

# Effect of Mineral and Organic Fertilizer on the Performance of Cassava (*Manihot esculenta* Crantz) in the Pissa region of the Central African Republic

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**Abstract**— *Inefficient and unbalanced use of fertilizer is some of the plausible reasons contributing to the significant cassava yield gaps in Sub-Saharan Africa. However, there is limited research regarding the responses of cassava to organic and inorganic fertilizers used in these agrological settings. We conducted a study in the Pissa areas with the participation of members of an agropastoral group to improve the cassava yield in rural areas of the Central African Republic. The experimental layout was a randomized complete block design (RCBD) with four treatments replicated four times and comprising 16 elementary plots of 25m<sup>2</sup> (5m by 5m). The treatments were randomly assigned from 1 to 4 (T1, T2, T3, and T4). According to the treatments, the variabilities between cassava's growth, yield, and economic productivity in pure culture were measured and quantified. The data were subjected to Analysis of Variance (ANOVA) using a linear model of R statistical software version 3.1.2. We performed Principal Component Analysis (PCA) on several parameters. This study shows that treatments T4 (cassava + NPK + cow manure) and T3 (cassava + NPK) resulted in plants that have better growth in heights and diameters, unlike T1 (control) and T2 (peasant practice), which have the lowest values. The PCA confirmed that the variability between the treatments is up to 52.12% on the two axes (1 and 2) and affirms that the yields obtained during the study show a highly significant difference. The treatment T4 (cassava + NPK + cow manure) gave the highest yield and generated a good profit compared to other treatments. There was no correlation between treatments in terms of growth and productivity parameters. The T4 treatment proposed by the International Atomic Energy Agency (IAEA) performed better on all the evaluations. Therefore, organo-mineral fertilization can contribute to the improvement of cassava production.*

**Keywords**— *Cassava, Fertilizers, Yield, and Cow manure.*

## I. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is ranked the third most crucial tropical food crop contributing 32% of the world's food root and tuber production after potatoes, contributing 45% of the total to food security (FAOSTAT, 2016). This plant is widely cultivated and is the staple food of households in tropical and subtropical regions FAO (2014). Its starch-rich terrified roots are consumed. Also, the leaves are consumed as a vegetable in some countries (Celcos et al. (2012). Cassava is also suitable for industrial utilization and can be processed into flour, chips, starch, ethanol, and other non-food products (Balagopalan, 2009). In the last century, cassava has transitioned from a subsistence to a more commercial crop (Onyenwoke & Simonyan, 2014). Cassava is highly adaptable and can grow in different agroecological settings, and it can also grow on low-fertility soils and

has the advantage of flexibility in harvest periods (El-Sharkawy, 2014). It can withstand prolonged droughts and erratic rainfall (Okogbenin et al., 2013). Therefore, it is considered a highly resilient crop in the face of current climatic changes (Jarvis et al., 2012). Thus, cassava can be crucial in tackling food insecurity and hunger in the face of climate uncertainty (Biratu et al., 2018).

In Africa, cassava is the second most important food source in terms of calories consumed per capita (Roothaert & Magado, 2011). Sub-Saharan Africa is the largest cassava producer globally: For instance, out of the 277 million tons produced worldwide in 2013, 158 million tons were from Africa (Bennett, 2015). Cassava is also the first food crop in the Central African Republic (CAR), which plays a vital role in household food security, especially in rural and urban areas. It is the staple food of more than 95% of Central Africans (Zinga et al., 2006). Central African agriculture remains the heart of economic development, employing 75% of the active population and contributing 45% of the Gross Domestic Product (GDP). The CAR wonderland enjoys a myriad of natural resources, comprising of vast arable land, covering about 15 million hectares, of which only 800,000 hectares are annually cultivated. Also, the average area cultivated per agricultural worker is 0.53 hectares; it has five zones within which cassava and other crops are cultivated, but the productions are not the same since each zone has specific characteristics. Despite all its resources, there is a considerable yield gap between actual productivity in farmers' fields and the potential cassava productivity (Ezui et al., 2016). The yield gaps between farmer and researcher-managed trials remain large; for instance, In Nigeria, Adiele et al. (2020) reported a root dry matter yield of 35 t ha<sup>-1</sup> compared to 2.51 t ha<sup>-1</sup> obtained on farmers' fields in Africa (De Souza et al., 2017).

Given its tolerance to various climatic stresses (El-Sharkawy, 2005), cassava is usually grown in nutrient-depleted soils with little or no input of fertilizer (Howeler, 2002), thus the low yields. Trials in Africa, Brazil, and India showed increased cassava root yield production with fertilizer application (FAO, 2013). Research in DR Congo (Munyahali et al., 2017) and Zambia (Biratu et al., 2018) has shown that fertilizer can improve cassava yield. Hence, bridging the yield gap lies on a better understanding of soil organo-mineral fertilization.

Further, application of soil amendments at appropriate doses does not only increase crop yield but also preserves the soil's productive capacity during crop's growth cycle (Palm et al., 2001; Akanza et al., 2001). Agricultural soils in some CAR regions have a low level of intrinsic fertility. This notwithstanding, the use of mineral and organic fertilizers on food crops in rural areas remains insignificant due to the low purchasing power of farmers and input scarcity in the market (Akanza and Yao – Kouamé, 2011). Organic resources play an essential role in soil fertility management, for instance, animal manure, a locally available resource, improves soil structure for easier root penetration and development. It can also contribute to long-term soil organic matter formation and improve soil biological properties (Blanchet et al., 2016). Additionally, nutrients contained in organic manure are released more slowly and are stored for a longer time (Rani et al., 2022). However, cassava is an exhausting plant, given the mineral mobilizations that its cultivation entails at the end of the cycle (Pouzet, 1988; Raffailac & Nedelec, 1984; Troupa & Koné, 2003). Therefore, sustaining cassava tuber production, which has been on the decline (IRAD, 2013), is dependent on the use of both organic and mineral fertilizers.

