



RESEARCH ARTICLE

EFFECT OF WOOD ASH AS A BIOFERTILIZER ON SOME AGROMORPHOLOGICAL PARAMETERS OF PEPPERS (*Capsicum* sp.) IN NAPIEDOUGOU, NORTHERN CÔTE D'IVOIRE

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ABSTRACT

In Côte d'Ivoire, annual pepper production is estimated at approximately 10,000 tons. However, soil fertility is a limiting factor in its production. Chemical fertilizers, which are commonly used, present environmental and health risks. The search for more effective alternative methods is therefore necessary. The objective of this study is to evaluate the effect of wood ash as a biofertilizer on pepper growth and production. The experimental design was a single-factor randomized Fisher block design. Three treatments—wood ash, chemical fertilizer, and a control with no fertilizer—were applied to the habanero pepper variety. Fertilizer application rates were 50 g/planting hole for wood ash (T1), 125 g/growing bed of NPK, and 50 g/ growing bed of urea and potassium sulfate (T2), with three applications per plant. The results showed a significant difference between plant height (T1: 105.33 ± 5.67 cm and T2: 119.8 ± 1.67 cm) and the number of flowers (T1: 267 ± 3.46 and T2: 288 ± 1.53). However, there was no significant difference between stem diameter (T1: 15.99 ± 0.50 mm and T2: 16.44 ± 0.87 mm), the number of fruits (T1: 260 ± 4.41 and T2: 264 ± 3.51), and fruit yield (T1: 8.79 ± 0.45 t/ha and T2: 8.92 ± 0.12 t/ha). This study showed that wood ash at a dose of 50 g/planting hole has a positive effect on pepper production. It improved the fruit yield of the peppers; therefore it could constitute an alternative to the use of chemical fertilizers in agriculture.

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INTRODUCTION

Market gardening has emerged as a key component of urban and peri-urban agriculture, contributing significantly to the economic development of cities (Cissao, 2011). Market gardening is an important economic activity that contributes to food security and poverty reduction for rural households in Africa (Koné et al., 2022). The main vegetables grown and consumed locally in Côte d'Ivoire are tomatoes, okra, eggplant, and peppers (Fondio et al., 2015). Peppers belong to the genus *Capsicum* and the family *Solanaceae* (Kouassi et al., 2016). They are used for their pungent properties, linked to capsaicin, and for their richness in minerals and vitamins A and C (Eching El-Ghoraba et al., 2013). Their roots, leaves, and fruits are consumed as vegetables or condiments (Akaza et al., 2022). They are also used in traditional medicine (Koffi-Nevry et al., 2012) and in the pharmaceutical industry for their antioxidant and antibiotic properties (Kouassi et al., 2016). Its global production is estimated at over 27 million tons per year, while in Côte d'Ivoire, annual production is estimated at around 10,000 tons (Kouassi et al., 2016). Furthermore, peppers are one of the crops diversifying agricultural exports in Côte d'Ivoire, due to their increasingly attractive price. However, numerous factors limit pepper production in Côte d'Ivoire, including pest infestations, which are often vectors of disease (Akesse et al., 2015), and reduced soil fertility (Segnou et al., 2012).

In northern Côte d'Ivoire, the problem of improving soil fertility remains a pressing issue (Diomandé et al., 2014). The appropriate and more intensive use of chemical fertilizers is recognized as necessary to rapidly increase agricultural yields (Defoer et al., 2000). However, chemical fertilizers, in addition to being costly, pollute groundwater and hinder soil fertility as well as the quality of products with adverse effects on human, animal and plant health (Tchaniley et al., 2020). In this context, it appears necessary to seek more effective alternatives for the development of sustainable agriculture. One such alternative is the use of biofertilizers (CNA, 2020). Wood ash is an organic and ecological amendment that is not only economical but also easy to apply, providing the necessary nutrients for plants (Kaboré et al., 2025). Studies have shown that wood ash can be used as a fertilizer in agriculture (Kaboré et al., 2025; Kebli et al., 2017; Maltas and Sokrat, 2017). The objective of this study is to evaluate the effect of wood ash as a biofertilizer on the growth and production of peppers.

