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Original Article

Upgrading of the hull of pod of cocoa as a source of fertilizer, compared to trade NPK fertilizer in production of cassava (Manihot esculenta Crantz) an Ivory Coast.


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Abstract

The aim of this study was to value the by-product of the cocoa pod and recommend as a source of cost-effective and environmentally preservative fertilizers. Abandoned in the field after the cocoa cracking, the hull of cocoa represents more than 70% of dry matter of the entire pod. Physicochemical analysis showed that it is very rich in potassium (K) containing up to 986.3 mg / 100 g and phosphorous (P), 274.6 mg / 100 g. It has low rates of nitrogen N (3.6 mg / 100 g), calcium Ca (0.8 mg 100 g), magnesium Mg (1.3 mg 100 g) and sulphur (2.1 mg 100 g). This study has shown that the hull of cocoa, dried and incinerated would be a good source of NPK fertilizers with an addition of urea (46% N) as a nitrogen source. The system of traditional culture after three weeks of planting of cassava cuttings, shows that the T1 plants are growing rapidly from 12 cm to T2 and T3 plants. Thus 610 kg / ha (NPK + 46 N of urea) and 200 kg/ha of trade (15. 15. 15) NPK fertilizers applied respectively to the plants of each of the subplots, 17.7 t/ha and 16.8 t/ha for tubers have been obtained. For the witness without fertilizer T2 subplot, 11.9 t/ha of cassava tubers were obtained. The hull of cocoa as a source of fertilizer gives a performance comparable to that of the fertilizer market or trade.

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Introduction

The hulls of cocoa pod, the placentas and mucilage of cocoa juice are sub-products of cocoa, which are abandoned in the field after extraction of cocoa beans, represent a large mass of agricultural waste and in the long run become a source of contamination [3]. In tropical Africa, [4] reported in 2007 that more than 1.2 million tones of dry matter of hull of cocoa are produced annually. The hull represents more than 70% of dry matter of the entire pod. With a production of more than 1 200 000 tons of cocoa merchant, Ivory Coast produces more than 1.700.000 tones of dry matter of hulls of cocoa per year [12]. They could be economically valued after drying in the livestock feed and increase the income of the producer by reducing the index of brown rot [1] . They could also be dried, incinerated, used as a source of potash for the manufacture of local SOAP and as a excellent fertilizer for plants with tubers [3].

With the steady decline in the global costs of the cocoa merchant for years, Ivory Coast as first cocoa producer countries, will gain in redirecting the connection by valuing this by-product. It is in this perspective that the study of the hull of cocoa for a more efficient use in a test of cassava (Manihot esculenta Crantz) production an Ivory Coast was undertaken. The aim of this work is therefore to study the influence of the hull of pod of cocoa as a source of fertilizer, compared to trade NPK fertilizer in production of cassava (Manihot esculenta Crantz) an Ivory Coast.

1.Materials and Methods

1.1 Materials

Cassava cuttings used are the improved variety 'Bonoua' aged at least six months, 25 cm with 4 to 6 knots [5] and the hull of cocoa incinerated, used as a source for the manufacture.

1.2 Methods

1.2.1 Extraction of the hull of the cocoa pod

After the cocoa cracking, the cocoa beans are removed and
the byproduct of cocoa, that is, the hull, is put in a bag and transported to the laboratory.

1.2.2 Physicochemical analysis
pH measurement is performed with a couple electrodes of glass-electrode reference (CONSORT 107, Belgium) and a magnetic stirrer (P SELECTA, Belgium). The minerals and trace elements could be determined by the AOAC method [2]. Tubers sinkers have been made using a reference scale Baxtran BPI (BP 115).

1.2.3 Study site
The study was carried out in Assié-Coumassi, a village located in the region of the Nzi-Comoé at 24 Km from Bongouanou. We chose this site as the experimental plot because it is the area of cocoa production. The climate of the region has four (4) seasons: a main dry season (November-February), a main rainy season (March-June), a small dry season (July-August) and a small rainy season (end August - end of October) [9]. Rainfall varies between 1000 and 1500 mm per year.

1.2.4 Study of soil
After a physical description of the soil, samples are collected from different horizons and sent to the laboratory for analysis. These analyses have focused on the pH, the levels of exchangeable bases and on some minerals.

1.2.5 Description of the traditional system
Description of the traditional system of cassava cultivation -based on fertilizer in competition.

The traditional system has been used in our study [6] (figure 1). The preparation of the parcel divided into three subplots w as made as follows:

- the T1 subplot with a NPK fertilizer hull of cocoa-based (PBEC: parcel fertilizer of hull of cocoa-based);
- the T2 subplot without fertilizer (SWASP: parcel witness without fertilizers);
- the T3 subplot with market NPK fertilizer (parcel market fertilizer-based: PBEM).