Previous studies conducted on cassava show that mineral elements such as N, P, K, Ca, and Mg are essential in increasing cassava tuber yield (Ngome et al., 2013). This calls for mechanized farming systems that use fertilizer among other inputs. On the contrary, little attention has been given to the potential of organo-mineral fertilization in combating soil fertility problems in cassava fields (Biratu et al., 2022). In the current study, we report on the potential of integrated management practices in improving cassava yield. The central hypothesis is that cow manure and mineral fertilizer will achieve higher cassava yields than the sole application.

## II. MATERIALS AND METHODS

### 2.1 Study area, trial site history, and land clearing

The study was conducted in the municipality of Pissa. The trial was initiated near M'baiki in the Prefecture of Lobaye (4.046°N, 18.166°E) south of CAR (Figure 1). The study was conducted in collaboration with lead farmers who were members of the Groupement Agro-Pastoral Pissa 2 (GAP2) with a participatory approach. The climate is Guinean forest characterized by nine

months of the rainy season with annual rainfall amounts ranging from 1600 to 1800mm with a mean annual temperature of between 23 and 26 °C. With a maximum annual temperature of 29°C and a minimum of 18°C, the average relative humidity is 77%. The predominant vegetation is of the forest type. Given these climatic divergences, the municipality of PISSA is found in the agroecological zone No. 1. Cassava is the main food crop grown and an important cash crop grown by the majority of farmers. Other major crops grown in the area are; coffee, cocoa, and banana. The predominant soil is clay-sandy soil near the national road. It is a fallow of more than five years dominated by fertility indicator plants, namely *Pueraria javanica* (Roxb.) Benth and *Chromoleana odorata* (L.).

This study used rudimentary tools such as a hoe and a machete to open the plot. A total area of 1369m<sup>2</sup> (37 m by 37m) was delimited and cleared; we piled up the waste on the plot's edges and proceeded to plough finally to make the soil loose for the establishment of culture. The plot was divided into small elementary plots with a dimension of 25m<sup>2</sup> (5m by 5m); the milestones were cut to two meters (2m), and the stakes of one meter long were used; the area was divided into four blocks, and each block had four elementary plots whose treatments were randomly assigned, the plot was separated by two meters of the driveway between the blocks and one meter between the elementary plots and a border to avoid the edge effect and predators.

