Original Research Article

Effect Of Vermicompost And Vermiwash On Vegetative Growth Of Rubber Plants in Bagged Nurseries

التعليق [DS٢١]: Vermicompost tea

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ABSTRACT

Success in rubber growing is linked to the production of vigorous plants in the nursery. However, this cruel stage faces difficulties related to the cost of chemical fertilizer and its availability. This work carried out in ٤ localities (Bimbresso, Alépé, Abengourou and Daoukro) in Côte d'Ivoire aimed to improve the production of rubber plant material in nurseries in polyethylene bags using vermicompost and Vermicompost tea ~~vermiwash~~. The experimental design used is a Fisher block with three treatments and two repetitions. The vermicompost, Vermicompost tea ~~vermiwash~~ and control factors were compared with each other. The addition of vermiwash and the control for three months while the addition of vermicompost was done only once. The results indicated that Vermicompost tea ~~vermiwash~~ is the most expressive treatment on the vegetative development of plants regardless of the study site. In Bimbresso, the Vermicompost tea ~~vermiwash~~ and vermicompost treatments gave the highest increases with ١.٢٣ and ١.٢١ mm.month$^{-١}$, compared to ١.١٣ mm.month$^{-١}$ for the control. Also, the highest rate of graftable plants, grafting success and plants transferable to the field was obtained with Vermicompost tea ~~vermiwash~~. Likewise, the mortality rate obtained with vermicompost and Vermicompost tea ~~vermiwash~~ was less than ٢٠٪. These treatments could be recommended in the production of rubber plant material.

التعليق [DS٢٢]: Vermicompost tea

التعليق [DS٢٣]: Vermicompost tea

التعليق [DS٢٤]: Vermicompost tea

التعليق [DS٢٥]: Vermicompost tea

التعليق [DS٢٦]: Vermicompost tea

التعليق [DS٢٧]: Vermicompost tea

التعليق [DS٢٨]: Put a word (Vermicompost tea) Instead of (vermiwash) in the entire manuscript

*Keywords : vermicompost, **Vermicompost tea** ~~vermiwash~~, nursery, Hevea brasiliensis, Côte d'Ivoire*

١. INTRODUCTION

Agriculture is the backbone of Côte d'Ivoire economy. This sector represents approximately ٣٣٪ of GDP and ٦٦٪ of the country's export earnings. It employs more than two thirds of the country's active population [١]. Côte d'Ivoire is the world's leading producer of cocoa, the leading producer of rubber in Africa and the third African producer of cotton and coffee [١]. Agriculture has contributed significantly to the growth of the Ivorian economy and continues to be its cornerstone. In addition to its economic role, agriculture makes Côte d'Ivoire a mosaic of agricultural lands, patiently shaped by human labour, each with its own combination of different modes of production: cash crops, food crops, livestock, market gardening, fruit and horticultural production, forestry, etc. However, this important agricultural economy, dependent on its land resources and their potential, is subject to significant degradation and a decline in soil fertility [٢]. Indeed, in Côte d'Ivoire, soils are subject to increasingly intensive agricultural exploitation due to the growing needs generated by demographic growth and the lack of arable land [٣]. The major constraint mentioned by farmers is the gradual decline in the production capacity of cultivated land. This situation results from inadequate management of land fertility. However, agricultural by-products and other organic materials considered as waste are widely available and renewable and can be recovered in the form of soil amendment products as they are or transformed by various techniques. One of the processing techniques is composting, which allows for organic matter to be sufficiently developed to release nutrients into the soil-plant complex. However, the compost which is commonly used certainly allows an improvement in the physicochemical properties of the soil and soil fauna but could contain heavy metals which can deteriorate the nutritional quality of agricultural products [٤]. Considering all its disadvantages, the use of organic~~bio~~fertilizers (vermicompost and~~ ~~ Vermicompost tea ~~vermiwash~~) appear to be credible alternatives for the farming community, particularly among rubber tree nurseries. These organic fertilizers are the products of a new technology called vermitechnology. This technology is a method of converting and recovering organic waste into Organic fertilizers ~~biofertilizers~~ useful to plants thanks to the actions of earthworms [٥, ٦]. This is a natural, odourless aerobic process that is different from conventional composting. This process produces a compost, which does not include a thermophilic phase (no heat) in its production, and a liquid, called “Vermicompost tea ~~vermiwash~~ or compost juice or tea”. The effectiveness of vermicompost and Vermicompost tea ~~vermiwash~~ in soil fertilization and phytosanitary protection of plants has been proven by several studies [٧ - ٩]. This study aims to improve the production of rubber plant material using Organic fertilizers ~~biofertilizers~~ (vermicompost and Vermicompost tea ~~vermiwash~~) of earthworm metabolic products.