Note that:
T1: PBEC: subplot with a fertilizer (610 kg / ha + 46 urea N) based on dried and incinerated cocoa hulls;
T2: EOPS: subplot with no fertilizer.
T3: PBEM: subplot with a market NPK fertilizer (200 kg / ha).

The experiment lasted seven months (March-September). The classic activities carried out included: clearing, ploughing, mounding, planting online, weeding and harvesting. This system is based on the culture in line with the common NPK fertilizer. This system is based on the culture in line with NPK fertilisers of hull of cocoa respectively on the subplots PBEM and PBEC (Figure 2) and trade. This device has been repeated twice. It should be noted that the subplot SWASP benefited from no fertilizer.

1.2.6 Description of the measure of the size of plants.
Three weeks after planting (1 m x 1 m) cuttings of cassava to 25 cm long (4 to 6 knots) of the 'Bonoua' variety, we performed measurements on seedlings, first with a rule and then graduated with a Ribbon of a meter from the 5th week on. This was to measure the size of the plants of the 3rd to 14th week.

1.2.7 Effect of fertilizers on yield
This study will enable us to compare the growth of plants, tubers (weight) morphology and performance of fertilizers in the cycle of seven months at the end of the harvest.

1.2.8 Statistical analyses
Results have been the subject of analysis of variance [7]. The used post Anova test is the smallest significant amplitude (PPAS), in this case the comparison of Newman-Keuls test. These analyses are performed using programmed Statistical 6.0 (Chicago, USA).

2 Results and Discussion
2.1 Analysis of the experimental soil :
This study permeated us to characterize the soil of the experimental plot. The results of the analyses are summarized in table 1. Soil physicochemical analysis showed varying rates depending on the depth of the soil. Thus, we have high levels of sand (35.9%), clay (34.5%) of 0 to 12 cm of deep and 35.8%, 33.5% of clay for the depth of 12 to 30 cm.

The pH varies from 5.3 to 5.9. The rate of saturation is very low (0.1 to 0.07%) respectively ranging from 0 to 12 cm and 12 to 30 cm in depths. Experimental soil has low nutrient base. Exchangeable potassium is present in it with a concentration of 34.2 meq / 100 g (0 to 12 cm) and 24.6 meq / 100 g (12 to 30 cm).

![Fig-1: Traditional Culture System](image-url)
Texture soil dominated by clay and sand has a low nutrient content of base and even trace elements with a low saturation rates. These results reflect the extreme imbalance in nutrients of the experimental plot. According to [16], a balanced nutrition depends on the importance of nutrient base and especially micronutrients such as iron, Manganese, Zinc and copper. This was confirmed by [13]. Low saturation rates would favor, according to [17], good assimilation of minerals for the fertilization of the soil improvement.

Thus, a contribution of organic matter is positive because they increase the rate of CO2 in the soil, allowing the dissolution of calcite.

2.2 Chemical characteristics of the hull of cocoa

The chemical analysis of the hull according to the method of drying, showed no difference between the chemical characteristics of the hull of cocoa pod. However, we observe that the chemical composition of the hull left in the field for drying (CLC) has a slight rise compared to the laboratory (CSL), and Sun (CSS). The nitrogen content (3.6 mg / 100 g), phosphorus (274.6 mg / 100 g) and potassium (986.3 mg / 100 g) shells left in the field are slightly higher than the others. Also, minor elements of the hull left in the field have rates of concentration which are respectively 0.8 mg / 100 g, 1.3 mg / 100 g, 2.1 mg / 100 g calcium, magnesium and sulphur (table 2). There is therefore no difference between results according to the method of drying of the hull.

A by-product of the fruit of cacao, the hull contains almost all minerals with levels depending on the mineral. Unlike the content in nitrogen N (3.6 mg 100 g), very low, chemical analysis of the hull showed high levels of two other "major element" phosphorus P plant based nutrients (274.6 mg / 100 g) and Potassium K (986.3 mg 100 g).

Table 2: Average values of the chemical characteristics of the hull of dents cocoa according to types of drying

