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Effect of rubber tree seed cake on the vegetative growth of oil palm in a nursery in La Mé, Southeast of Côte d'Ivoire

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ABSTRACT

The use of organic fertilizers is beneficial and less costly for both plant growth and environmental improvement. Therefore, this study aims to promote the use of rubber tree seed cake as a source of organic fertilizer in the production of oil palm plantlets and plants in nurseries. To do this, the rubber tree seed cake was transformed into a liquid fertilizer and tested at different doses on plantlets and plants either by application to substrate, watering or foliar spraying. The results obtained showed that this liquid bio-fertilizer had a beneficial effect on young oil palms when used correctly. In the pre-nursery stage, only foliar application was used. At this stage, a dose of 10 ml per plantlet resulted in the best vegetative growth performance. In the nursery stage, with this bio-fertilizer, the best vegetative growth performance was observed with a dose of 50 ml per plant applied to the substrate, 75 ml per plant applied by watering, and 100 ml per plant applied by foliar spraying. However, the foliar spraying application proved to be the most effective and did not cause any plant mortality regardless of the bio-fertilizer dose. These results demonstrate the agronomic efficacy of this bio-fertilizer derived from rubber tree seed cake. This bio-fertilizer is therefore useful in the cultivation of oil palms at the juvenile stage and could be used as an alternative to chemical fertilizers.

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INTRODUCTION

The oil palm (*Elaeis guineensis* Jacq.) is an oilseed plant belonging to the Arecaceae family. Native to West Africa, it is cultivated in tropical regions of Asia, Africa, and South America (CIRAD, 2022). The oil palm is primarily grown for its oils: palm oil and palm kernel oil. It is the leading source of vegetable fat on the global market due to its oil yields, which are 4 to 10 times higher than those of other oilseeds (Noumouha, 2015). Global palm oil production is estimated at 82,720,000 tons in 2025, with Indonesia (58%) and Malaysia (25%) accounting for the majority of this production (USDA, 2026).

Oil palm cultivation plays a dominant role in the agricultural sector in tropical Africa, particularly in West African countries such as Nigeria and Côte d'Ivoire (Gogoue *et al.*, 2024). In Côte d'Ivoire, this agricultural sector generates over 500 billion XOF in revenue annually, representing 3.13% of the gross domestic product (GDP), and ranks fourth in the Ivorian economy after cocoa, cashew nuts, and rubber tree latex (Kouadio and Kouamé, 2020). Unfortunately, this production is insufficient to meet the needs for fats at both the national and sub-regional levels, as demand for fats increases by 3% each year (Hala, 2020). To meet the demand for palm oil, Côte d'Ivoire is working to increase its production (Gogoue *et al.*, 2024). With this in mind, research programs are being undertaken to provide producers with high-performing plant material combined with technical itineraries adapted to the production environment and other agro-ecological zones (Noumouha, 2022).

The nursery stage of oil palm cultivation represents a crucial agronomic aspect. Sometimes, the expected nursery results are not achieved due to pests, diseases, or nutrient deficiencies, often linked to soil quality and the ever-increasing cost of chemical fertilizers. However, rubber tree seed cake, used as a fertilizer due to its nitrogen, phosphorus, and potassium content, could promote the growth of oil palm in nurseries. This use of rubber tree seed cake could address nutritional problems in oil palms and even replace mineral fertilizers, which are too expensive for growers, especially smallholders.

This investigation aims to promote the use of rubber tree seed cake as a source of organic fertilizer for the vegetative development of oil palm in nurseries.

MATERIALS AND METHODS

Plant material

The plant material used for the present study consisted of oil palm plantlets and plants of seed category C1001F from the second cycle of recurrent selection. This category of seed was created by the CNRA and distributed since 1995. It has a production potential of 25 tons/ha/year and an oil content of 26% (Kouamé *et al.*, 2014). It also has an industrial oil extraction rate varying between 22 and 23%. It is characterized by strong resistance to fusarium wilt, an economic operating life of up to 30 years and early productivity in fresh fruit bunches (Kouamé *et al.*, 2014).

