International Journal of Plant & Soil Science

Volume 37, Issue 12, Page 174-187, 2025; Article no.IJPSS.149499
ISSN: 2320-7035

Effect of a Compost Formulation Based on Agricultural Residues (Coffee Husks and Rice Straw) on Soil Chemical Quality and Agronomic Performance of Rain-fed Rice in Vavoua, Côte d'Ivoire

Kouame Amany Guillaume [a*], Zadi Florent [b], N'ganzoua Kouamé René [a], Bolou-Bi Bolou Emile [c] and Bakayoko Sidiky [a]

[a] *Department of Agropedology, Agroforestry Faculty, Jean Lorougnon Guédé University, Box 150 Daloa, Côte d'Ivoire.*
[b] *Station de Recherche de Man, Centre National de Recherche Agronomique de Côte d'Ivoire (CNRA), 01 Box 1740 Abidjan 01, Côte d'Ivoire.*
[c] *Department of Soil Science and Sustainable Agriculture, Faculty of Earth Sciences and Mining Resources, Felix Houphouët-Boigny University, 22 ox 582 Abidjan, Ivory Coast.*

Authors' contributions

This work was carried out in collaboration among all authors. Authors KAG and NKR designed the study and drafted the protocol for the first version of the manuscript. Authors ZF and BBE performed the statistical analysis and interpretation. Author BS performed the final revision of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2025/v37i125882

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/149499

Original Research Article

Received: 28/09/2025
Published: 15/12/2025

**Corresponding author: E-mail: amanyguillaumek@yahoo.fr;*

Cite as: *Kouame Amany Guillaume, Zadi Florent, N'ganzoua Kouamé René, Bolou-Bi Bolou Emile, and Bakayoko Sidiky. 2025. "Effect of a Compost Formulation Based on Agricultural Residues (Coffee Husks and Rice Straw) on Soil Chemical Quality and Agronomic Performance of Rain-Fed Rice in Vavoua, Côte d'Ivoire". International Journal of Plant & Soil Science 37 (12):174–187. https://doi.org/10.9734/ijpss/2025/v37i125882.*

ABSTRACT

Background: Food self-sufficiency is a real challenge for Côte d'Ivoire today, with national decreasing of rice production for population's needs. This production deficit is attributed not only to the use of unsuitable and unproductive varieties, but also and above all to the infertility of rice-growing land.

Aims: This study aims to improve rice production in Vavoua through the use of organic fertilisation in a context of sustainable organic farming.

Place and Duration of Study: The experiment was conducted in the field in 2024 in the village of Mignoré, in the sub-prefecture of Séitifia and in the department of Vavoua, in central-western Côte d'Ivoire, by the agropedology research team at Jean Lorougnon Guédé University in Daloa, Côte d'Ivoire.

Methodology: three formulations (C1, C2 and C3) of composts were developed based on coffee husks and rice straw in different proportions. The formulations were for compost C1 (100% rice straw), C2 (50% rice straw + 50% coffee husks) and C3 (100% coffee husks). These different composts were applied as an organic amendment at a rate of 40 t/ha to two varieties of local rainfed rice, “Akadi” and the improved “C26”, in two applications (basal and top dressing) in a randomised Fisher block design with three replicates. The parameters collected were height, number of tillers, number of panicles and yield.

Results: the experiment showed that C2 compost had the best physicochemical characteristics compared to the other two and most improved the agronomic performance of the rice. The C26 rice variety stood out by achieving the highest yield.

Conclusion: C2 compost in the formulation (50% coffee husks and 50% rice straw) can be recommended as a good substitute for mineral fertilisers in the ecosystem of our study.

Keywords: Rice cultivation; compost; formulation; organic fertilisation; yield.

1. INTRODUCTION

Rice is one of the world's staple foods and the basis of the diet for more than half of the population (STATISTA, 2017, Méndez del Villar, 2020). In sub-Saharan Africa, growing demand for rice is the result of population growth and urbanization (OECD/FAO, 2016). In Côte d'Ivoire, annual consumption, estimated at 94 kg per capita (USDA, 2017), far exceeds national production, which is dominated by rain-fed rice farming, where yields remain low at around 1.3 t ha^{-1} (ADERIZ, 2019). This low productivity is mainly due to the degradation of soil fertility linked to overexploitation and a lack of suitable soil amendments (N'Ganzoua et al., 2023), as well as strong land pressure (Kasongo et al., 2013). The use of mineral fertilizers, although beneficial to plant growth and development, is not without consequences for the environment (Coulibaly et al., 2021, Gala Bi et al., 2011) and human health (Hien et al., 2018). Furthermore, their high cost makes them inaccessible to small farmers (N'Ganzoua et al., 2023, Useni et al., 2013), and a lack of knowledge about sustainable fertilization or the misuse of these chemical fertilizers in farming practices hinders the quality and health of cultivated soils, which can adversely affect crop yields (Mulaji Kyela, 2011). Therefore, the use of local organic resources appears to be a sustainable alternative for restoring soil fertility and improving rice productivity in the long term. Organic amendments derived from the composting of plant or animal residues contribute to enriching the soil with nutrients and improving its physicochemical and biological properties (Yao et al., 2012, Warnock et al., 2007, Tchabi et al., 2012, Mukalay et al., 2013). With this in mind, the present study aims to evaluate the effect of compost made from coffee husks and rice straw on soil fertility and the agronomic performance of rainfed rice. It is part of an approach to sustainable soil fertility management and the use of agricultural residues in Côte d'Ivoire.

2. MATERIALS AND METHODS

2.1 Study Area Description

The study was conducted in 2024 in the village of Mignoré, in the sub-prefecture of Séitifia, and in the department of Vavoua, in central-western Côte d'Ivoire (Fig. 1) by the agro-pedology research team at Jean Lorougnon Guédé University in Daloa, Côte d'Ivoire. The climate in this area is tropical humid, characterized by four seasons, including a long rainy season (April to mid-July), followed by a short dry season (mid-July to mid-September), then a short rainy season (mid-September to November) and a long dry season (December to March). The vegetation is dominated by pre-forest savanna, growing on ferralsol soils. The local economy is based mainly on agriculture, with a predominance of cash crops (cocoa, coffee) and food crops for self-consumption.

