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RESEARCH PAPER

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Influence of mineral and organic fertilization on some agronomic parameters of Cassava (*Manihot esculenta* Crantz) seedlings in Daloa (Centre-West, Côte d'Ivoire)

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Abstract

This study evaluated the effect of mineral and organic fertilization on some agronomic parameters of cassava nursery plants Bocou 1 and Yavo (*Manihot esculenta* Crantz). For this purpose, 1200 cassava plants were produced on 10 substrates based on soil supplemented with chicken droppings, sawdust, carbonized rice husks and NPK 10 18 18. The trial was conducted in a completely randomized Fisher block design on two 880 m2 subplots 6 m apart. The planting density was 1 m x 1 m with three replications per treatment, i.e. 600 plants per cassava variety. The manures used were chicken manure, charred rice husks and NPK 10-18. Results showed that treatments T2S6 (T2: Carbonized rice husks; S6: Substrate 6) and T2S3 (T2: Carbonized rice husks; S3: Substrate 3) induced better plant growth than the other treatments for the two cassava varieties studied. The highest yields were obtained with treatments T3S2 (T3: NPK 10 18 18; S2: Substrate 2) (456.83 t/ha) and T2S8 (T2: Carbonized rice husks; S8: Substrate 8) (423.25 t/ha) at Bocou 1 and Yavo, respectively. The results of this study will help optimize cassava production in Côte d'Ivoire and improve the purchasing power and livings standard of producers.

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Introduction

Cassava (*Manihot esculenta* Crantz) is a tropical plant cultivated mainly for its starch-rich tuberized roots (IITA, 1990). Cassava is a recognized abundant and inexpensive source of food energy (Bruijn and Fresco, 1989). With the strong demographic growth and the rapid expansion of cassava cultivation, there has been a sharp increase in the area cultivated and a continuous exploitation of the soil.

The continuous cultivation of soils causes a rapid degradation of their fertility, which translates into a decrease in agricultural yields (Feller & Milleville, 1997; Traoré *et al.*, 2007). One promising approach is to provide soils with different types of organic matter and mineral fertilizers in order to increase the availability of soil nutrients (Palm *et al.*, 1997).

In general, the use of mineral and organic fertilizers on food crops in rural areas remains insignificant given the low purchasing power of the farmer. Mineral fertilizer is used on only 5.17 percent of the land on small family farms, compared to 5.21 percent on large farms (Troupa and Koné, 2003). In addition, organic fertilizer in the form of manure is only used in a tiny proportion of less than 2%, regardless of the type of farm (Troupa and Koné, 2003).

However, cassava is known to be a soil-depleting plant in terms of the mineral mobilization required for its cultivation. Moreover, at the end of the cycle, the fixed assets of a production of 25t.ha-1 of tuberous cassava roots are high and correspond on average to 151 units of N, 52 units of P2O5, 245 units of K2O, 120 units of CaO and 48 units ofmgO (Pouzet, 1988; Raffaillac and Nedelec, 1984). Thus, it seems appropriate to optimize the production of speculative surplus value through mineral and organic fertilization. Hence the objective of this study, which is to evaluate the impact of mineral and organic fertilization on certain agronomic descriptors of cassava nursery plants.

More specifically, it is to evaluate the effect of mineral and organic fertilization on the cover rate and vigor of cassava plants and to determine the effect of mineral and organic fertilization on the production parameters of cassava nursery plants.

Materials and methods

Site of the study

This study was carried out at the University Jean Lorougnon Guédé (UJLoG) of Daloa (between 6°53 North latitude and 6°27 West longitude) in Côte d'Ivoire.

Plant material

The plant material used in this study consisted of 45-day-old cassava nursery plants Bocou 1 and Yavo. These plants were produced on 10 substrates based on soil supplemented with chicken droppings, sawdust, carbonized rice husks and NPK that are:

- S0 (control): 100% soil substrate;
- S1: 50% soil + 50% sawdust;
- S2: 50% soil + 50% chicken droppings;
- S3: 50% soil + 50% charred rice husks;
- S4: 50% soil + 25% sawdust + 25% chicken droppings;
- S5: 50% soil + 25% sawdust + 25% charred rice husks;
- S6: 50% soil + 25% chicken dung + 25% charred rice husks;
- S7: 25% soil + 25% sawdust + 25% chicken dung + 25% charred rice husks;
- S8: 50% soil + 50% NPK (10 18 18);
- S9: 50% soil + 25% NPK (10 18 18).

Fertilizers and treatments

During the study three types of fertilizer were used, namely chicken droppings (T1), carbonized rice husks (T2) and N P K 10 18 18 (T3).

In fact, the combination of substrates with different fertilizers made it possible to obtain a total of 40 treatments, 30 of which were formulated with fertilizers and 10 with the control (T0: without fertilizer). The different treatments obtained are recorded in Table 1.

Table 1. Different treatments formulated.

Fertilizers/ controls	Substrates	Treatments
To	So	ToSo
To	S1	ToS1
To	S2	ToS2
To	S3	ToS3
To	S4	ToS4
To	S5	ToS5
To	S6	ToS6
To	S7	ToS7
To	S8	ToS8
To	S9	ToS9
T1	So	T1So
T1	S1	T1S1
T1	S2	T1S2
T1	S3	T1S3
T1	S4	T1S4
T1	S5	T1S5
T1	S6	T1S6
T1	S7	T1S7
T1	S8	T1S8
T1	S9	T1S9
T2	So	T2So
T2	S1	T2S1
T2	S2	T2S2
T2	S3	T2S3
T2	S4	T2S4
T2	S5	T2S5
T2	S6	T2S6
T2	S7	T2S7
T2	S8	T2S8
T2	S9	T2S9
T3	So	T3So
T3	S1	T3S1
T3	S2	T3S2
T3	S3	T3S3
T3	S4	T3S4
T3	S5	T3S5
T3	S6	T3S6
T3	S7	T3S7
T3	S8	T3S8
T3	S9	T3S9

Methods

Experimental design

The trial was conducted in a completely randomized Fisher block design. The plot was subdivided into two subplots (22m wide and 40m long) 6 m apart, taking into account the two cassava varieties. Each subplot was subdivided into a 5m x 40m block with 3 replicates (blocks) each. These plots each had 40 subplots consisting of 10 control plots (no fertilizer), 10 plots with chicken manure, 10 plots with charred rice husks and 10 plots with NPK 10-18-18. The surface area of an elementary plot is 5m2, i.e. 5m long and 1 m wide, i.e. one line of 05 cassava plants per elementary plot. The blocks are spaced 3.5 m apart.