٢. MATERIAL AND METHODS

٢.١ Study Area

The study was conducted in four localities in Côte d’Ivoire, they are the Bimbresso Research Station of the CNRA, Alépé, Daoukro and Abengourou (Fig ١). The choice of these localities was based on the high representativeness of rubber cultivation. The experimental site of the CNRA Bimbresso Research Station (N ٠٥° ١٨' ٤٥.٢" and W ٠٠٤° ٩' ١٨.٩"), in the commune of Songon, in the South-East of Côte d’Ivoire, ٢٤ kilometers from Abidjan, on the Abidjan – Dabou axis. The department of Alépé is in the South-East of Côte d'Ivoire between (N ٠٥° ١٧' and ٦° ٧٠' and W ٠٠٤° ٦٦' and ٣° ٤٣'). The town of Alépé is located at ٤٥ km northeast of Abidjan. The Abengourou department is in the East of Côte d’Ivoire, in the Indénié-Djuablin region, between latitudes (N ٠٥° ٤٥ and ٧° ١٠ and W ٠٠٣° ١٠ and ٣° ٥٠). Finally, the Daoukro department (N ٠٦° ٥٥' and ٧° ٣٢' and W ٠٠٣° ٢٩' and ٤° ٣٤') is in the N'zi Comoé region, in the Centre-East of Côte d'Ivoire. According to information from Sodexam (٢٠٢٠), the experimental site of the CNRA Research Station of Bimbresso and the Department of Alépé is ma Tablerked by a transitional humid subtropical climate with four seasons including a long dry season from January to February, a long rainy season from March to July, a short dry season in August and a short rainy season from October to December.

التعليق [DS٢٩]: That is right

التعليق [DS٢١٠]: Organic fertilizers not biofertilizers

منسّق:الخط: دون غامق، دون مائل، خط اللغة العربية وغيرها: دون غامق، مائل

التعليق [DS٢١١]: vermicompost andVermicompost tea are Organic fertilizers not biofertilizers. Please correct it in the entire manuscript.

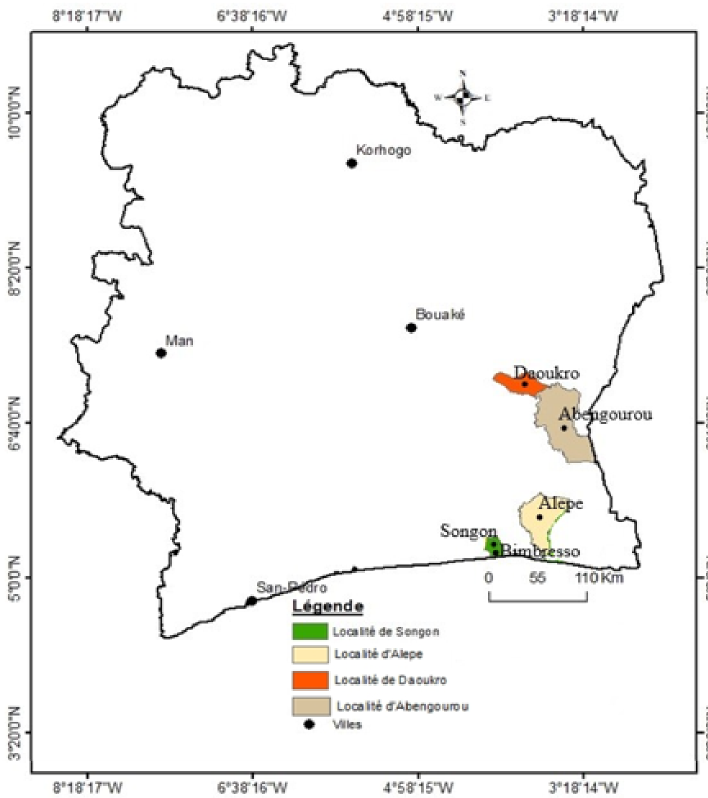


Figure ١ : Localisation of study sites

٢.٢ Vegetal material

The GT١ clone of *Hevea Brasiliensis* was used as rootstock. This clone was selected for its high rate of success in grafting plants [١٠]. The plant material used to graft the plants varies from one nurseryman to another. These grafts come from the five clones popularized in rural areas in Cote d'Ivoire. There clones are GT ١, PB ٢١٧, IRCA ٤١, IRCA ٢٣٠ and IRCA ٣٣١.

٢.٣ Fertilizer material

Vermicompost tea ~~Vermiwash~~, vermicompost and mineral fertilizers were used for soil fertilization. Urea (٤٦٪ N), Super-Gro, NPK and Fertimax are the mineral fertilizers used as controls in the experimental plots.

٢.٤ Production of organic ~~bio~~fertilizer (vermicompost and~~-~~ Vermicompost tea ~~vermiwash~~)

The production of organic ~~bio~~fertilizers (vermicompost and Vermicompost tea ~~vermiwas~~h) starts from a pre-decomposition of chicken droppings in black tarpaulins lasting approximately ١.٥ to ٢ months depending on the number of turnings and watering on the site (Fig ٢ A). After the partial decomposition stage, the pre-decomposed organic matter is put into drums with a volume of ~~of~~ ١٠٠ l fitted with a tap at the base. These drums are filled in successive layers from the base to the opening as follows:

- laying a layer of rubble or crushed granite ١٠ to ٢٠ cm thick (Fig ٢ B).
- laying a layer of fine sand ٥ to ١٠ cm thick (Fig ٢ B).
- laying a layer of mature compost (chicken droppings) ٤٠ to ٦٥ cm thick (Fig ٢ B)
- introduction of ٥٠ to ٦٠ individuals of mature earthworms per barrel, preferably of the Eisenia genus (Fig ٢ C).
- supply of water, with a volume of ٢ l in a drainer suspended from the table above the barrels.

