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Comparative Efficiency of Organic and Inorganic Fertilizers on Maize (*Zea mays* L.) Growth and Yield in the Rainforest Zone of Centre Cameroon

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Abstract

Maize is a major crop grown and consumed in the world and it requires a high fertilizer input. Although chemical fertilizers are an important input to get higher crop productivity, they have an impact on soil fertility, environment and human health. A field study was carried out to find alternatives to the mineral fertilization of maize. The aim of this study was to determine the influence of fertilizers on maize growth and yield while evaluating economic profitability. Four treatments (control, compost, poultry manure and mineral fertilizer NPK 20-10-10) and two maize varieties (local variety and improved variety CMS 8704) were used in a split-plot design with four replicates. Physicochemical analyses of soil and organic fertilizer were determined. Growth parameters, yield and acceptability index were evaluated. As results, poultry manure and compost are rich in nitrogen and phosphorus. At 9 weeks after sowing (WAS) the best stem diameter was obtained by the local variety in the plots fertilized with mineral fertilizer (2.83±0.31 cm). The yield of the CMS 8704 variety was significantly higher in the plots fertilized with poultry manure (2.23 t ha^{-1}) than the yield of the local variety in the control plots (1.16 t ha^{-1}). Principal component analysis (PCA) shows that compost and poultry manure were characterized by an increase in growth parameters as well as mineral fertilizer NPK. Poultry manure had the highest acceptability index of 1.25. In view of these results, it is clear that organic fertilizers; especially poultry manure, would have a positive impact on increasing maize production.

Keywords: *Zea mays*, compost, poultry manure, growth, yield, acceptability index

1. Introduction

As the world's population continues to grow and food needs increase, agricultural production must increase significantly (Baligar & Frageria, 1997). This situation predisposes the soil to mechanical erosion, the dissolving action of water, and the rapid depletion of nutrients, especially nitrogen and phosphorus (Yemefack et al., 2006; Kaho et al., 2011). The consequences are low yields for the main food crops, especially cereals.

Maize (*Zea mays* L.) is one of the most widely grown cereals in the world. It occupies more than 33 million ha each year (FAO, 2015). A bulk of 1.162 billion tons of maize grains was produced worldwide in 2020. While in Cameroon, maize is cultivated on about 1.18 thousand hectares with a yield production of about 2.09 thousand tons (FAO, 2022). It is the staple food for nearly 80% of the population. Nevertheless, as the third most important commodity after cassava and plantain, maize production in Cameroon remains very low. The improvement of food security, which implies, among other things, increasing maize production, faces production constraints such as declining soil fertility, low adaptability of genotypes to climates, irregular rainfall, diseases, pests (Kimuni et al., 2013), soil acidity and particularly alumina toxicity (Mapiemfu-Lamaré et al., 2011). Without forgetting the use of chemical fertilizers and their high cost (Olaniyi et al., 2010).

Moreover, numerous studies have concluded that the effectiveness of chemical fertilizers is only noticeable during the first years of continuous supply and after a few years, their use leads to considerable degradation of soil properties in addition to yield decreases and also pollutes groundwater (Kasongo et al., 2013; Mahmood et al., 2017). Conventional mineral fertilization remains expensive and inaccessible to small farmers (Useni et al., 2013). Moreover, the application of mineral fertilizer cannot guarantee long-term crop productivity in many soils since they are not effective to maintain and improve soil fertility (Sigaye et al., 2020). Faced with this controversy, viable alternative solutions both economically and environmentally are indispensable. Several studies point out that organic fertilization input by producers is an integrated crop management alternative aimed at reducing or eliminating synthetic fertilizers (Abawi & Widmer, 2000; Islam & Munda, 2012). These amendments improve the physical, chemical and biological properties of the soil reduce environmental pollution and increase harvest and yields (Li et al., 2012; Sikuzani et al., 2014; Berhe & Andargachew, 2020). In particular, composts are rich in nutrients and recent research has shown that inputs of these products increase soil organic matter levels, cation exchange capacity, the biomass of microorganisms and their activities. Also, poultry manure is an inexpensive fertilizer rich in nitrogen, phosphorus and potassium that could be used in combination with mineral fertilizer to improve soil quality and increase crop yields (Biekre et al., 2018). The acquisition of a high yield in maize production requires an adequate and balanced fertilizer supply, as declining soil fertility is a major constraint for maize production (Khan et al., 2016). Very high maize yields are achieved through the balanced use of high-quality organic inputs alone and in combination with inorganic fertilizers, compared to the single application of inorganic fertilizers (Barbieri et al., 2012; Verde et al., 2013). The study was conducted to determine the influence of fertilizers on maize growth and yield while evaluating economic profitability in the rainforest zone of Cameroon.