2.2 Material

2.2.1 Plant material

The rice seed used in this study consists of a local variety called "Akadi" and an improved variety called "C26" from the Sémivoire facility in Côte d'Ivoire (Fig. 2). Akadi rice is a highly prized local rice variety with a cycle of approximately 135 days and an estimated yield of around 2 to 3 t/ha. The improved variety is characterized by long, fragrant grains with a short production cycle ranging from 90 to 120 days and an estimated yield of around 4 to 5 t/ha.

2.2.2 Fertilizer material

Two types of fertilizers were used in this study (Fig. 3). These were organic fertilizers derived from agricultural residues, namely coffee husks (shells from the husking of coffee cherries) and rice straw (biomass from dry rice stalks and leaves after harvesting), and NPK mineral fertilizer (17-17-17).

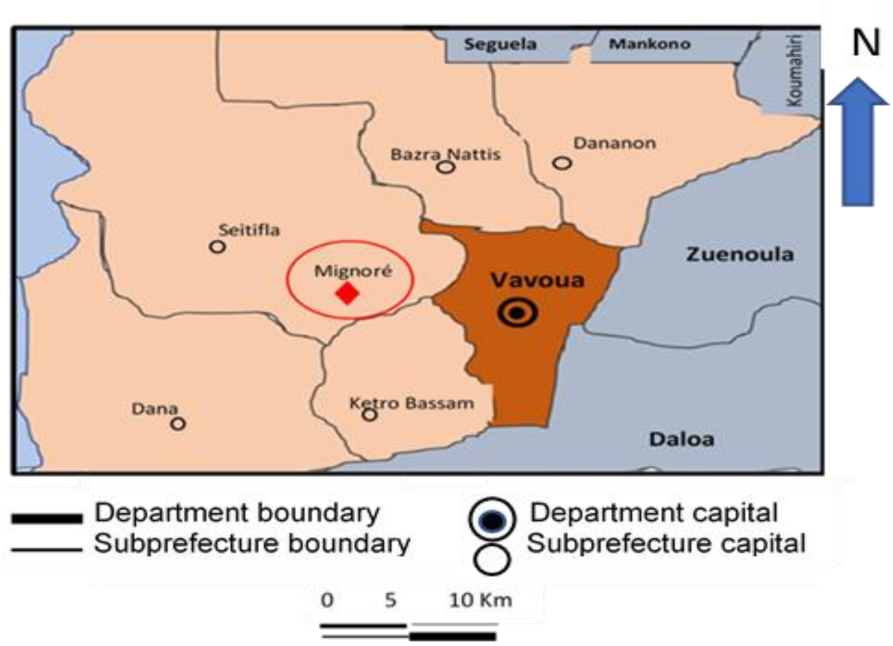
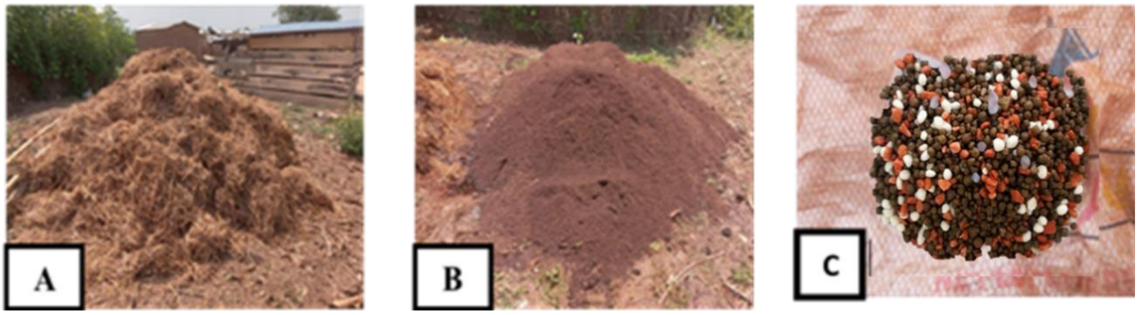


Fig. 1. Study's site overview

Local rice variety « AKADI» **Improved rice variety « C26 »**

Fig. 2. Rice varieties used



A: Rice straw B: Coffee shell C: NPK (17-17-17)

Fig. 3. Organic and chemical fertilizers used

2.3 Methods

2.3.1 Organic formulations and composting

The compost was produced using the windrow composting method, chosen for its simplicity and efficiency. Nitrogenous waste (coffee husks) and carbonaceous waste (rice straw) were arranged in alternating layers on a previously prepared site, sprinkled with 1 kg of wood ash and moistened using a 10-liter watering can, then covered with plastic sheeting to maintain heat and humidity. Turning the mixture twice a week for three months, adjusting the moisture content and monitoring the temperature, produced three types of mature, stabilized compost:

- Compost C1 is made from formulation F1 (100% rice straw)
- Compost C2 is produced from formulation F2 (50% rice straw + 50% coffee husks)
- Compost C3 is produced from formulation F3 (100% coffee husks)

2.3.2 Experimental design and application of organic (compost) and mineral (NPK) fertilizers

The study, conducted on a 72 m² plot using a randomized Fisher design with three replicates, aimed to evaluate the effect of different fertilizers on two rice crop varieties. The experimental design included two main factors. The fertilizer factor with four treatments (Composts C1, C2, C3, and NPK Fertilizer) and the biological factor with two varieties (improved and local). The treatments resulted from the distribution of these factors, divided into three blocks subdivided into 6 m² sub-blocks serving as experimental units. All treatments are listed in Table 1. The 20 treatments generated were applied to both varieties, with a distance of 0.5 m between treatments, 0.2 m between plants within a treatment, and 1 m between blocks, as shown in Fig. 4. Fertilizers were applied as basal dressing at a rate of 20 t/ha for compost and 75 kg/ha for NPK before sowing, then reapplied at the same doses as top dressing during the growth and reproduction stages of rice, for a total of 40 t/ha of compost and 150 kg/ha of NPK during the trial. The rice was sown directly in holes in the four corners and in the center of each microplot at a rate of 4 grains per hole.