All these activities made it possible to produce vermicompost and Vermicompost tea ~~vermiwash~~ in the production device presented in Figure ٢D.

Figure ٢ : Vermicompost and Vermicompost tea ~~vermiwash~~ production steps **A:** Pre-decomposing chicken droppings; **B:** Rubble, sea sand, pre-decomposed chicken droppings; **C**: Earthworms of the genus Eisenia introduced into the filled barrel; **D**: Complete assembly of a vermicompost and Vermicompost tea ~~vermiwash~~ production device with drainers, ١٠٠ l drums and ٢٥ l cans to collect the Vermicompost tea ~~vermiwash~~

٢.٥ Experimental Design

The experiment, on all study sites, was carried out using a Fisher block design with ٣ treatments (control, vermicompost and Vermicompost tea ~~vermiwash~~) and repeated twice (Fig ٣). The blocks, being separated by ١ m, are each made up of ٨٠ tetrads spaced ٢٠ cm.

Each treatment contains ٣٢٠ plants, or ٩٦٠ plants for the three treatments. The vermicompost treatment bags were filled with ٢/٣ potting soil and ١/٣ vermicompost. As for the Vermicompost tea ~~vermiwash~~ treatment, it consisted of applying the Vermicompost tea ~~vermiwash~~ in polyethylene bags, filled entirely with potting soil, at the foot of each plant, ٣ times during the experiment (٤٥th; ١٠٥th and ١٦٥th day after transplanting). Before application, the Vermicompost tea ~~vermiwash~~ was diluted to ٥٠٪ with water. The control treatment was the usual practice of nurserymen for fertilizing plants in nurseries. This treatment was the application of urea (٤٦٪ N) on the Bimbresso site, Fertimax on the Alépé site, Super-Gro on the Abengourou site and NPK at Daoukro site according to the recommended doses. Each plant receives ٤ g of urea diluted in ٥٠ ml of water.

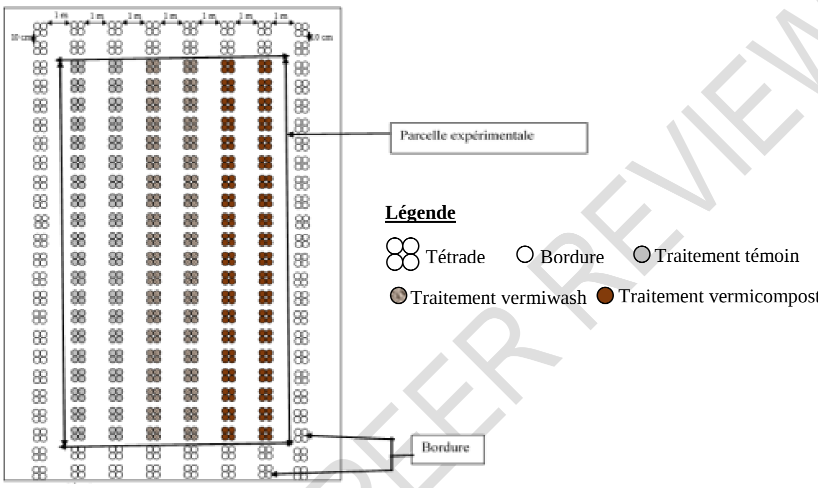


Figure ٣: Experimental Design

٢.٥ Collection of data

٢.٥.١ Monitoring vegetative growth parameters

Measurements of the vegetative growth parameters of the rubber plants were carried out monthly during and at the end of the nursery cycle, from the ١st to the ٦th month after transplanting. These measurements are taken on the height (mm), the diameter at the collar (mm). The measurement of these two parameters (height and diameter at the collar) made it possible to calculate the average monthly increase in height (ΔH) and diameter at the collar (ΔC), as well as the growth gain expressed as a percentage of the relationship with the control substrate taken as a reference.

$$\Delta C\left(\text{mm}.mois^{-١}\right) = \frac{Mf-M_i}{\Delta t} \times ٣٠ \quad (١)$$

ΔC : Average monthly increase in collar diameter and height ;
Mf**:** Final measurement,
Mi: Final measurement.
Δt : Period between final measurement and initial measurement

٢.٥.٢ Production of rubber plant of nursery

- **Rate of graftable rubber plants**

The rate of graftable rubber plants, determined from the ٦th month after transplanting, was calculated according to the following formula:

$$T \times G\ (\%) = \frac{NbPt(٩)}{NbPtT} \times ١٠٠ \qquad (٢)$$

TxG (%): Rate of graftable rubber plants.
NbPt (٩): Number of plants with a diameter ≥ ٩ mm [١١].
NbPtT: Total number of plants.