MATERIALS AND METHODS

Study Area: Napiéolédougou, more commonly known as Napié, is a sub-prefecture located in northern Côte d'Ivoire, specifically in the Poro region, 23 km from Korhogo. Its geographical coordinates are 9°17'29" north latitude and 5°35'25" west longitude. The climate is Sudanese, with two distinct seasons: a rainy season from April to

October and a dry season, accompanied by the harmattan wind, between November and March. Annual rainfall varies between 1200 and 1400 mm. The soil of Napié is primarily composed of a mixture of moderately to slightly desaturated ferralitic soils and ferruginous soils, all characterized by an acidic pH below 5.5.

Plant material: The plant material used was the yellow habanero pepper variety. The choice of pepper cultivation was justified by its earliness, its adaptation to local ecological conditions, and its market value.

Fertilizer materials: This consisted of mango wood ash, a mineral fertilizer composed of NPK with a formulation of 15-15-15+S+(MgO) and Urea CO(NH₂)₂.

Mineral analysis of mango wood ash: The analysis of the wood ash was carried out at the Plant and Soil Analysis Laboratory (PSAL) of the Doctoral School of Agronomy (DSA) of the Houphouët-Boigny National Polytechnic Institute (HB-NPI) in Yamoussoukro, Côte d'Ivoire. Mineral content and pH were determined.

Cultivation techniques: The nursery was established on a plot measuring 1 m x 2 m, covering an area of 2 m². For sowing, the seeds were sown in 20 rows spaced 20 cm apart. The plot was covered with straw after sowing to retain shade, moisture, and heat in the soil. The experimental plot was cleared by hand with machetes to minimize the impact of herbicides on the soil. The soil was plowed to a depth of 0-20 cm after clearing.

Experimental Design: The experimental design was a single-factor randomized Fischer block with three treatments repeated three times. The area of the experimental plot was 115 m². Each plot measured 2.5 m x 2 m, or 5 m². The distance between plots was 1 m.

Treatments: The treatments were as follows: T1: treatment with wood ash, T2: treatment with chemical fertilizer, T0: untreated control (no application). Wood ash was applied to the planting holes two weeks before transplanting in the T1 treatment plots. The quantity used was 50 g/planting hole. Then, 15 and 45 days after transplanting, wood ash was applied around the pepper plants. Regarding the chemical fertilizer (NPK), it was applied one day before transplanting the peppers in the T2 plot. The quantity of NPK applied was 125 g/growing bed. Urea and potassium sulfate were applied 30, 60, and 90 days after transplanting at a rate of 50 g/growing bed.

Crop Maintenance: The plots were watered daily from tilling until flowering or the start of the rainy season. The experimental plot was regularly weeded manually to remove weeds, potential hosts for insect pests or vectors of disease. Maintenance of the plots also included hoeing around the planting holes to promote aeration and infiltration of irrigation water. Chemical pesticides were applied every two weeks to the plants in treatments T1 and T2.

Observations and measurements: Observations were made on nine vigorous plants showing good development in each plot. The observations focused on growth and production parameters. The observed growth parameters were plant height, measured using a tape measure, and stem diameter, measured using calipers. Regarding production parameters, the number of flowers, determined by counting; the number of fruits, counted at harvest time; the harvest mass, assessed using a precision balance; and the yield were determined for each treatment. The yield was calculated using the following formula (Atepeke, 2021):

$$R = (m / n) \times (N / 1000)$$

R: yield in t/ha; m: mass of pepper harvested in Kg; n: number of plants on which the harvest was made; N: number of plants per hectare.

Data Processing: Statistical analysis was performed using Stata version 14 software to determine the effects of the treatments on the

different parameters studied. The Kruskal-Wallis test at a 5% significance level was used to compare the means.