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>CLC</th>
<th>CSL</th>
<th>CSS</th>
<th>SEM</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>5.3</td>
<td>5.3</td>
<td>5.9</td>
<td>0.09</td>
<td>0.002</td>
</tr>
<tr>
<td>Coarse sand, (%)</td>
<td>35.9</td>
<td>35.8</td>
<td>38.5</td>
<td>0.03</td>
<td>0.001</td>
</tr>
<tr>
<td>Fine sand, (%)</td>
<td>12.8</td>
<td>12.9</td>
<td>12.9</td>
<td>0.03</td>
<td>0.001</td>
</tr>
<tr>
<td>Coarse silt, (%)</td>
<td>4.2</td>
<td>6.0</td>
<td>6.0</td>
<td>0.52</td>
<td>0.013</td>
</tr>
<tr>
<td>Fine silt, (%)</td>
<td>7.5</td>
<td>7.0</td>
<td>7.0</td>
<td>0.14</td>
<td>0.003</td>
</tr>
<tr>
<td>Clay (%)</td>
<td>34.5</td>
<td>33.5</td>
<td>33.5</td>
<td>0.29</td>
<td>0.001</td>
</tr>
<tr>
<td>Carbon ( %)</td>
<td>2.15</td>
<td>1.87</td>
<td>1.87</td>
<td>0.89</td>
<td>0.022</td>
</tr>
<tr>
<td>Nitrogenize (%)</td>
<td>0.14</td>
<td>0.11</td>
<td>0.11</td>
<td>0.01</td>
<td>0.000</td>
</tr>
<tr>
<td>P2O5 (meq/100g)</td>
<td>8</td>
<td>12</td>
<td>12</td>
<td>1.16</td>
<td>0.028</td>
</tr>
<tr>
<td>Ca exchg (meq/100g)</td>
<td>0.82</td>
<td>0.40</td>
<td>0.40</td>
<td>0.12</td>
<td>0.003</td>
</tr>
<tr>
<td>Mg exchg. (meq/100g)</td>
<td>0.98</td>
<td>0.65</td>
<td>0.65</td>
<td>0.09</td>
<td>0.016</td>
</tr>
<tr>
<td>K exchg ( meq/100g)</td>
<td>34.2</td>
<td>24.6</td>
<td>24.6</td>
<td>2.77</td>
<td>0.067</td>
</tr>
<tr>
<td>Rates of saturation (%)</td>
<td>0.10</td>
<td>0.07</td>
<td>0.07</td>
<td>0.01</td>
<td>0.000</td>
</tr>
</tbody>
</table>

meg/100 g (milli-equivalent by 100g) : Cmol/kg (centimoles by kg de sol). SEM : Cmol/kg (centimoles per kg of ground).

SEM: standard error of the average. Exchangeable (exchg.)

Other secondary and minor elements that contribute to the development of the plant were also found, even if they are low in the hull of cocoa.

The K2O concentration of the hull after study is greater than those reported by [19] and [15] for mucilage of cocoa juice, another by-product of it. Variability on the chemical composition of a by-product which confirms its origin and the technology for its treatment. According to [11] with low content of the hull in nitrogen, the addition of a nitrogen source would provide a relatively complete fertilizer. [3] was therefore correct to say that the ashes of the hull of cocoa would be an excellent fertilizer (NPK) for plants with tubers.

2.3 Effect of fertilizers on the growth of plants

We noticed that plants of subplots T1 (610 kg / ha N P K + 46 N) and T2 (200 kg / ha NPK: 15.15 15) grew faster than those of the T3 subplot (without fertilizers). The cassava growth is slow on the subplot without fertilizer. The level of growth of 3 to 14 weeks estimated by the terminal leaf stage of the stem of each plant is summarized in table 3. This difference in growth is exacerbated during the production cycle. There than the hull of cocoa as a source of fertilizer and fertilizer NPK (15.15 15) grow in almost the same way.
With the hull of cocoa as a source of fertilizer for T1 and T3 fertilizer market fertilizer, plants of these subplots have undergone rapid growth compared with the T2 subplot that had no fertilizer. This is confirmed by the work carried out by [8] who reported that the level of soil fertility strongly influences the growth of stems. The hull of cocoa can be compared therefore with the NKP fertilizer of the market that gives almost the same results.

### 2.4 Effect of fertilizer on the morphology of tuber

The analysis of parameters shows that fertilizers have an effect on the morphology of the tubers. They are closely linked according to the treatment suffered. The length and diameter of the root tubers are also improved by the level of soil fertility. For a same root weight class, it gets lengths and different diameters according to the treatment (table 4). Roots are long and have much higher diameters for T1 and T3 contrary to T2 in which lengths are lower with much lower diameters.

### 2.5 Effect of fertilizer on roots

Subplot witness without fertilizer T2 has a total number of tubers higher than T1 and T3 fertilized subplots. The more the tubers are, the less the total weight is high (table 5). With the same origin, the same quality of cuttings, ploughing and identical management on all the subplots, we agree that the effect of the fertility of the soil plays on the proportion of roots. That finding has been demonstrated by [14] and confirmed by [10] on a study on the behavior of the cassava (Manihot esculenta Crantz variety CB) at different planting densities.

