Effects of coffee parchment-based compost on yield of two rice varieties (*Oryza sativa* L.) grown in Bofesso, village in Man Department, Côte d'Ivoire.

Abstract

Rice (*Oryza sativa* L.) is a food that contributes to food security of Côte d'Ivoire population. Government allocates billions of dollars each year to meet the needs of its ever-growing population. Rainfed rice cultivation, which is most widely practiced in rural areas and should fill this gap, nevertheless faces challenges related to soil fertility, as farmers lack sufficient resources to purchase chemical fertilizers. Objective of this study was to evaluate impact of applying coffee parchment-based compost on yield of two traditional rice varieties. Results showed that number of fertile tillers and panicle branching were significant for both amended and control subplots. Fertility rate varied from 68 to 79% for variety 1 and from 54 to 83% for variety 2. Number of panicle branches varied from 8 to 11 (variety 1) and from 6 to 8 (variety 2). On the other hand, number of grains per panicle was higher for plants from amended sub-plots where grain sterility rate was also low. Sterility rate varied from 10.15 to 12.32% against control (11.6%) for variety 1 and from 9.22 to 14.49% against 16.71% for control of variety 2. On all amended sub-plots, average mass of 1,000 grains was high compared to control sub-plots. In conclusion, coffee parchment-based compost can be used to improve soil fertility and increase rice yields.

Keywords: *Oryza sativa*, compost, coffee parchment, organic fertilization

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Introduction

In Côte d'Ivoire, rice (*Oryza sativa* L.) is main staple food for population, with an annual production of approximately 2.7 million tons for period 2023 (ADERIZ, 2023). However, this production remains insufficient to meet needs of population, whose average demand is estimated at 84 kg/inhabitant/year (FAO, 2025). To ensure food security of this population, it's appropriate to implement strategies likely to increase food production (Gbodje, 2021) especially with major consumption crops such as rice. In Côte d'Ivoire, rice production is carried out according to three systems: irrigated rice cultivation, flooded rice cultivation and rainfed rice cultivation (Courtois, 2007). Rainfed rice cultivation, which is most practiced, and more particularly in study area, has low yields due to harmful effects of climate change, but above all decline in soil fertility while farmers do not have sufficient means to obtain chemical fertilizers (Mukenza et al., 2021). In addition, practice of slash-and-burn cultivation contributes to destruction of organic matter, microflora and microfauna in soil (Materechera and Mkhabela, 2001; Styger et al., 2007), thus exposing crops to pathogens. This study was conducted to evaluate impact of coffee parchment-based compost on some yield parameters of two traditional rice varieties grown in locality. Studies conducted by Dzung et al. (2013) reported that application of coffee parchment-based compost at a rate of 2 to 3 kg/plant/year for 3 years improved soil fertility, plant growth while reducing chemical fertilizer use by 70 to 80% in an industrial coffee plantation in Vietnam. In banana plantations in Côte d'Ivoire, work carried out by Pinon and Godefroy (1973) had mentioned that compost based on coffee parchments would provide nitrogen (795 kg/ha), phosphorus (30 kg/ha), potassium (798 kg/ha), calcium (331 kg/ha), magnesium (87 kg/ha), manganese (2 kg/ha) and iron (36.5 kg/ha). This compost, in addition to being an organic fertilizer, is a soil conditioning agent (Oliveira et al., 2008). Moreover, according to studies carried out by Kochi et al. (2010), composts applied to poor and acidic tropical soils can provide mineral elements necessary for growth and development of plants in order to increase yield. Therefore, organic fertilization would be an alternative to restore soil fertility.

Materials and Methods

Materials

Study area

This study was conducted in Man Department (Figure 1), Tonkpi Region, Côte d'Ivoire. Man Department is located in western Côte d'Ivoire between longitudes 07°25' and 07°55' West and latitudes 07°00' and 07°40' North. Experimental site was a plot located in Bofesso, village in Sandougou-Soba Sub-Prefecture, Man Department. Climate is tropical with two seasons. Rainy season begins in March and ends in November, and dry season lasts from December to February. Average temperature ranges between 24 and 28°C. January is hottest month, with an average temperature of 28°C. September is wettest month with more than 150 mm of rain (Goné, 2001).