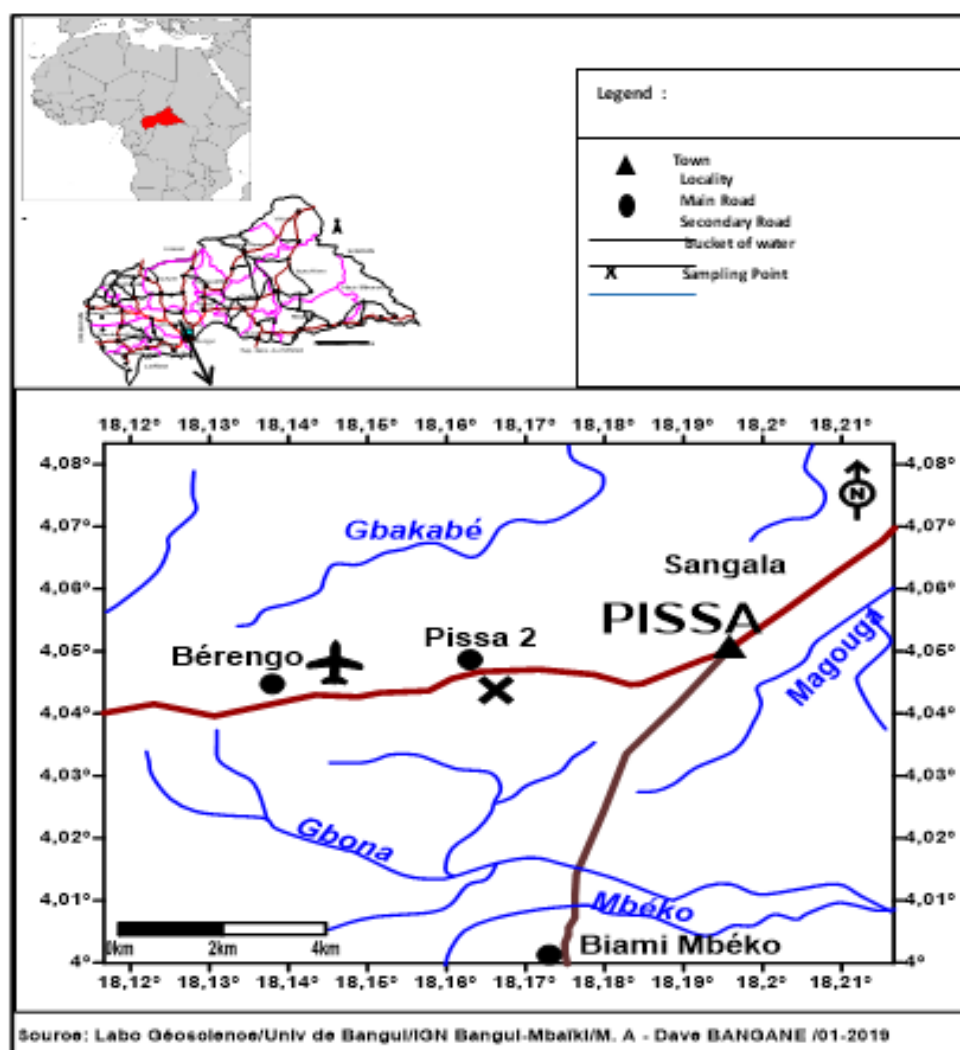
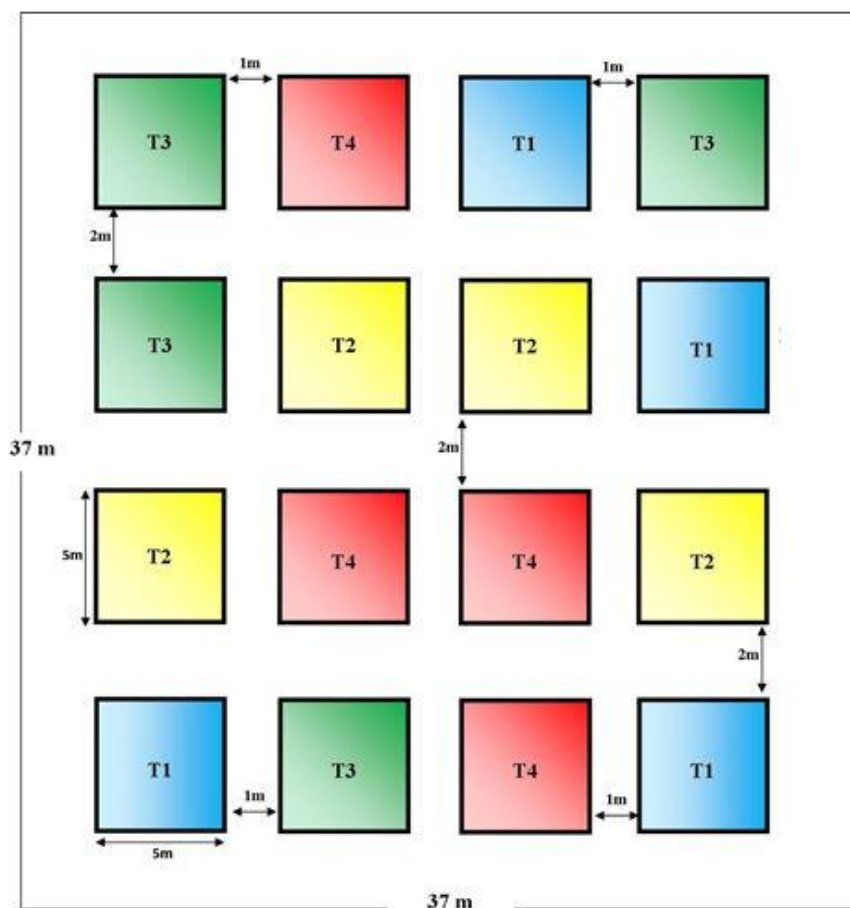


FIGURE 1: Study site

## 2.2 Trial design

The experiment adopted a randomized complete block design (RCBD) with four treatments and four replications comprising 16 elementary plots of 25m<sup>2</sup> (5m by 5m). The four treatments were randomly assigned from 1 to 4 (T1, T2, T3, and T4) (Figure 2). Where; T1 is the Control plot; T2 is the Peasant practice; T3 is the practice recommended by the University of Bangui (80kg N, 40kg P and 120kg K) and T4 is the practice recommended by the IAEA; 90 kg N, 30 kg P, and 180kg K. For the

fertilizer application N and K were divided into three 1/2 doses of N, K, and 1/2 in the third month and the rest in the fifth month, but the full P 2/2 was applied in the first month. The mineral fertilizers used consist of urea ( $\text{CO}(\text{NH}_2)_2$ ) containing 46% N, potassium sulphate ( $\text{K}_2\text{SO}_4$ ) containing; 50% K, and triple superphosphate, TSP ( $\text{Ca}(\text{H}_2\text{PO}_4)_2$ ) containing 46% P. The rates for these three fertilizers were 80, 40, and 120kg/ha or 90, 30, and 180 kg/ha. Plants in their ammoniacal form do not directly assimilate urea, with 46% nitrogen in granular form. It is hydrolyzed into ammonium for 2-3 days in the soil before use by the absorbent hairs of the roots.



**FIGURE 2: Experimental design**

### 2.3 Trial establishment and crop husbandry

A total area of 1369 m<sup>2</sup> (37 m × 37 m) was divided into four blocks, each of which has four elementary plots of 25 m<sup>2</sup> (5 m × 5 m). The cuttings used (12 months old) were cut into small pieces of 15-20cm. The plant material consists of a local cassava cultivar, "Gabon" (Figure 3). This cultivar has been identified because of its resistance to the African cassava mosaic (CMD), its agronomic performance, from the point of view of yield, it is highly appreciated by cassava producers (Zinga et al., 2012). The variety is also available in the region (Pissa2). Cassava cuttings were collected from the field of the agropastoral group.

The cuttings were sown in five rows and five columns with 25 cuttings per elementary plot. The total number of cuttings in the entire area was 400. The cutting points measured 1 m between and on the line (1m by 1m). The gaps between the blocks were 2m. Each block had a cultivable area of 100 m<sup>2</sup> (5 m x 5 m x 4); the plot had an area of 400 m<sup>2</sup> or 0.04 ha. A 4 m border was laid out around the plot. The experimental plots were maintained weed-free throughout the season with no herbicides. During the experiment, no phytosanitary treatment was administered.