2. Materials and Methods

2.1 Study Site

This experiment was undertaken in Mars 2015 on a fallow farm (5 years old) in the locality of Akonolinga, Loum, (03° 48.136' N and 012° 15.518' E, altitude 663 m), in the Centre Region of Cameroon. Crops like groundnut, macabo and cassava are routinely been cultivated in this area. This locality belongs to the agroecological zone 5 of Cameroon (humid forest zone with bimodal rainfall). The site is characterized by a Congo-Guinean sub-equatorial climate, with two dry seasons alternating with two rainy seasons. The average rainfall is 1633 mm/year distributed in a small rainy season (March-June) and a long rainy season (September-November). The average annual temperature is relatively constant (around 23 to 27 ℃). Relative and average humidity is above 80% (Moudingo, 2007). The soil is ferralitic and is characterized by outcrops of the indurated horizon in the form of slabs or gravel.

2.2 Experimental Design and Cultural Practices

A plot of land (31 x 11 m) was cleared and ploughed. The experimental design was a "split-plot" with four replicates. Seeds of two maize varieties constituting the main plots were randomly replication with two variants: local variety and improved CMS 8704. The local variety was characterized by the white color of grains obtained from local villagers and is the most locally cultivated by farmers. The improved variety CMS 8704 is characterized by the yellow color of the grains produced and yield of up to 4 to 6 t ha^{-1}, under the best growing conditions at the Institute of Agricultural Research for Development (IRAD) station. Treatments were randomized sub-plots of the main plot (control, compost, poultry manure and mineral fertilizer (N-P-K 20-10-10)). Compost from three-month-old household waste was obtained from an Association named "GIC le Vert" and poultry manure was provided by the poultry complex to both in Yaounde. The mineral fertilizer used was the complex fertilizer N-P-K (20-10-10) with the trade name YARA existing in granular form. Eight treatments resulting from the combination of the levels of the two factors were tested. Each combination that constitutes sub-plots uses 21 packets of 3 lines and 7 packets per line at intervals of 0.80 x 0.50 m. A total of 32 sub-plots measuring 4 m x 2 m were counted, and separated by 1 m paths and blocks were separated by 2 m paths. Weeding was done at 3, and 6 weeks after sowing (WAS) using a hand hoe.

2.3 Soil and Organic Fertilizer Analysis

In order to elaborate on the fertilization of the plants, the physicochemical properties of the soil and organic fertilizers were determined in the Laboratory of the Institute of Agricultural Research for Development (IRAD) Yaounde-Nkolbisson. The soil sample was collected at a depth of 15 cm in different locations in the experimental field. These soil samples were analyzed to determine the following characteristics: texture (sand, silt, and clay), pH, organic carbon, total nitrogen, exchangeable bases (Ca, Mg, K) and available phosphorus using the methods described by Anderson & Ingram (1993); Buondonno et al. (1995). The organic fertilizers (compost and poultry manure) were also analyzed to determine total nitrogen, potassium and phosphorus according to the NF ISO 11261; 31108 and 11263 standards respectively and calculated following the formula proposed by Pauwels et al.

(1992).

2.4 Treatment Applications

The organic fertilizers were mixed with soil at a depth of 5 cm and applied 1 week before seeding (Gomgnimbou et al., 2019) in the respective sub-plots at 0.12 kg per pots (Yerima et al., 2014). Mineral fertilizer was applied two weeks after seeding at a rate of 11.2 g per plant according to Ojetayo et al. (2011). The organic and inorganic fertilizers were applied only once during the experiment.

2.5 Data Collection

Emergence was observed from the 7th to 9th day after sowing (DAS). The ratio of the number of plantlets actually emerged to the total number of seeds sown made it possible to determine the emergence rate according to the formula used by Ngatsi et al. (2017)

$$ER (\%) = (n/N) \times 100$$

Where: ER (%) emergence rate, N = number of emerged plantlets and N = total number of sown seeds.