- **Grafting success rate**

The grafting success rate, expressed as a percentage, is equal to the ratio of the number of successful grafts to the total number of grafts placed.

$$T \times R\ (\%) = \frac{NbPtR)}{NbPtP} \times ١٠٠ \qquad (٣)$$

TxR (%): Grafting success rate.
NbPtR: Number of plants successfully grafted,
NbPtP: Number of plants planted.

- **Rate of plants transferable to the field**

The diameter measurements at the collar taken ٦٠ days after grafting made it possible to determine the rate of plants transferable to the field. A rubber plant in the nursery, successfully grafted, can be transferred to the field when it reaches a collar diameter greater than or equal to ١٥ mm [١١, ١٢]. The rate of plants transferable to the field is formulated as follows:

$$T \times T\ (\%) = \frac{NbPt\ (١٥)}{NbPtT} \times ١٠٠ \qquad (٤)$$

TxT (%): Rate of plants transferable to the field after grafting;
NbPt (١٥): Number of grafted plants with a diameter greater than or equal to ١٥ mm
NbPtT: Total number of plants received at grafting.

٢.٥.٣ Plant mortality rate in the field

The mortality rate of rubber plants was determined according to the following formula:

$$TM\ (\%) = \frac{NbPtM}{NbPtT} \times ١٠٠ \quad (٥)$$

TM (%): Mortality rate.
NbPtM: Number of dead plants
NbPtT: Total number of plants per treatment

٢.٦ Statistical data analysis

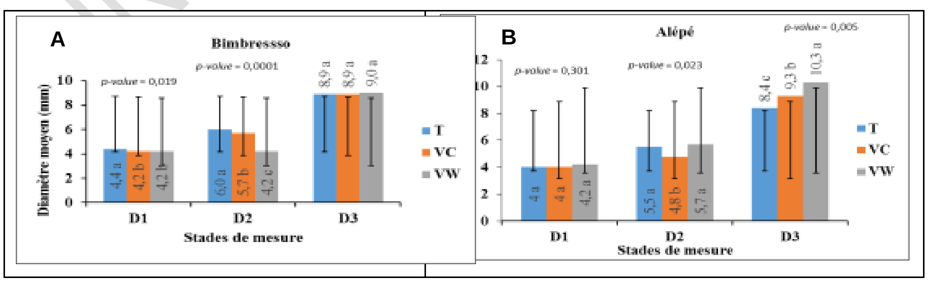
Tests for comparing the means of a variable are widely discussed [١١ - ١٣]. The choice of a method depends on several parameters. In this study, where it was often a matter of comparing the means of variables tested on more than two treatments, one-way analysis of variance (ANOVA ١) was used. The degree of freedom is ($n – k$) where n and k are the numbers of observations and groups respectively. The level of significance chosen for this analysis is ٥٪ (*p-value* ≤ ٠.٠٥). When the difference is significant, a post-hoc test (*Tukey test*) was carried out to classify and find out which of the treatments are different. This analysis was carried out with XLSTAT software version ١٢.٠

٣. RESULTS

٣.١ Vegetative growth parameters of rubber plants

- **Diameter at the collar of rubber plants**

The analysis of variance of the diameter at the collar of the rubber plants carried out at ١st measurement (٥٠ day after transplanting) showed that there is a significant difference between the different treatments (*p-value* = ٠.٠١٩) at Bimbresso (Fig ٤A). At the ٢nd measurement (٧٩ day after transplanting), a statistical difference was observed (p-value = ٠.٠٠٠١). The control treatment presented the highest mean diameter values (٦ mm). This was followed by vermicompost (٥.٧ mm) and Vermicompost tea ~~vermiwash~~ (٤.٢ mm) treatments. The average values of diameter at the collar at the ٣rd measurement (١٦٧ day after transplanting) of the rubber plants of the three treatments indicated statistically similar values (٨.٩ to ٩ mm). In Alépé, at the ١st measurement, no significant difference was observed between the average values of plant diameter (*p-value* = ٠.٣٠١). The diameter varied from ٤ to ٤.٢ mm (Fig ٤B). However, significant differences were noted in the ٢nd and ٣rd measurements (*p-value* = ٠.٠٢٣ *and* ٠.٠٠٥). The Vermicompost tea ~~vermiwash~~ treatment is the one which recorded the highest average diameter values of around ٥.٧ mm (٢nd measurement) and ١٠.٣ mm (٣rd measurement). At Abengourou, no significant difference was observed whatever the stage of the measurements (*p-value* = ٠.٠٥٢) (Fig ٤C). The average values of plant diameters were ٤.٣ mm, ٦.٣ mm and ١٠.٣٣ mm respectively at the ١st, ٢nd and ٣rd observations for all treatments. At Daoukro, significant differences were observed between the diameters of the plants of the different treatments at all observations (*p-value* = ٠.٠٠٠١, Fig ٤D). At the ١st observation, the plants of the control treatment displayed the highest average values of diameter at the collar (٤.٣ mm), followed by those treated with Vermicompost tea ~~vermiwash~~ (٣.٩ mm) and vermicompost (٣.٤ mm). At the ٢nd and ٣rd measurements, the Vermicompost tea ~~vermiwash~~ treatment presented the highest average values of ٥.٤ to ١٠.١ mm respectively at the ٢nd and the ٣rd measurement.