Setting up the plot

The preparation of the land consisted, among other things, of clearing the land with machetes followed by ploughing with a daba. Then, the plot was staked with pieces of wood following the experimental device to mark the planting points. Finally, openings (holes) were made at the level of these marks using a pickaxe.

Transplanting

For this experiment, the planting took place in the morning, that is to say, from 6 a.m. to 8 a.m., then in the afternoon from 4:30 p.m. to 7 p.m. During the transplanting, the vigorous plants free of diseases were selected while reserving the weak ones for the future replacements. The following operations were carried out in order to ensure the good recovery of the plants: (i) the respect of the planting hours, i.e. the cool hours of the day (before 10 a.m. and after 4 p.m.) were chosen; (ii) the bag, well held in the hand, was then split with a pair of scissors or with a machete and delicately removed to avoid injuring or damaging the plants without destroying the substrate; (iii) the root ball (substrate) containing the seedlings was placed vertically in the planting holes corresponding to the different treatments and varieties of cassava up to the level of the plant collar at the rate of one plant per hole; (iv) the root ball was brought back around the foot, tamping it down progressively until the hole was completely plugged; (v) the seedlings were immediately watered to prevent them from wilting (Fig. 1 .).

Fig. 1. Nursery of two cassava varieties (JPG file, 1920 x 2560 magnification).

Maintenance

It consisted of manual weeding with dabas on demand from the plot. For this study, four weedings were done in the first year and two more in the second year of cultivation to dominate the weeds and keep the plantation clean.

Fertilization

In the case of cassava, the long cycle of the cassava varieties studied imposed a fractioning of the total amount to be applied for efficient use. The application is carried out in crown, at approximately 20cm around the plants with watering taking into account the season.

The first application took place at 6 weeks, the second at 12 weeks after planting and the last application was made at 20 weeks after planting with the same quantity of fertilizer per plant and per variety. In addition, mineral fertilizer (NPK) (30 g/plant) and carbonized rice husks were applied in solid form at the same dose (1 kg/plant) and at the same time. Chicken droppings (1 kg / L / plant) were applied in the form of slurry.

Data collection

The observations were made on the one hand on the growth parameters such as height, diameter at the collar, number of branches and number of secondary stems of the plants and on the other hand on the production parameters such as diameter, length, number and fresh weight of tuberous roots and fresh yield.

Statistical analysis of the data

The collected data were subjected to statistical tests using XSL STAT 2019 software. An analysis of variance (ANOVA) was used to evaluate the effect of fertilizers on agro-morphological parameters of the plants and characteristics of the harvested tuberous roots. In case of significant difference between treatments, Fisher's LSD test at 5% threshold was used to classify them into homogeneous groups.

Results

Chemical characteristics of organic fertilizers

The chemical characterization analysis conducted shows variability in the chemical composition of the organic fertilizers used (Table 2). The analysis in Table 1 indicates that carbonized rice husks are rich in mineral elements, including carbon (27%), potassium (1.57%) and calcium (3.693%) with a weakly acidic pH (pH = 6.2). On the other hand, carbonized rice husks are low in nitrogen, phosphorus and magnesium with respective values of 0.42%, 0.34% and 0.314. Chicken droppings are rich in carbon (20.14%) and nitrogen (1.34%) and poor in phosphorus (0.45%), potassium (0.957%), calcium (0.851%) and magnesium (0.318%). In addition, it has a relatively neutral pH (pH = 6.9). As for sawdust, its chemical characterization revealed a high content of carbon (23.95%), potassium (1.098%) and calcium (1.027).

However, it is poor in nitrogen, phosphorus, magnesium respectively 0.56%; 0.25% and 0.328% with a slightly alkaline pH (pH = 7.4). However, analysis of variance of means revealed a highly significant difference between the mineral element contents of charred rice husks and chicken droppings. The same is true for sawdust and chicken droppings. However, this difference is not significant between charred rice husks and sawdust. From this analysis, it appears that sawdust and charred rice husks in particular are very rich in carbon, potassium and calcium.

Table 2. Chemical characteristics of organic fertilizers.

Samples	Water pH	Proportion of minerals (%)						
		C	N	C/N	P	K	Ca	Mg
BRC	6.2^{b}	27.96^{a}	0.42^{b}	66.57^{a}	0.34^{abc}	1.517^{a}	3.693^{a}	0.314^{a}
FP	6.9^{ab}	20.14^{c}	1.34^{a}	15.02^{c}	0.45^{a}	0.957^{b}	0.851^{c}	0.318^{a}
SB	7.4^{a}	23.95^{b}	0.56^{b}	42.71^{b}	0.25^{c}	1.098^{b}	1.027^{bc}	0.328^{a}

Within a column, means followed by different letters are statistically different ; those followed by the same letter are statistically the same. BRC : Carbonized rice husks ; C : Carbon ; C/N : Carbon-nitrogen ratio ; Ca : Calcium ; FP : Chicken droppings ; K : Potassium ;mg : Magnesium ; N : Nitrogen ; Na : Sodium ; P : Phosphorous ; SB : Sawdust.