Urea and potassium sulphate was applied twice, and phosphorus and cow manure were simultaneously applied (Table 1). First, 1/3 of the amount of urea and potassium was applied one month after cassava planting, another 1/3 after 3 months, and finally, the last third in the fifth month of planting. The total amount of phosphorus was applied during the first treatment (Table 2). After 12 months of testing, cassava tuberous roots were harvested to assess the average yield in fresh weight and number of cassava roots per plant according to treatments.



**FIGURE 3: Preparation of cuttings by farmers**

**TABLE 1**  
**SUMMARY OF MINERAL AND ORGANIC FERTILIZERS AND RECOMMENDED TREATMENTS BY ELEMENTAL PLOT**

Treatment	Manure Rate (Kg/ha)	Mineral fertilizer (Kg/ha)		
		N	P	K
T1	0	0	0	0
T2	0	0	0	0
T3	0	80(1/3 N+	40(3/3P+	120(1/3K
T4	3000	90(1/2N+	30(2/2P+	180(1/2P

**TABLE 2**  
**QUANTITIES AND TIMES OF FERTILIZERS APPLICATION**

Duration			
Quantity	Start of cuttings	Three months after cuttings	Five months after cuttings
N	$\frac{1}{3}$ OU $\frac{1}{2}$	$\frac{1}{3}$ OU $\frac{1}{2}$	$\frac{1}{3}$ OU $\frac{1}{2}$
P	$\frac{3}{3}$ OU $\frac{2}{2}$ -		-
K	$\frac{1}{3}$ OU $\frac{1}{2}$	$\frac{1}{3}$ ou $\frac{1}{2}$	$\frac{1}{3}$ OU $\frac{1}{2}$
Cow manure	3000Kg/ha -		-

## 2.4 Data collection

### 2.4.1 Soil sampling and analysis

Before the experimental installation, surface soil was sampled using an Edelman auger at 0-20cm depth, bulked together, and harmonized to obtain a composite. The soil was air-dried, passed through a 2mm sieve, and analyzed for texture and chemical properties. The particle size distribution was done using the hydrometer method described by Bouyoucos (1951).

The pH was determined in water at 1.2.5 solution using a pH meter (Okalebo, 2002). Organic carbon determination followed the method of Heanes (1984), and total nitrogen was determined by Kjeldahl digestion and colorimetric analysis (Bremmer,1982). Exchangeable cations, available macronutrients, and the available phosphorus were extracted using Melich 3 method. All the analyses were performed by the Kenya Agricultural and Livestock Research Organisation (KALRO, NARL).

### 2.5 Parameters to be studied

The 23 descriptors presented below (Table 3) were used during the study to collect field data related to agro-morphological characterization.

**TABLE 3**  
**AGRO-MORPHOLOGICAL DESCRIPTORS**

<b>Three months descriptors:</b>		
<b>No.</b>	<b>Descriptors</b>	<b>Codes</b>
1	Fundraising rate	TL
2	Plant circumference	CP
3	Height of seedlings	HP
4	Number of leaves 10 cm from the apical part	NF
<b>Six months descriptors:</b>		
5	Leaf retention	RF
6	Length of lobes	LL
7	Width of the lobe	LI
8	Lobe margin	ML
9	Petiole length	LP
10	Flower	F
11	Pollen	P
<b>9-months descriptors:</b>		
12	Foliar Healing	CF
13	Length of internodes	LEN
14	Length of stipules	LS
15	Margin of Stipules	MS
<b>12 months descriptors:</b>		
16	Fruit	F
17	Seeds	S
18	Plant height	PH
19	Branching level	NR
20	Number of roots per seedling	NR/P
21	Number of marketable roots/seedlings	NRC/P
22	Average root weight	MR
23	Disease observation	OM

## 2.6 Statistical analysis:

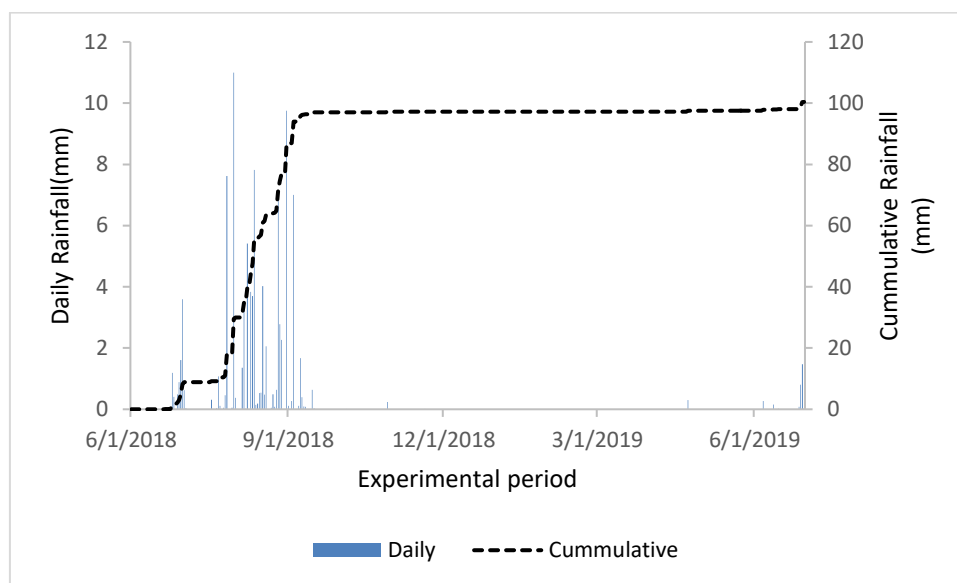
The statistical analyses were performed in the R software version 3.6.1 (Team, 2013). Data on cassava growth attributes were checked for normal distribution using the hist function. Principal Component Analysis (PCA) was performed on several agronomic parameters. Data were then subjected to analysis of variance using the generalized linear model to determine the effect of treatments and the means separated using Tukey-Kramer Honest Significant Difference Test at  $P \leq 0.05$ .