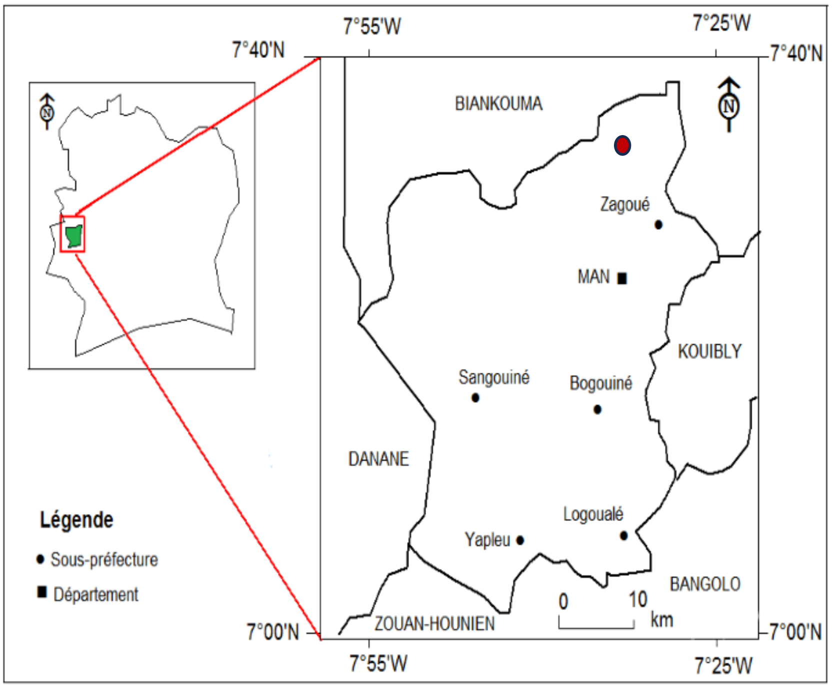

Figure 1. Man Department

: Experimental Site

Plant material

Plant material consisted of grains from two rice varieties (*Oryza sativa* L.) commonly grown in western Côte d'Ivoire (Figure 2). These rice varieties were provided free of charge by Young Farmers' Association (AJA) cooperative in Bofesso, as part of a project funded by Fund for Science, Technology, and Innovation (FONSTI). Variety 1 is brown in color, and variety 2 is dark brown. Choice of these varieties was motivated by taste favored by farmers.

Figure 2. Plant material used

Fertilizing material

Fertilizing material consisted of compost and chemical fertilizer. Compost, formulated with coffee parchment, beef excrement, and green plants (*Pueraria phaleosoides*) in a ratio of 50-25-25, was obtained after composting by association members after six months. Chemical fertilizer, composed of NPK (12-22-22) and 46% urea, was provided by Laboratory of Agricultural Production Improvement, University Jean Lorougnon Guédé. Characteristics of compost are listed in Table 1 below.

Table 1: Characteristics of Compost Used

		Content (% d.m)						Content (ppm)				
pH	C/N	N	P	K	Ca	Mg	C	Mn	Cu	Pb	Zn	Fe
6,6	11,79	2,18	2,56	0,91	0,87	0,415	25,7	8,2	4,1	1,2	7,5	25,1

d.m: dry matter; Compost used: coffee parchments, beef excrement and green plants (50-25-25). C: Carbon, N: Nitrogen, C/N: nitrogen/carbon ratio, P: Phosphorus, K: Potassium, Ca: Calcium, Mg: Magnesium, Mn: Manganese, Cu: Copper, Pb: lead, Zn: Zinc.

Methods

Experimental design

A Fisher block experimental design was adopted to evaluate effect of compost on rice yield. Experimental plot consisted of 36 subplots, with 18 subplots (6 subplots x 3 replicates) of 10 m² (2 m x 5 m) each per rice variety. A distance of 1 m was observed between two subplots for one rice variety. For two rice varieties, a distance of 2 m was observed between subplots.

Compost was applied one week before sowing. Sowing was broadcast followed by plowing according to village technique in early May 2024 at a rate of 0.6 kg/10 m². NPK and urea were applied at sowing. Following treatment was adopted: control (unamended rice cultivation), slash-and-burn rice cultivation, NPK+urea (application of NPK (0.2 kg/10 m²) and urea 46% (0.1 kg/10 m²)), compost application at 5 kg/10 m², compost application at 10 kg/10 m², and compost application at 15 kg/10 m². Manual weeding was performed during rice plants' growing cycle.