2.4 Data Collection

2.4.1 Analysis of soil and compost produced

The data collected concerned the chemical parameters of the soil at the experimental site. To do this, samples were taken from the top 0-20 cm of soil not only before the trial was set up but also after the trial. This was done using an auger in the four corners and in the centre of each microplot corresponding to the treatment. Thus, for each treatment, a composite sample was made from the individual samples per plot. These were then sent to the laboratory and 1 kg of composite soil was taken to determine the chemical parameters of the soil, in particular acidity (pH), soil organic carbon (C) and soil organic matter (MO), total nitrogen (N), available phosphorus (P_2O_5), exchangeable bases (K^+, Mg^{2+}, Ca^{2+}) and cation exchange capacity (CEC). These chemical analyses were carried out at the Plant and Soil Laboratory of the Houphouët-Boigny National Polytechnic Institute in Yamoussoukro, Côte d'Ivoire, using well-known standard methods:

- pH measurement using the electronic glass pH meter method in a soil/solution ratio of 1/2.5 wascarried out (Diack & Loum, 2014). The principle of this method consists of immersing the glass electrode of the pH meter in the soil mixture and reading the pH value directly from the pH meter dial after stabilisation.

- The organic carbon content was determined using the Walkley & Black method described by (Nelson & Sommers, 1996). The principle consists of cold oxidation of the total organic carbon present in the soil using a potassium dichromate ($K_2Cr_2O_7$) solution in the presence of sulphuric acid (H_2SO_4). The excess dichromate is titrated in a strongly acidic medium using a 0.5N ferrous sulphate solution ($FeSO_4$, $7H_2O$). The proportion of total organic carbon is determined after the solution turns brown. The organic matter content is determined by multiplying the percentage of carbon in the soil by a conversion factor of 1.724 (%C x 1.724 = OM) according to (Bouma et al., 2010).
- The nitrogen content was also determined using the modified Kjeldahl method (Murphy & Riley, 1962). The principle consists of transforming, in an acidic environment, the organic nitrogen compounds into ammonium sulphate $SO_4(NH4)_2$, in the presence of concentrated sulphuric acid (H_2SO_2), at high temperature, and a mixture of catalysts (K_2SO_4 and $CuSO_4$). The ammonia thus formed is displaced from its compounds by concentrated caustic soda (NaOH), distilled by steam stripping, collected in a boric acid (H_3BO_3) solution and titrated with sulphuric acid.
- The determination of the assimilable phosphorus content was carried out using the Olsen-Dabin method described by (Olsen & Sommers, 1982). Assimilable phosphorus in the soil is extracted using a sodium bicarbonate solution ($NaHCO_3$;0.5N), pH 8.5 on an autoanalyser, by measuring the intensity of the phosphomolybdenum blue complex.
- The cation exchange capacity (CEC) and exchangeable bases (Ca^{2+}, Mg^{2+}, K^+) were extracted by rinsing with an ammonium acetate solution (NH4C2H3O2, 1N) at pH 7. The principle of this method is based on the fact that the amount of ammonium retained by the soil after washing away the excess ammonium acetate is expressed as cation exchange capacity (CEC). The retained ammonium is released by percolation and determined by autoanalyser. Exchangeable bases (Ca^{2+} and Mg^{2+}) are determined by atomic absorption spectrophotometry and K+ by flame photometry.

Table 1. Different treatments performed and their abbreviations

Abbreviations	Treatments
Te	Rice plants without fertiliser application
T1	Compost C1 applied at a rate of 40 t/ha to rice plants
T2	Compost C2 applied at a rate of 40 t/ha to rice plants
T3	Compost C3 applied at a rate of 40 t/ha to rice plants
T4	NPK applied at a rate of 150 kg/ha to rice plants

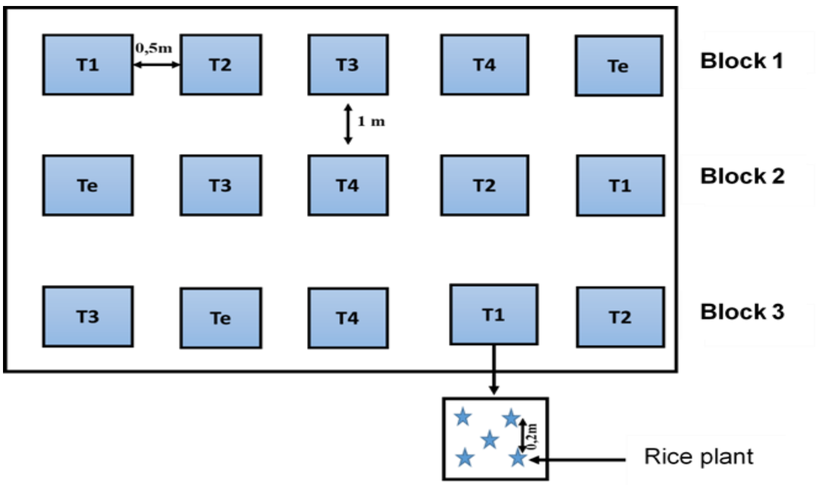


Fig. 4. Experimental setup

2.4.2 Determination of the agromorphological parameters of rice

Rice growth and yield data were collected from 15 plants per variety in each plot and included measurements of plant height using a tape measure, the number of tillers and panicles by counting, and finally the yield using the following formula:

Yield (tha-1) = (Dry grain weight/6m²) × (10/1000) × ((100-HUM)/86)

with HUM = Grain moisture fixed at 14 p.c

2.5 Statistical Analysis

The collected data were analysed using STATISTICA version 7.1 software, and an analysis of variance (ANOVA) was used at a significance level of α = 0.05. In cases of significant differences, a post hoc test of the Smallest Significant Difference (SSD) was applied to identify homogeneous groups. A Pearson correlation analysis (r) was also performed to establish the link between the substrates and the agromorphological parameters determined. The correlation was established at a threshold of r = 0.60, with statistical significance tested at a threshold of α = 0.05.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Soil content in its initial state and in the various composts

3.1.1.1 Chemical characteristics of the soil in its initial state

The chemical element content obtained after analysis of the soil samples initially collected is presented in Table 2. It indicates that the soil was initially very acidic to acidic with a pH = 5.3 < 5.5, containing organic carbon (C= 0.47 < 1.5%), organic matter (0.81 < 2.58%), nitrogen (N=0.08 < 0.1%), phosphorus (P= 2.34 < 6 ppm) and a C/N ratio (C/N= 5.65 < 10), all of which are very low compared to the standard reference values (Baize, 2000). The exchangeable cations were also very low, with potassium (K= 0.07 < 0.25 cmol.kg-1), calcium (Ca=0.86 < 4 cmol.kg-1) and magnesium (Mg=0.43 < 0.6 cmol.kg-1) contents. However, the cation exchange capacity (CEC = 19 cmol.kg-1) is average, ranging between 12 and 25 cmol.kg-1.