Data were recorded from a sample of 6 randomly selected plants labeled per sub-plot and the growth variables were observed over a period of 3 to 9 weeks after sowing (WAS) with 2 weeks interval. Stem diameter using a caliper, plant height per meter and leaves number were assessed. Maize grain yield (t ha^{-1}) was conducted 122 days after sowing (DAS) on 12 plants randomly harvested from each sub-plot in each block and calculated by the following formula.

$$\text{Yield (t ha}^{-1}) = \text{Grain weight (kg/m}^2) \times 10000 \text{ m}^2/\text{ha} \times 1 \text{ t}/1000 \text{ kg}.$$

2.6 Economic Profitability of Fertilizer Types

To identify the best treatment that is easily adopted by farmers, gross income (GR) and acceptability index (AI) were calculated (Nyembo et al., 2014). The gross income is equal to the yield (kg ha^{-1}) multiplied by the market price per kilogram of grain maize (Pr).

$$GR = \text{yield} \times Pr.$$

The Acceptability Index (AI) compares the net profit of the new treatments (NPt) to the reference treatment (control) known by the farmers (NPc).

$$AI = NPt/NPc$$

According to Kaho et al. (2011); Useni et al. (2012), for a technology to be adopted, the Acceptability Index (AI) value must be equal to or greater than 2. Adoption is reluctant if this value is between 1.5 and 2; and below 1.5 there is rejection.

2.7 Statistical Analysis

The data collected were subjected to a one-way and two-way analysis of variance (ANOVA) and the Principal Components Analysis (PCA) using R software version 4.1.2 (R Development Core Team 2022). PCA was constructed with the growth parameters at all periods, yield and fertilizer types. The multiple comparisons of Duncan's test mean threshold follows the analysis of variance when significant differences ($P < 0.05$) for one of the factors are detected and before, the normality test (Shapiro-Wilk test $P > 0.05$) and homogeneity of variance (Levene’s test $P > 0.05$) were verified.

3. Results

3.1 Physicochemical Characterization of Soil, Compost and Poultry Manure

Soil analysis results during this growing season show that the soil is acidic with a sandy and clay texture and silt (Table 1). Assimilable phosphorus is 0.3 g kg^{-1}, total nitrogen (0.18 g kg^{-1}) and exchangeable calcium (1.91 mol kg^{-1}). The organic matter content is 34.6 g kg^{-1}. The carbon and nitrogen ratio (C/N) is 10 and the cation exchange capacity (CEC) is 9.03 cmol kg^{-1}. Compost and poultry manure is rich in nitrogen (20.6 and 16.35 g kg^{-1} respectively). As regards phosphorus and potassium respectively, poultry manure contains 35.77- 49.75 g kg^{-1} and compost (16.35-33.32 g kg-^{1}). The soil locality pH is acidic (pH KCl: 4.5 and pH H_2O: 5.6) as opposed to the pH of compost (pH KCl: 7.59 and pH H_2O: 7.97) and poultry manure (pH KCl: 7.89 and pH H_2O: 8.03) which are basic.

Table 1. Physicochemical properties of soil, compost and poultry manure

Soil		Compost		Poultry manure	
Characteristics	Contents	Characteristics	Contents	Characteristics	Contents
Clay (%)	31.3	N g kg^{-1}	20.6	N g kg^{-1}	16.35
Silt (%)	5.3	P (P_2O_5) g kg^{-1}	16.35	P (P_2O_5) g kg^{-1}	35.77
Sand (%)	62.4	K (K_2O) g kg^{-1}	33.32	K (K_2O) g kg^{-1}	49.75
pH (KCl)	4.5	pH (KCl)	7.59	pH(KCl)	7.89
pH (H_2O)	5.6	pH (H_2O)	7.97	pH(H_2O)	8.03
OM (g kg^{-1})	34.6				
OC (g kg^{-1})	1.8				
Total nitrogen (g kg^{-1})	0.18				
C/N	10				
AP (mg kg^{-1})	0.3				
Ca^{2+} (mol kg^{-1})	1.91				
Mg^{2+} (mol kg^{-1})	0.10				
K^+ (mol kg^{-1})	0.10				
CEC (cmol kg^{-1})	9.03				

OM: Organic Matter; OC: Organic Carbon; C/N: Carbon/Nitrogen; AP: Assimilable Phosphorus; CEC: Cation Exchange Capacity; N: Nitrogen; P: Phosphorus; K: Potassium.