Fertilization materials

The fertilization material consisted of urea and rubber tree seed cake provided by the CNRA research station in Bimbresso. The rubber tree seed cake served as the test, while the urea served as a relative control.

Filling bags for setting up the trials

Bags measuring 10 x 20 cm for the pre-nursery and 40 x 40 cm for the nursery, perforated one-third of the way up from the bottom, were filled with seemingly healthy potting soil. Each bag was filled to within 1 cm of the top edge, with moderate compaction of the substrate. The filled bags were then transported to the area prepared for the trial.

Setting up the pre-nursery

On the eve of sowing pre-germinated oil palm seeds, the bags were thoroughly watered. The seeds were sown by making a 2-3 cm deep hole in the center of each bag using an index finger. The seeds were then placed in the holes with the radicle facing down and the stem facing up, and finally covered with potting soil. This process was observed for three (3) months.

Setting up the nursery

On the eve of transplanting the three-month-old plantlets from the pre-nursery, the bags filled with potting soil were thoroughly watered. The plantlets were transplanted by making a 10-15 cm deep hole in the center of each bag using a dibber. In each hole, a plantlet was planted with its root ball removed from its bag. The root ball was then covered with the soil removed during the digging. This process was observed for six months.

Transformation of rubber tree seed cake into liquid fertilizer

The rubber tree seed cake has been transformed into liquid form. To do this, 2 kg of this cake were dissolved in 10 L of water in a drum. In this drum, this aqueous solution was fermented for 15 days with daily homogenization. On the 15th day, this solution was filtered using a device consisting of a drum fitted with a tap at the base (Fig. 1A). The barrel setup for filtering the solution to obtain a liquid derived from rubber tree seed cake (Fig. 1B) ready for fertilizing the plants involved four components. Arranged sequentially from the base to the barrel opening, these components were: (i) a layer of gravel (20 cm thick) extending above the level of the tap; (ii) a woven polypropylene bag (70 x 120 cm) containing the solution, tied shut at the top; (iii) a plastic sheet placed over the bag containing the solution; and (iv) two concrete bricks placed on top of the plastic sheet. The woven polypropylene bag and the pressure from the bricks acted as a press to filter the solution, making it ready for use in fertilizing the plantlets and plants.



Fig. 1. Extraction of Rubber Tree Seed Cake Transformed into Liquid Fertilizer, A: Liquid rubber seed cake extraction device; B: Liquid rubber seed cake

Use of rubber tree seed cake as a liquid fertilizer

The rubber tree seed cake transformed into an aqueous fertilizer was supplied to the plants either by foliar application, spraying watering or direct application to substrates. This aqueous bio-fertilizer was applied in the evenings, at sunset, regardless of the application method. Each dose per treatment was diluted with water to a 50% concentration.

In the pre-nursery phase, rubber tree seed cake, processed into an aqueous fertilizer, was applied once to the plantlets when they reached two (2) months of age. In contrast, during the nursery phase, this fertilization was carried out monthly, one month after the nursery was established.

The foliar spray application method was carried out using a backpack sprayer. Those by watering and by direct application to substrates were respectively carried out using a watering can and pods. However, in the pre-nursery phase, only foliar application by spraying was adopted for economic reasons, both in plant material and in time.

Furthermore, the urea constituting the relative control was applied according to usual practices.

Experimental setup

Regardless of the application method of processed rubber tree seed cake as a liquid fertilizer and the vegetative development stage of the oil palm (pre-nursery and nursery), the experimental design was a completely randomized Fisher block design. However, all three application methods were used at the nursery stage, while only foliar spraying was used at the pre-nursery stage. Different quantities of this processed seed cake constituted the various treatments applied at the pre-nursery (Table 1) and nursery (Table 2) stages. Each treatment was repeated three times.

Trial follow-up

The plantlets in the pre-nursery and the plants in the nursery were watered every morning between 6 and 7

a.m. using a watering can. To avoid overwatering, watering was not carried out during rain. Weeds growing in the bags were removed manually. Weed control in the surrounding area of the trial was carried out using chemical herbicides applied with a backpack sprayer. However, the area housing the trial was hoed with a daba (a type of hoe) to avoid any potential harm to the plants from the use of herbicides.

