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Combined Effects of Compost and Some Agro-Climatic Parameters on Oil Palm Fresh Fruit Bunches Production in La Mé, Southeast Côte d'Ivoire

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Abstract **Original Research Article**

Organic fertilizer is ideal for environmental protection and plant fertilization. Therefore, this investigation aims to valorize oil palm bunch processing waste, cow manure, and *Panicum maximum* as a source of fertilizer in oil palm fruit bunches production. To this end, different doses of compost made from these organic materials were tested on oil palms in production. Under the influence of agro-climatic parameters such as rainfall, temperature, and hygrometry, production parameters such as the number of oil palm fresh fruit bunches, total oil palm fresh fruit bunches weight, and average oil palm fresh fruit bunches weight were evaluated. The results obtained showed that the oil palms responded favorably to the compost used in this study. Comparison of the results from the different doses revealed that higher doses of compost led to increased oil palm fresh fruit bunches weight. Furthermore, a dose of 7 kg of this compost per oil palm proved optimal for good oil palm fresh fruit bunches production. Like compost, agro-climatic parameter such as rainfall, temperature, and hygrometry have influenced oil palm fresh fruit bunches production. Therefore, the use of compost made from incinerated oil palm bunch roundups, cow manure, and *Panicum maximum* is beneficial for fertilizing producing palm groves when agro-climatic conditions are favorable.

Keywords: Compost dose, residues, agronomic performance, Côte d'Ivoire.

INTRODUCTION

Since independence, Côte d'Ivoire's economy has relied primarily on cash crops such as coffee, cocoa, and rubber. This economic focus has neglected other strategic agricultural products. Today, fluctuating prices for these crops, combined with increasing climate challenges, have led the Ivorian government to adopt a policy of agricultural diversification and intensification. This strategy aims to boost the national economy, strengthen the resilience of production systems, and ensure food security. The oil palm sector has thus become a key and rapidly expanding sector in both rural areas and agro-industrial zones (Yéo *et al*., 2022).

In Côte d'Ivoire, oil palm plays a crucial role in food, economic and social terms, serving as an important source of income for producers and supplying local markets as well as processing units (Kouadio *et al*., 2023). However, since the 1990s, in a context of forest scarcity and strong land pressure, oil palm cultivation in Côte d'Ivoire has experienced a new boom marked by replanting and extensions on degraded and infertile soils. This now requires the integration of fertilization into oil palm cultivation practices. However, the intensive use of chemical fertilizers to the detriment of organic manure certainly increases immediate yields, but gradually degrades the structure of the soil and the environment (Ballo, 2009). It often causes a physicochemical and microbiological imbalance in soils while increasing the susceptibility of plants to diseases (Ballo, 2009). A promising strategy consists of enriching soils with organic matter via organic residues used as amendments or fertilizers (Koné *et al*., 2009) in order to compensate for nutrient losses and deficiencies observed in agricultural production systems (Bationo *et al*., 2006). In most palm oil mills, the majority of stalks are stored or incinerated without adequate treatment, thus cluttering the sites. These unsuitable practices lead to a net loss of nutrients for agricultural soils because these residues are not returned to the palm groves. It is therefore relevant to recycle them in the form of compost in combination with *Panicum maximum* and cow dung to improve the productivity of oil palm in oil palm fresh fruit bunches. This is how the present study aims to promote compost based on these organic materials as a source of organic fertilization in the production of oil palm bunches.

MATERIALS AND METHODS

Plant Material

The plant material used consisted of 10-year-old oil palms. These oil palms were propagated from the C1001F seed category, selected and promoted by the CNRA since 1995. This oil palm variety has a production potential of 25 tons of bunches per hectare per year, an oil content of 26%, an industrial extraction rate of 22 to 23%, early bunch production, strong resistance to *Fusarium* wilt, and an economically viable lifespan of approximately 30 years. It is currently the reference variety for all new oil palm plantations in Côte d'Ivoire.

Fertilization Materials

The fertilization material consisted of compost made from *Panicum maximum*, cow manure, and ash from the incineration of oil palm bunch roundups. This incineration was carried out to sanitize a palm oil mill.