3.2 Effect of Fertilizers and Variety on Emergence Rate

The emergence rate of plants varies over time in all treatments used (Table 2). There are significant differences ($P < 0.05$) between treatments at 7, 8 and 9 days after sowing (DAS). At 9 DAS, the emergence rate was significantly low in the sub-plots treated with poultry manure (75.74%) and compost (76.94%) compared to the control (79.53%) and the plots that received the mineral fertilizer NPK (80.12%). No significant difference between varieties were observed at 7 DAS (F-value=2.039, df=1, P-value=0.167) compared at 8 DAS (F-value=6.152, df=1, P-value=0.0213) and 9 DAS (F-value=7.303, df=1, P-value=0.013) for the emergence rate.

Table 2. Effect of treatments and variety on maize seed emergence rate

Treatments	7 DAS	8 DAS	9 DAS
Control	74.28 ±1.54a	76.79 ±1.65a	79.53 ±1.95a
Compost	71.08 ±1.08b	73.57 ±0.96b	76.94 ±1.55b
Poultry manure	72.68 ±2.09ab	73.77 ±2.10b	75.74 ±1.02b
Mineral fertilizer	74.26 ±1.57a	77.02 ±1.87a	80.12 ±1.47a
F-value	5.385	7.247	10.31
Pr(>F)	0.0069**	0.0017**	<0.001***
Varieties			
Local variety	72.50 ±2.07a	74.16 ±2.04a	77.05 ±1.92b
CMS 8704	73.65 ±1.87a	76.41 ±2.03b	79.17 ±2.27a
F-value	2.039	7.303	6.152
Pr(>F)	0.167ns	0.013*	0.0213*

Values followed by the same letter are not significantly different according to Duncan's test at ($P < 0.05$).

3.3 Growth Parameters and Yield

3.3.1 Stem Collar Diameter

Plant stem diameter is reported in Table 3. From this table, no significant differences are recorded at 3 weeks after sowing (WAS). At 5 WAS, the treatment effect (F-value=3.92, df=3, *P*-value<0.001) and variety effect (F-value=11.22, df=1, *P*-value=0.036) are observed. The largest diameter is obtained by the local variety in the plots fertilized with mineral fertilizer NPK (2.40±0.26 cm) than the stem diameter of variety CMS 8704 in the control plots (1.54±0.13 cm). At 9 WAS, no significant difference was registered between treatments and variety*treatment interaction. Only the variety effect is recorded (F-value=8.62, df=1, *P*-value=0.008). The local variety has a larger diameter (2.62±0.43 cm) than the improved variety CMS 8704 (2.20±0.39 cm). The results show that during this period, the plots fertilized with mineral fertilizer NPK of the local variety obtained the best diameter (2.83±0.31 cm).

Table 3. Effect of treatments and variety on the stem diameter of maize plants

Varieties	Treatments	3 WAS	5 WAS	7 WAS	9 WAS
Local variety	Control	1.00±0.12a	1.70±0.34c	1.82±0.11bc	2.29±0.38ab
	Compost	1.29±0.28a	2.26±0.09ab	2.55±0.42a	2.68±0.42ab
	Poultry	1.05±0.38a	1.83±0.32bc	2.36±0.48ab	2.67±0.55ab
	NPK	1.02±0.49a	2.40±0.26a	2.58±0.15a	2.83±0.31a
Means V1		1.09±0.33a	2.05±0.39a	2.33±0.43a	2.62±0.43a
CMS 8704	Control	0.96±0.08a	1.54±0.13c	1.74±0.16c	2.12±0.24b
	Compost	1.15±0.26a	1.89±0.27bc	1.88±0.29bc	2.11±0.54b
	Poultry	1.17±0.12a	1.59±0.26bc	2.10±0.18abc	2.15±0.39ab
	NPK	1.09±0.19a	2.25±0.45ab	2.01±0.56bc	2.38±0.48ab
Means V2		1.08±0.17a	1.82±0.40b	1.93±0.34b	2.20±0.39b
Pr(>F) V		0.9706ns	0.0357*	0.0026**	0.008**
Pr(>F) T		0.3787ns	<0.001***	0.0207*	0.3465ns
Pr(>F) V x T		0.7649ns	0.8678ns	0.3001ns	0.7914ns

V1: local variety, V2: improved variety CMS 8704, V: varieties, T: treatments, V x T: interaction, WAS: week after sowing. Values followed by the same letter are not significantly different according to Duncan's test at ($P < 0.05$).

