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Effect of organic fertilization with coffee husk compost and rice husk ash on agronomic parameters of two rainfed rice varieties (*Oriza sativa*) in western Côte d'Ivoire

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ABSTRACT

The objective of this study was to improve the production of rainfed rice by using rice husk ash and coffee husk compost. The tests were carried out in Dingouin, in the western part of Côte d'Ivoire. Two varieties of rainfed rice (Pkôhoun and Wôyô) were treated with either coffee husk compost applied at a dose of 5 t.ha^{-1} (D5), 10 t.ha^{-1}, (D10) and 15 t.ha^{-1} (D15), rice husk ash applied at 5 t/ha (D5), 10 t.ha^{-1}, (D10) and 15 t.ha^{-1}, (D15), or the chemical fertilizer NPK 15-15-15 (200 kg.ha^{-1}). The design used was a completely randomized block with three replications. The results obtained showed that the agronomic parameters varied depending on the fertilizer and the dose applied. The effect of all treatments was superior to the control. However, the best yields were obtained with D10 t.ha^{-1} of compost and the dose D15 t.ha^{-1} of ash in both rice varieties. The yields were respectively 6.52 t.ha^{-1} and 7.18 t.ha^{-1} for the Pkôhoun variety and 9.33 t.ha^{-1}; 8.80 t.ha^{-1} for the Wôyô variety. Coffee husk compost and rice husk ash improved the agronomic parameters of rainfed rice, so they can be recommended to producers to improve soil fertility to increase rice yield.

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Keywords: Rainfed rice, Coffee husk compost, Rice husk ash, Growth, Yield.

INTRODUCTION

In Côte d'Ivoire, rice is a highly consumed commodity (58 kg.inhab.yr^{-1}). It is ranked third among food crops after yams and cassava (Ouedraogo et al., 2021). According to the National Rice Development Office (ONDR, 2012), national production has for decades covered only 50% of the needs of the Ivorian population. In 2022, the national production of milled rice in Côte d'Ivoire was estimated to 1.107 million tones against an estimated consumption requirement of 2.45 million tones.

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This underproduction is would be mainly linked to poor soils and low use of organic inputs to improve fertility (Konan et al., 2024; Gbenou et al., 2025). Added to this is the sedentary lifestyle of farmers due to land pressure, which reduces the length of fallow periods, leading to soil impoverishment and, consequently, lower crop yields (Abobi et al., 2014; Ouattara et al., 2017; Gnénakan et al., 2025). In addition, the adverse effects of climate variation, pest pressure and the non-use of improved varieties accentuate the low productivity of local rice. It is therefore necessary to increase local production in order to achieve self-sufficiency in rice, as the country has a natural potential for rice cultivation. The use of chemical fertilizers has led to an increase in agricultural yields. However, in addition to their high cost, these fertilizers also have negative effects on the physical and chemical properties of the soil, the environment and human health (FAO, 2015). It is therefore necessary to develop new high-yield cultivation techniques that are more respectful of the environment and meet the challenges of sustainable agriculture (Meynard, 2008). To achieve this, the rational use of organic fertilizers could be an alternative for improving agricultural production and contributing to food security while reducing the risk of environmental pollution (Konan et al., 2020; Hien et al., 2025; Brahima et al., 2025). For example, the use of household waste, animal dung, sewage sludge and also agricultural residues including coffee husks and rice husks, which are the subject of our study (Mankoussou et al., 2017).

Coffee husks and rice husks are rich in organic matter, particularly cellulose, hemicellulose, pectin and lignin, potassium (K) and nitrogen (N) (Pandey et al., 2000). They have been the subject of several studies and have been tested on several crops either as simple mulch, ash or compost to increase crop yields and improve soil fertility (Zeynep et al., 2015). The present study falls within this framework. It aimed to assess the effects of increasing doses of coffee husk compost and rice husk ash on the growth and yield parameters of rainfed rice.

MATERIALS AND METHODS

Study site

The study was conducted in Dingouin, a village in the Biankouma department located between 7°44'00" north latitude and 7°37'00" west longitude. The climate is tropical, with an average annual temperature of 24°C. Soil texture is sandy-clay. Average annual rainfall is 1,589 mm (Kouadio et al., 2007, ANADER, 2009). Forest, savannah and mixed formations intermingle (Tiesse et al., 2017).

Plant material

The plant material used to carry out this work consisted of two local varieties of rainfed rice locally called Wôyô and Pkôhoun. These two rice varieties have a 120-day cycle.

Organic matter

The organic matter consisted of coffee husk, pig slurry and rice husk. The coffee husk and rice husk were collected from hulling units in Biankouma, and the pig manure was collected from a farmer in the village of Dingouin, 10 km from Biankouma.