Yield parameter evaluation

Four yield parameters were selected in this study: tiller fertility rate, number of branches and grains per panicle, grain sterility rate, and average mass of 1,000 dry grains. Method of evaluating these yield parameters is shown in Table 2 below (Table 2).

Table 2. Yield Parameters and Evaluation Method

Performance parameters	Method of evaluating performance parameters
Tiller fertility rate (%)	To study this parameter, after emergence, 15 rice pockets were randomly identified and labeled. On 150th day after sowing, number of tillers spikelets per rice pocket was assessed by simple counting. Tiller fertility rate was calculated using following formula: $$\mathrm{fr} = \sum_{\mathrm{i}=1}^{\mathrm{n}=15} \frac{(\text{number of tillers plucked per pocket})}{TNT} \mathrm{X}\ 100$$ fr : fertility rate ; TNT : total number of tillers
	To assess this parameter, 10 rice panicles were sampled at 180 days after sowing in each elementary subplot randomly per treatment, for a

Evaluation of branches or grains per panicle number	total of 30 panicles per treatment. Number of branches bearing rice grains and number of grains per panicle were counted manually. Average number of branches or grains per panicle was calculated using the following formula: $$\text{Nb. or grains} = \sum_{i=1}^{n=30} (\text{Nb. ou grains per panicle})/\text{TNP}$$ Nb: number of branches, TNP : total number of panicles
Grain sterility rate (%)	After hulling grains on each panicle, full grains were separated from empty grains. Number of empty grains was counted manually and sterility rate was calculated according to following formula: $$\text{Infertility rate} = \sum_{i=1}^{n} (\text{number of empty grains}/\text{TNGP}) \times 100$$ TNGP : total number of grains per panicle
Average mass of 1,000 dry grains of rice (g)	To calculate mass of rice grains, 1,000 full grains per treatment type were selected in 3 replicates and dried for 7 days at room temperature, then placed on an electronic scale for weighing. Average mass of 1,000 dry grains were calculated using following formula: $$\text{Mg} = \sum_{i=1}^{n=3} (\text{mass of 1,000 grains per treatment})/\text{N}$$ Mg : mass of grains ; N : number of repetitions (N = 3)

Statistical analysis of data

Collected data were subjected to a one-way analysis of variance (ANOVA) using STATISTICA software, version 7, at 5% threshold. When $p < 0.05$, difference was considered significant. Homogeneous means were grouped using Newman-Keuls test at 5% threshold.

Results

Number of tillers, fertile tillers, and fertility rate

Table 3 shows number of tillers and fertile tillers per rice variety according to fertilizer type and doses applied. Number of tillers ranged from 3 to approximately 9 for variety 1 and from approximately 6 to 9 for variety 2. For both rice varieties, number of tillers was higher in subplot treated with NPK+urea, followed by one receiving 10 kg of compost. Lowest values were recorded in controls (varieties 1 and 2) and slash-and-burn treatment (variety 1). Statistical tests carried out for this purpose confirmed that number of tillers varied according to sub-plots for each rice variety (P = 0.001). Similarly, number of spikelet tillers varied according to compost doses applied. Highest values were observed in sub-plots treated with NPK + urea (6.8 spikelet tillers for varieties 1 and 2), and 10 kg compost (4.9 spikelet tillers in variety 1 and 7 spikelet tillers in variety 2). Tiller fertility rate was, however, higher for sub-plots treated with 10 kg compost. It was 79.03 and 83.33% for variety 1 and variety 2, respectively. For variety 1, fertility rate was higher than 68% across all subplots and higher than 54% for variety 2. Controls and subplots treated with 15 kg of compost recorded lowest values.