Compost Preparation

A concrete-walled building measuring 2 x 1 x 1.5 m served as a composting pit for the decomposition of *Panicum maximum*, cow manure, and ash from the incineration of oil palm bunch roundups. The volumetric ratio of the constituents was 2 parts *Panicum maximum* to 1 part cow manure and 1 part ash from incinerated oil palm bunch roundups. The composting pit was filled in layers. The components of each layer were placed as follows:

- Twelve (12) wheelbarrows of *Panicum maximum*;
- Six (6) wheelbarrows of ash from incinerated oil palm bunch roundups;
- Six (6) wheelbarrows of cow manure.

After each layer, 40 liters of water were added for irrigation. This composting process was repeated until the desired volume was reached. Once the desired volume was reached, the compost pit was covered with a tarpaulin. One month after the pit was set up, the compost was turned every 15 days. These turnings were immediately followed by watering to moisten the compost. The maturity of the compost was determined by the absence of odor and heat.

Experimental Setup

The trial was conducted on a 10-year-old oil palm plot. The oil palms were planted in a staggered pattern (equilateral triangle) with a spacing of 9 meters, at a density of 143 plants/ha. The experimental design used a completely randomized Fisher block design, where different doses of each compost constituted the treatments (Table 1). Regardless of the treatment, the standard oil palm fertilization management plan was strictly followed. Each micro-plot consisted of 16 trees and the experiment was replicated three times.

Table 1: Different treatments applied to oil palms

Treatments	Description
T0	Without compost (Absolute control)
T1	With 2 kg of compost
T2	With 3 kg of compost
T3	With 4 kg of compost
T4	With 5 kg of compost
T5	With 6 kg of compost
T6	With 7 kg of compost
T7	With 8 kg of compost

Spreading of the Compost

Before spreading the compost, round around oil palm with a 2-meter radius were drawn around the base of the oil palms. The amount of compost applied was measured using templates. These quantities were then evenly distributed over the entire area of the round around oil palm, starting 1 meter from the base of each oil palm.

Evaluation of Production Parameters

Production data were recorded on the number and weight of oil palm bunches harvested per treatment. Oil palm bunches were harvested every 15 days using a sickle. At each harvest, the number of oil palm bunches per treatment was counted. The total weight of the harvested oil palm bunches, including detached seeds, was also measured using a balance scale. The number of oil palm bunches (NB) and the total oil palm bunch weight (TBW) were used to calculate the average oil palm bunch weight (PMR) per treatment using the following formula:

$$ABW = \frac{\mathrm{TBW}}{\mathrm{NB}}$$

ABW: Average weight of the oil palm bunches; TBW: Total weight of the bunches; NB: Number of oil palm bunches

Agro-climatic Assessment

The agro-climatic data focused on rainfall, hygrometry, and temperature. These data were collected daily at the CNRA La Mé meteorological station over a three-month period preceding and during the experiment. This data allowed researchers to establish correlations between climatic conditions and oil palm fresh fruit bunch production.

Statistical Analyses

The collected data were analyzed using SAS version 9.4. Normality tests were first performed to verify the conditions for applying parametric statistical analyses. Once the normality of the data was confirmed, the different variants were then compared using a one-way analysis of variance. Means were compared at the 5% significance level using the Student-Newman-Keuls test. Graphs and histograms were created using SAS 9.4 and Excel 2016.

RESULTS

Influence of Compost on Oil Palm Fresh Fruit Bunches Production Parameters Depending on Different Treatments

Analysis of Table 2 shows that the number of oil palm fresh fruit bunches (NB) changed independently of the treatments applied to the trees (P = 0.672). However, the total bunch weights (TBW) and average bunch weights (ABW) increased with increasing compost application rates. The absolute control (T0) exhibited the lowest TBW values (16.04 ± 0.08 kg) and ABW values (10.54 ± 1.55 kg/bunch). Regarding TBW, the lowest value observed in the absolute control was statistically identical to those of the four lowest compost application rates. However, the two highest doses of compost resulted in the highest oil palm bunch weights (T6: 20.74 ± 1.31 kg; T7: 22.94 ± 1.36 kg), but these were statistically identical. In the ABW level, the lowest value observed in the absolute control was statistically identical to those observed in the lower dose treatments, specifically treatments T1 (10.75 ± 0.91 kg/bunch), T2 (10.77 ± 0.86 kg/bunch), and T3 (11.03 ± 0.18 kg/bunch). Conversely, the highest doses of compost recorded the highest ABWs (T6: 13.68 ± 0.37 kg/bunch; T7: 13.86 ± 0.22 kg/bunch). However, the values of these last two ABWs were statistically identical to each other.