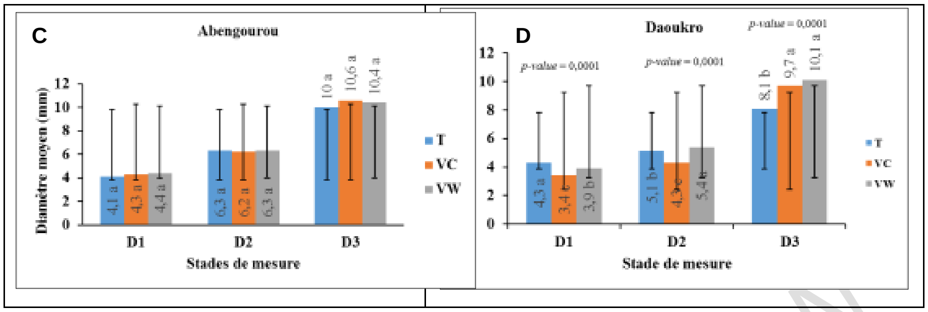


Figure ٤ (A, B, C et D): Evolution of the diameter at the collar during the ٠٣ measurement stages in Bimbresso, Alépé, Abdennour and Daoukro. The average values followed by the same letter *a, b, c,* in the same column are not significantly different at the ٥٪ threshold, p: Probability. T: Control, VC: Vermicompost, VTW:-Vermicompost tea Vermiwash)

➢ **Average monthly growth of rubber plants**

The analysis of variance of the average monthly growth of rubber plants showed that on the Bimbresso site, the Vermicompost tea vermiwash and vermicompost treatments favoured the highest average monthly growth for respective values of ١.٢٣ and ١. ٢١ mm. month-١ (Fig ٥). In Alépé, statistical differences were observed (*p-value* < ٠.٠٥). The Vermicompost tea vermiwash treatment presented the highest average monthly increase of around ١.٥١ mm. month-١ (Fig ٥). It was followed by vermicompost treatments (١.٣ mm. month-١) and the control (١.٠٩ mm. month-١). At the Daoukro site, the average monthly increase presented high values for the vermicompost (١.٦٩ mm. month-١) and Vermicompost tea vermiwash (١.٦٦ mm. month-١, Fig ٥) treatments. The plants in the control treatment had the lowest values (١.٠٢ mm. month-١). At Abengourou, no statistical difference was observed between the different treatments. The average monthly increase is between ١.٦١ and ١.٦٩-mm. month-١ (Fig ٥).

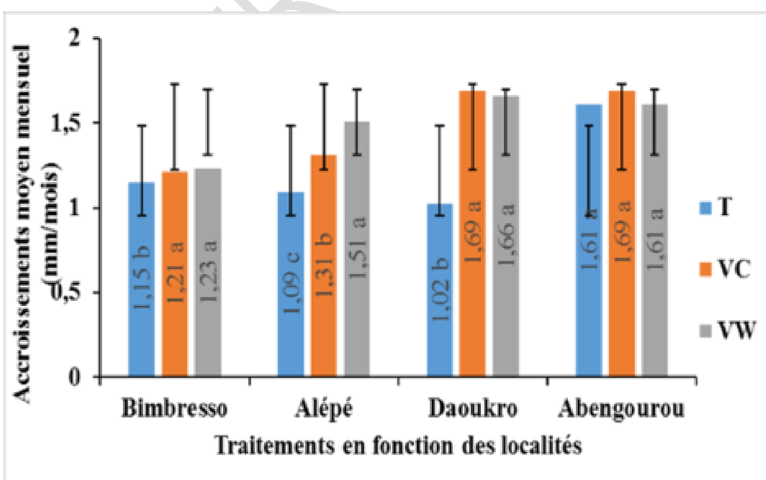


Figure ٥: The collar diameter increasing average by month with the different treatments according to the different localities (Mean values followed by the same letter in the same column are not significantly different at the ٥٪ threshold. T: Witness; VC: Vermicompost; VTW: Vermicompost tea Vermiwash).

٣.٢ Weight dimensional parameters

- **Rate of graftable plants**

The evaluation of the rate of graftable plants (TxG) indicated significant differences between the treatments on the four sites. In Bimpresso (Fig ٦B), this rate was higher with the control treatment (٧٤٪). It was followed by Vermicompost tea vermiwash treatment (٧١٪). The vermicompost treatment recorded the lowest rate of graftable plants (٦٩٪). In Alépé (Fig ٦ B), the rate of graftable plants was high for the Vermicompost tea vermiwash treatment with a proportion of (٧١.٢٥٪). On the Abengourou experimental site (Fig ٦ C), the rate of graftable plants was high for the Vermicompost tea vermiwash treatment with (٧٦.٢٥٪) and the control treatments, vermicompost showed rates of ٧٠ and ٦٤٪ respectively. Finally, in Daoukro (Fig ٦ D), it was the Vermicompost tea vermiwash treatment which presented the highest rate of graftable plants (٤٤٪).