Preparing coffee husk compost and rice husk ash

To prepare the coffee husk compost, a pit (1 m × 1 m × 1 m) was dug and the bottom cemented to prevent nutrient loss. The pit was filled with 100 kg of coffee husk, 100 kg of pig slurry and 50 kg of green manure (*Tithonia diversifolia*). The pit was covered with oil palm (*Elaeis guineensis*) leaves to maintain humidity between 50% - 60%. The contents of the pit were turned and watered every three days during the composting period, using the “Indian Indore method” to ensure good microbial activity (FAO, 1980). Three months after composting, the chemical composition of coffee husk composts was determined.

The ash was obtained by incinerating the rice husks over a period of 72 h in a complete combustion process (Pierre, 2014). After incineration, the ash obtained was collected for use as fertilizer. Its chemical composition was also determined.

Experimental design

This study was conducted over two consecutive years during the 2021 and 2022 rice seasons. The trials were conducted in a complete randomized block design with three replicates. In each block, eight treatments were applied to each rice variety. Each treatment corresponded to an elementary plot measuring 3 m × 2 m, or 6 m^2. Each block therefore comprised sixteen elementary plots. A total of 48 treatments were laid out over the entire experimental plot. Two consecutive elementary plots were separated by a one-meter-wide, regularly weeded strip manually. Sowing points on an elementary plot were set at a spacing of 20 x 20 cm between bunches, giving a density of 25 plants.$m^{2\ -1}$. On an elementary plot, organic fertilizers were applied as a base dressing over the entire surface and lightly ploughed in at a depth of 3 to 5 cm. Coffee husk compost was applied a week before sowing, while rice husk ash was applied on the day of sowing. All organic fertilizers were applied in single doses of 0.5 $kg.m^{2\ -1}$, i.e. 5 $t.ha^{-1}$ (D5), 1 $kg.m^{2\ -1}$, i.e. 10 $t.ha^{-1}$ (D10) and 1.5 $kg.m^{2\ -1}$, i.e. 15 $t.ha^{-1}$ (D15). NPK 15-15-15 was applied fractionally in two applications, the first at the start of tillering and the second at panicle initiation. Each application was made at a rate of 20 $g.m^{2\ -1}$, i.e. 100 $kg.ha^{-1}$.

Agronomic parameters measured

Agronomic parameters were measured on 10 rice plants randomly selected from each elementary plot for each treatment. Growth parameters were plant height and number of tillers produced per plant. Plant height was determined by measuring the distance from the collar to the top of the most developed leaf using a tape measure, and the number of tillers by direct counting after tillering. Yield parameters included: number of panicles per plant (Number of Panicles.$Plant^{-1}$ = NPP); number of grains per panicle (Number of Grains. $Panicle^{-1}$ = NGP); percentage of full grains per panicle (Percentage of Full Grains . $Panicle^{-1}$ = PGFP); and weight of 1000 grains (W1000 = weight of 1000 grains /1000).

Yield was estimated using the following formula:

Yield = (Number of poquet . $m^{2\ -1}$) x (Number of panicles . $bunches^{-1}$) x (Number of grains. $panicle^{-1}$) x (Percentage of full grains . $panicle^{-1}$) x (weight of 1000 grains).

Chemical analysis of coffee husk compost and rice husk ash

Fertilizers analysis were carried out at the Laboratory of Plant and Soil Analysis (LPSA) of the Graduate School of Agronomy (GSA) of the Institute National Polytechnique Houphouet-Boigny (INP-HB) of Yamoussoukro, Côte d'Ivoire. The content of organic carbon (C), organic matter (OM), nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg) and calcium (Ca). The results obtained were used to calculate the carbon and nitrogen (C/N) ratios of the various fertilizers. The pH of the fertilizers was also determined.

Data analysis

A multivariate analysis of variance was performed to assess the overall effect of fertilizer dose and rice variety on the variables. When a significant difference was noted, a two-factor analysis of variance (ANOVA 2) was used to study the influence of fertilizer type and dose on growth and yield variables. Test significance was determined by comparing the probability (P) associated with the test statistic with the theoretical value $\alpha = 0.05$. When a significant difference was noted between the factors considered for a given trait, the test for the smallest significant difference (ppds) was performed. All tests were performed using R software.

RESULTS

Chemical parameters of organic residues

The results of laboratory analysis showed a difference in the chemical composition of the different organic fertilizers tested (Table 1). The results of chemical parameter analysis for compost and rice husk ash showed an acidic pH-water (5.7) for compost and a basic pH-water for rice husk ash (8.5). C/N values were above 25 for both fertilizers. Organic carbon and organic matter

contents were higher in compost (49.95% and 85.91%) than in rice husk ash (4.25% m.s. and 7.31%). The coffee husk compost contained high levels of nitrogen (N = 1.69%), phosphorus (P = 1.25% m.s) and potassium (K = 2.42% m.s), compared with rice husk ash (N = 0.13%), (P = 0.52% m.s) and (K = 2.25% m.s). Magnesium was more abundant in coffee husk compost (0.36% m.s) than in rice husk ash (0.28 m.s). Calcium was more abundant in rice husk ash (2.23% m.s) than in coffee husk compost (2.01% m.s).