3.3.2 Plants Height

Plant growth was better in the treated plots compared to the control plots (Table 4). It was observed that during the periods of parameter sampling, the variety*treatment interaction was not significant ($P > 0.05$). Nevertheless, at 3 WAS (F-value=0.29, df=3, *P*-value=0.834), the highest height was observed in the plots receiving the compost (0.45±0.07 m) of the local variety. At 9 WAS (F-value=2.06, df=3, *P*-value=0.132), plots fertilized with poultry manure (2.14±0.08 m) of the local variety and plots fertilized with compost (2.14±0.11 m) of the CMS 8704 variety obtained the best heights compared to the control plots (1.90±0.19 m) of the CMS 8704 variety.

Table 4. Effect of treatments and variety on maize plant height

Varieties	Treatments	3 WAS	5 WAS	7 WAS	9 WAS
Local variety	Control	0.37±0.02bc	0.89±0.25c	1.44±0.63bc	1.99±0.10bc
	Compost	0.45±0.07a	0.99±0.25b	1.49±0.61ab	2.06±0.07ab
	Poultry	0.43±0.05ab	1.10±0.21a	1.59±0.56a	2.14±0.08a
	NPK	0.40±0.04ab	1.12±0.22a	1.51±0.54ab	2.09±0.12ab
Means V1		0.41±0.05a	1.03±0.23a	1.51±0.95a	2.07±0.08a
CMS 8704	Control	0.31±0.02d	0.82±0.25d	1.36±0.59c	1.90±0.19c
	Compost	0.41±0.03ab	0.86±0.28cd	1.58±0.54a	2.14±0.11a
	Poultry	0.39±0.02abc	1.00±0.26b	1.55±0.53ab	2.10±0.13ab
	NPK	0.34±0.01cd	1.01±0.25b	1.45±0.58bc	2.08±0.11ab
Means V2		0.36±0.04b	0.92±0.26b	1.49±0.56a	2.05±0.11a
Pr(>F) V		0.0007***	<0.001***	0.459ns	0.529ns
Pr(>F) T		0.0012**	<0.001***	0.0017**	0.0002***
Pr(>F) V x T		0.834ns	0.707ns	0.170ns	0.131ns

V1: local variety, V2: improved variety CMS 8704, V: varieties, T: treatments, V x T: interaction, WAS: week after sowing. Values followed by the same letter are not significantly different according to Duncan's test at ($P < 0.05$).

3.3.3 Leaf Number

The number of leaves of maize varieties varies in the different treatments and as a function of time (Table 5). The data in the table show a significant difference at 5 WAS (F-value=3.30, df=3, *P*-value=0.037) and 9 WAS (F-value=3.67, df=3, *P*-value=0.026) for variety*treatment interaction, as well as the treatment effect at 9 WAS (F-value=5.56, df=3, *P*-value=0.004). At 5 WAS, the plots receiving the mineral fertilizer NPK (10.75±0.50 leaves) of the variety CMS 8704 obtained the highest number of leaves than the control plots of the same variety

(9.25±0.96 leaves). At 9 WAS, the plots fertilized with mineral fertilizer NPK of the local variety (17.25±0.96) and the CMS 8704 variety (16.05±0.74) have the highest number of leaves.

Table 5. Effect of treatments and variety on the number of leaves of maize plants

Varieties	Treatments	3 WAS	5 WAS	7 WAS	9 WAS
Local variety	Control	8.50±0.10a	10.50±0.58ab	12.50±0.58ab	15.00±0.78c
	Compost	8.25±0.50a	10.54±1.00ab	13.00±0.82ab	16.25±0.54b
	Poultry	8.00±0.82a	10.50±0.58ab	13.25±0.96ab	16.25±0.96b
	NPK	8.25±0.40a	10.05±0.82abc	13.00±0.82ab	17.25±0.96a
Means V1		8.25±0.68a	10.40±0.72a	12.94±0.77a	16.19±1.05a
CMS 8704	Control	7.75±0.96a	9.25±0.96c	12.25±0.96b	16.00±0.82b
	Compost	8.00±0.61a	10.00±0.64abc	13.50±1.01ab	16.00±0.68b
	Poultry	8.50±0.58a	9.50±0.58bc	13.00±0.82ab	16.05±0.65b
	NPK	8.00±0.58a	10.75±0.50a	13.75±0.50a	17.25±0.74a
Means V2		8.06±0.57a	9.88±0.81a	13.13±0.96a	16.33±0.44a
Pr(>F) V		0.4251ns	0.0522ns	0.5253ns	0.5691ns
Pr(>F) T		0.9738ns	0.4705ns	0.0452*	0.0048**
Pr(>F) V x T		0.3158ns	0.0373*	0.5142ns	0.0263*

V1: local variety, V2: improved variety CMS 8704, V: varieties, T: treatments, V x T: interaction, WAS: week after sowing. Values followed by the same letter are not significantly different according to Duncan's test at (*P < 0.05*).