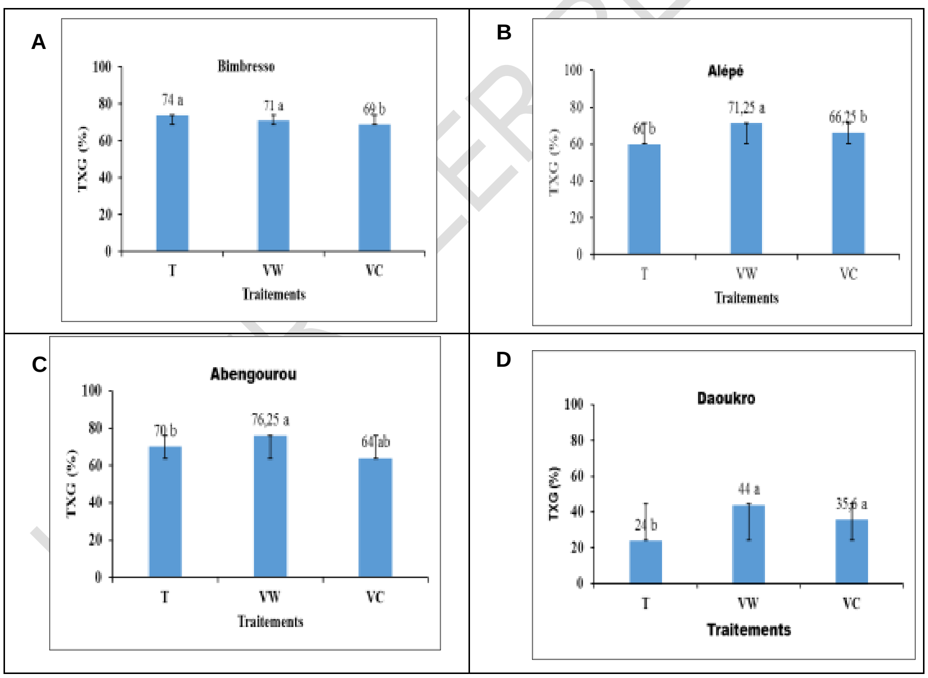


Figure ٦ (A, B, C et D): Rate of graftable plants by treatment by locality (T: Control; VC: Vermicompost; VW: Vermiwash)

- **Success rate of plants at grafting**

The evaluation of the grafting success rate of the plants showed a good expression of the Vermicompost tea ~~vermiwash~~ (VW) treatment between the treatments on the four sites. At Bimpresso, the proportion of plants successfully grafted was higher for the Vermicompost tea ~~vermiwash~~ treatment with ٧٩٪ (Fig ٧A). It was ٧٥٪ for the control treatment and ٦٦٪ for the vermicompost treatment. In Alépé, the Vermicompost tea ~~vermiwash~~ and control treatments respectively presented rates of (٧١.٨٧٪) and ٧٠٪ of plants successfully grafted (Fig ٧B). The success rate for grafting plants from the vermicompost treatment was ٥٣.٧٥٪. At Abengourou site (Fig ٧C), the plants from the Vermicompost tea ~~vermiwash~~ and control treatments had respective grafting success rates of ٧٨.١٢ and ٧٦.٨٧٪ for the control. This rate was ٦٥.٦٢٪ for the vermicompost treatment. In Daoukro (Fig ٧D), plants treated with Vermicompost tea ~~vermiwash~~ had a grafting success rate of ٤٥.٦٢٪, compared to ٤٠٪ for the control treatment and ٣٥.٦٢٪ for vermicompost.

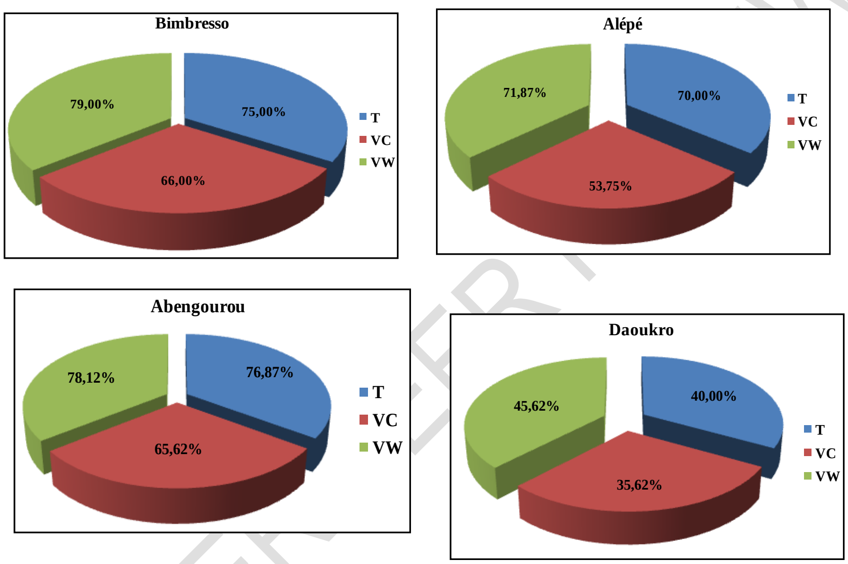


Figure ٧ (A, B, C et D): Success rate (TxR) for grafting by treatment and by locality (T: Control; VC: Vermicompost; VT~~W~~: Vermicompost tea ~~Vermiwash~~)