Average plant height

Analysis of the results shows that the averages obtained are statistically different according to the treatments with a probability of $P < 0.05$. For the variety Yavo, the highest average height was recorded with treatment T2S6 (110cm) and the lowest was obtained with treatment T2S5 (70.1cm) (Fig. 2.). Concerning the variety Bocou 1, the treatment T2S3 recorded the highest height (130cm). On the other hand, the lowest height is observed in treatment T2S5 about 69cm (Fig. 3.)

Fig. 2. Planting process of cassava seedlings in the field (JPG file, 1920 x 2560 magnification).

A: Slit of the nursery bag; B: Partially removed nursery bag; C: Completely removed nursery bag; D: Putting the cassava plant in the hole; E: Closing the hole; F: Watering the cassava plant

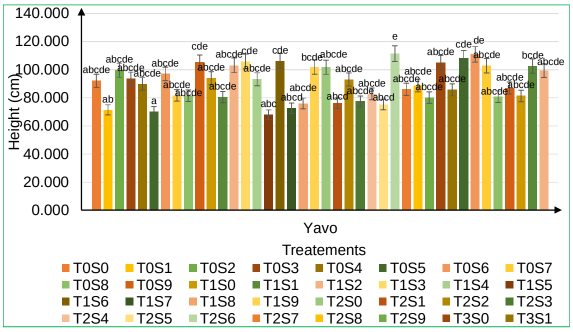

Fig. 3. Plant height of the Yavo variety as a function of treatments. Means for each treatment (same colored vertical bars) followed by different letters indicate the presence of significant differences between substrates at the 5% threshold according to Tukey's HSD test.

Average number of branches

The results of the effect of treatments on the number of branches produced by Bocou 1 and Yavo 8 plants after transplanting are recorded in Table 2. For this parameter, the values of the means are statistically significant from one treatment to another at the level of the varieties studied ($p = 0.001$).

For the variety Yavo, the comparison test shows that the highest number of branches is observed with the T3S8 treatment (4 branches on average per plant). On the other hand, the T0S1 treatment induced the lowest number of branching with an average of 0.40 branching/plant (Table 2).

For the Bocou 1 variety, the analysis of variance of the means indicates that the highest number of branchings is recorded with the T3S8 treatment (10 branchings per plant). This is in contrast to treatment T0S1 which had the lowest number of branches (2 branches per plant) (Table 2).

Diameter at the collar of the plants

For this parameter, the values of the averages obtained are significantly different from one treatment to another for the Yavo variety ($P < 0.05$). On the other hand, this difference is not significant for the variety Bocou 1 ($P > 0.05$). With respect to the Yavo variety, treatments T0S4 and T2S6 induced the largest diameters of 45 mm and 48 mm respectively, while the smallest diameters were obtained with treatments T0S0, T0S1, T0S6 and T1S5, whose values ranged from 24 mm to 25 mm (Fig. 4.). For the variety Bocou 1, the values of the averages obtained are statistically identical at the level of the treatments and then vary from 23 mm to 31 mm in diameter (Fig. 5.).

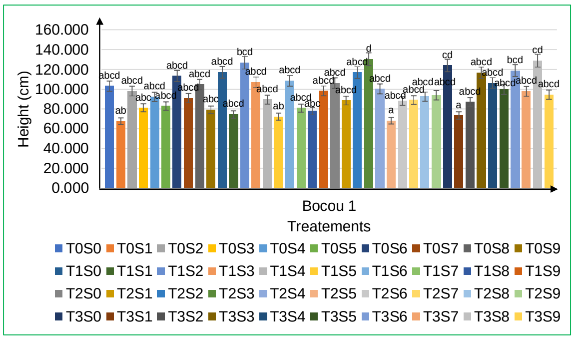

Fig. 4. Plant height of the Bocou 1 variety according to treatments. Means for each treatment (same colored vertical bars) followed by different letters indicate the presence of significant differences between substrates at the 5% threshold according to Tukey's HSD test.

Effect of fertilizers on plant production parameters

Diameter and length of tuberous roots

Table 3 shows the results of the effect of fertilizers on the diameter and length of tuberized roots of Bocou 1 and Yavo. Indeed, the values of the recorded averages are statistically identical for these two parameters at the level of the treatments and for each cassava variety studied ($P > 0.05$).

For the Bocou 1 variety, the diameter of tuberized roots ranged from 7.23 ± 29.83cm (T0S2) to 8.77 ± 87.72cm (T2S6). As for the length of these roots, it varies from 34.7± 15.09 (T0S2) to 52.49± 16.81cm (T3S8) (Table 3). For the Yavo variety, the average diameter of tuberized roots per cassava plant ranged from 7.394 ± 16.20cm (T0S1) to 10.11 ± 12.34cm (T2S6) and the average length ranged from 36.06 ± 8.70cm (T0S1) to 55.37± 13.85cm (T3S8) (Table 3). However, the highest averages were observed with treatments T3S8 and T2S6.

Table 3. Average number of branches of Bocou 1 and Yavo cassava plants at 08 months.