Table 2: Evolution of oil palm fresh fruit bunch production parameters according to different treatments

Treatments	Number of fresh fruit bunches	Total weight of fresh fruit bunches (kg)	Average weight of fresh fruit bunches (kg/FFB)
T0 (Control)	1.44 ± 0.50^{a}	16.04 ± 0.08^{de}	10.54 ± 1.55^{c}
T1	1.40 ± 0.49^{a}	14.82 ± 1.19^{e}	10.75 ± 0.91^{c}
T2	1.34 ± 0.48^{a}	15.28 ± 0.73^{e}	10.77 ± 0.86^{c}
T3	1.50 ± 0.50^{a}	16.45 ± 0.22^{d}	11.03 ± 0.18^{c}
T4	1.36 ± 0.49^{a}	17.14 ± 0.87^{cd}	12.65 ± 0.54^{b}
T5	1.44 ± 0.50^{a}	18.87 ± 1.66^{bc}	12.84 ± 0.39^{b}
T6	1.56 ± 0.50^{a}	21.52 ± 1.28^{ab}	13.68 ± 0.37^{a}
T7	1.56 ± 0.56^{a}	22.60 ± 1.39^{a}	13.86 ± 0.22^{a}
P	0.672	0.0011	0.0001
F	0.84	2.96	2.77

In the number of regimes column, average values assigned the same letter are not significantly different (Newman-Keuls test at 5%).
***FFB:** fresh fruit bunches*

Effects of Agro-climatic Parameters on Oil Palm Fresh Fruit Bunch Production

Temperature

Analysis of Figure 1 shows that the average weight of the oil palm fresh fruit bunch (ABW) followed a generally inverse trend to that of the temperature. Indeed, when the temperature increased from 28°C in October 2024 to 35°C in January and February 2025, the ABW decreased from 13.70 kg/bunch in October to 11.25 kg/bunch in February 2025. Conversely, the gradual decrease in temperature observed from February 2025 (from 35°C to 31°C in May 2025) was accompanied by an increase in the ABW, which rose from 11.25 kg/bunch to 17.14 kg/bunch in May 2025.