- **Rate of plants transferable to the field ٦٠ days after grafting**

The evaluation of the rate of plants transferable to the field on the Bimpresso experimental site indicated significant differences between the three treatments (*p-value* = ٠.٠٣٠). This rate was ٦٥.٨٩٪ for the Vermicompost tea ~~vermiwash~~ treatment. The control and vermicompost treatments have a rate of ٦٢.١٣٪ and ٥٢٪ respectively (Fig ٨). In Alépé, the rate of plants transferable to the field was higher with the Vermicompost tea ~~vermiwash~~

(٦٧.٢٠٪) and control (٦٥٪) treatments. This rate was low for the vermicompost treatment (٥٠.٢١٪). At the Abengourou site, a significant difference was observed between the treatments (*p-value* = ٠.٠٠١). The rate of plants transferable to the field was higher for Vermicompost tea ~~vermiwash~~ treatments with ٧٤.٣٧٪ (Fig ٨). The control treatment followed with ٦٧.٥٠٪ and the vermicompost treatment ٦٣.٧٥٪, the lowest rate. In Daoukro, a significant difference was also observed (*p-value* = ٠.٠٢١). The rate of plants transferable to the field was always high for the Vermicompost tea ~~vermiwash~~ treatment (٢٤.٣٧٪). It was ٢٠٪ for the control treatment. As for vermicompost treatment, this proportion was very low (١٢.٥٠٪).

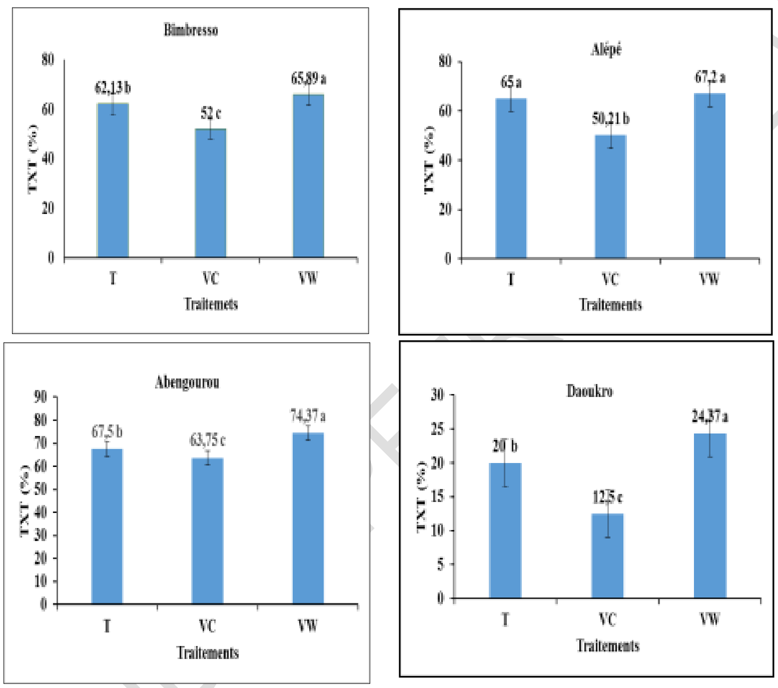


Figure ٨٣ **:** Rate of plants transferable to the field at ٦ months depending on the treatments on the different study sites (T: Control; VC: Vermicompost; VT~~W~~:–Vermicompost tea ~~Vermiwash~~)

- **Average mortality rate of nursery of rubber tree**

On the Bimbresso experimental site (Fig ٩), the mortality rate was ٨.٨٠٪ for the vermicompost treatment, ٧٪ for the control treatment and ٣.٩٠٪ for the Vermicompost tea ~~vermiwash~~ treatment. In Alépé, the Vermicompost tea ~~vermiwash~~ and control treatments presented mortality rates of ٥.٦٣٪ and ٦.٥٠٪ respectively. The vermicompost treatment showed a rate of ١١.٨٨٪. On the Abengourou site, the highest plant mortality rate, of ٢١.٣٨٪, was recorded with the vermicompost treatment. Those of the Vermicompost tea ~~vermiwash~~ and control treatments were around ٨.٣٪ and ١١.٢٥٪ respectively. This rate was for treatment. In Daoukro, plants treated with Vermicompost tea ~~vermiwash~~ showed a mortality rate of ٨.٣٠٪, those of the control (١٠.٧٥٪) and vermicompost (٢١.٣٨٪) treatments. The average mortality rate of rubber plants is presented in Table ١. The average mortality rate of plants was greater for the vermicompost (١٥.٣٦٪) and control (٨.٨٧٪) treatments. This rate was low for the Vermicompost tea ~~vermiwash~~ treatment (٦.٤٨٪).