	Number of branches of the plants	
Treatements	*Yavo*	*Bocou 1*
T0S0	0.80 ± 1.01 abc	6.60 ± 6.58 abcd
T0S1	0.40 ± 0.63 a	2.43 ± 3.31 a
T0S2	3.00 ± 2.10 abcde	8.40 ± 7.97 abcd
T0S3	2.26 ± 2.89 abcde	5.10 ± 6.26 abcd
T0S4	2.00 ± 2.29 abcde	7.23 ± 11.05 abcd
T0S5	0.66 ± 0.97 ab	3.06 ± 4.37 ab
T0S6	10.86 ± 1.68 abcde	9.667 ± 11.22 abcd
T0S7	2.00 ± 1.41 abcde	5.53 ± 6.40 abcd
T0S8	2.60 ± 2.55 abcde	8.93 ± 13.82 abcd
T0S9	4.06 ± 2.71 cde	5.10 ± 4.08 abcd
T1S0	1.13 ± 1.68 abcd	7.06 ± 5.98 abcd
T1S1	0.93 ± 1.03 abcd	3.93 ± 6.08 abc
T1S2	3.13 ± 2.38 abcde	13.36 ± 9.80 cd
T1S3	1.13 ± 1.12 abcde	8.10 ± 10.87 abcd
T1S4	2.78 ± 2.66 abcde	5.96 ± 6.66 abcd
T1S5	1.06 ± 1.53 abcd	3.83 ± 5.88 abc
T1S6	2.20 ± 1.65 abcde	8.46 ± 9.72 abcd
T1S7	1.60 ± 1.76 abcde	5.53 ± 7.63 abcd
T1S8	2.86 ± 3.06 abcde	5.60 ± 3.73 abcd
T1S9	2.73 ± 2.34 abcde	5.63 ± 5.02 abcd
T2S0	1.26 ± 0.70 abcde	4.70 ± 5.48 abcd
T2S1	0.93 ± 1.22 abcd	4.54 ± 6.71 abc
T2S2	2.73 ± 2.28 abcde	9.10 ± 2.11 abcd
T2S3	1.46 ± 1.40 abcde	9.53 ± 7.66 abcd
T2S4	2.01 ± 2.04 abcde	5.27 ± 5.85 abcd
T2S5	1.20 ± 1.14 abcde	3.60 ± 4.59 abc
T2S6	2.26 ± 1.98 abcde	6.70 ± 9.56 abcd
T2S7	2.26 ± 1.87 abcde	6.00 ± 6.74 abcd
T2S8	3.06 ± 1.79 bcde	7.73 11.66 abcd
T2S9	2.66 ± 2.84 abcde	5.46 ± 8.44 abcd
T3S0	3.60 ± 2.41 bcde	10.76 ± 10.25 cd
T3S1	2.80 ± 2.27 abcde	4.56 ± 5.51 abcd
T3S2	3.60 ± 2.13 bcde	6.70 ± 14.77 abcd
T3S3	3.46 ± 1.99 bcde	11.63 ± 12.73 cd
T3S4	4.06 ± 3.01 bcde	8.40 ± 13.65 abcd
T3S5	3.73 ± 3.17 bcde	9.03 ± 8.87 bcd
T3S6	3.46 ± 2.03 bcde	9.26 ± 10.20 bcd
T3S7	3.13 ± 1.95 bcde	10.10 ± 14.50 abcd
T3S8	4.93 ± 2.78 e	13.33 ± 10.60 d
T3S9	4.60 ± 3.15 de	10.13 ± 10.41 bcd
P-value	0.0001	0.0001

Within a column, means followed by different letters are significantly different. P: Probability; S0: 100% soil substrate; S1: 50% soil + 50% sawdust; S2: 50% soil + 50% chicken dung; S3: 50% soil + 50% charred rice husks; S4: 50% soil + 25% sawdust + 25% chicken dung; S5: 50% soil + 25% sawdust + 25% carbonized rice husks; S6: 50% soil + 25% chicken dung +% carbonized rice husks; S7: 25% soil + 25% sawdust + 25% chicken dung + 25% carbonized rice husks; S8: 50% soil + 50% NPK (10 18 18); S9: 50% soil + 25% NPK (10 18 18). T0: No fertilizer; T1: Chicken manure; T2: Charred rice husks; T3: N P K 10 18 18.

Fresh weight of tuberized roots

For the fresh weight of tuberized roots, a significant difference (P= 0.000) is observed between treatments according to the cassava varieties tested. In the Yavo variety (Fig. 6.), the highest fresh weight was recorded with the T3S2 treatment (10 kg) while the lowest weight was obtained with the T0S5 treatment (4 kg). For the variety Bocou 1, the T3S2 treatment induced the highest fresh weight (10 kg). On the other hand, the lowest weight was given by the T1S0 treatment (2 kg) compared to the other treatments (Fig. 7).

From this analysis, it appears that treatment T3S2 significantly impacted the fresh weight of tuberized roots of the cassava varieties studied.

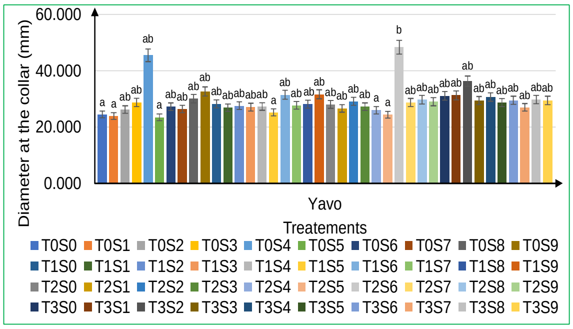

Fig. 5. Diameter at the collar of Yavo plants according to treatments. Means for each treatment (same colored vertical bars) followed by different letters indicate the presence of significant differences between substrates at the 5% threshold according to Tukey's HSD test.

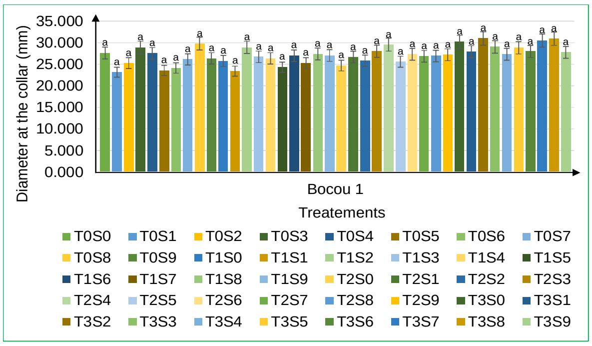

Fig. 6. Diameter at the crown of Yavo plants according to treatments. Means for each treatment (same colored vertical bars) followed by different letters indicate the presence of significant differences between substrates at the 5% threshold according to Tukey's HSD test.