3.1.1.2 Chemical quality of the compost produced

Laboratory analysis of the mature compost samples revealed the levels shown in Table 3. Overall, the composts have a pH within the standard range of 6.5 to 8.5 for mature compost and close to the ideal pH value for mature compost (pH = 7.5), which is neutral to slightly alkaline. The carbon and organic matter content are within the standard range (30 to 45% for carbon and 30 to 60% for organic matter). The nitrogen content of compost C1 is low (N= 0.41 1.5%), while that of compost C 3 (N= 2.16%) is within the standard range (1.5%<N <3.5%) and that of compost C 2 (N=4.31%) is slightly above the optimal value. The C/N ratio of compost C3 (C/N = 12.76) is within the standard range for mature compost (10<C/N<15), while composts C1 ((C/N = 37.27) and C2 (C/N = 24.80) have very high C/N ratios, exceeding the standard values for mature compost (>15). The phosphorus content of the composts was generally low for composts C1 (P = 0.07 ppm), C2 (P = 0.70 ppm), and C 3 (P = 0.33 ppm) compared to the standard values for mature compost, which range from 25 to 250 ppm. The exchangeable cation (K+, Ca2+ and Mg2+) contents were also very low for all composts produced compared to the standard values for mature compost. However, the cation exchange capacity (CEC) levels appear normal for all composts and are within the standard range for agricultural soil (12 cmol.kg-1 <CEC <25 cmol.kg-1).

3.1.1.3 Chemical characteristics of different composts

The chemical element contents of the composts produced are compared in Table 4. Overall, there is a significant difference (p <0.05) between the contents of the composts produced. Specifically, the pH ranged from neutral (Compost C3 with a pH = 7.3 and Compost C1 with a pH = 7.8) to slightly alkaline (Compost C2 with a pH = 8.1). For carbon and organic matter content, the highest values were recorded in Compost C1 (C= 40.51% and OM = 69.66%), compost C2 (C = 34.79% and OM = 59.85%) and compost C3 (C = 26.58% and OM = 45.75%) in descending order. For nitrogen, compost C2 had the highest content (N = 4.31%), followed by compost C2 (N = 2.16%) and compost C1 (N = 0.41%). The C/Na ratio was higher in compost C1 (C/N = 37.27) compared to compost C3, which had a normal C/N ratio (C/N = 12.76), and compost C2, which had a moderate C/N ratio (C/N = 24.8). The phosphorus content was higher in composts C2 (P = 0.70 ppm), C2 (P = 0.33 ppm) and C1 (P = 0.07 ppm) in descending order. For CEC, the lowest content was found in compost C2 (CEC = 18.40 cmol.kg-1) and the highest content was observed in compost C3 (26.13 cmol.kg-1), while compost C1 had an intermediate content (CEC = 20.00 cmol.kg-1). Potassium and calcium showed statistically similar variations in content, with the highest levels in compost C2 (K = 2.01 cmol.kg-1 and Ca = 2.64 cmol.kg-1) and the lowest levels in compost C1 (K = 1.58 cmol.kg-1 and Ca = 0.60 cmol.kg-1). Compost C3 was intermediate (K = 1.75 cmol.kg-1 and Ca = 1.14 cmol.kg-1). Similarly, the magnesium content was higher in compost C2 (Mg = 1.27 cmol.kg-1), while composts C1 and C2 showed statistically identical values.

3.1.2 Overall effect of composts on the agromorphological parameters of rice

3.1.2.1 Average variation in agromorphological parameters of rice

Variations in agromorphological parameters (Table 5) showed highly significant differences ($p < 0.05$) between the effects of the different composts compared to the blank control. All agromorphological parameters evaluated (height, tillers, panicles and yield) were significantly more impacted ($p< 0.05$) by compost C2 in the same order as the positive NPK control compared to the other composts. Specifically, considering the compost treatments, the agromorphological parameters were best with the C2 compost treatment (height = 77.3 cm; Tallies = 49 tallies ; Panicles = 63 panicles ; Yield = 5.94 tonnes per hectare, in the same order as the positive NPK control), the C3 compost treatment and the C1 compost treatment in descending order.

3.1.2.2 Effects of composts on agromorphological parameters by rice variety

The results in Table 6 show the variations in agromorphological parameters affected by composts by rice variety. It can be seen that the two rice varieties used are significantly ($p < 0.05$) stimulated by composts compared to the control without compost, showing the best growth and yield parameters. Similarly, regardless of the rice variety, compost C2 induced better growth and yield than the other composts C1 and C2. However, NPK remains the best positive control. Overall, the yield was higher for all varieties in descending order with the NPK treatment, compost C2, compost C3 and compost C1. Specifically, the rice yield was statistically identical for the compost C2 treatment and the positive NPK control treatment for both the local variety "AKADI ‘ (C2 compost yield = 3.05 t/ha; NPK yield = 3.20 t/ha) and the improved variety ’C26" (C2 compost yield = 5.87 t/ha; NPK yield = 6.80 t/ha).

3.1.2.3 Variety effect on the agromorphological parameters of rice

The results in Table 7 show the variation in agromorphological parameters by variety effect. There is a clearly significant difference ($p < 0.05$) between the local variety and the improved variety. The improved variety developed better growth characteristics (height, tillers and panicles) and yield than the local variety.

3.1.2.4 Stimulatory correlations between rice agromorphological parameters and composts

The correlation coefficients between the different treatments and the agromorphological parameters of rice (Table 8) highlight variable relationships depending on the nature and quality of the amendment. It should be noted that all correlations established between treatments and growth and yield parameters are positive. However, these relationships are significantly correlated ($R=0.60$; $p = 0.05$) only for compost C2, compost C3 and NPK treatments with growth and yield parameters, regardless of the rice variety.