3.3.4 Grain Yield

Regarding yield, no significant difference to fertilization was observed with interaction variety*treatment (F-value=2.81, df=3, *P*-value=0.06). The control plot of the local variety (1.16±0.19 t ha^{-1}) and CMS 8704 variety (1.21±0.17 t ha^{-1}) has the lowest yield, followed by the local variety in plot treated with compost (1.69±0.13 t ha^{-1}) and mineral fertilizer NPK (1.69± 0.05 t ha^{-1}). On the other hand, the plots that received poultry manure (2.23±0.27 t ha^{-1}) and compost (2.16±0.21 t ha^{-1}) of the improved CMS 8704 variety had the highest yields.

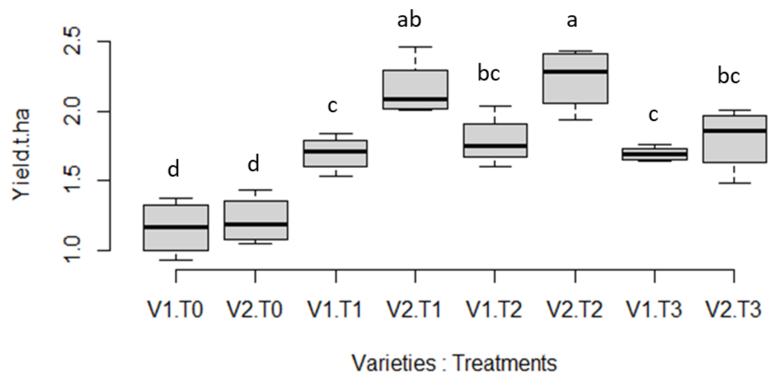

Figure 1. Effect of treatment and variety on maize yield; V1: local variety, V2: improved variety CMS 8704, T0: control, T1: compost, T2: poultry manure, T3: mineral fertilizer NPK (20-10-10)

3.4 Multivariate Analysis

Principal Component Analysis (PCA) was performed to show the relationship between agronomical parameters and treatments are presented in Figure 2. The two PCA explain 91.6% of the variance. The PCA1 represents 67.7% of the variation of the studied system; the variables are height (at 3, 5, 7 and 9 WAS), yield, number of leaves (at 5, 7 and 9 WAS), and stem diameter (at 7 WAS). The PCA2 contributed about 24% of the variability. Stem diameter at 5 WAS, number of leaves at 3 WAS and height at 5 WAS were the most representative variable. Poultry manure and compost were characterized by an increase in growth parameters as well as mineral fertilizer NPK. But poultry manure and compost yielded than mineral fertilizer NPK. Control is the opposite of the three techniques of fertilization and yields lower.