Data collection

The data collected included the number of functional leaves, height, diameter at the collar, and mortality rate. In the pre-nursery phase, data were collected once, at the end of this stage, three (3) days after planting. In the nursery, data were collected first 15 days after transplanting the plantlets and at the end of this phase, six (6) months after transplanting.

Regardless of the vegetative development stage, the number of functional leaves was determined by counting. Plantlet and plant heights were measured using graduated rulers. Diameters at collar were measured using calipers. Mortality rates were calculated.

Table 1. Different quantities of liquid rubber seed cake applied to oil palms in the pre-nursery stage

Treatments	Description
To1	Without fertilizer (Absolute control)
To2	With urea (Relative control)
T1	Application of 10 ml of liquid rubber tree seed cake per plantlet
T2	Application of 20 ml of liquid rubber tree seed cake per plantlet
T3	Application of 30 ml of liquid rubber tree seed cake per plantlet
T4	Application of 40 ml of liquid rubber tree seed cake per plantlet

Table 2. Different quantities of liquid rubber seed cake applied to oil palms in nurseries

Treatments	Description
To1	Without fertilizer (Absolute control)
To2	With urea (Relative control)
T1	Application of 25 ml of liquid rubber tree seed cake per plant
T2	Application of 50 ml of liquid rubber tree seed cake per plant
T3	Application of 75 ml of liquid rubber tree seed cake per plant
T4	Application of 100 ml of liquid rubber tree seed cake per plant
T5	Application of 125 ml of liquid rubber tree seed cake per plant
T6	Application of 150 ml of liquid rubber tree seed cake per plant

Data analysis

The collected data were subjected to ANOVA analysis using SAS software version 9.4. Differences between treatment means were separated using Tukey's test at a significance level of 5%.

RESULTS

Influence of rubber tree seed cake transformed into liquid fertilizer on the vegetative growth of oil palm seedlings in pre-nursery

Regardless of the growth parameter, results of analysis of variance showed a decrease in vegetative growth with increasing doses of processed rubber tree seed cake as liquid fertilizer (Table 3). Treatment T1, with the lowest dose of processed rubber tree seed cake as liquid fertilizer, exhibited the highest vegetative growth values (diameter at collar: 8.37 ± 0.14 mm; number of functional leaves: 5.61 ± 0.32; height growth: 25.88 ± 0.44 cm).

These values were followed by those elicited by fertilization with urea To2 (diameter at collar: 7.91 ± 0.19 mm; number of functional leaves: 5.16 ± 0.98; height growth: 24.01 ± 1.02 cm), which were statistically identical to those expressed by the treatment T2 (diameter at collar: 7.43 ± 0.49 mm; number of functional leaves: 4.18 ± 0.51; height growth: 22.38 ± 1.23 cm). On the other hand, the treatment T4 with the highest dose of rubber tree seed cake transformed into liquid fertilizer showed the lowest vegetative growth (diameter at collar: 5.87

± 0.08 mm; number of functional leaves: 1.85 ± 0.11; height growth: 15.04 ± 1.68 cm). In ascending order, these were followed by those exhibited by treatment T3 (diameter at collar: 6.38 ± 0.32 mm; number of functional leaves: 2.58 ± 0.57; height growth: 19.23 ± 1.32 cm), which were in turn followed by those of the absolute control treatment T01 (diameter at collar: 7.07 ± 0.35 mm; number of functional leaves: 2.62 ± 0.52; height growth: 20.78 ± 1.52 cm). Furthermore, regarding plantlet mortality, results of analysis of variance showed that the higher the quantity of the bio-fertilizer liquid, the higher the mortality rate (Table 3).