3.1.3 Chemical content of the soil at the initial and final stages

A comparative analysis of the chemical properties of the soil before and after amendment shows an overall improvement in the chemical quality of the environment as a result of the compost (Table 9). The soil’s pH, which was initially acidic (pH=5.3), rose to between 7.3 and 7.6. Carbon © and organic matter (OM) content showed a slight decrease after cultivation for the compost treatments. It fell from 0.47% (initial soil) to 0.27% (soil with C2 compost). However, C1 compost retained levels close to the initial state. Total nitrogen (Nt) decreased significantly, from 0.08% initially to 0.03% after cultivation with C2 compost treatment. In addition, the C/N ratio increased considerably, from 5.65 initially to 17.3

after cultivation under the C2 compost treatment. Similarly, assimilable phosphorus increased dramatically, from 2.34 ppm initially to 295.8 ppm under the C1 compost treatment. Finally, the cation exchange capacity (CEC) remained stable overall (12.4–22.4 cmol.kg-1). However, exchangeable bases (K^+, Ca^{2+}, Mg^{2+}) increased slightly, thereby enhancing the chemical fertility of the soil.

3.2 Discussion

The initial physicochemical properties of the soil underwent significant changes in their final state following amendment with the various composts. First, the soil pH changed from acidic to neutral after the addition of organic fertilisers. This change is attributed to organic amendment, corroborating the work of (Sawadogo et al., 2020), which highlights the powerful ability of composts to improve the physicochemical and biological qualities of soil. Similarly, (Bolan et al., 2003) also assert that the incorporation of basic pH composts can reduce soil acidity and decrease the export of metals to plants. According to these authors, the structural improvement of the soil by compost is due to the polysaccharides and biopolymers derived from composts (He et al., 2000). However, this assertion is contradicted by (Pascual et al., 1997), who state that polysaccharides in composts serve mainly as a source of carbon and energy for microbial biomass, while structural improvement of the soil is ensured by polysaccharides of microbial origin. Furthermore, the change in cation exchange capacity (CEC), also due to the incorporation of compost, is consistent with (Tittarelli et al., 2007). They explain that the organic matter provided by compost increases the number of negative charges in the soil, thereby promoting the fixation of positive ions (Ca^{2+}, K^+ and Na^+). Finally, the low C/N ratio of the soil (6) reflects its nutrient deficiency, a result similar to that of (Guene, 2002), who indicates that a C/N ratio of less than 10 is synonymous with rapid mineralisation of organic matter, which quickly becomes essential for plants.

The soils that received the different treatments revealed varying characteristics. In particular, Soil C2 had low carbon, organic matter, nitrogen and phosphorus contents compared to Soils C1 and C3. These low levels are attributed to high mineralisation of organic matter by microorganisms, resulting in the rapid conversion of carbon (C) into organic matter (OM), nitrogen (N) and phosphorus (P). This intense mineralisation is directly linked to the high C/N ratio of Soil C2. These results corroborate those of (Ayidego & Guy, 2018), who state that a C/N ratio between 15 and 30 is optimal for efficient decomposition of organic matter. Consequently, this good mineralisation has promoted better assimilation of mineral resources by plants, explaining their low residual content in Soil (C2). Conversely, soils C1 and C3, with a C/N ratio below 15, undergo rapid mineralisation but generate little humus. According to (Chenu & Stotzky, 2002), this leads to a decrease in microorganism activity, resulting in a smaller decrease in carbon, nitrogen and phosphorus content.

Analysis of the pH of composts C1, C2 and C3 indicates that they are all mature, with values between 7 and 8, which corroborates the maturity criteria defined by (Avnimelech et al., 1996) (pH between 7 and 9). However, the carbon/nitrogen (C/N) ratio appears to be the main factor responsible for the differences observed in rice growth, development and production. The C/N ratio reveals the capacity and speed of organic matter mineralisation. (Guene, 2002) states that the higher this ratio, the slower the mineralisation rate. Thus, the C/N ratio of C2 compost (24.8) is considered conducive to mineralisation, unlike C1, where it is very slow. This high mineralisation of C2 ensures a continuous and sufficient release of nutrients for the plant. In addition, the high levels of major (N, P, K) and secondary (Mg, Ca) elements recorded in Compost C2 also explain the superior agronomic results. Indeed, the application of this compost at 40t/ha provides more nutrients than the others. These observations are consistent with those of (Sawadogo et al., 2008), who acknowledge that the effectiveness of compost depends on its ability to provide essential minerals to the plant. Furthermore, the basic pH of Compost C2 may have improved root absorption. This is in line with (Ngnikam & Tanawa, 2006), who point out that high Mg2+, Ca2+ and Na+ contents deacidify the soil by fixing H+ ions on the absorbent complex. Finally, the difference in morphological characteristics and productivity between local and improved varieties results from their intrinsic characteristics and environmental factors. The improved variety benefited from suitable soil and climate factors to fully express its development and production potential. These results are consistent with (Mendez Del Villar et al., 2017), who link plant

Table 2. Initial soil chemical element content

Treatments	pH	C (%)	MO (%)	Nt (%)	C/N	P (ppm)	CEC (cmol.kg-1)	K (cmol.kg-1)	Ca (cmol.kg-1)	Mg (cmol.kg-1)
Initial Soil T0	5.3	0.47	0.81	0.08	5.65	2.34	19	0.07	0.86	0.43
Normative reference values for soil *	5.5 - 6.5	1.5 – 2.5	2.58 - 4.3	0.1 - 0.15	10 - 12	6 - 25	12 - 25	0.25 - 0.40	4 - 8	0.6 - 1.2

