10±2.27$^{bcd}$ | 21.30±4.11b | 20.43±2.81ab |
| **Significance** | Variety | s | s | s |

| | | | | |
|---|---|---|---|---|
| | Fertilizer treatment | s | s | s |
| | Variety * Fertilizer treatment | s | s | s |

**s:** significant, **ns:** not significant. Values (mean ± standard deviation) within the same column with different superscript are statistically significantly different at a probability threshold of 5% according to LSD.

**Table 8. Effects of fertilizer treatments on fruit diameter.**

| | | Fruit diameter (cm) | | |
|---|---|---|---|---|
| **Varieties** | **Fertilizer treatment** | **1$^{st}$ harvest** | **2$^{nd}$ harvest** | **3$^{rd}$ harvest** |
| **Poinsett-76** | Control | 1.39±0.52$^{g}$ | 4.36±0.28$^{g}$ | 1.39±0.80$^{c}$ |
| | Poultry manure | 5.77±0.08$^{abc}$ | 5.59±0.33$^{ab}$ | 5.80±0.06$^{a}$ |
| | Urban waste | 1.89±0.67f$^{g}$ | 4.51±0.26$^{fg}$ | 2.60±0.64$^{bc}$ |
| | NPK-20-10-10 | 3.11±1.30$^{e}$ | 4.63±0.24$^{efg}$ | 4.43±0.67$^{ab}$ |
| | Poultry manure+ NPK | 5.69±0.25$^{abc}$ | 5.46±0.1$^{abc}$ | 5.06±0.03$^{a}$ |
| | poultry manure + urban waste | 5.83±0.70$^{ab}$ | 4.74±0.39$^{efg}$ | 4.67±0.48$^{ab}$ |
| | Urban waste + NPK | 2.30±0. 06$^{ef}$ | 4.64±0.22$^{efg}$ | 4.60±0.06$^{ab}$ |
| **Classico F1** | Control | 2.69±0.75$^{ef}$ | 4.9±0.23$^{def}$ | 4.12±0.11$^{ab}$ |
| | Poultry manure | 5.95±0.26$^{a}$ | 5.87±0.25$^{a}$ | 5.90±0.30$^{a}$ |
| | Urban waste | 4.58±0.45$^{d}$ | 5.4±0.04$^{bc}$ | 4.89±0.86$^{ab}$ |
| | NPK-20-10-10 | 5.01±0.15$^{bcd}$ | 5.33±0.05$^{bcd}$ | 4.83±0.50$^{ab}$ |
| | Poultry manure+ NPK | 5.51±0.06$^{abc}$ | 5.45±0.38$^{abc}$ | 5.79±0.25$^{a}$ |
| | poultry manure + urban waste | 5.27±0.29$^{ab}$cd | 5.69±0.39$^{ab}$ | 5.24±0.29$^{a}$ |
| | Urban waste + NPK | 4.87±0.32$^{cd}$ | 5.08±0.40$^{cde}$ | 4.90±0.36$^{ab}$ |
| **Significance** | Variety | s | ns | ns |

| | | | |
|---|---|---|---|
| Fertilizer treatment | s | s | ns |
| Variety * Fertilizer treatment | s | ns | ns |

**s:** significant, **ns:** not significant. Values (mean ± standard deviation) within the same column with different superscript are statistically significantly different at a probability threshold of 5% according to LSD.

### 3.2.2 Fruit shelf-life

Weight loss is an important indicator of the post-harvest quality of fresh produce. Results showed that cucumber fruits harvested in experimental units in which organic and inorganic fertilizers were applied, had an increasing trend in weight loss during storage, reaching 20% in 21days after harvest (Figure 3). Moreover, it was also observed that, Poinsett-76 fruits harvested in NPK applied units stored in ambient conditions showed important weight loss at three weeks after harvesting. Amongst the stored fruits, those obtained from the control, urban waste compost, and urban waste compost + NPK treatments of Classico F1, lost less weight.