Table 3. Variation in growth parameters of oil palm plantlets according to different doses of rubber tree seed cake transformed into liquid fertilizer, applied by foliar spraying

Treatments	Number of functional leaves	Diameter at collar (mm)	Height growth (cm)	Mortality (%)
T01	2.62 ± 0.52^{c}	7.07 ± 0.35^{d}	20.78 ± 1.52^{d}	2.78
T02	5.16 ± 0.98^{ab}	7.91 ± 0.19^{bc}	24.01 ± 1.02^{b}	2.13
T1	5.61 ± 0.32^{a}	8.37 ± 0.14^{a}	25.88 ± 0.44^{a}	4.17
T2	4.18 ± 0.51^{b}	7.43 ± 0.49^{cd}	22.38 ± 1.23^{c}	9.85
T3	2.58 ± 0.57^{c}	6.38 ± 0.32^{e}	19.23 ± 1.32^{d}	35.12
T4	1.85 ± 0.11^{d}	5.87 ± 0.08^{f}	15.04 ± 1.68^{e}	63.24
P	0.0011	0.0231	0.0101	

Values with the same letter in the same column are not significantly different according to Tukey's test ($p < 0.05$).

Table 4. Variation in plant growth parameters according plant growth parameters to different doses of rubber tree seed cake transformed into liquid fertilizer, applied to substrate

Treatments	Number of functional leaves	Diameter at collar (cm)	Height growth (cm)	Mortality (%)
T01	8.32 ± 0.33^{c}	4.07 ± 0.33^{cd}	54.68 ± 0.37^{b}	0
T02	13.03 ± 1.08^{a}	7.16 ± 0.35^{a}	64.72 ± 0.36^{a}	0
T1	10.59 ± 1.09^{b}	5.93 ± 0.41^{bc}	58.77 ± 0.39^{b}	0
T2	12.86 ± 1.15^{a}	6.53 ± 0.21^{b}	62.57 ± 0.21^{a}	0
T3	9.86 ± 1.06^{b}	5.92 ± 1.06^{bc}	54.74 ± 1.08^{b}	8.33
T4	6.57 ± 0.35^{d}	3.65 ± 0.19^{d}	19.58 ± 1.41^{c}	25
T5	3.30 ± 1.95^{e}	3.39 ± 0.04^{e}	6.36 ± 1.31^{d}	58.33
T6	-	-	-	100
P	0.0114	0.0031	0.0102	

Values with the same letter in the same column are not significantly different according to Tukey's test $p<0.05$.

Influence of rubber tree seed cake transformed into liquid fertilizer on the vegetative growth of oil palm when applied to a substrate during the nursery phase

The analysis of variance revealed that, whatever the growth parameter, the increase in the dose of rubber tree seed cake transformed into liquid fertilizer initiated an increase in the growth of the plants until reaching the peaks at the level of treatment T2 (Table 4). From treatment T2, the growth values evolved regressively with the increase in the dose of rubber tree seed cake transformed into liquid fertilizer.

Whatever the growth parameter, treatment T02 (Relative control: urea) displayed the highest values. However, in terms of the number of functional leaves, the value expressed by treatment T02 (13.03 ± 1.08) was statistically identical to the value obtained by T2 (12.86 ± 1.15). The same was true for plant height where the value obtained from T02 (64.72 ± 0.36 cm) was statistically identical to that displayed by treatment T2 (62.57 ± 0.21 cm). In terms of collar diameter, only the value presented by treatment T02 (7.16 ± 0.35 cm) was greater than that expressed by treatment T2 (6.53 ± 0.21 cm). The latter was statistically identical to that displayed by the T3 treatment (5.92 ± 1.06 cm). Furthermore, plant mortality was observed from treatment T3 (8.33%).

From this treatment, the increase in the dose of rubber tree seed cake transformed into liquid fertilizer initiated that of the mortality of the plants until causing the death of all the plants subjected to the maximum dose of the bio-fertilizer (T6: 100%).

Table 5. Variation in plant growth parameters according to different doses of rubber tree seed cake transformed into liquid fertilizer, applied by watering

Treatments	Number of functional leaves	Diameter at collar (cm)	Height growth (cm)	Mortality (%)
To1	8.41 ± 0.37^{c}	3.85 ± 0.37^{d}	50.34 ± 0.41^{d}	0
To2	12.89 ± 0.34^{a}	7.49 ± 0.34^{a}	62.69 ± 0.36^{b}	0
T1	10.94 ± 0.56^{bc}	5.83 ± 0.18^{c}	60.58 ± 0.20^{c}	0
T2	12.78 ± 0.9^{a}	6.32 ± 0.19^{b}	65.84 ± 0.21^{b}	0
T3	13.22 ± 0.98^{a}	7.92 ± 0.98^{a}	74.33 ± 0.96^{a}	0
T4	11.47 ± 0.61^{b}	6.21 ± 0.07^{b}	59.34 ± 0.09^{c}	0
T5	9.07 ± 1.38^{c}	3.93 ± 0.15^{d}	32.38 ± 0.97^{e}	8.33
T6	7.07 ± 0.92^{d}	3.62 ± 0.11^{e}	28.24 ± 0.17^{f}	25
P	0.0011	0.0231	0.0101	