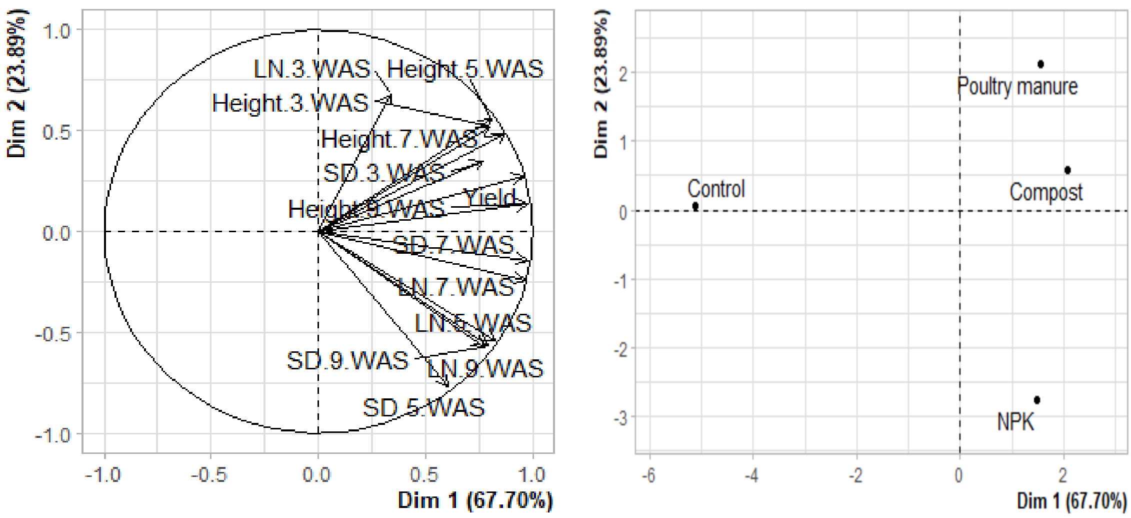

Figure 2. Principal components analysis (PCA) between the parameters studied. SD: stem diameter, LN: leaf number, WAS: week after sowing

3.5 Economic Profitability of the Use of Different Types of Fertilizers

The results of the economic profitability of the different types of fertilization are presented in Table 6. It appears that the acceptability index of NPK mineral fertilization is lower (1.04), contrary to that of organic fertilization. Fertilization with poultry manure gave the highest acceptability index of 1.25. Also, it can be seen that fertilization with compost is the most expensive.

Table 6. Economic profitability of the use of different types of fertilizers

Treatments	Quantities in 50 kg bags	FPP /ha (USD)	SpC (USD)	TC (USD)	Yield (kg ha^{-1})	GR (USD)	NP (USD)	AI
Control	0	0	0	0	1186.94	453.07	453.07	0
Compost	60	229.03	18.32	247.35	1925.19	734.87	487.52	1.08
Poultry	60	183.22	18.32	201.54	2009.16	766.92	565.38	1.25
NPK	6	178.64	18.32	196.96	1746.20	666.55	469.58	1.04

FPP: Fertilizer Purchase Price Yara 29.77 USD/bag of 50 kg; SpC: Spreading Cost; TC: Total Cost; GR: Gross Income (0.38 USD/kg selling price of grain maize); NP: Net Profit; AI: Acceptability Index. Price of compost purchase 3.82 USD/bag and poultry manure 3.05 USD/bag of 50 kg.

4. Discussion

In general, the best practice for maintaining soil fertility remains the use of organic fertilization (Lunze et al., 2007). In order to maintain this fertility in a sustainable way and to ensure the sustainability and durability of soil use, organic farming practices, which appear to be an alternative solution to mineral fertilization, could play a major role in promoting and maintaining soil fertility compared to conventional agriculture (Muyayabantu, 2010). The objective of the study is to determine the influence of fertilizers on maize growth and yield while evaluating economic profitability in the rainforest zone of Cameroon.

The different organic fertilizers used during the experiment had high levels of major nutrients (N, P and K). As demonstrated by Hassani & Presoon (1994), the nutrient content would depend in the case of compost, on the different organic elements involved during composting (the animal and/or plant organic matter composition of the household waste), the composting method and the storage method. In the case of poultry manure, it would depend on the quality of the feed consumed by the poultry, and the method of drying and storage. However, these organic fertilizers, in addition to providing the plant with the nutrients necessary for its growth and development (Saha et al., 2008), would also contribute to enhancing the fertility of nutrient-poor soils (Adelekan et al., 2010; Useni et al., 2012).