Overall effect of different fertilizers rice varieties and their interactions on rice agronomic parameters

The results of the multivariate analysis of variance (MANOVA) showed that fertilizers, rice varieties and their interactions (fertilizers × varieties) had a positive effect on measured agronomic parameters ($P < 0.05$) (Table 2). However, as the interactions were significant, interpretations were made only with the interaction table (ANOVA 2).

Influence of coffee husk compost and rice husk ash on rice growth parameters

Figures 1 and 2 show the results of the fertilizer-variety interaction on rice growth parameters (average plant height 90 days and number of tillers). Figures (1 & 2) show that fertilizer application led to an increase in the size of rice seedlings and in the number of tillers. Growth parameters were significantly higher than those of the witness ($P < 0.05$). Peaks in mean plant size (90 days) and number of tillers were observed with the D10 $t.ha^{-1}$ compost dose (111.20 cm) and the D15 $t.ha^{-1}$ rice husk ash dose (112.67 cm). Similarly, for the Wôyô variety, the tallest plants were observed with the D10 $t.ha^{-1}$ dose (132.73 cm) of compost and the D15 $t.ha^{-1}$ dose of ash (135.28 cm). The average number of tillers produced per plant of the Pkôhoun variety was highest with compost at D10 $t.ha^{-1}$ (4.30) and ash at D15 $t.ha^{-1}$ (4.58). For the Wôyô variety, the highest average number of tillers produced per plant was obtained with compost at D10 $t.ha^{-1}$ (4.42) and ash at D15 $t.ha^{-1}$ (4.38).

Influence of coffee husk compost and rice husk ash on rainfed rice yield parameters

Tables 1 and 2 show a significant variation in rainfed rice yield parameters ($P < 0.05$) between the control and the different treatments. The mean values for number of panicles. $plant^{-1}$, number of grains.$panicle^{-1}$, percentage of full grains.$panicle^{-1}$ and weight of 1000 grain obtained using coffee husk compost and rice husk ash were higher than those obtained using the witness. However, the D10 $t.ha^{-1}$ compost dose and the D15 $t.ha^{-1}$ rice husk ash dose obtained the highest averages compared with the other treatments over the two years of experimentation for both rice varieties. For example, the highest 1000-grain weight of the Pkôhoun rice variety was 31.25 g, and that of the Wôyô rice variety was 39.42 g in plants treated with D15 t ash.

Effect of coffee husk compost and rice husk ash on rice yields

Figures 3 and 4 show the yields of the two rice varieties as a function of the treatment received. Observation of these Figures shows that there is no significant difference between the yields obtained when considering the combined variety-treatment effect ($P > 0.05$). However, the analyses reveal a significant difference at the level of the treatments and the two rice varieties tested ($P < 0.05$). All treatments produced higher yields than the control. On the other hand, the D10 dose of compost (6.52 t. ha^{-1}) and the D15 dose of rice husk ash (7.18 t. ha^{-1}) gave better yields with the Pkôhoun variety. Also, with the Wôyô variety, the D10 dose of compost (9.33 t. ha^{-1}) and the D15 dose of rice husk ash (8.80 $t.ha^{-1}$) gave the highest yields. However, the Wôyô variety outperformed the Kpôhoun variety in all treatments.

Table 1: Chemical parameters of organic residues.

Parameters	Rice husk ash	Coffee husk compost
pH	8.50	5.70
C (%)	4.25	49.95
N (%)	0.13	1.69
O.M (%)	7.31	85.91
P (% m.s)	0.52	1.25
K (% m.s)	2.26	2.42
Mg (% m.s)	0.28	0.37
Ca (% m.s)	2.24	2.01
C/N	32.69	29.55

C :Carbon, N :Nitrogen, P :Phosphorus, K :Potassium, Ca :Calcium, Mg : Magnesium, C/N :Ratio Carbon–Nitrogen ; OM : Organic Matter

Table 2: Overall effect of rice variety and fertilizer on growth and yields parameters.