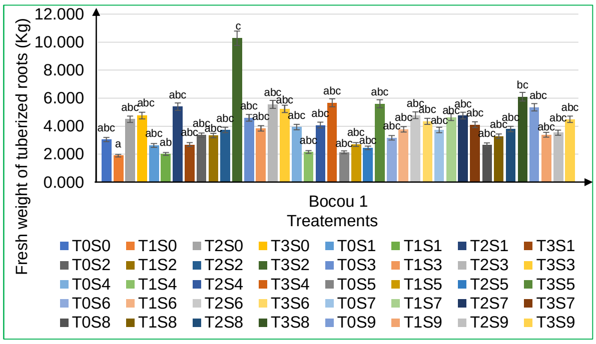

Fig. 7. Fresh weight of tuberous roots of the cassava variety Bocou 1 according to treatments. Means for each treatment (same colored vertical bars) followed by different letters indicate the presence of significant differences between substrates at the 5% threshold according to Tukey's HSD test.

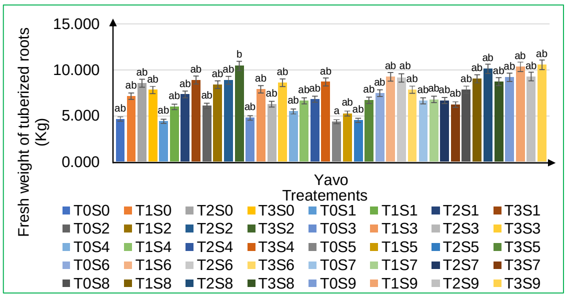

Fig. 8. Fresh weight of tuberous roots of the cassava variety Yavo as a function of treatments. Means for each treatment (same colored vertical bars) followed by different letters indicate the presence of significant differences between substrates at the 5% threshold according to Tukey's HSD test.

Table 4. Effect of treatments on tubers of Bocou 1 and Yavo cassava plants.

Treate-ments	Tuber diameter at 18 months		Tuber length at 18 months	
	Bocou 1	*Yavo*	*Bocou 1*	*Yavo*
T0S0	78.23 ± 42.78 [a]	86.27± 15.76 [a]	37.50 ± 20.26 [a]	45.00 ± 22.47 [a]
T0S1	75.72 ± 15.52 [a]	86.61 ± 12.23 [a]	38.18 ± 13.89 [a]	45.80 ± 13.62 [a]
T0S2	85.42 ± 21.26 [a]	100.61 ± 14.57 [a]	44.03 ± 21.84 [a]	52.48 ± 22.67 [a]
T0S3	80.66 ± 17.79 [a]	87.67 ± 20.14 [a]	45.70 ± 11.13 [a]	47.84 ± 10.66 [a]
T0S4	69.86 ± 15.87 [a]	73.94 ± 16.20 [a]	35.03 ± 13.07 [a]	36.06 ± 8.70 [a]
T0S5	78.26 ± 18.84 [a]	86.85 ± 10.32 [a]	35.16 ± 14.86 [a]	38.03 ± 12.27 [a]
T0S6	83.71 ± 20.63 [a]	94.62 ± 16.91 [a]	42.37 ± 15.43 [a]	45.88 ± 13.75 [a]
T0S7	78.13 ± 20.45 [a]	89.75 ± 21.16 [a]	40.10 ± 14.10 [a]	49.11 ± 8.36 [a]
T0S8	72.38 ± 29.83 [a]	76.63 ± 27.51 [a]	34.70 ± 15.09 [a]	43.06 ± 14.32 [a]
T0S9	79.01 ± 30.86 [a]	99.50 ± 20.83 [a]	36.68 ± 12.82 [a]	42.96 ± 6.25 [a]
T1S0	79.28 ± 20.71 [a]	96.50 ± 10.97 [a]	41.20 ± 12.39 [a]	47.52 ± 11.94 [a]
T1S1	87.48 ± 15.14 [a]	92.76 ± 13.40 [a]	51.44 ± 15.91 [a]	40.87 ± 6.59 [a]
T1S2	75.12 ± 22.70 [a]	84.56 ± 20.31 [a]	37.02 ± 15.44 [a]	37.68 ± 16.97 [a]
T1S3	81.87 ± 18.36 [a]	95.12 ± 9.53 [a]	42.53 ± 18.04 [a]	42.98 ± 18.45 [a]
T1S4	80.63 ± 14.77 [a]	92.08 ± 9.26 [a]	38.79 ± 14.21 [a]	36.58 ± 8.28 [a]