RESULTS

Mineral composition and pH of wood ash: The results of the mineral analysis of mango wood ash revealed that it contains macroelements and microelements (Table I). Regarding macroelements, the calcium content was the highest (39.2 g/kg DM), followed by potassium (24.15 g/kg DM). In contrast, the phosphorus content was 3.55 g/kg DM. Iron, a microelement, had a content of 14.66 g/kg DM. The pH of the mango wood ash was nine, indicating a basic pH.

Table I. Mineral content and pH of mango wood ash

Minerals	Content (g/Kg DM)	pH
N	17,8	
P	3,55	
K	24,15	
Ca	39,2	
Mg	3,95	
Cl	0,65	
S	2,1	9
Na	0,288	
B	0,021	
Cu	0,235	
Mn	0,402	
Zn	0,285	
Fe	14,66	

N: Nitrogen, P: Phosphorus, K: Potassium, Ca: Calcium, Mg: Magnesium, Cl: Chlorine, S: Sulfur, Na: sodium; B: boron; Cu: copper; Mn: manganese; Zn: zinc; Fe: iron

Effect of treatments on pepper growth: The results in Table II show that the plant heights were 105.33 ± 5.67 cm, 119.8 ± 1.76 cm, and 73.6 ± 1.85 cm for treatments T1, T2, and T0, respectively. Analysis of the results revealed a significant difference between the treatments (P = 0.0273). However, regarding stem diameter, analysis of the results revealed a non-significant difference between the treatments (P = 0.0608). Thus, the stem diameter of treatment T1 (15.99 ± 0.50 mm) is statistically identical to that of plants in treatments T2 and T0, which were 16.44 ± 0.87 mm and 14.37 ± 0.23 mm, respectively.

Table II. Pepper growth parameters as a function of treatments

Treatments	Plant height(Cm)	Stem Diameter (mm)
T1	105,33 ± 5,67a	15,99 ± 0,50a
T2	119,8 ± 1,76b	16,44 ± 0,87a
T0	73,6 ± 1,85c	14,37 ± 0,23a
P	0,0273	0,0608
Significance	S	NS

T1: Treatment with wood ash; T2: Treatment with chemical fertilizer; T0: Control without fertilizer; P: P-value; S: Significant; NS: Not significant; values followed by the same letters in the same column are not significantly different (Kruskal-Wallis test at 5%).

Effect of treatments on production: Table III presents the pepper production parameters according to the treatments. Data analysis shows that treatment T2 (mineral fertilizer application) resulted in greater flowering than treatments T1 (wood ash application) and T0 (no fertilizer). The number of flowers in treatment T2 was 288 ± 1.53, followed by treatments T1 and T0 with 267 ± 3.46 and 187 ± 2.89 flowers, respectively. However, there was no significant difference between treatments T1 and T2 regarding the number of fruits, fruit mass, or yield. The number of fruits produced for T1, T2, and T0 was 260 ± 4.41, 264 ± 3.51, and 181 ± 1, respectively. Treatments T1 and T2 yielded statistically similar fruit masses. Regarding yield, treatment T2 had the highest yield at 8.92 ± 0.12 t/ha, followed by treatment T1 at 8.79 ± 0.45 t/ha. However, there was no significant difference between the yields of T1 and T2. Treatment T0, which

Table III: Pepper production parameters depending on treatments

Treatments	Number of flowers	Number of fruits	Fruit mass (g)	Yield (t/ha)
T1	267 ± 3,46a	260 ± 4,41a	1318,33± 2,42a	8,79 ± 0,45a
T2	288 ± 1,53b	264 ± 3,51a	1341 ± 2,01a	8,92 ± 0,12a
T0	187 ± 2,89c	181 ± 1c	918 ± 1,66c	6,12 ± 0,03c
P	0,0265	0,0273	0,0273	0,0273
Significance	S	S	S	S

T1: Treatment with wood ash; T2: Treatment with chemical fertilizer; T0: Control without fertilizer; P: P-value; S: Significant; values followed by the same letters in the same column are not significantly different (Kruskal-Wallis test at 5%).

which corresponds to the treatment without fertilizer application, obtained the lowest yield (6.12 ± 0.03 t/ha). There was a significant variation between the different treatments ($0.0265 \leq P \leq 0.0273$).