Values with the same letter in the same column are not significantly different according to Tukey's test ($p < 0.05$).

Influence of Rubber tree seed cake transformed into liquid fertilizer on the vegetative growth of oil palm when applied by watering during the nursery stage

Results of analysis of variance showed that, regardless of the growth parameter, increasing the dose of processed rubber tree seed cake as liquid fertilizer initiated an increase in plant growth, reaching peaks at treatment T3 (Table 5). From treatment T3 onward, growth values decreased with increasing doses of processed rubber tree seed cake as liquid fertilizer. However, the number of functional leaves and diameter at collar values observed with treatment T3 were statistically identical to those of treatment T2. Furthermore, plant mortality was observed at the highest doses of processed rubber tree seed cake as liquid fertilizer, particularly at treatments T5 (8.33%) and T6 (25%).

Table 6. Variation in plant growth parameters according to different doses of rubber tree seed cake transformed into liquid fertilizer, applied by foliar spraying

Treatments	Number of functional leaves	Diameter at collar (cm)	Height growth (cm)	Mortality (%)
To1	8.32 ± 1.04^{e}	4.07 ± 1.01^{e}	54.68 ± 7.24^{c}	0
To2	13.03 ± 0.39^{c}	7.16 ± 0.42^{c}	64.72 ± 4.39^{bc}	0
T1	12.12 ± 0.23^{d}	6.01 ± 0.28^{d}	54.68 ± 8.28^{c}	0
T2	14.45 ± 0.25^{b}	7.11 ± 0.32^{c}	68.16 ± 6.32^{bc}	0
T3	15.52 ± 0.88^{ab}	8.88 ± 0.76^{ab}	77.92 ± 4.74^{ab}	0
T4	16.79 ± 0.60^{a}	9.22 ± 0.67^{a}	83.34 ± 2.16^{a}	0
T5	16.27 ± 0.94^{a}	9.02 ± 0.25^{a}	78.34 ± 4.02^{ab}	0
T6	13.64 ± 0.19^{c}	8.18 ± 0.27^{b}	73.15 ± 5.34^{b}	0
P	0.0011	0.0131	0.0114	

Values with the same letter in the same column are not significantly different according to Tukey's test ($p < 0.05$).

Influence of rubber tree seed cake transformed into liquid fertilizer on the vegetative growth of oil palm when applied by foliar spray during the nursery phase

Overall, regardless of the dose of processed rubber tree seed cake converted into liquid fertilizer, growth values were higher than those observed in the control treatments. Results of analysis of revealed that, regardless of the growth parameter, increasing the dose of processed rubber tree seed cake converted into liquid fertilizer initiated an increase in plant growth, reaching peaks at treatment T4 (Table 6). From treatment T4 onward, growth values decreased with increasing doses of processed rubber tree seed cake converted into liquid fertilizer. Furthermore, no plant mortality was observed with the foliar application of processed rubber tree seed cake, regardless of the dose of this fertilizer.

DISCUSSION

The use of rubber tree seed cake as an organic fertilizer has highlighted a change in growth parameters, with average values more or less higher than those recorded in the control treatments.

This demonstrates that rubber tree seed cake, transformed into a liquid bio-fertilizer, had a significant effect on the growth of juvenile oil palms. This increase in growth parameters could be explained by the fact that the rubber tree seed cake, transformed into a liquid bio-fertilizer, is rich in nutrients such as nitrogen, phosphorus, potassium, etc. According to Taiz *et al.* (2015), the nutrient richness of this cake promotes photosynthesis, cell division, differentiation, protein synthesis, and meristem elongation. Similar studies conducted in Côte d'Ivoire by Essehi *et al.* (2016) showed that the application of organic fertilizer based on rubber tree seed cake has a positive impact on the growth parameters of young rubber tree plants and legumes.