Source of variations	Growth parameters			Yield parameters		
	DF	**F**	**P**	**DF**	**F**	**P**
Fertilizers	35	15.43	<0.001	21	17.32	<0.001
Varieties	5	264.77	<0.001	3	42.11	<0.001
Fertilizers - Varieties	35	1.65	<0.05	21	1.60	< 0.05

DF : degree of freedom

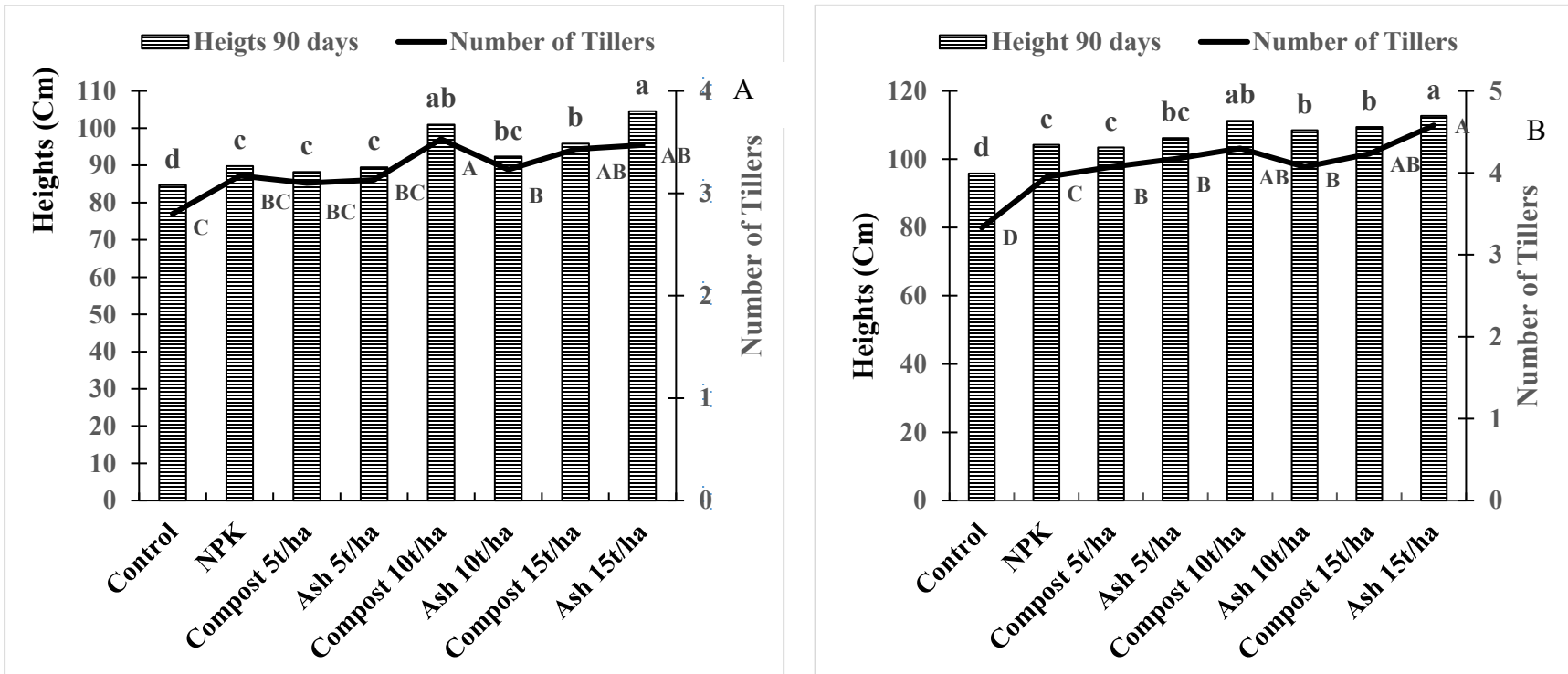


Figure 1: Average values of growth parameters of the Pkôhoun variety as according of fertilizer dose.
A : Season 2021 ; B : Season 2022.
Means bearing the same letters are statistically equal ($P < 0.05$).