**Table 3:** Average values of the size of the seedlings according to fertilizers applied to the various sub-compartments

<table>
<thead>
<tr>
<th>Sub-compartments</th>
<th>Plants T1 cm</th>
<th>Plants T2 cm</th>
<th>Plants T3 cm</th>
<th>SEM</th>
<th>T1 cm</th>
<th>T2 cm</th>
<th>T3 cm</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>3rd week</td>
<td>5.6</td>
<td>12.0</td>
<td>10.7</td>
<td>0.37</td>
<td>0.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4th week</td>
<td>30.1</td>
<td>46.3</td>
<td>39.6</td>
<td>1.94</td>
<td>0.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th week</td>
<td>80.7</td>
<td>109.6</td>
<td>98.7</td>
<td>3.15</td>
<td>0.07</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6th week</td>
<td>103.3</td>
<td>127.1</td>
<td>113.2</td>
<td>4.02</td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7th week</td>
<td>132.3</td>
<td>151.2</td>
<td>143.3</td>
<td>2.25</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8th week</td>
<td>171.2</td>
<td>217.5</td>
<td>198.8</td>
<td>5.41</td>
<td>0.13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10th week</td>
<td>188.1</td>
<td>235.7</td>
<td>228.9</td>
<td>1.96</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12th week</td>
<td>207.0</td>
<td>269.4</td>
<td>253.6</td>
<td>4.57</td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14th week</td>
<td>209.7</td>
<td>273.6</td>
<td>255.8</td>
<td>5.14</td>
<td>0.12</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SEM:** standard error of the average

The root tubers of plants of T1 and T3 subplots that have benefitted of fertilizer, has higher length and diameter compared to those of the witness subplot without fertilizer T2. We are therefore in line with the results of [18] which showed that on a poor soil without fertilizer, the diameter of the root tubers is decreased and increased in length for each category of weight from a fertilized soil.) According to [18], these morphologies have repercussions on the processing operations (manual or mechanical peeling performance) or the marketing of fresh tubers (the aspect of tubers).

### 2.6 Effect of fertilizer on the production of tubers

Subplot witness without fertilizer T2 has a total number of tubers higher than T1 and T3 fertilized subplots. The more the tubers are, the less the total weight is high (table 5). With the same origin, the same quality of cuttings, ploughing and identical management on all the subplots, we agree that the effect of the fertility of the soil plays on the proportion of roots. That finding has been demonstrated by [14] and confirmed by [10] on a study on the behavior of the cassava (Manihot esculenta Crantz variety CB) at different planting densities.

**Table 4:** average values of the characteristics of the effect of manure on the morphology of the tubers of the sub-compartments.

<table>
<thead>
<tr>
<th>Sub-compartments</th>
<th>Dimensions of the tubers</th>
<th>L cm</th>
<th>D cm</th>
<th>L cm</th>
<th>D cm</th>
<th>L cm</th>
<th>D cm</th>
<th>L cm</th>
<th>D cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tubers of 50g</td>
<td>L: average length of the tubers; D: average diameter of the tubers after the cut</td>
<td>12.3</td>
<td>2.31</td>
<td>10.6</td>
<td>2.09</td>
<td>13.1</td>
<td>2.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tubers of 150g</td>
<td>23.5</td>
<td>2.52</td>
<td>18.4</td>
<td>1.96</td>
<td>20.3</td>
<td>2.82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tubers of 250g</td>
<td>30.1</td>
<td>3.27</td>
<td>21.3</td>
<td>2.29</td>
<td>27.5</td>
<td>2.94</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tubers of 350g</td>
<td>42.2</td>
<td>4.58</td>
<td>26.1</td>
<td>2.84</td>
<td>39.3</td>
<td>4.25</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Numbers total tubers by penny-piece</th>
<th>PBEC</th>
<th>T1</th>
<th>PTSE T2</th>
<th>PBEM</th>
<th>T3</th>
<th>SEM</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of tubers (weight≥ 400g)</td>
<td>132</td>
<td>169</td>
<td>148</td>
<td>4.62</td>
<td>0.113</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total weight of tubers per sub compartment( t/ha)</td>
<td>17.73</td>
<td>11.90</td>
<td>16.83</td>
<td>0.26</td>
<td>0.006</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Furthermore, considering the performance of the production, they are 18 tons per hectare of cassava tubers which could be produced and made available for human and animal food. What could fight against food insecurity in the world and specifically an Ivory Coast. 3. Conclusion and perspectives

With an estimated amount of thousands tones of cocoa hulls each year, the production of this by-product solids increased over the years. With a particular quantity of potassium and phosphorus, its basis for plant nutrient composition is comparable to that of the NPK sold fertilizer in the Ivorian market as used as a source of fertilizer. The hull of cocoa is an excellent fertilizer for plants with tubers such as cassava. However, the rate of nitrogen is low. Given the difficulties that are met the cocoa sector and the importance of the by-products mass, it would be preferable to make more in-depth study in this area to find the best formulation for a very good value.
References

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