## III. RESULTS

### 3.1 Rainfall distribution and soil physicochemical properties

During the experimental period, the cassava received different amount of rainfall distributed differently over the growing period (Figure 4). Cumulatively rainfall received during the experimental season was 100.4mm. The highest daily rainfall amount was recorded in July 2018 (11mm). The site experienced a meteorological drought (defined as the absence of rainfall for a period of more than 28 days during the growing period) and dry spells (absence of rainfall in periods between 10-28 days

during the experimental period) (Okeyo et al., 2014; Kiboi et al., 2017). During the growing season, the site experienced dry spells of 18, 20, 21, and 23 days with meteorological droughts of 30 and 90 days.



**FIGURE 4: Daily and cumulative rainfall during the experimental period (June 2018-June 2019)**

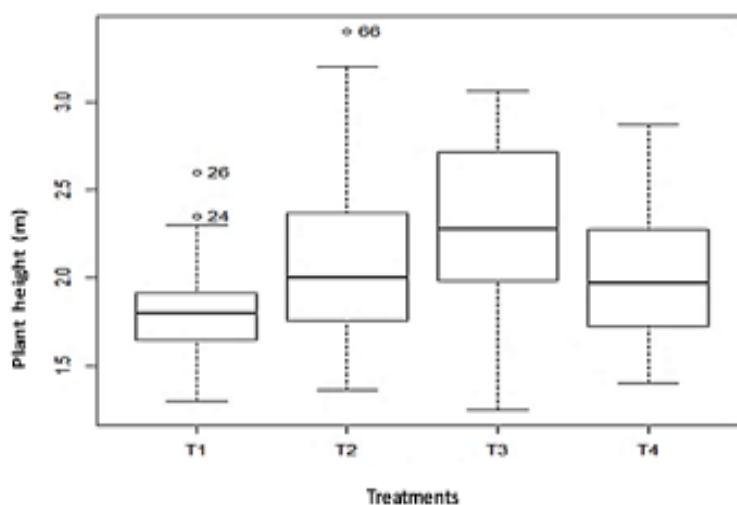
Table 4 shows the results of the soil physicochemical analysis of the experimental site before the establishment of the trial. In terms of the soil's physical properties, sandy texture dominated the soil particle size distribution (76-78%) with low levels of silt (4-6%) and clay (16-20%). The soil reaction in the experimental site was 5.5, which can be rated as strongly acidic (Hazleton & Murphy, 2016). Based on the nutrient supply capacity, the soils are deficient in organic carbon (0.8%) and total nitrogen (0.06%) with very low CEC (3.37 cmol (+) /kg) and low in basic cations ( $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{K}^+$ ,  $\text{N}^{\text{a}+}$ ).

**TABLE 4**  
**SELECTED PHYSIOCHEMICAL SOI PROPERTIES OF TOPSOIL (0-20) BEFORE PLANTING**

Parameter	Soil analysis
pH (Water)	5.5
Organic carbon (%)	0.8
Total nitrogen (%)	0.06
C/N	13
Available P(mg/Kg)	1.54
CEC (cmol(+)/Kg)	3.27
<b>Exchangeable bases (Cmol(+)/Kg)</b>	
Ca	1.64
Mg	0.56
K	0.15
Na	0.05
<b>Micronutrients (mg/Kg)</b>	
Zn	0.5
Cu	1.45
Fe	34
<b>Particle Size (%)</b>	
Sand	76
Silt	4
Clay	20
Texture Class	Sandy Loam

### 3.2 Plant height

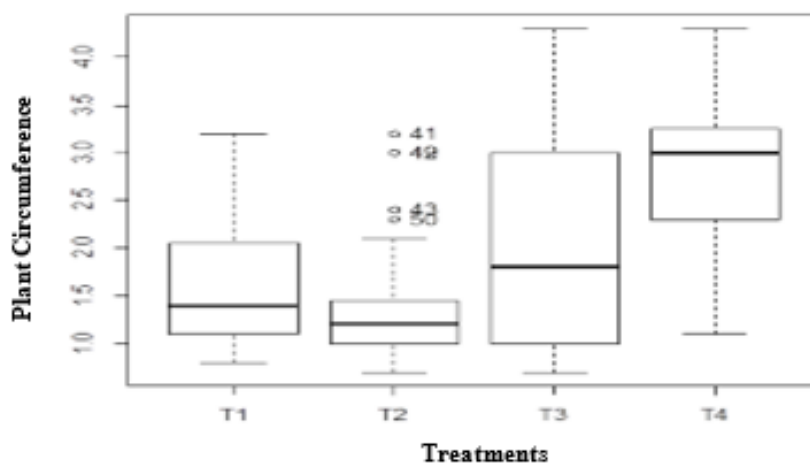
The animal manure and mineral fertilizer significantly ( $P = 0.001$ ) influenced plant height at 12 months. Plant height significantly increased under T4 (7.32m) and T3 (2.13m) compared with T1 (1.82m), T2 (1.13m) (Figure 5).