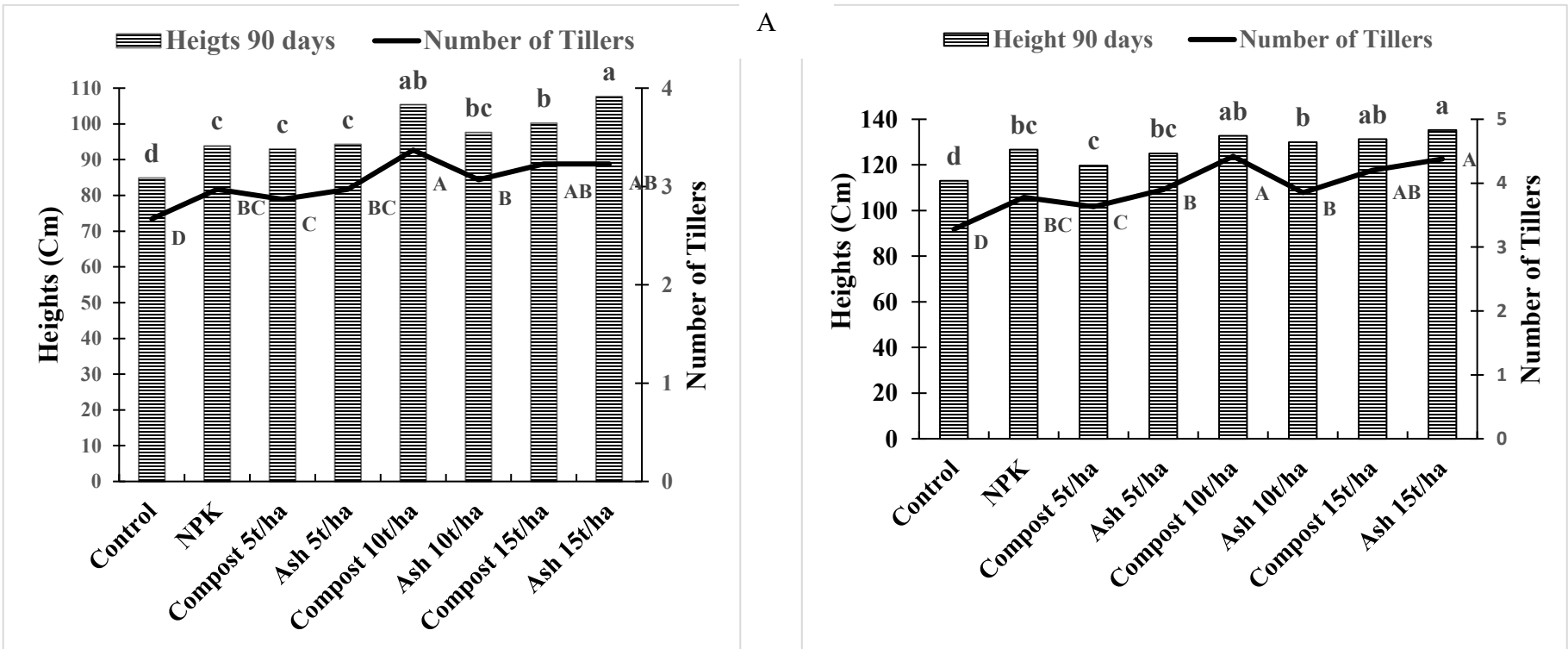


Figure 2 : Average values of growth parameters of the Wôyô variety according to fertilizer dose.
A : Season 2021 ; B : Season 2022
Means bearing the same letters are statistically equal ($P < 0.05$).

Table 3 : Average values of yield parameters for the Pkôhoun rice variety as a function of fertilizer dose.

	Season 2021				Season 2022			
Treatments	**NPP**	**NGP**	**PFGP**	**W1000G**	**NPP**	**NGP**	**PFGP**	**W1000G**
Control	2.30 ± 0.53^{c}	104.33 ± 40.10^{c}	0.55 ± 0.11^{c}	23.33 ± 0.58^{c}	3.34 ± 0.60^{d}	165.86 ±35.03^{d}	0.84 ± 0.07^{d}	28.95 ± 0.78^{d}
NPK	2.87 ± 0.78^{b}	122.87 ±4 2.66^{bc}	0.64 ± 0.12^{b}	24.33 ± 0.58^{b}	3.92 ± 0.72^{c}	186.22 ± 56.93^{c}	0.85 ± 0.07^{c}	29.63 ± 1.13^{c}
Compost 5 t	2.73 ± 0.52^{b}	119.17 ± 30.82^{bc}	0.61 ± 0.12^{bc}	24.33 ± 1.15^{b}	4.07 ± 0.76^{b}	184.65 ± 37.98^{c}	0.84 ± 0.06^{d}	29.88 ± 0.89^{c}
Compost 10 t	3.37 ± 0.61^{a}	141.13 ± 40.17^{ab}	0.69 ± 0.10^{a}	26.3 3± 1.53^{a}	4.30 ± 0.81^{ab}	217.20 ± 40.00^{ab}	0.89 ± 0.03^{a}	30.83 ± 0.59^{b}
Compost 15 t	3.17 ± 0.87^{ab}	133.57 ± 37.38^{b}	0.67 ± 0.11^{ab}	25.67 ± 0.58^{ab}	4.23 ± 0.81^{ab}	206.40 ± 42.16^{b}	0.86 ± 0.06^{bc}	30.76 ± 0.99^{b}
Ash 5 t	2.83 ± 0.65^{b}	120.47 ± 34.23^{bc}	0.65 ± 0.10^{b}	24.67 ± 0.58^{b}	4.07 ± 0.80^{b}	195.53 ± 37.84^{bc}	0.86 ± 0.06^{bc}	30.69 ± 0.71^{b}
Ash 10 t	3.03 ± 0.76^{ab}	128.77±36.43^{b}	0.68 ± 0.08^{ab}	25.33 ± 0.57^{ab}	4.17 ± 0.69^{b}	202.88 ± 49.19^{b}	0.87 ± 0.06^{b}	30.94 ± 0.81^{b}
Ash 15 t	3.37 ± 0.61^{a}	149.93 ± 31.54^{a}	0.70 ± 0.13^{a}	26.67 ± 1.53^{a}	4.53 ± 0.83^{a}	225.40 ± 50.43^{a}	0.88 ± 0.05^{ab}	31.25 ± 0.60^{a}
P	< 0.01	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Means with the same letters in the column are statistically equal (P < 0.05). **NPP:** number of panicles per plant**; NGP:** number of grains per panicle; **PFGP:** percentage of full grains per panicle; **W1000G:** weight of 1000 grains.