** soil standard (Baize, 2000)*

Table 3. Chemical element content of compost produced

Treatments	pH	C (%)	MO (%)	Nt (%)	C/N	P (ppm)	CEC (cmol.kg-1)	K (cmol.kg-1)	Ca (cmol.kg-1)	Mg (cmol.kg-1)
Compost C1	7.8	40.51	69.66	0.41	37.27	0.07	20.00	1.58	0.60	0.24
Compost C2	8.1	34.79	59.85	4.31	24.80	0.70	18.40	2.01	2.64	1.27
Compost C3	7.3	26.58	45.75	2.16	12.76	0.33	26.13	1.75	1.14	0.30
Standard reference values for compost*	6.5 - 8.5	30 - 45	30 - 60	1.5 - 3.5	10 - 15	25 - 250	12 - 25	5 - 8	5 – 10	1 -3

****** Standard NFU 44-051 (AFNOR, 2006); Elliott et al., 2014; Davis et al., 2002*

Table 4. Comparative chemical element content in compost products

Treatments	pH	C (%)	MO (%)	Nt (%)	C/N	P (ppm)	CEC (cmol.kg-1)	K (cmol.kg-1)	Ca (cmol.kg-1)	Mg (cmol.kg-1)
Compost C1	7.8b	40.51c	69.66c	0.41a	37.27c	0.07b	20.00b	1.58a	0.60a	0.24a
Compost C2	8.1c	34.79b	59.85b	4.31c	24.8b	0.70c	18.40a	2.01c	2.64c	1.27b
Compost C3	7.3a	26.58a	45.75a	2.16b	12.76a	0.33a	26.13c	1.75b	1.14b	0.30a
P > F	0.023	0.01	0.01	0.04	0.02	0.01	0.02	0.03	0.007	0.01

Values marked with the same letter in the column are statistically identical at the α = 0.05 threshold.

Table 5. Average variation in agromorphological parameters of rice according to compost types

	Agromorphological parameters			
Treatments	**Height (cm)**	**Number of tillers**	**Number of panicles**	**Yield (t/ha)**
Control	62.8a	10.77a	12.7a	2.6a
Compost C1	65.06b	16.46b	18.66b	4.76b
Compost C2	77.3d	49d	63d	5.94d
Compost C3	71.33c	32.33c	47.33c	5.33c
NPK	78.43d	50.41d	65.91d	6.5d
P > F	0.022	0.003	0.001	0.001

Values marked with the same letter in the column are statistically identical at the α = 0.05 threshold.

Table 6. Average variation in agromorphological parameters by rice variety according to composts

Treatments	**Local variety « AKADI »**				**Improved variety « C26 »**			
	Height (cm)	**Number of tillers**	**Number of panicles**	**Yield (t/ha)**	**Height (cm)**	**Number of tillers**	**Number of panicles**	**Yield (t/ha)**
Control	12.22b	20.66b	21.9b	1.82b	14.56a	28.166a	25.6a	2.15a
Compost C1	65.06b	16.46b	18.66b	2.18b	71.06b	25.06b	35.08b	4.65b
Compost C2	77.3d	49d	63d	3.05d	76.33c	62.33d	69.33d	5.97d
Compost C3	71.33c	32.33c	47.33c	2.50c	71.16b	35c	51.45c	5.32c
NPK	78.43d	50.41d	65.91d	3.20d	76.83c	64.91d	71.91d	6.80d
P > F	0.55	0.000	0.000	0.02	0.022	0.003	0.001	0.001

Values marked with the same letter in the column are statistically identical at the α = 0.05 threshold

Table 7. Average variation in agromorphological parameters according to rice variety

Variety	**Height (cm)**	**Number of tillers**	**Number of panicles**	**Yield (t/ha)**
Local variety « AKADI »	14.56a	28.166a	25.6a	2.81a
Improved variety « C26 »	17.22b	51.66b	64.9b	6.05b
P > F	0.032	0.023	0.001	0.032

Values marked with the same letter in the column are statistically identical at the α = 0.05 threshold.

Table 8. Correlation value between composts and agromorphological parameters of rice

Treatments	Height (cm)	Number of tillers	Number of panicles	Yield (t/ha)
Control	R=0.011 ; *P = 0.065*	R=0.024 ; *P = 0.080*	R=0.012 ; *P = 0.075*	R=0.025 ;*P= 0.124*
Compost C1	R=0.450 ; *P = 0.070*	R=0.410 ; *P = 0.080*	R=0.523 ; *P = 0.054*	R=0.524 ;*P= 0.050*
Compost C2	R=0.870 ; *P = 0.001*	R=0.750 ; *P = 0.037*	R=0.860 ; *P = 0.001*	R=0.910 ;*P= 0.000*
Compost C3	R=0.680 ; *P = 0.033*	R=0.701 ; *P = 0.025*	R=0.764 ; *P = 0.035*	R=0.81 ; *P = 0.001*
NPK	R=0.880 ; *P = 0.000*	R=0.770 ; *P = 0.011*	R=0.886 ; *P = 0.001*	R=0.93 ; *P= 0.000*

The correlation between substrates and parameters is established for R = 0.60 and is significant at the threshold of = 0.05.

Table 9. Comparison of chemical element content in soil at initial and final stages

	pH	C (%)	MO (%)	Nt (%)	C/N	P (ppm)	CEC (cmol.kg-1)	K (cmol.kg-1)	Ca (cmol.kg-1)	Mg (cmol.kg-1)
Initial Soil T0	5.3	0.47	0.81	0.08	5.65	2.34	19	0.07	0.864	0.43
Final soil Compost C1	7.4	0.41	0.80	0.07	9.5	295.8	18	0.2	0.82	0.456
Final soil Compost C2	7.6	0.23	0.58	0.03	17.3	252.6	12.4	0.2	0.94	0.453
Final soil Compost C3	7.3	0.34	0.71	0.05	12.1	278.5	22.4	0.2	0.94	0.448
Soil reference standard values	5.5 - 6.5	1.5 – 2.5	2.58 - 4.3	0.1 - 0.15	10 - 12	6 - 25	12 - 25	0.25 - 0.40	4 - 8	0.6 - 1.2

growth to their environment and, above all, to their genotype. According to (Radhouane et al., 2014), the productivity of a variety improves when environmental and health conditions and cultivation methods are favourable, this adaptability being attributable to the intrinsic values of the plant.