Treate-ments	Tuber diameter at 18 months		Tuber length at 18 months	
	Bocou 1	*Yavo*	*Bocou 1*	*Yavo*
T1S5	87.63 ± 20.60 [a]	99.35 ± 14.77 [a]	39.98 ± 12.33 [a]	38.65 ± 7.57 [a]
T1S6	82.99 ± 15.08 [a]	90.72 ± 14.45 [a]	39.10 ± 13.85 [a]	38.81 ± 13.13 [a]
T1S7	80.53 ± 17.99 [a]	93.02 ± 15.62 [a]	39.92 ± 18.67 [a]	44.24 ± 20.63 [a]
T1S8	75.14 ± 13.54 [a]	81.10 ± 11.93 [a]	38.85 ± 11.15 [a]	39.24 ± 6.42 [a]
T1S9	82.01 ± 20.30 [a]	94.30 ± 16.89 [a]	46.59 ± 14.65 [a]	50.95 ± 14.51 [a]
T2S0	80.13 ± 18.76 [a]	93.73 ± 12.45 [a]	34.51 ± 12.13 [a]	38.86 ± 9.47 [a]
T2S1	76.88 ± 17.54 [a]	88.07 ± 10.67 [a]	41.25 ± 17.04 [a]	40.93 ± 15.72 [a]
T2S2	76.25 ± 18.76 [a]	91.27 ± 11.46 [a]	36.28 ± 10.56 [a]	38.12 ± 12.24 [a]
T2S3	86.71 ± 20.85 [a]	98.77 ± 14.47 [a]	40.59 ± 11.01 [a]	39.77 ± 6.41 [a]
T2S4	77.13 ± 21.31 [a]	91.26 ± 18.77 [a]	38.22 ± 9.34 [a]	40.67 ± 9.29 [a]
T2S5	81.74 ± 19.89 [a]	95.32 ± 12.02 [a]	46.74 ± 13.95 [a]	50.18 ± 17.28 [a]
T2S6	87.72 ± 18.42 [a]	101.01 ± 12.34 [a]	43.01 ± 22.53 [a]	41.38 ± 5.44 [a]
T2S7	84.37 ± 19.59 [a]	92.91 ± 21.24 [a]	42.12 ± 11.12 [a]	46.96 ± 12.33 [a]
T2S8	72.58 ± 16.65 [a]	75.73 ± 20.20 [a]	39.87 ± 17.18 [a]	46.45 ± 17.42 [a]
T2S9	80.81 ± 15.89 [a]	89.14 ± 12.18 [a]	38.57 ± 14.27 [a]	39.42 ± 15.14 [a]
T3S0	78.26 ± 19.45 [a]	93.27 ± 9.61 [a]	39.58 ± 11.83 [a]	42.08 ± 12.07 [a]
T3S1	78.65 ± 16.35 [a]	84.44 ± 18.16 [a]	37.36 ± 12.74 [a]	40.86 ± 15.15 [a]
T3S2	74.06 ± 16.62 [a]	86.14 ± 14.45 [a]	38.91 ± 16.23 [a]	46.94 ± 18.26 [a]
T3S3	81.03 ± 19.62 [a]	93.71 ± 13.66 [a]	40.47 ± 15.11 [a]	48.07 ± 15.80 [a]
T3S4	78.88 ± 21.60 [a]	91.77 ± 13.52 [a]	40.20 ± 14.41 [a]	46.10 ± 16.54 [a]
T3S5	76.06 ± 18.94 [a]	84.74 ± 9.93 [a]	52.49 ± 16.81 [a]	55.37 ± 13.85 [a]
T3S6	79.35 ± 15.75 [a]	85.43 ± 17.72 [a]	49.55 ± 23.09 [a]	51.85 ± 24.73 [a]
T3S7	76.12 ± 18.95 [a]	86.41 ± 19.23 [a]	45.64 ± 13.66a [a]	50.11 ± 11.80 [a]
T3S8	75.00 ± 20.66 [a]	91.22 ± 12.93 [a]	43.18 ± 11.50 [a]	46.32 ± 10.55 [a]
T3S9	78.65 ± 28.46 [a]	99.31 ± 10.55 [a]	42.94 ± 22.313 [a]	49.70 ± 22.96 [a]
P-value	0.692	0.083	0.112	0.092

Within a column, means followed by different letters are significantly different. P: Probability; S0: 100% soil substrate; S1: 50% soil + 50% sawdust; S2: 50% soil + 50% chicken dung; S3: 50% soil + 50% charred rice husks; S4: 50% soil + 25% sawdust + 25% chicken dung; S5: 50% soil + 25% sawdust + 25% carbonized rice husks; S6: 50% soil + 25% chicken dung +% carbonized rice husks; S7: 25% soil + 25% sawdust + 25% chicken dung + 25% carbonized rice husks; S8: 50% soil + 50% NPK (10 18 18); S9: 50% soil + 25% NPK (10 18 18). T0: No fertilizer; T1: Chicken manure; T2: Charred rice husks; T3: N P K 10 18 18.

Table 5. Yields in t/ha of Bocou 1 and Yavo according to the treatments applied.

Treatements	*Bocou 1* (t/ha)	*Yavo* (t/ha)
T0S0	77.25	105.95
T0S1	55.76	102.41
T0S2	81.62	179.02
T0S3	156.65	108.51
T0S4	128.32	141.67
T0S5	38.60	103.76
T0S6	81.95	254.79
T0S7	102.04	202.55
T0S8	83.95	247.39
T0S9	154.74	265.86
T1S0	35.25	184.13
T1S1	42.83	157.39
T1S2	21.24	256.18
T1S3	98.79	260.88
T1S4	46.65	223.16
T1S5	62.79	114.04
T1S6	136.37	315.25
T1S7	160.97	231.34
T1S8	91.62	284.55
T1S9	98.04	389.58
T2S0	148.83	247.44
T2S1	231.34	177.95
T2S2	113.62	265.39
T2S3	212.51	184.55
T2S4	130.79	210.43
T2S5	63.34	77.02

Treatements	*Bocou 1* (t/ha)	*Yavo* (t/ha)
T2S6	35.63	296.97
T2S7	165.72	182.41
T2S8	131.86	423.25
T2S9	113.48	340
T3S0	186.88	226.04
T3S1	83.44	280.37
T3S2	456.74	371.44
T3S3	184	266.65
T3S4	223.02	278.23
T3S5	202.37	224.65
T3S6	143.72	247.25
T3S7	135.72	199.53
T3S8	283.90	288.65
T3S9	153.44	408.65

S0: 100% soil substrate; S1: 50% soil + 50% sawdust; S2: 50% soil + 50% chicken dung; S3: 50% soil + 50% charred rice husks; S4: 50% soil + 25% sawdust + 25% chicken dung; S5: 50% soil + 25% sawdust + 25% charred rice husks; S6: 50% soil + 25% chicken dung + 25% carbonized rice husk; S7: 25% soil + 25% sawdust + 25% chicken dung + 25% carbonized rice husk; S8: 50% soil + 50% NPK (10 18 18); S9: 50% soil + 25% NPK (10 18 18). T0: No fertilizer; T1: Chicken manure; T2: Charred rice husks; T3: N P K 10 18 18.