Table 4: Average values of yield parameters for the Wôyô rice variety as a function of fertilizer dose.

	Season 2021				Season 2022			
Treatments	**NPP**	**NGP**	**PFGP**	**W1000G**	**NPP**	**NGP**	**PFGP**	**W1000G**
Control	2.33 ± 0.48^{c}	92.83 ± 34.60^{d}	0.57 ± 0.07^{c}	27.33 ± 0.58^{c}	3.28 ± 1.04^{d}	172.47 ± 36.62^{d}	0.79 ± 0.10^{d}	37.40 ± 0.58^{d}
NPK	2.80 ± 0.48^{b}	118.23 ± 45.10^{bc}	0.67 ± 0.13^{ab}	28.67 ± 1.53^{b}	3.78 ± 0.85^{bc}	222.88±35.85^{b}	0.81 ± 0.07^{c}	38.15 ± 1.06^{bc}
Compost 5 t	2.73 ± 0.52^{b}	108.97 ± 27.93^{c}	0.64 ± 0.09^{b}	28.33 ± 0.58^{b}	3.62 ± 0.83^{c}	201.33 ± 41.75^{c}	0.83 ± 0.07^{bc}	37.87 ± 1.06^{c}
Compost 10 t	3.27 ± 0.45^{a}	137.27 ± 33.44^{a}	0.69 ± 0.11^{ab}	30.00 ± 0.00^{a}	4.42 ± 0.94^{a}	243.05 ± 39.29^{a}	0.87 ± 0.05^{a}	39.87 ± 0.35^{a}
Compost 15 t	3.20 ± 0.48^{ab}	126.83 ± 38.50^{b}	0.67 ± 0.11^{ab}	29.00 ± 0.00^{ab}	4.20 ± 0.92^{ab}	234.75 ± 34.00^{ab}	0.85 ± 0.05^{ab}	39.55 ± 1.02^{ab}
Ash 5 t	2.77 ± 0.68^{b}	111.97 ± 27.78^{c}	0.65 ± 0.09^{b}	28.77 ± 0.58^{b}	3.85 ± 0.94^{bc}	213.85 ± 35.86^{bc}	0.83±0.06^{bc}	38.77 ± 1.17^{bc}
Ash 10 t	2.97 ± 0.56^{ab}	122.73 ± 32.26^{b}	0.69 ± 0.08^{ab}	29.00 ± 0.00^{ab}	3.90 ± 0.77^{bc}	226.02±45.44^{b}	0.84 ± 0.08^{b}	39.03 ± 1.57^{b}
Ash 15 t	3.13 ± 0.35^{ab}	132.83 ± 22.32^{ab}	0.72 ± 0.13^{a}	29.33 ± 0.58^{ab}	4.37 ± 0.86^{a}	234.75±43.66^{ab}	0.86 ± 0.07^{a}	39.42 ± 1.02^{ab}
P	< 0.01	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Means with the same letters in the column are statistically equal (*(P < 0.05).*).
NPP: number of panicles per plant**; NGP:** number of grains per panicle; **PFGP:** percentage of full grains per panicle; **W1000G:** weight of 1000 grains.