Comparing the organic fertilizers, urban waste was found to have higher influence on the preventing weight loss than poultry manure. One of the most important results of present study is that urban waste combined with Classico F1 was found to have the highest impact on the preventing weight loss. Under 7days of storage, fruits obtained from controlled treatments reached 1.08% (Classico F1) and 2.65% (Poinsett-76) weight loss. Weight loss of fruits obtained from treatments of poultry manure and urban waste varied from 2.75% to 3.38% while fruits obtained from NPK treatments demonstrated 9.09% weight loss in 7 days (Figure 3). Thus, fruits grown with mineral fertilizer showed higher weight loss under ambient conditions than fruits grown with organic fertilizers.

**Table 9. Yield response to organic and inorganic fertilizer applications.**

| Varieties | Fertilizer treatment | Yield (t ha$^{-1}$) | | | |
|---|---|---|---|---|---|
| | | 1$^{st}$ harvest | 2$^{nd}$ harvest | 3$^{rd}$ harvest | Total |
| **Poinsett-76** | Control | 0.69±0.0$^{4f}$ | 2.83±0.1$^{e}$ | 0.93±0.51$^{g}$ | 4.45±0.71$^{g}$ |
| | Poultry manure | 6.94±0.28$^{b}$ | 6.96±0.16$^{ab}$ | 7.45±0.11$^{a}$ | 20.36±0.44$^{bc}$ |
| | Urban waste | 1.14±0.71$^{f}$ | 2.70±0.30$^{e}$ | 1.54±0.37$^{fg}$ | 5.38±1.36$^{g}$ |
| | NPK-20-10-10 | 1.93±1.28$^{e}$ | 3.24±0.37$^{e}$ | 2.89±0.46$^{def}$ | 8.07±2.00$^{fg}$ |
| | Poultry manure+ NPK | 6.08±1.38$^{bcd}$ | 5.26±0.44$^{cd}$ | 4.32±0.34$^{bcd}$ | 15.67±1.29$^{de}$ |
| | poultry manure + urban waste | 4.47±1.17$^{bc}$ | 3.74±0.70$^{de}$ | 3.75±1.15$^{cde}$ | 11.96±0.91$^{ef}$ |
| | Urban waste + NPK | 2.51±0.00$^{f}$ | 3.03±0.33$^{e}$ | 2.95±0.19$^{def}$ | 7.50±0.39$^{g}$ |
| **Classico F1** | Control | 2.08±1.09$^{f}$ | 3.43±0.51$^{e}$ | 2.03±0.78$^{efg}$ | 7.55±1.35$^{g}$ |
| | Poultry manure | 15.75±0.41$^{a}$ | 10.86±0.98$^{a}$ | 5.30±1.44$^{abc}$ | 31.92±2.12$^{a}$ |
| | Urban waste | 4.22±1.79$^{bc}$ | 1.54±0.37$^{fg}$ | 5.17±1.21$^{abc}$ | 16.7±4.52$^{bcd}$ |
| | NPK-20-10-10 | 5.83±1.02$^{bcde}$ | 2.89±0.46$^{def}$ | 5.08±1.17$^{abc}$ | 16.47±2.48$^{cd}$ |
| | Poultry manure+ NPK | 7.30±0.37$^{b}$ | 7.02±0.79$^{ab}$ | 6.26±1.97$^{a}$ | 20.58±1.27$^{b}$ |
| | poultry manure + urban waste | 6.68±1.17$^{bc}$ | 7.44±1.28$^{a}$ | 6.09±0.74$^{ab}$ | 20.22±2.90$^{bc}$ |
| | Urban waste + NPK | 5.04±1.44$^{cde}$ | 2.95±0.19$^{def}$ | 4.65±2.05$^{abcd}$ | 14.98±5.73$^{de}$ |
| **Significance** | Variety | s | s | s | s |
| | Fertilizer treatment | s | s | s | s |
| | Variety * Fertilizer treatment | s | s | s | ns |

**s:** significant, **ns:** not significant. Values (mean ± standard deviation) within the same column with different superscript are statistically significantly different at a probability threshold of 5% according to LSD.