4. CONCLUSION

The study of the effect of compost in the department of Vavoua made it possible to identify the best compost formulation for optimising rice production. It appears that of the two rice varieties used, the improved variety has the greatest production potential. However, an organic amendment at a dose of 40 t/ha based on compost composed of 50% coffee husks and 50% rice straw improves rice production. This compost improves the physical, chemical and biological properties of the soil. Indeed, this compost raises the pH of the soil and improves its absorption capacity, thereby enhancing its fertilising power. This fertilising power has contributed to better development and production of rice plants. Compost based on coffee husks and rice straw could be a good substitute for NPK in rice cultivation in the Vavoua area. However, the C26 rice variety should be used for its good agronomic performance.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

ADERIZ. (2019). *Rice statistics in Côte d'Ivoire*. Statistics and Monitoring and Evaluation Department; Rice Sector Development Agency (ADERIZ). https://www.aderiz.ci/fr/statistique-production

AFNOR. (2006). *Amendements organiques – Dénominations, spécifications et marquage*. https://www.boutique.afnor.org/fr-fr/norme/nf-u44051/amendements-organiques-denominations-specifications-et-marquage/fa125064/1900

Avnimelech, Y., Bruner, M., Ezrony, I., Sela, R., & Kochba, M. (1996). Stability indexes for municipal solid waste compost. *Compost Science & Utilization, 4*(2), 13–20. https://doi.org/10.1080/1065657X.1996.10701825

Ayidego, C. H., & Guy, M. (2018). *Study of the effectiveness of bokashi, compost and biopesticide solutions promoted by the Songhai Centre to improve lettuce and amaranth production in southern Benin* (Master's thesis). University of Gembloux. https://matheo.uliege.be/handle/2268.2/8440

Baize, D. (2000). Teneurs totales en « métaux lourds » dans les sols français : résultats généraux du programme ASPITET. *Le Courrier de l'environnement de l'Inra*, (39), 39–54. https://hal.science/hal-01203415/file/C39Baize.pdf

Bolan, N. S., Adriano, D. C., Natesan, R., & Koo, B. J. (2003). Effects of organic amendments on the reduction and phytoavailability of chromate in mineral soil. *Journal of Environmental Quality, 32*, 120–128. https://doi.org/10.2134/jeq2003.1200

Bouma, J., Hartemink, A. E., Jellema, H. W. F., van Grinsven, J. J. M., & Verbauwen, E. C. (Eds.). (2010). *Profiel van de Nederlandse Bodemkunde. 75 jaar Nederlandse Bodemkundige Vereniging (1935–2010)*. Nederlandse Bodemkundige Vereniging. https://edepot.wur.nl/654733

Chenu, C., & Stotzky, G. (2002). Interactions between microorganisms and soil particles: An overview. In P. M. Huang et al. (Eds.), *Interactions between soil particles and microorganisms: Impact on the terrestrial ecosystem* (pp. 3–40). John Wiley & Sons. http://www.wiley.com/WileyCDA/WileyTitle/productCd-.0471607908.html

Coulibaly, A., Kouakoua, Y. E., & Amani, N. G. (2021). Physico-chemical and organoleptic characteristics of certain varieties of local rice cultivated in Côte d'Ivoire. *International Journal of Progressive Sciences and Technologies, 29*(1), 668–674. https://ijpsat.ijsht-journals.org/index.php/ijpsat/article/view/1711

Davis, J. G., Iversen, K. V., & Vigil, M. F. (2002). Nutrient variability in manures: Implications for sampling and regional database creation. *Journal of Soil and Water*

Conservation, 57(6), 474–478. https://doi.org/10.2489/jswc.57.6.474

Diack, M., & Loum, M. (2014). Characterisation by geostatistical approach of the variability of soil properties on the agro-pastoral farm of Gaston Berger University (UGB) in Saint-Louis, in the lower Senegal River Delta. *Leïdi Laboratory Geography Review, 12*, 1–15. https://www9.ugb.sn/revues-lsh/images/LEIDI/LEIDI12/LEIDI12-01MateugueDiack.pdf

Elliott, J., Deryng, D., Müller, C., Frieler, K., Konzmann, M., Gerten, D., … Wisser, D. (2014). Constraints and potentials of future irrigation water availability on agricultural production under climate change. *Proceedings of the National Academy of Sciences of the United States of America, 111*(9), 3239–3244. https://doi.org/10.1073/pnas.1222474110

Gala Bi, T. J., Camara, M., Yao-Kouame, A., & Keli, Z. J. (2011). Profitability of mineral fertilizers in rainfed rice cultivation on plateaus: The case of the Gagnoa area in central-western Côte d'Ivoire. *Journal of Applied Biosciences, 46*, 3153–3162. https://www.biosciences.elewa.org/JABS/JABS46_October2011.html

Guene, O. (2002). Home composting integrated into household waste management—Field data and dissemination tools. In *Proceedings of International Symposium on Environmental Pollution Control and Waste Management* (pp. 349–356). http://www.citet.nat.tn/Portail/doc/SYRACUSE/18008

He, Y., Inamori, Y., Mizuochi, M., Kong, H., Iwami, N., & Sun, T. (2000). Measurements of N_2O and CH_4 from the aerated composting of food waste. *Science of the Total Environment, 254*(1), 65–74. https://doi.org/10.1016/S0048-9697(00)00439-3

Hien, O. C., Salissou, I., Ouedraogo, A., Ouattara, L., Diarra, B., & Hancock, J. D. (2018). Comparative effects of diets based on "ESPOIR" and "SR21" maize varieties on the productivity of Cobb-500 broiler chickens. *International Journal of Biological and Chemical Sciences, 12*(4), 1557–1570. https://doi.org/10.4314/ijbcs.v12i4.4

Kasongo, L. M. E., Mwamba, M. T., Tshipoya, M. P., Mukalay, M. J., Useni, S. Y., Mazinga, K. M., & Nyembo, K. L. (2013). Response of soybean (*Glycine max* L. (Merril)) to the addition of green biomass from *Tithonia diversifolia* (Hemsley) A. Gray as organic fertiliser on Ferralsol soil in Lubumbashi, DR Congo. *Journal of Applied Biosciences, 63*, 4727–4735.