Table 3. Number of tillers and fertile tillers

Fertilizers	Rice varieties					
	Variety 1			Variety 2		
	tillers	t.spikelets	fr (%)	tillers	t.spikelets	fr (%)
Control	3,8±1,39[a]	2,6±1,42[a]	68,42[a]	5,7±0,82[a]	3,1±0,87[a]	54,38[a]
S.a.b	3,2±1,03[a]	2,4±0,84[a]	75,00[b]	6,6±1,83[a]	4,9±1,28[c]	74,24[c]
NPK + urea	8,8±2,25[b]	6,8±1,47[c]	77,27[d]	9,1±0,73[b]	6,8±0,91[b]	74,72[d]
5kg of compost	5,8±1,61[c]	4,4±1,77[b]	75,82[c]	6,7±1,05[a]	5,3±1,05[c]	79,10[e]
10kg of compost	6,2±1,54[c]	4,9±1,59[b]	79,03[e]	8,4±1,42[b]	7,0±1,05[b]	83,33[f]

15kg of compost	5,7±1,63^{c}	3,9±1,14^{ab}	68,42^{a}	6,6±1,77^{a}	4,5±1,35^{c}	68,18^{b}
F	14,93	13,1	369,1	9,08	17,62	176783
P	0,001	0,001	0,001	0,001	0,001	0,001

t: tiller; fr: fertility rate; s.a.b. : slash-and-burn. Within same column, means followed by same alphabetical letters are not statistically different according to Newman-Keuls test at 0.5% threshold.

Number of branches and grains per panicle

Data reported in Table 4 represent number of branches and grains per rice panicle. Generally, number of branches per panicle was greater in variety 1 than in variety 2. It ranged from 8.33 to 10.65 branches on average for variety 1 and from 6.76 to 8.16 branches for variety 2. Number of branches was significantly greater for subplots that received NPK+urea and compost, except for 15 kg compost treatment for both varieties. Highest number of branches for variety 1 was observed with 10 kg compost (10.65 branches) and for variety 2 with 5 kg compost (8.16 branches). They are roughly same as NPK+urea treatment. For number of grains, it was higher for variety 1 than variety 2. Values ranged from 89.63 to 143.21 grains for variety 1 and from 63.63 to 107.93 grains for variety 2. For variety 1, this number was higher on all sub-plots, but much higher with NPK+urea (143.21 grains), 5 kg compost (130.93 grains) and 10 kg compost (137.93 grains) treatments. As for variety 2, more than 100 grains per panicle were observed in subplots treated with 5 kg of compost (107.93 grains).

Table 4: Number of branches and rice grains per panicle

Fertilizers	Rice varieties			
	Variety 1		Variety 2	
	branches	total grains	branches	total grains

Control	8,33±1,37[a]	89,63±22,70[a]	6,83±1,49[a]	67,4±12,27[a]
S.a.b	9,83±1,91[ab]	126,43±40,54[b]	7,66±1,85[ab]	90,13±19,42[b]
NPK + urea	10,64±1,78[b]	143,21±38,25[b]	7,9±1,44[b]	85,43±18,66[b]
5kg of compost	10,33±1,72[b]	130,93±36,31[b]	8,16±1,51[b]	107,93±79,47[c]
10kg of compost	10,65±1,89[b]	137,93±43,75[b]	7,63±1,42[ab]	68,63±19,38[a]
15kg of compost	9,10±1,61[ab]	118,48±34,28[b]	6,76±1,59[a]	63,63±16,49[a]
F	4,36	4,51	3,2	23,17
P	0,01	0,01	0,04	0,001

S.a.b. : slash-and-burn. Within same column, means followed by same alphabetical letters are not statistically different according to Newman-Keuls test at 0.5% threshold.

Rice grain sterility rate

Table 5 shows grain sterility rate calculated from number of empty grains per rice panicle. For variety 1, no significant difference was observed between empty grain means (P = 0.24), as well as sterility rate (P = 0.88). Sterility rate remained around 11%. For variety 2, number of empty grains varied depending on fertilizers and doses used (P = 0.01). This number was low for 10 kg compost (6.33 grains) and 15 kg compost (6.7 grains) treatments, and high for slash-and-burn and 5 kg compost treatments. Value was 13.06 grains for both treatments (slash-and-burn and 5 kg compost). As for sterility rate, no significant difference was recorded between sub-plots (P = 0.11).