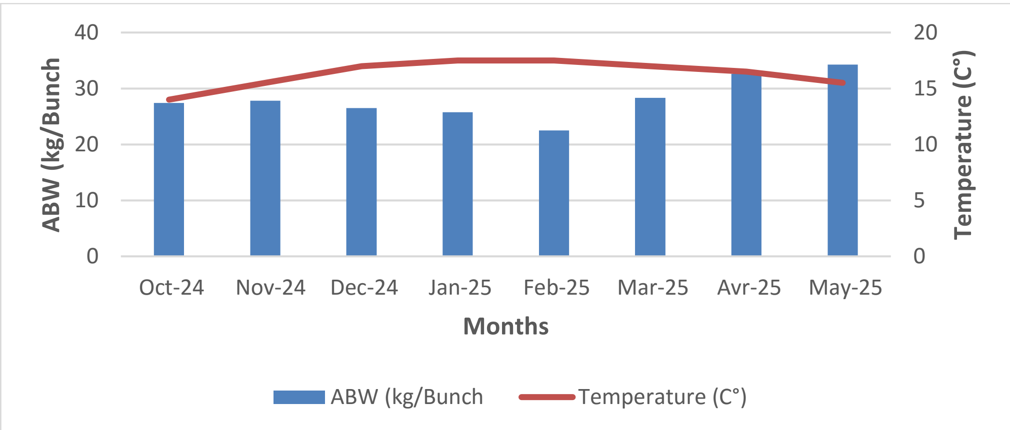

Figure 1: Evolution of average weights of diets as a function of temperature

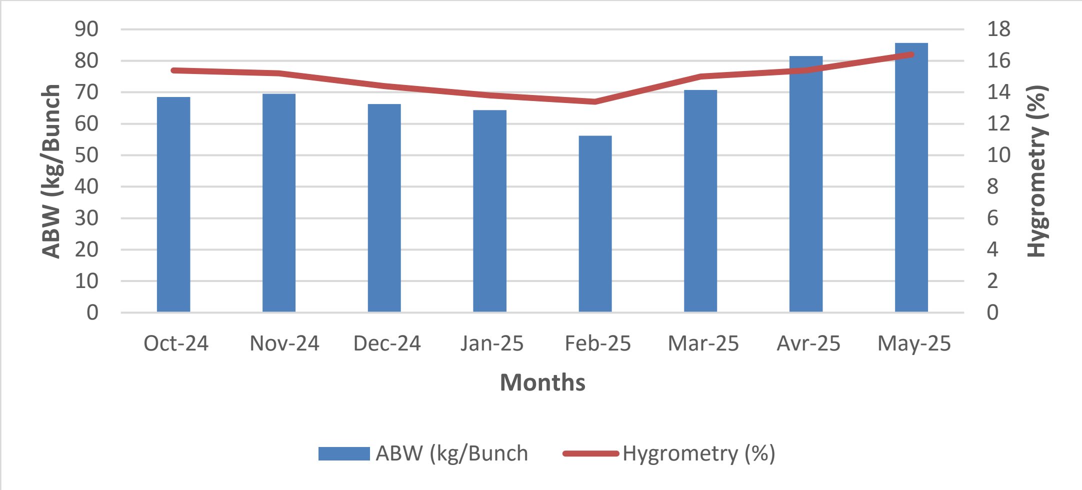

Figure 2: Evolution of average weights of oil palm fresh fruit bunches as a function of hygrometry

Rainfall

During the experiment, the average weight of the oil palm fresh fruit bunches (ABW) generally evolved in line with rainfall (Figure 3). Indeed, the decrease in rainfall, from 249 mm in October 2024 to 6 mm in February 2025, led to a decrease in ABW during this period, with values falling from 13.7 kg/bunch in October 2024 to 11.25 kg/bunch in February 2025. Conversely, the increase in rainfall observed between February 2025 (6 mm) and May 2025 (166 mm) caused an increase in ABW, which rose from 11.25 kg/bunch to 17.14 kg/bunch. During this period, ABW values were the highest (14.16 to 17.14 kg/bunch) although the amounts of rain during this period remained overall lower than those observed in the period from October to December 2024.

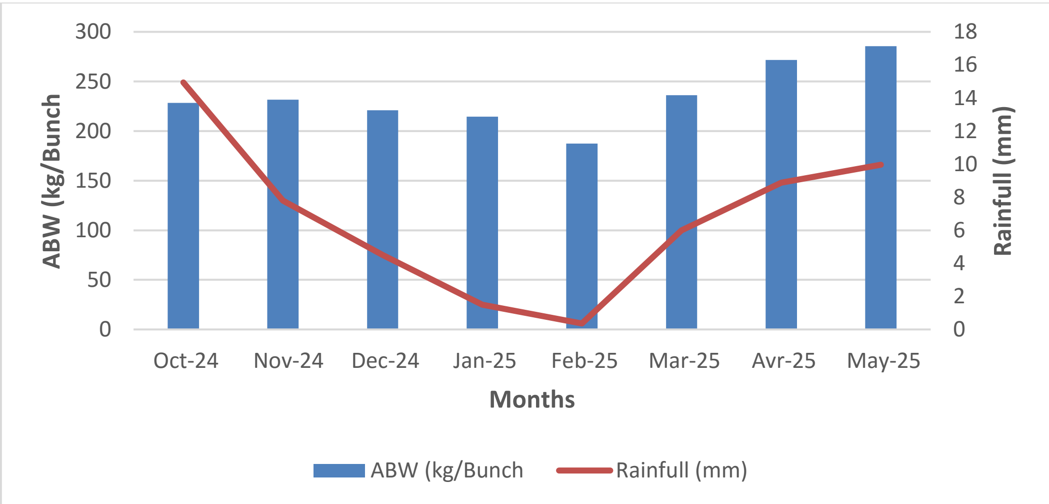

Figure 3: Evolution of average weights of oil palm fresh fruit bunches as a function of rainfall

DISCUSSION

Regarding the number of oil palm fresh fruit bunches, the analysis of the results revealed no significant difference between the different doses of compost made from incinerated oil palm bunch roundups, *Panicum maximum*, and cow manure. This shows that the application of this compost did not influence oil palm bunch formation or production. According to Beirnaert (1935), this observation could be explained by the fact that the number of oil palm bunches is primarily influenced by internal physiological and climatic factors that contribute to floral differentiation, which occurs several months before harvest. However, according to Goh *et al.,* (2000), only production expressed in terms of weight can be demonstrated in the short term following fertilization in oil palm production. Based on this, it was not surprising to observe significant differences between the variables related to total oil palm fresh fruit bunch weight (TBW) and average oil palm fresh fruit bunch weight (ABW) in the present study. This could mean that the compost used in this study had effects on the production of oil palm bunches. This influence of compost on oil palm fresh fruit bunch weight could be explained by its availability of essential nutrients such as nitrogen, phosphorus, and potassium, which promote fruit growth and development. These results are consistent with those of Jacquemard (2012), who argued that organic fertilization improves soil fertility and contributes to increased oil palm yield.