Méndez del Villar, P. (2020, January). Global rice prices rise sharply. *Monthly report on the global rice market*, (191), 4 pp. https://www.infoarroz.org/

Mendez Del Villar, P., Tran, T., Adayé Akou, B., Bancal, V., & Allagba Konan. (2017). *Analyse de la chaîne de valeur manioc en Côte d'Ivoire*. Rapport final. CIRAD–Université Félix Houphouët Boigny. https://agritrop.cirad.fr/588006/

Mukalay, M. J., Kasongo, L. M. E., Mwamba, M. T., Tshipoya, M. P., Useni, S. Y., Mazinga, K. M., & Nyembo, K. L. (2013). Response of soybean (*Glycine max* L. (Merril)) to the addition of green biomass from *Tithonia diversifolia* (Hemsley) A. Gray as organic fertiliser on Ferralsol soil in Lubumbashi, DR Congo. *Journal of Applied Biosciences, 63*, 4727–4735.

Mulaji Kyela, C. (2011). *Utilisation des composts de biodéchets ménagers pour l'amélioration de la fertilité des sols acides de la province de Kinshasa (République Démocratique du Congo)* (Doctoral thesis). University of Liège – Gembloux Agro-Bio Tech. https://orbi.uliege.be/handle/2268/104845

Murphy, J., & Riley, J. P. (1962). A modified single solution method for the determination of phosphate in natural waters. *Analytica Chimica Acta, 27*, 31–36. https://doi.org/10.1016/S0003-2670(00)88444-5

Nelson, D. W., & Sommers, L. E. (1996). Total carbon, organic carbon, and organic matter. In D. L. Sparks et al. (Eds.), *Methods of soil analysis. Part 3. Chemical methods* (pp. 961–1010). Soil Science Society of America. https://doi.org/10.2136/sssabookser5.3

N'Ganzoua, K. R., Alla, K. T., Zadi, F., & Bakayoko, S. (2023). Comparative effect of composting time on the chemical fertility of two organic fertilisers commonly used in market gardening in Daloa, Ivory Coast. *ESI Preprints*. https://doi.org/10.19044/esipreprint.9.2023.p107

Ngnikam, E., & Tanawa, E. (2006). *African cities facing their waste*. Belfort-Montbéliard University of Technology. https://www.pseau.org/outils/ouvrages/utb m_les_villes_d_afrique_face_a_leurs_dechets_2006.pdf

OECD/FAO. (2016). *OECD-FAO agricultural outlook 2016–2025*. OECD Publishing. https://doi.org/10.1787/agr_outlook-2016-fr

Olsen, S. R., & Sommers, L. E. (1982). Phosphorus. In A. L. Page et al. (Eds.), *Methods of soil analysis, Part 2: Chemical and microbiological properties* (2nd ed., pp. 403–430). American Society of Agronomy; Soil Science Society of America. https://doi.org/10.2134/agronmonogr9.2.2ed

Pascual, J. A., Ayuso, M., Garcia, C., & Hernandez, T. (1997). Characterization of urban wastes according to fertility and phytotoxicity parameters. *Waste Management & Research, 15*, 103–112. https://doi.org/10.1006/wmre.1996.0067

Radhouane, L., Aissa, N., & Romdhane, L. (2014). Effects of water stress applied at different stages of development on the quantitative and qualitative aspects of an indigenous ecotype of sorghum seed grain. *Journal of Applied Biosciences, 74*, 6149–6156. https://doi.org/10.4314/jab.v74i1.6

Sawadogo, H., Bock, L., Lacroix, D., & Zombré, N. P. (2008). Restoration of degraded soil potential using zaï and compost in Yatenga (Burkina Faso). *Biotechnology, Agronomy, Society and Environment, 12*(3), 279–290. https://popups.uliege.be/1780-4507/index.php?id=2573

Sawadogo, J., Coulibaly, P. J. A., Bambara, F. J., Savadogo, A. C., Compaore, E., & Legma, J. B. (2020). Effects of organic fertilisers on soil physicochemical parameters and onion (*Allium cepa* L.) productivity in the Central West region of Burkina Faso. *Africa Science, 17*(6), 44–57. https://doi.org/10.35759/JABs.167.8

STATISTA. (2017). *Global rice consumption in kilograms per capita between 2010 and 2018*. http://fr.statista.com/statistiques/564291/utilization-du-riz-mondiale-par-habitant-2000/2020

Tchabi, V. I., Azocli, D., & Biaou, G. D. (2012). Effet de différentes doses de bouse de vache sur le rendement de la laitue (*Lactuca sativa* L.) à Tchatchou au Benin. *International Journal of Biological and Chemical Sciences, 6*(6), 5078–5084. https://doi.org/10.4314/ijbcs.v6i6.26

Tittarelli, F., Petruzzelli, G., Pezzarossa, B., Civilini, M., Benedetti, A., & Sequi, P. (2007). Quality and agronomic use of compost. In L. F. Diaz et al. (Eds.), *Compost science and technology* (Vol. 8, pp. 119–157). Elsevier Science. https://www.elsevier.com/books/compost-science-and-technology/diaz/978-0-08-043960-0

USDA. (2017). *Ivorians, Malians and Senegalese consume more than 90 kg of rice per year*. www.commodafrica.com

Useni, S. Y., Chukiyabo, K. M., Tshomba, K. J., Muyambo, M. E., Kapalanga, K. P., Ntumba, N. F., Kasangij, K. P., Kyungu, K. A., Baboy, L. L., Nyembo, K. L., & Mpundu, M. M. (2013). Using recycled human waste to increase maize (*Zea mays* L.) production on a ferralsol soil in southeastern Democratic Republic of Congo. *Journal of Applied Biosciences, 66*, 5070–5081. https://doi.org/10.4314/jab.v66i0.95005

Warnock, D. D., Lehmann, J., Kuyper, T. W., & Rillig, M. C. (2007). Mycorrhizal responses to biochar in soil—Concepts and mechanisms. *Plant and Soil, 300*(1–2), 9–20. https://doi.org/10.1007/s11104-007-9391-5

Yao, Y., Gao, B., Zhang, M., Inyang, M., & Zimmerman, A. R. (2012). Effect of biochar amendment on sorption and leaching of nitrate, ammonium, and phosphate in a sandy soil. *Chemosphere, 89*(11), 1467–1471. https://doi.org/10.1016/j.chemosphere.2012.06.002

Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/149499