Fresh yield of cassava tubers

The results relating to the fresh yield of tubers of the cassava varieties Bocou 1 and Yavo are recorded in Table 4. For the variety Bocou 1, the highest yield was observed in the T3S2 treatments, i.e. 456.83 t/ha. However, the lowest tuber yield was produced by treatment T1S0 about 35.25 t/ha. The other treatments produced average yields. For the Yavo variety, treatment T2S8 gave the highest yield (423.25 t/ha) followed by treatments T1S9 and T3S9 respectively 389.58 t/ha and 408.65 t/ha. On the other hand, treatment T0S1 recorded the lowest yield (102.41 t/ha). It appears from this analysis that the highest yields were obtained with treatments T3S2 with the variety Bocou 1 and T2S8 with the variety Yavo.

Discussion

Characterization of the different fertilizers in this study revealed that carbonized rice husks are rich in macroelements (N, P, K) and trace elements (Ca,mg). These results are in line with those of Alla (2018), obtained in his work on the effects of chicken droppings and banana peel fertilization on agromorphological and biochemical parameters of Kalenda and N'Drowa eggplant. He showed that plantain peel potash is rich in primary mineral elements such as potassium and phosphorus and secondary constituents such as calcium and magnesium. Similarly, these results are consistent with the work of Biego *et al.* (2010) who demonstrated that plantain by-product ash is an important source of mineral elements including potassium, phosphorus and calcium. These results also support the work of Niebi *et al.* (2016) on the extraction of potash from the stem of plantain. Furthermore, the study showed that nitrogen and phosphorus contents in chicken droppings are significantly higher than in sawdust rich in potassium and microelements (calcium and magnesium). In addition, the study also revealed that the pH of the organic fertilizers ranged from slightly acidic (charred rice husks and chicken droppings) to basic (sawdust). This could be explained by the chemical composition and C/N ratio of these fertilizers. The weakly acidic pH of chicken droppings and sawdust could be related to their relatively high ammonium and nitrate content. Indeed, ammonium (N-NH4), which dissociates during the nitrification process, releases H+ ions, thus causing the pH to drop. These same observations were made by Dommergues & Mangenot (1970), according to whom nitrification is a microbial process generating acidity. On the other hand, according to Maltas & Sinaj (2013) the slightly basic pH obtained in sawdust is due to its relatively high content of potassium, calcium and magnesium.

In this study the treatments applied had a relatively significant effect on the growth of both cassava varieties by using mineral T3 (NPK 10 18 18) and organic T1 (chicken droppings) and T2 (charred rice husks) fertilizers. These results could be due to the effect of nitrogen, phosphorus and potassium in chicken droppings, carbonized rice husks and mineral fertilizer. This is in agreement with the work of Eleiwa *et al.* (2012). These authors showed that vegetative growth of potato plants is strongly related to nutrient uptake, especially nitrogen as well as potassium and phosphorus which play a prominent role in the foliar development of photosynthetic activity. Indeed, these are major mineral elements in the plant, even essential to the growth and development of plants. Nitrogen is involved in plant growth by promoting the development of leaves and stems. Phosphorus plays a determining role in the transfer of energy by stimulating plant growth (roots, young plants, flowering, photosynthesis).

As for potassium, it is strongly fixed by the absorbing complex and is more difficult to release. It has a slow action on vegetative growth. Potassium is also used by plants to build up their carbohydrate reserves and to increase their vigor and resistance to drought.

The study also showed that T2S6 and T2S3 carbonized rice husk fertilizers significantly influenced plant height and crown diameter in cassava. This could be explained by the physicochemical characteristics of the carbonized rice husks. Indeed, the favorable effect of carbonized rice husks on cassava plant growth could be due to its ability to improve soil structure, water holding capacity and pH by promoting phosphorus assimilation. This view is shared by Alla (2020) in his work on the effects of chicken droppings and banana peel fertilization on agromorphological and biochemical parameters of eggplant Klenda (*Solanum melongen* L.) and N'drowa (*Solanum aethiopicum* L.). The latter showed that potash from plantain peel had an alkaline pH that could neutralize soil acidity, increase mineralization of the material and make mineral elements such as nitrogen and phosphorus available to the plant. In addition, the carbonized rice husks used in this study appear to contain mineral elements such as potassium, magnesium and calcium that contribute to the development of cassava plants. This confirms the work of Leikam *et al.* (1983).
They demonstrated that adequate phosphorus and potassium nutrition can increase the growth of the crop. The results also showed that the number of branches was strongly impacted by the mineral fertilizer treatments T3S6 (T3 : NPK 10 18 18; S6: substrate composed of 50% soil – 25% chicken droppings - 25% carbonized rice husks) and T3S8 (T3: NPK 10 18 18; S8: substrate composed of 75% soil-25% NPK 10 18 18) regardless of the cassava variety studied. Indeed, this impact would be due to the presence of nitrogen, phosphorus and potassium in the chemical fertilizer that induce better plant growth. In addition, the high number of branching and secondary stems is explained by the high photosynthetic activity of the leaves. This is in accordance with the experiments of Lahai *et al.* (2003). They also showed that the increase in foliage was explained by the increase in chlorophyll a and b concentrations in the leaves. Furthermore, according to Lamhamedi *et al.* (1997), height, number of leaves and stems are considered among the morphological factors that can best predict the performance of plants after planting.

Furthermore, treatments with chicken manure (T1) in the form of slurry had no significant impact on growth parameters in the cassava varieties studied. These results are in disagreement with those of Bakayoko *et al.* (2007) who in their work on organic manure and cassava (Manihot esculenta Crantz) productivity in Côte d'Ivoire showed that organic manure had no significant impact on the growth parameters of the cassava varieties. These authors showed that organic manure has a significant effect on the height of cassava plants. This difference could be explained by the fact that it is leached by runoff or infiltration water. Alla (2020) confirmed in his work that the rapid mineralization of banana peel compost could lead to the infiltration of minerals into the lower soil horizons, making them inaccessible to the roots; hence poor morphological growth of the plants.

In addition, there are significantly strong and positive correlations between plant growth parameters.