Table 5: Rice grain sterility rate per panicle

Fertilizers	Rice varieties					
	Variety 1			Variety 2		
	total gr.	empty gr.	sr(%)	total gr.	empty gr.	sr(%)
Control	89,63±22,70[a]	10,4±6,19[a]	11,60[a]	67,4±12,27[a]	11,26±6,10[ab]	16,71[a]

S.a.b	126,43±40,54^{b}	12,83±11,85^{a}	10,15^{a}	90,13±19,42^{b}	13,06±8,21^{b}	14,49^{a}
NPK + urea	143,21±38,25^{b}	16,46±13,48^{a}	11,49^{a}	85,43±18,66^{b}	11,1±7,27^{ab}	12,99^{a}
5kg of compost	130,93±36,31^{b}	16,13±8,56^{a}	12,32^{a}	107,93±79,47^{c}	13,06±7,77^{b}	12,10^{a}
10kg of compost	137,93±43,75^{b}	14,24±8,64^{a}	10,32^{a}	68,63±19,38^{a}	6,33±3,88^{a}	9,22^{a}
15kg of compost	118,48±34,28^{b}	14,31±9,84^{a}	12,07^{a}	63,63±16,49^{a}	6,7±5,27^{a}	10,52^{a}
F	4,51	1,55	0,33	23,17	4,6	2,28
P	0,01	0,24	0,88	0,001	0,01	0,11

S.a.b. : slash-and-burn. gr: grains; sr: sterility rate; In the same column, means followed by same alphabetical letters are not statistically different according to Newman-Keuls test at 0.5% threshold.

Mean rice grain mass

Figure 3 groups together data for mean mass of 1,000 rice grains according to treatments and varieties. Analysis of this figure indicates that mean grain mass varied according to treatments for each rice variety. Generally, mean grain mass of variety 2 was slightly higher than that of variety 1, except for the NPK+urea treatment. For variety 1, highest mean grain mass was recorded in NPK+urea (26.9 g) and 5 kg compost (26.64 g) subplots, while for control, it was 24.92 g. On the other hand, in variety 2, this mass was greater for 15 kg compost treatment (28.07 g), followed by slash-and-burn sub-plot treatments (26.94 g) and 5 kg compost (26.8 g). In this variety, control value was 26.64 g, slightly higher than that of NPK+urea (26.5 g).

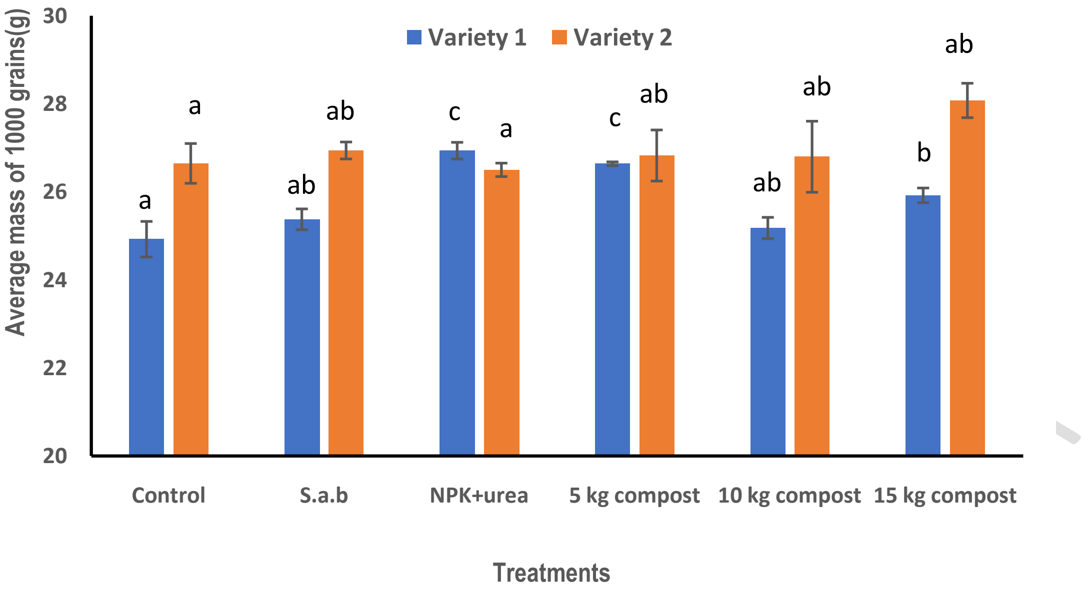

Figure 3. Average mass of 1,000 rice grains according to treatments

S.a.b. : slash-and-burn. On same histogram, bars followed by same alphabetical letters are not statistically different according to Newman-Keuls test at 0.5% threshold.