**FIGURE 5: Plant height at 12 months**

### 3.3 Plant circumference

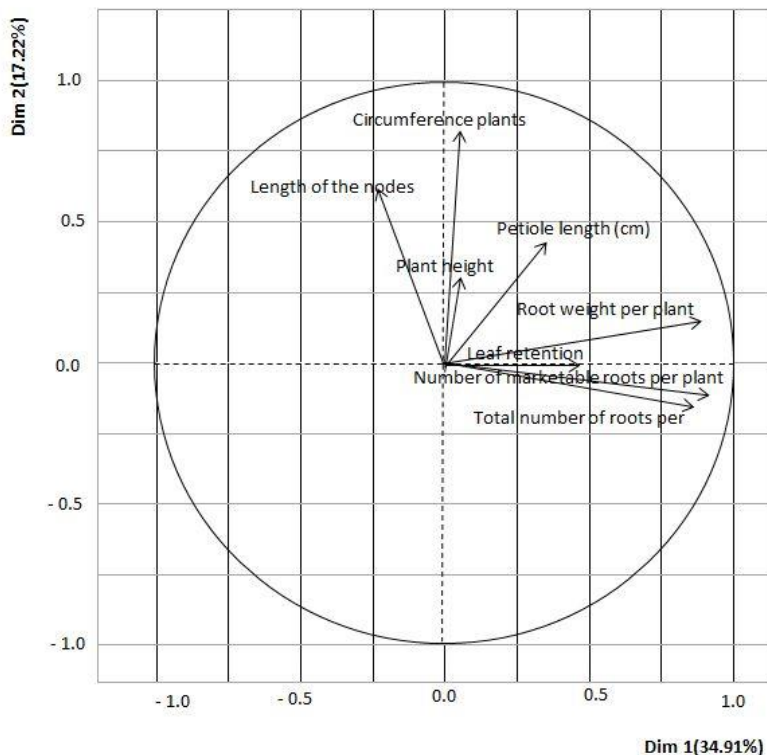
There was a significant ( $P = 13e-12$ ) treatment effect on cassava plant circumference. The plant circumference was in the descending order of T4, T3, T1, and T2 (Figure 6).



**FIGURE 6: plant circumference based on different treatments**

### 3.4 Agro-morphological characterization

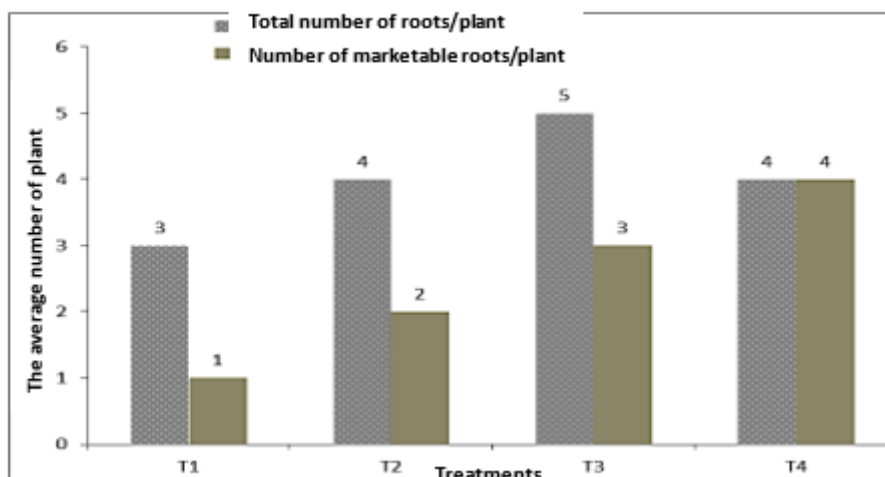
The nature and degree of divergence of descriptors were assessed using the Principal Component Analysis (PCA) with quantitative and qualitative variables (Figure 7). The two axes revealed 52.13% of the total variability—Axis 1 with 34.91% variability and 17.22% for axis 2. Based on axis 1, petiole length, root weight per plant, leaf retention, marketable roots per plant, and the total number of roots per plant were highly correlated. However, on axis 2, the strongly correlated parameters were the plant's height, the length of the nodes, and the plant circumference. On the other hand, there was no correlation between the parameters of axis one and those of axis 2. Based on these results, it is clear that the treatments did not impact the morphological characteristics of accessions but influenced growth and productivity, as shown by the strong correlation between these parameters.



**FIGURE 7: Agro morphological characterization**

**3.5 Evaluation of production and root yield**

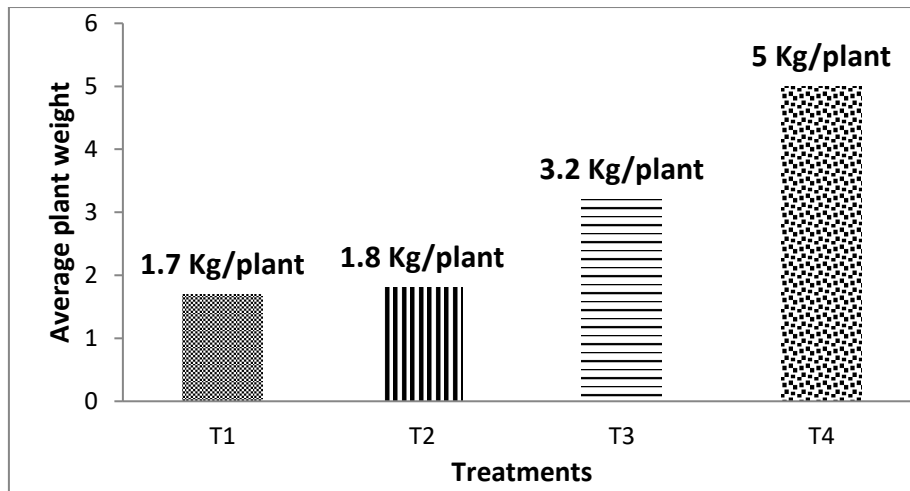
At 12 months, treatments significantly ( $P = 0.001$ ) influenced the number of tubers per plant (NT/P) and the number of marketable tubers (NTRC/P) (Fig. 8). The total number of roots per plant was in the descending order of T3, T4, T2, and T1. Manure and mineral fertilizer use significantly influenced ( $p= 0.004$ ) the number of marketable roots per plant. The highest number of marketable roots was obtained with T4, which was not statistically different from T3. The treatments under T2 and T1 gave the lowest marketable roots per plant.