The effect of fertilizers on maize growth revealed significant differences ($P < 0.05$) in emergence rate at 7, 8 and 9 days after sowing (DAS). Significantly low mean emergence rates of 76.94 and 75.74% were recorded in the poultry manure and compost treatments, respectively. These results would be related to the depth of seed burial in the soil, or to the environmental conditions during the emergence phase and not to the nutrient supply, because at the germination stage, the seed's only nutrient source comes from the reserves contained in its cotyledons (Useni et al., 2013). Regarding the number of leaves and stem collar diameter, it was observed that during the first weeks of the plant's vegetative cycle, the effect of mineral fertilizer NPK (20-10-10) was clearly demonstrated at 5 WAS by significantly high values. However, it was only from the last weeks onwards that the application of organic fertilizers to the crop significantly influenced plant growth. The results obtained would be justified by the fact that chemical fertilizer, being obtained by synthesis, contains highly soluble mineral elements that have the advantage of being easily absorbed by the plant at the root level (Kimuni et al., 2013). Therefore, the nutrient supply (especially major nutrients) of the chemical fertilizer and the effect of the latter on plant growth and development would be direct and immediately observable from the first weeks of the plant growth phase (Galla et al., 2011). On the other hand, organic fertilizers applied to plants do not always make the nutrients they contain immediately available and easily accessible (Aliyu, 2000). These nutrients must first be mineralized by soil microorganisms before they are available (Vagstad et al., 2001; Giroux et al., 2007). These results are identical to those obtained by Adelekan et al. (2010) on maize cultivation in Nigeria. However, treatment with poultry manure and compost improved the height of maize plants of both varieties at 9 WAS. Ahmad et al. (2013) note that excess nitrogen stimulates exuberant growth of the aerial part, and promotes carbohydrate utilization as well as the export of mineral elements and plant growth. A significant effect ($P < 0.05$) between varieties is observed for stem collar diameter and height of maize plants. Indeed, the local variety recorded high values for these parameters compared to the improved variety which recorded low values. This would be only a consequence of the morphogenetic characteristic of the local variety, which over time has adapted to the local ecological conditions and which according to the local residents is likely to present an imposing morphology. Ngatsi et al. (2017) showed that the local variety most cultivated by the farmers of this locality presents a more imposing morphology (stem diameter and height) compared to the improved varieties used. Also, this difference might be due to the genetic potential difference between the varieties (Berhe & Andargachew, 2020).

Poultry manure and compost performed significantly better yields than the other treatments. This result confirms the results of Agyenim et al. (2012); Segnou et al. (2012) obtained after a study on mineral and organic fertilization of maize and pepper (*Capsicum annuum* L.). This result could be explained by the dual role played by poultry manure as an organic fertilizer (Effa et al., 2022). A role of nutrient supply, and a role of soil amendment by improving the physical (structural stability, erosion control, increase in water retention capacity, soil aeration and warming), chemical (supply of major nutrients, supply of trace elements, increase in CEC, increase in pH of acidic soils) and biological (stimulation of soil microbial activity) properties of the soil (Saha et al., 2008). This would contribute to plant growth and thus promote good yields. As for the control, the lack of fertilization and soil characteristics would be at the origin of the low yield (Kasongo et al., 2013). According to Kitabala et al. (2016); Sigaye et al. (2020), organic fertilization subsequently improved crop performance, and soil characteristics and increased yields. The improved variety is significantly more productive compared to the local variety According to Zaidi et al. (2003), improved cultivars in the tropics have shown that they can initiate better grain yield stability in maize.

Principal component analysis between fertilization types, growth parameters and yield shows that the addition of fertilizer increases the growth and yield of maize varieties compared to the control. Kouassi et al. (2019) in their work on the “effects of organic and organo-mineral fertilizers based on plant and animal wastes on soybean growth and yield (*Glycine max* L.)” show that mineral fertilizer application improves early soybean growth parameters. This author also shows that organic fertilization promotes better pod production by plants. The acceptability index of the different types of fertilization is below 1.5 and therefore all are rejected. This could be justified by the fact that organic fertilizers (compost and poultry manure) were probably applied at low doses (3 t ha^{-1}), and only once, as was the case with mineral fertilizer. This rate is lower than that applied in most cases (Olaniyi et al., 2010; Nyembo et al., 2014).

5. Conclusion

The organic fertilizers used during the experiment had high levels of major nutrients. During the vegetative period, compost from household waste and poultry manure had significant effects on maize plant growth only from the seventh week after sowing, as well as the chemical fertilizer used, which had effects on plant growth from the first weeks after sowing. The local variety recorded the highest values for stem diameter and height. Poultry manure is the most suitable organic fertilizer for obtaining better yields (2.23 t ha^{-1}) with CMS 8704 variety than the control plot (1.16 t ha^{-1}) with local variety. The variety effect results led to the conclusion that the improved variety is more suitable for obtaining better yields. Thus, organic fertilizers, especially poultry manure, give better value to maize compared to the control and chemical fertilizers.

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Competing interests

The authors declare that they have no conflict of interest.

Author Contributions

Bekolo Ndongo selected the scope of the work; Bekolo Ndongo and Zachée Ambang reviewed and edited the manuscript. Behly Tanekou Ndja'a conducted the field experiment, Patrice Zemko Ngatsi supervised the Fieldwork, analyzed data and writes the first draft of the manuscript. All authors have read and approved the final version of the manuscript.

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