Height, diameter, number of branches and secondary stems are closely related and evolve in the same direction in the two cassava varieties tested. These observations are in agreement with those made by Touckia *et al.* (2015) who showed positive and high intensity correlations between the growth parameters of Jatropha curcas. In addition, height is a good indicator of photosynthetic capacity and transpiration area, which are closely correlated with leaf and stem number. However, it should be noted that height, diameter and stem number are closely related and move in the same direction.

The results related to the effect of fertilizers on production parameters show that the treatments compared had a strong influence on the number, fresh weight, diameter and length of tubers of both cassava varieties. In the Yavo variety, diameter was significantly influenced by the organic fertilizer treatments T2S6 and T2S8 (T2: carbonized rice husks), respectively, while the mineral fertilizers T3S8 and T3S2 (T3: NPK 10 18 18) caused strong growth and higher fresh weight of tubers compared to the control (T0: no fertilizer) and chicken manure (T1). However, for the Bocou 1 variety, the NPK fertilizer treatments (T3S8 and T3S2) had a strong impact on tuber length and fresh weight. The largest diameters were given by plants treated with charred rice husks (T2S6). These results confirm the work of Toukourou & Carsky (2001), who studied the response of cassava to nitrogen, phosphorus and potassium on Hayakpa bar land (Altantic Department). This could also be explained by the fact that the nutrients provided by the mineral (NPK 10 18 18) and organic (carbonized rice husks) fertilizers were well assimilated by the plants. In addition, growth parameters are indicators of crop prediction. This may be reflected in the strong positive correlations observed in the two cassava varieties. Thus, these relationships would reveal physiological regulations common to both cassava varieties. According to Hassan *et al.* (2005), nitrogen, phosphorus and potassium constitute 80% of many genetic and structural compounds in plants involved in the synthesis of phytohormones (auxins and cytokinins). This is supported by Taiz & Zeiger (2002) in their study on the growth hormone auxin. Indeed, these authors have shown that these compounds rich in nitrogen and carbon, are responsible for the regulation of root and leaf growth. Furthermore, Loué (1977) reported that potassium contributes to the improvement of size, while a K deficiency leads to a greater proportion of small sizes. Several works including Njoku *et al.* (2001) and Kebdani *et al.* (2014) also confirmed that N and K supply are essential for sweetpotato production. This confirms the results obtained at the level of physical characteristics of cassava tubers produced by the two varieties studied.

With respect to yield, the results revealed a significant difference between the different treatments applied to the two cassava varieties. The use of mineral and organic fertilizers increased the yield of fresh tuberous roots of both cassava varieties. In Bocou 1, the highest yield was obtained with treatment T3S2 (T3: NPK 10 18 18 fertilizer; S2: substrate composed of soil and chicken droppings), while treatment T2S8 (T2: carbonized rice husks; S8: substrate composed of soil and NPK 10 18 18) was different from the others in Yavo. These results are likely to be due either to the direct accessibility of the nutrients N, P and K provided to the soil by these fertilizers, or to the combined effects of the three elements N, P and K. Similar results have been obtained in Côte d'Ivoire on cassava (Bakayoko *et al.*, 2009) and in other countries (Borah *et al.*, 2010; Zoundi, 2012). Similarly, Lompo & Belem (2012) obtained in Burkina Faso, the best yields and fresh weights of tuberous roots with the mineral formula of N60P30K100 on sweet potato.

Moreover, according to Bationo & mokwunye (1991) and then Bado *et al.* (1997), the simultaneous use of organic matter and mineral fertilizers reduces losses and promotes mineral and water supply to crops, thus leading to increased yields. Also, Alla (2020) demonstrated that this association made more available mineral elements to eggplant plants, leading to their growth and the good development of their vegetative and fruiting organs. Furthermore, differences in fresh tuberous root yields at harvest (15 months after planting) are thought to result from the difference in the speed of transport of nutrient reserves from the leaves to the roots (Bakayoko *et al.* 2007). In addition, in cassava, the development of leafy shoots occurs with the supply of processed materials (Osiru, 1990). This elaborated material is shared between shoots and tubers, which leads to a strong competition between these parts. Therefore, an optimum leaf area index is essential to ensure the best possible tuberization according to Bakayoko *et al.* (2013). Moreover, the yield of cassava tubers could depend on the photosynthetic capacity of the leaf canopy. This capacity that the plant translocated the assimilates from the leaf to the root and their ability to assimilate them. Therefore, it is possible that translocated photosynthetic assimilation to the roots may have contributed to the high root yields (Brobbey, 2015). Schafer (1999) in his work also showed that rapid and high leaf development is a necessary condition for high tuber yields.

The study of the influence of variety on production parameters showed a significant difference between the variety Bocou 1 and the variety Yavo. The Yavo variety obtained higher values for all parameters. This result could be explained by the fact that the Yavo variety reacted favorably to the different fertilizer treatments applied. This difference could also be due to the genetic characteristics of each species. This same observation was made by Kouamé *et al* (2021) during their work on organic and mineral fertilization of two okra varieties (Abelmoschus esculentus (l) moench, malvacea) in Daloa, Côte d'Ivoire. These authors showed that the influence of okra varieties on agronomic parameters would be due to the genetic characteristics of each species. Also, in a study of chili varieties in the Batéké Plateau in Kinshasa, Muwo *et al.* (2018) stated that the differences in yields observed can be justified by the genetic characteristics specific to each variety.

Conclusion

In this study, which focused on the evaluation of the impact of mineral and organic fertilization on the agronomic descriptors of the cassava seedlings Bocou 1 and Yavo, it should be noted that all the fertilizing treatments significantly influenced the growth and production parameters of the seedlings. However, the treatments induced a better growth of the cassava varieties Bocou 1 and Yavo. In addition, the best tuber yields were obtained with the T3S8 fertilizer treatment in the Bocou 1 variety and with T3S9 in the Yavo variety.

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