Furthermore, the more pronounced effect of compost at higher doses suggests a dose-response relationship, indicating that nutrient supply becomes optimal above a certain threshold.

Regarding agro-climatic parameters, the analysis of the results obtained showed that climatic factors played a determining role in the variation of the weight of oil palm bunches, with effects related to temperature, hygrometry and rainfall being the most important agro-climatic parameters for the production of oil palm bunches.

Analysis of the results revealed an inverse relationship between temperature and oil palm bunch weight. Indeed, the temperature increase from 28°C in October 2024 to 35°C between January and February 2025 led to a decrease in oil palm fresh fruit bunch weight, while the gradual decrease in temperature to 31°C in May 2025 resulted in a significant increase in oil palm fresh fruit bunch weight. This finding could be attributed to the effects of heat stress on the oil palm's physiological functions. High temperatures increase transpiration, exacerbate water deficits, and induce stomata closure, thus limiting photosynthesis and the production of assimilates necessary for oil palm bunch development. These results are consistent with the findings of Jacquemard (2013), who demonstrated that the optimal temperature range for oil palm is between 24 and 32°C and that beyond this range, physiological performance and yield are compromised.

Furthermore, a positive correlation was observed between hygrometry and oil palm fresh fruit bunch weight. Indeed, a decrease in relative hygrometry from 77% in October 2024 to 67% in February 2025 was associated with a decrease in oil palm fresh fruit bunch weight, while an increase to 82% in May 2025 led to a significant improvement in oil palm fresh fruit bunch weight. This finding suggests that high hygrometry reduces the vapor pressure deficit, thereby reducing excessive transpiration and maintaining good cell turgor, thus promoting fruit growth. These results are consistent with those of investigations conducted by Taiz and Zeiger (2010), who demonstrated that water exchange and stomata function are strongly influenced by atmospheric humidity.

Furthermore, the decrease in rainfall between October 2024 (249 mm) and February 2025 (6 mm) resulted in a reduction in oil palm bunch weight, while the increase to 166 mm in May 2025 was accompanied by a rise in the average oil palm fresh fruit bunch weight, reaching 17.14 kg/bunch. This suggests that water plays a central role in nutrient transport and fruit filling, thus increasing bunch weight. This assertion is supported by Jacquemard (2012), who states that insufficient rainfall is one of the main limiting factors for oil palm productivity in tropical zones. However, analysis of the results showed that the highest average oil palm fresh fruit bunch weights were recorded between March and May 2025, even though rainfall and hygrometry levels were sometimes lower than those observed at the beginning of the experiment. According to Morais *et al.,* (2024), this situation is explained by the evidence of a delayed effect of climatic conditions on fresh fruit bunch development. Indeed, in oil palm, the processes of floral differentiation and fruit development extend over several months (Beiraert, 1935). Thus, as Fleiss *et al.,* (2022) demonstrated, prior climatic conditions would have strongly influenced the production values observed in this study. This would explain the differences observed between instantaneous climatic conditions and productive performance.

In summary, the results of this study suggest intra-climatic interactions and those between different climatic factors and oil palm bunch production. The period from March to May 2025, characterized by moderate temperatures (31°C), high humidity (82%), and a resumption of rainfall (166 mm), corresponds to the most favorable conditions, with the highest oil palm bunch weights. This agro-climatic combination maximizes physiological processes such as photosynthesis, assimilate circulation, and oil palm bunch development. Conversely, the dry season, characterized by high temperatures, low hygrometry, and a rainfall deficit, constitutes a major constraint on production.

CONCLUSION

Based on this investigation, it is worth noting that agro-climatic parameters and compost made from incinerated oil palm bunch roundups, *Panicum maximum*, and cow manure did not influence oil palm bunch production in terms of quantity. However, this compost and these agro-climatic parameters had significant effects on oil palm bunch weight. This variable related to bunch production responded favorably to increased doses of the compost used in this study, thus increasing oil palm bunch weight. Objectively, a dose of 7 kg of this compost per oil palm proved optimal for good oil palm bunch yield.

Author contribution: The manuscript was edited and revised by all authors.

Conflicts of Interest: The authors declare no conflict of interest.

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