**FIGURE 8: Evaluation of production and root yield**

**3.6 Average root weights**

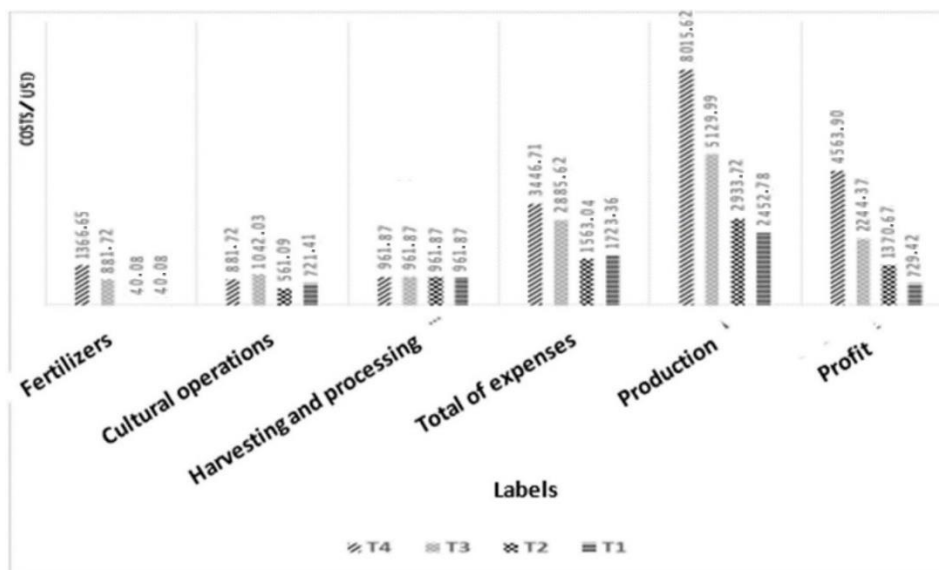
The use of animal manure and mineral fertilizer significantly ( $p = 4.01e - 16$ ) influenced the mean root weight. The higher mean weight was obtained with T4 (5kg/plant) followed by T3 (3.2kg/plant). There was no statistical significance between T1(1.7kg/plant) and T2(1.8kg/plant) (Figure 9).



**FIGURE 9: Average root weight under different treatments**

**3.7 Economic evaluation**

The results relating to income and profits generated following different treatments are in figure. (10). The T4 treatment was the best in terms of yield, with a total production cost is (7870,22 USD/ha) and a total profit of (4486,03 USD/ ha), followed by T3 treatment with a total production cost of (5036,94 USD/ha) but with a profit of 2203,66 USD/ha. Farmers can successfully adopt T4 and T3 treatments. On the other hand, given the yield obtained by T4 and T3 from the growth parameters to the harvest, production can be doubled or tripled with mineral and organic fertilizers (cow manure). Economically, these treatments are more cost-effective with higher and more incomes than T1 and T2 treatments at the end of the cycle. Provided there is access to the necessary inputs at the proper doses; this increases the yield of cassava tubers while considering the benefit at the end of production.



**FIGURE 10: Economic valuation**

**IV. DISCUSSION**

Using animal manure and mineral fertilizer significantly ( $P = 0.001$ ) enhanced the cassava growth attributes: plant height, plant circumference, root yield, and the average weight of tubers. The plant height was highest in the T4 and T3 treatments. Increased plant height could be attributed to the readily available nutrient in the mineral fertilizer and the many secondary micro-nutrients in animal manure that enhanced plant growth (Biratu et al. 2022). These findings agree with Uwah et al. (2013), whose findings relate to our present study outcome. Similarly, a study carried out in the savannah zone in CAR by Ballot (2016) found that the use of organo-mineral fertilizers contributed to the enhanced growth of cassava. However, they conducted the study in an agro-climatic zone different from ours. The nature of organic manure, mineral fertilizers, and the study environment

characterized by environmental factors (pedo-climatic, soil, temperature, wind, rainfall, and vegetation) specific to each environment inevitably influences cassava's growth. In the Niari Valley in the Democratic Republic of Congo, Mombo-Tsimba (2008) and Nyombo et al. (2014), in a maize study, reported that the combination of chicken manure and mineral fertilizer had better performance compared to other treatments. Hence, it reinforces the importance of organic fertilizers for crop growth.