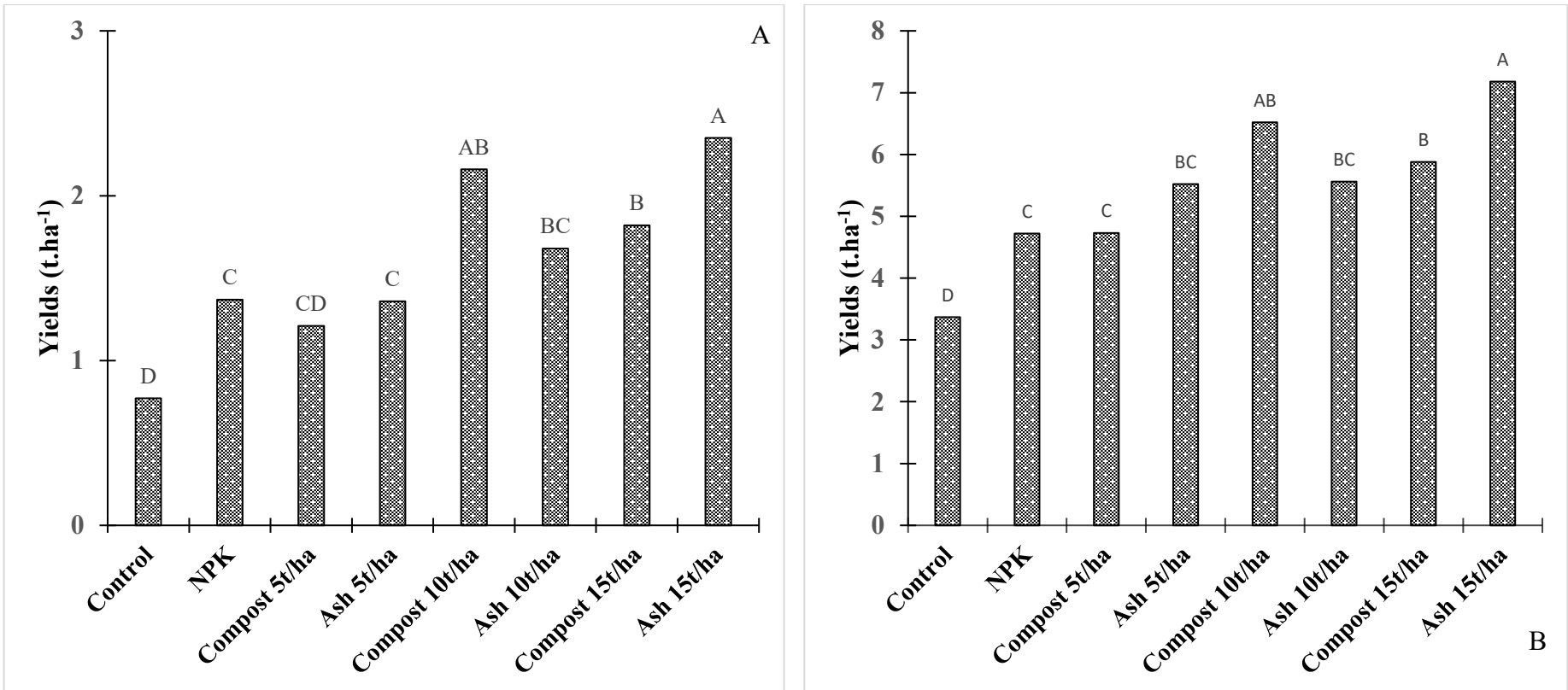


Figure 3: Average rice yield of Pkôhoun variety as a function of fertilizer dose.
A : Season 2021 ; B : Season 2022.
Means bearing the same letters are statistically equal ($P < 0.05$).