Discussion

Rice cultivation is influenced by several factors, including climate, soil properties, amount and type of fertilizer applied, cultivar, and cultivation method. This study, conducted with coffee parchment-based compost, is linked to type of fertilizer applied. Applied compost impacted growth and yield of rice plants. This can be explained by fact that all essential minerals (carbon, nitrogen, phosphorus, potassium, calcium, magnesium, manganese, copper, lead, and zinc) were contained in applied compost, along with a good C/N ratio (11.76). According to several researchers, applied compost would release nutrients into soil that would allow growth of plant and regeneration of microorganisms (Koulibaly et al., 2010; Traoré et al., 2015). Number of tillers increased with soil amendment with compost or NPK + urea compared to control and slash-and-burn crops. Our results are consistent with those of Eldin (1990) on millet. Indeed, latter showed that number of tillers had increased with application of fertilizers. Similarly, number of panicles increased with application of composts. Work of

Nesgea et al. (2012) on rice had mentioned that application of nitrogen had improved increase in number of panicles. In this study, number of panicles (spikelets) obtained corroborates that obtained by Nesgea and his colleagues (2012). However, low number of panicles observed in places on amended plots would be linked to mobility of minerals. Indeed, cultivation was carried out on sloping land and in rainy season. Nitrate being very mobile in soil and rainfed rice cultivation which is carried out in middle of rainy season would have contributed to movement of this mineral element. This is why, in fertilization in rainfed rice cultivation, Gala et al. (2007) mentioned in their study that it would be very important to know application of urea to improve yield. Quantity of nitrogen provided improved growth of rice plants. Data recorded for this purpose were significant with NPK + urea followed by 10 kg compost /10 m^2. Similarly, presence of essential minerals as well as trace elements in compost contributed to increase in fertility rate of rice plants grown on amended media. Work carried out by Ngoucheme et al. (2020) confirmed our results by showing that fertile soils improved fertility rate of rice plants. For grain yield, after pollination, embryo and endosperm begin to form in young grains. Photosynthates, as well as starch and proteins previously stored in leaves and stems, are redirected by plants to young grains. Rice is generally ready for harvest between 25 and 35 days after full flowering, during dry season, and after 35 to 40 days during wet season and usually at this stage, 85 to 90% of panicles turn yellow to golden yellow (FAO, 2003). In this study, harvest took place at 180 days after sowing, approximately 30 days after full flowering. Number of grains per panicle was higher for rice plants grown in soils amended with compost or NPK + urea. However, number of empty grains or sterility rate was substantially same for variety 1 while for variety 2, only control presented a high sterility rate. Work carried out by many researchers has mentioned that final weight of the grains was under influence of nitrogen; in such a condition rice grains produced are heavy (Osman et al., 2015). In our study, mass of grains was as important in control plants as in plants from amended soils; but slightly high in plants from amendments. Compost and chemical fertilizer NPK + urea influenced mass of grains except NPK + urea treatment for variety 2. Our results are consistent with those of Kimou et al. (2018) carried out on maize (*Zea mays*) fertilized with organic fertilizer. These authors indicated that mass of 100 seeds was higher compared to grains of control plots. According to these authors, this performance of organic fertilizer could be explained by its biological nature. This fertilizer formulation decomposes slowly to gradually enrich soil with nutrients necessary for healthy plant growth. In rice plants, adding compost to soil enriched its mineralogical composition. Number of grains per panicle and average mass of 1,000 grains were higher in amended subplots. Cobo et al. (2002) explain this by fact that decomposition of organic matter and increased productivity are closely linked to synchronization between nutrient release and plant assimilation.

Conclusion

This study on organic fertilization in rainfed rice cultivation showed that coffee parchment-based compost was an excellent fertilizer. This compost improved yield of rice varieties used. Number of fertile tillers, number of branches and grains per panicle, and average mass of 1,000 grains were greater for rice plants from subplots amended with NPK+urea and compost.

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