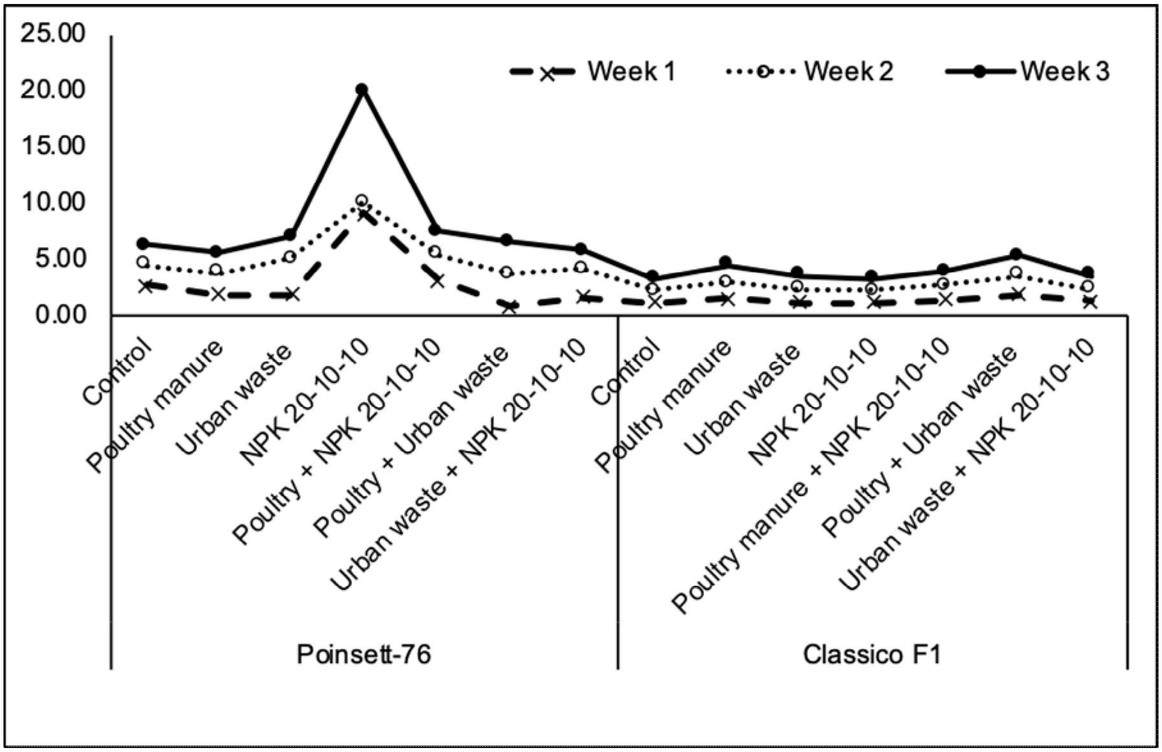


Figure 3. Effect of cucumber variety and fertilizer treatment on fruit shelf-life.

## 4. CONCLUSION

This study shows that organic and inorganic fertilizers play an important role in the agronomic performance of cucumber in the degraded soils of the western highlands of Cameroon. Amongst the fertilizer treatments tested, poultry manure presents results worth recommending to smallholder farmers in order to improve the growth and yield of cucumber. In addition, the incorporation of urban waste compost of the city council of Dschang may prolong the shelf-life of harvested cucumber fruits in a region where there is little or no post-harvest conservation facility.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## AUTHORS' CONTRIBUTIONS

This study was carried out in collaboration among all authors. All authors read and suggested comments that improved the structure and organization of the manuscript.

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