There was a significant ( $P = 13e-12$ ) treatment effect on the cassava plant diameter. Plots with treatment T4 (9.7 cm) had the largest diameter, followed by T3 (4.8 cm), T2 (3.6 cm), and T1 (3.04 cm). Munyahali et al. (2017) reported similar observations in their study conducted in the Democratic Republic of Congo. In their study, they observed upsurges in both height and cassava stem diameter with the use of NPK fertilizer. The rates of the organo-mineral fertilizer of T4 further impacted the growth of cassava in diameter compared to T3, where only mineral fertilizer was used at lower doses. Berger's (1996a) work on the impact of fertilization on crop production reported that the associated use of organic and mineral manure could give a satisfactory agronomic response to crop production. Similar results were also observed by Gnahoua et al. (2017), who reported a significant positive effect on stem diameter using mineral fertilizer.

The Principal Component Analysis (PCA) carried out using quantitative and qualitative variables made it possible to assess the variability between agro-morphological parameters and fertilization regimes. The analysis revealed that the two axes have values greater than one and express 52.13% of the total variability. Parameters such as leaf retention, marketable roots per plant, and the total number of roots per plant are highly correlated. However, plant height, length of the nodes, and plant circumference are the parameters strongly correlated on axis two. Kosh-Komba et al. (2014) in the Central African Republic and Djaha et al. (2017) in Côte d'Ivoire, in their study carried out on the agro-morphological characterization of different cassava accessions, obtained respectively an overall variability of 55% and 63.84% higher than within accessions for the first six axes cumulated with a partial contribution of 15 descriptors out of 27 in CAR against 08 out of 24 in Côte d'Ivoire. These authors pointed out that there is significant variability between accessions. Although the previous studies on different scales have similarities, like the descriptors, the results obtained differ under the variability within the parameters subjected to the analyses.

The overall response of cassava to mineral fertilizer and animal manure resulted in significant upsurges in the average weight of tubers and root yield. Treatments with mineral fertilizer and cow manure (T4) performed significantly higher than treatments with sole manure application (T3). The unfertilized treatment provided a baseline to which responses of all treatments were compared. The findings of this study parallel the observations from previous work (e.g., Molina & El-Sharkawy (1995); Fermont, 2009; Uwah et al., 2013; Biratu et al., 2018; Biratu et al., 2022) reported rises in cassava tuber weights with the usage of different fertilization regimes. The response shown by yield parameters to N and K could be associated with; acute photosynthesis surface and improved physiological activities leading to the creation of more assimilates that are moved and used in rapid tuber growth. N and K are essential for cassava root initiation and increase in tuber size and numbers (Uwah et al., 2013). Similar observations were made by Uwah et al., 2013 who reported that nitrogen surges the leaf chlorophyll content, thus promoting the photosynthesis capacity of plants and is responsible for plants' high yield. However, the observations in the present study are opposite to the reports of Lema et al., 2004 who observed no significant effect of mineral fertilizer on tuber yield with the use of both an improved and local cassava variety. Reports by Berger (1996) and Clermont (1998) pointed out that the nutrients provided have only a short-term effect on mainly sandy ferritic soils. Thus, these nutrients are quickly leached without organic matter, and the plants benefit only partially.

These results confirm the interest in the organic fertilizer used in T4, which has a good performance on the yield of cassava tubers. The contribution of manure enriches the soil with primary nutrients (NPK) and secondary trace elements that play an essential role in the physiology and metabolism of the plant, allowing for good growth and better returns. In addition, Dupriez et al. (1983), Feller (1995), and Nyembo et al. (2014) claimed that organic manure provides nutrients to the soil and improves its structure. These results are consistent with those of Anderson and Wood (1983), Akanza et al. (2002), and Compère et al. (1991). Who reported that a contribution of 20 t ha<sup>-1</sup> of manure is advisable to establish a viable and sustainable production system. Therefore, organic manure is an essential component of T4 treatment.

Based on the economic analyses, the T4 (cassava + N P K + cow manure) gave the best profit starting from the expenses made to the tune of 7870,22 US per hectare and generated a total profit of 4486,03 US/ha, followed respectively by T3 (2203,66 USD/ha); T2 (1345,81 USD/ha) and T1 (716,19 USD/ha). These findings agree with another study conducted in Western Kenya and Uganda (Fermont, 2009) that reported returns to investments using different fertilization regimes. Similarly, Ballot et al. (2016), in their work on cassava in the savannah area of CAR, confirm the economic gain generated by using different fertilization regimes. Even if the cost of fertilizers remains a significant challenge for producers compared to the country's

isolation, the results show there is always a benefit if adequately used. Using fertilizer increases producers' incomes and contributes to food security, as confirmed by James et al. (2000) and Oti et al. (2010) in their studies. The cassava sector is a necessary means to improve incomes if the actors consider the appropriate technical routes to add the efficient use of organo-mineral fertilizers per the results obtained.

## V. CONCLUSION

The study evaluated the effect of the combined application of cow manure and mineral fertilizer on cassava growth, root biomass yield, and profitability. We concluded that cassava responds more to the combined use of organic and inorganic fertilizers than the sole use of inorganic fertilizers. The combined use of fertilizer also resulted in higher profitability than other treatments. Thus we recommend using 3000Kg/ha manure in combination with 90N-30P-180K Kg/ha in regions similar to forest areas (municipality of Pissa) in the Central African Republic.

## CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

**Kosh-Komba:** Investigation, data collection, writing- original draft, supervision, and methodology, **Gougodo De Mon-Zoni:** Conceptualization, methodology, data collection, writing-review and editing, **Omenda J.A:** Writing- review and editing, **Zaman M.:** Proposal of treatments for trials and protocol for data collections and the protocol for data collection, **Mingabaye-Bendima:** Data collection, **Batawila K:** data analysis and validation of results, **Akpagana K:** Comceptualizationn

## DECLARATION OF COMPETING INTEREST

The authors declare no conflict of interest.

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