Analysis of the results revealed that the methods of application of the liquid bio-fertilizer based on rubber tree seed cake would have a considerable impact on the effectiveness of the bio-fertilizer. Indeed, the foliar application method by spraying highlighted the best agronomic performances in terms of growth parameters, more particularly with the treatment T4 (100 ml) in the nursery. This performance could be explained by the fact that the absorption of nutrients through the leaves triggers a rapid response from the plants. According to Pimentel *et al.* (2023), applying fertilizer via foliar spraying allows the plant to absorb some of the nutrients through leaf pores, particularly the stomata, making the nutrients immediately available. This aligns with the findings of Lessard (2024), who demonstrated that foliar spraying of fertilizers corrects deficiencies through a rapid plant response. Furthermore, some of the fertilizer may be carried in the substrate through runoff from the leaves, improving the substrate's physical and chemical properties to ensure better nutrient uptake by the plant (Marschner, 2012). Also, the analysis of the results also showed that the substrate and watering application methods were less effective than the foliar spraying application method, although their best performance on the growth parameter was highlighted by the treatment T2 (50 ml) at the substrate application level and by the treatment T3 (75 ml) at the watering application level. These results could be due to the fact that all or almost all of the bio-fertilizer applied to the plants accumulated in the substrate. Indeed, as with direct application of bio-fertilizer to the substrate, almost all or all of the bio-fertilizer applied to the plants by watering would have run off the plant cuticles to reach the substrate. Consequently, for both application methods (on substrate and by watering), the bio-fertilizer would have taken sufficient time in the plants' rhizosphere before reacting, or a large portion of this bio-fertilizer would have been lost through leaching due to the daily watering of the nursery. These results are consistent with those of studies conducted in Egypt by Rana and Nazik (2023), which showed that foliar application of fertilizer resulted in better performance in terms of rose height, number of leaves, and flowering compared to soil application. In a study on maize, Fageria *et al.* (2009) also showed that soil application of fertilizers could be less effective than foliar application under certain conditions, particularly when root activity is impaired.

Regarding plant mortality rates, the results showed that in the pre-nursery stage, for doses of 30 ml per plantlet (T3) and 40 ml per plantlet (T4), the recorded mortality was very high (T3: 35.12%; T4: 63.24%). This could be explained by the fact that, at this stage of vegetative development (0 to 3 months), the 30 ml and 40 ml doses could be toxic to the plantlets because, according to Okoma *et al.* (2025), rubber tree seed cake is rich in nitrogen (N), phosphorus (P), and potassium (K). These results are consistent with those of Essehi *et al.* (2016) and Tchabi *et al.* (2012), who showed that increasing fertilizer doses, making them toxic to plants, could lead to an increase in plant mortality rates. In the nursery, the application of the fertilizer product based on rubber seed cake both on substrate and by watering caused significant mortality of the plants, which was not the case with the method of application by foliar spraying where no mortality of the plants was observed.

This absence of mortality in the method of application by foliar spraying could be due either to a quantity of the fertilizing product being carried away by the wind or to a deviation of a quantity of this bio-fertilizing product towards the ground. This would eliminate the toxicity of the fertilization product whatever its dose.

It is in this consistency that M'Sadak *et al.* (2023) showed that plants receive less fertilizer through foliar spraying than through watering. On the other hand, M'Sadak *et al.* (2023) reported that the application of fertilizer to the substrate leads to an accumulation of the product at the substrate level and thus causes high plant mortality, 15 days after application.

CONCLUSION

Based on this investigation, it is clear that rubber tree seed cake, processed into a liquid fertilizer, has a beneficial influence on oil palm growth in both pre-nurseries and nurseries when used correctly. The application method affects the performance of this bio-fertilizer. In pre-nurseries, a dose of 10 ml per plantlet of this bio-fertilizer showed the best performance in terms of growth parameters. In nurseries, foliar spraying at a dose of 100 ml per plant resulted in the best performance in plant growth.

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