DISCUSSION

This study was conducted to evaluate the effect of wood ash as a fertilizer on pepper growth and production. Analysis of the results revealed variability in some of the parameters studied depending on the treatment. Regarding growth parameters, particularly plant height, the analysis of variance showed a significant difference between treatments. However, no significant difference was observed with stem diameter. Therefore, the mineral content of the wood ash was not sufficient to stimulate elongation (plant height) but was sufficient to stimulate thickness growth (stem diameter) in the pepper plants. This could be explained by the fact that the minerals in organic fertilizers are generally not immediately available, unlike those in chemical fertilizers. They must first undergo mineralization in the soil before their mineral elements become available (Kaya et al., 2001). Therefore, at a given stage of plant growth, the mineral content may or may not be sufficient to stimulate growth. These results are similar to those of Fuzesi et al. (2015) and Kaboré et al. (2025), who showed that applying wood ash did not increase plant height in mustard, ryegrass, and mung bean, respectively. However, Kaboré et al. (2025) obtained the opposite results regarding plant diameter. They indicated that there was no difference in diameter plants treated with wood ash and the untreated control.

In terms of production parameters, treatment T2 (chemical fertilizer) stimulated high flower production, statistically different from that of treatment T1 (wood ash). Data analysis revealed no significant difference in the number of fruits produced by treatments T1 and T2. Therefore, wood ash promoted the conversion of a high number of flowers (267 ± 3.46 flowers) into fruit (260 ± 4.41 fruits), unlike chemical fertilizer (264 ± 3.51 fruits out of 288 ± 1.53 flowers). This can be explained by the high potassium content (24.15 g/kg DM) of wood ash, which promotes flower and fruit development (Renaud, 2012). In terms of yield, wood ash resulted in a yield of 8.79 ± 0.45 t/ha, statistically similar to that of chemical fertilizer, which was 8.92 ± 0.12 t/ha. This yield is attributed, in part, to the high potassium content of wood ash. In agriculture, potassium contributes to increased yield (Segnou, 2014).

Furthermore, according to Ajavon et al. (2024), the macro- and micronutrient content of wood ash could also explain the observed yield increase. Indeed, these macro- and micronutrients constitute a resource for maintaining soil fertility (Pulgar et al., 2000). The progressive mineralization of organic fertilizers gives them a cumulative residual effect when applied repeatedly, which improves soil fertility and thus increases fruit yields over successive growing cycles (Kaho et al., 2011). These results are similar to those of Kaboré et al. (2025), who obtained an increase in mung bean grain yield after treatment with wood ash in Burkina Faso. Likewise, the positive effect of wood ash on production has been observed in oats, winter wheat, fescue, spinach, peas, maize, poplar, and soybeans by Demeyer et al. (2001). In this study, pepper plants treated with wood ash yielded 8.79 ± 0.45 t/ha. This is consistent with the work of Fondio et al. (2009), who stated that the average pepper yield varies from 6 to 12 t/ha depending on the species and variety.

CONCLUSION

This study shows that wood ash at a dose of 50 g/planting hole has a positive effect on flower-to-fruit conversion compared to chemical fertilizers. It resulted in a production of 260 ± 4.41 fruits per 267 ± 3.46 flowers. The pepper yield under wood ash fertilization was 8.79 ± 0.45 t/ha compared to 8.92 ± 0.12 t/ha for chemical fertilizers. Wood ash improved the fruit yield of the habanero pepper variety. It appears to be a viable alternative to the use of chemical fertilizers in agriculture.

Conflict of interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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LIST OF ABBREVIATIONS

DM: Dry Matter

DSA: Doctoral School of Agronomy

HB-NPI: Houphouët-Boigny National Polytechnic Institute

NPK: Nitrogen Phosphorus Potassium

pH: Hydrogen potential

PSAL: Plant and Soil Analysis Laboratory

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