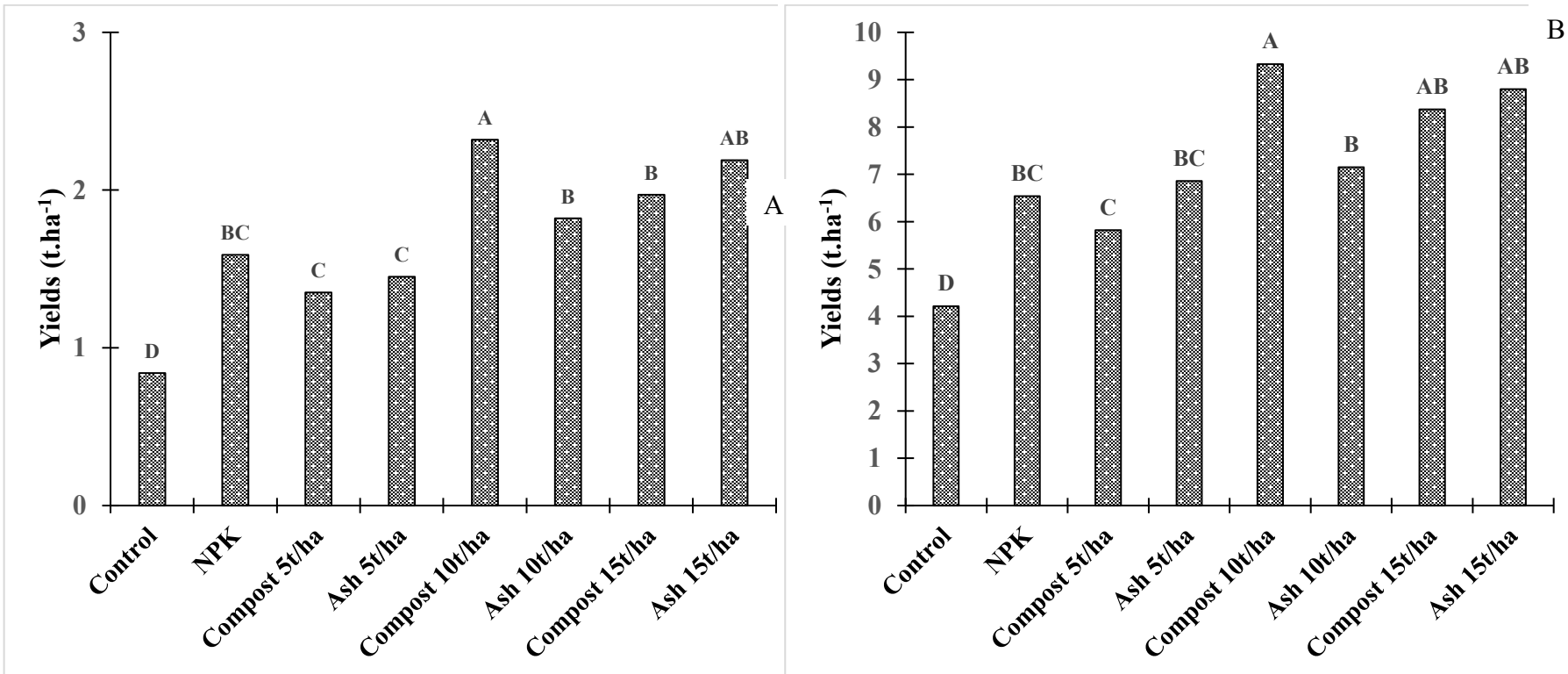


Figure 4: Average rice yield of Wôyô as a function of fertilizer dose.
A : Season 2021 ; B : Season 2022.
Means bearing the same letters are statistically equal ($P < 0.05$)..

DISCUSSION

The evaluation of the effect of different fertilizer doses was noticeable on rice growth and yield parameters. Fertilizer application led to an increase in average rice plant size, number of tillers produced number of panicles/plant, number of grains/panicle, weigh of 1000 grains and percentage of full grains/panicle. This performance is linked to the presence of nutrients such as nitrogen (N), phosphorus (P) and potassium (K), which are necessary for plant development (Sanogo, 2013). Nitrogen is an essential macroelement for the synthesis of photosynthesis enzymes (Thalineau et al., 2016). It also promotes the export of other mineral elements, plant growth, yield and grain quality (Paliwal, 2002; FAO, 2005). Potassium and phosphorus play a vital role in root development, in the absorption of cations (Ca^{2+}, Mg^{2+}, NH^{4+}...) and in maintaining cell turgor, thus ensuring tissue rigidity. According to Haque (2016), the number of tillers correlates with nitrogen supply conditions. Thus, tillers development could be linked to the physiological role of nitrogen. In addition, the use of organic fertilizers promotes soil aeration and increases the water retention and cation exchange capacity of the soil. This will ensure the availability and accessibility of mineral elements to the plant, good water and mineral nutrition and consequently good growth and higher yields (Abobi et al*.,* 2014). These results are in line with those of (Sifolo et al*.,* 2019; Bikila, 2020) who have shown the efficiency of nutrient-rich organic fertilizers (N, P, K) and their ability to increase plant development and crop yield.

The best rice responses to rice husk ash and coffee husk compost doses were seen with dose intensification. With rice husk ash, the dose (D15) gave the highest averages for all the variables studied. For coffee husk compost, on the other hand, dose (D10) proved optimal. The use of high levels of rice husk ash could be explained by the low retention of minerals, which would be washed to the bottom by leaching and thus inaccessible to the roots of the seedlings. In fact, the incineration of rice husks makes available the mineral elements which, by gravity, are carried to the depths by rainwater during the local rice production cycle, thus encouraging an increase in the quantity of ash to correct the plant's mineralogical requirements (Sadi, 2024). These results are in agreement with Useni et al. (2012) and Abobi et al. (2014) who have shown that higher doses of organic fertilizers provide more plant nutrients and therefore increase yields. However, high doses of compost lead to a reduction in production. In fact, the drop in the averages of the variables studied recorded at the compost dose (D15) could be explained by the high mineral element content, which would have been a limiting factor for the development of rice plants (Kouadio, 2007; Abobi et al., 2014). These high nutrient contents would have had a negative impact on plant growth, as there is a threshold beyond which any input would be harmful to the proper functioning of the plant.

Conclusion

The aim of this study was to improve soil fertility and increase rainfed rice production. The positive effects of coffee husk compost and rice husk ash on rice growth and yield parameters were demonstrated. All organic fertilizer doses improved the yields of Wôyô and Pkôhoun rice varieties. However, the 1kg.$m^{2\ -1}$ (10 $t.ha^{-1}$) dose of coffee husk compost and the 1.5 $kg.m^{2-1}$ (15 $t.ha^{-1}$) dose of rice husk ash were found to be optimal for better production of the two rainfed rice varieties tested. Also, to achieve good yields and ensure the stability and sustainability of rainfed rice systems, growers can use coffee husk compost or rice husk ash in their fields.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

All authors contributed to the work. All authors have read and approved the final version of this manuscript.

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