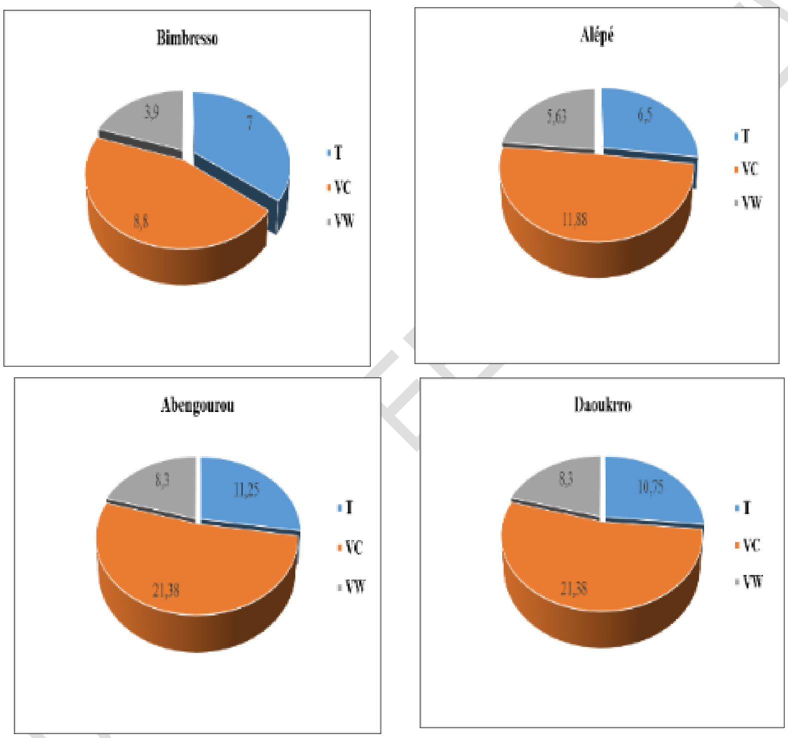


Figure ٩: Average mortality rate of nesury of rubber tree by locality

Table ١: Mortality rate by treatment for all localities

Treatments	Mortality average rate
T	٨,٨٧ ± ٢,٥١ b
VC	١٥,٣٦ ± ٣,١٥ a
VW	٦,٤٨ ± ٢,٢١ b

p-value	٠,٣٠١

Mean values followed by the same letter in the same column are not significantly different at the ٥٪ threshold. T: Witness; VC: Vermicompost; VTW: Vermicompost tea Vermiwash

٤. DISCUSSION

The evaluation of the effect of vermicompost and Vermicompost tea vermiwash on the vegetative development of rubber plants in bag nurseries showed that Vermicompost tea vermiwash and vermicompost promote good isodiametric development of the plants with significant monthly increases. This optimal development of rubber plants in nurseries under the effect of these organicbiofertilizers could be explained, on the one hand, by the fact that the organic matter contained in these fertilizers improves the structure of the soil because of its bonds with the particles. minerals and adhesive materials produced by microorganisms. Mineral elements therefore become easily assimilated by the plant. These results are like those of Coulibaly [٩] who showed that compost, particularly vermicompost, promotes stem development and leaf growth of *Largenaria siceraria*. On the other hand, earthworm droppings are an intimate mixture of plant and mineral particles, and the nutrients are present there in higher concentration and in a form easily assimilated by plants [١٦]. Added to this, the mucus secreted by earthworms during vermicomposting would increase the nitrogen content, as shown by [٩, ١٦-١٧], in their work. According to these authors, earthworms have nitrogenous substances in their mucus as well as growth hormones such as auxins, gibberellins, cytokinins and enzymes which promote plant growth. The investigations of Abdullah [٨], carried out in India, also showed that Vermicompost tea vermiwash and vermicompost promote good stem development as well as good foliar growth of spinach (*Spinacia oleracea*) and potato (*Solanum tuberosum*). According to Steffen [١٨], the nutrients in compost are slowly released into the soil at levels that strictly meet the needs of the plant and are easily assimilated. The high rates of graftable plants observed with Vermicompost tea vermiwash could be explained by the nutritional value of this liquid biofertilizer which results in rapid provision of the nutrients essential to the plant for its development. Indeed, Zambare [٧] and Ndegwa [١٩] showed that during vermicomposting, the most important nutrients such as nitrogen (N), potassium (K), phosphorus (P) and calcium (Ca) are quickly released and become easily absorbable by the plants. plants. These nutritional values of Vermicompost tea vermiwash have enabled several rubber plants to reach a significant rate of graftable plants in record time. This study also indicated that the probability of successful grafting of rubber plants in nurseries is higher with Vermicompost tea vermiwash on all sites. This could be explained by the good mineral element content of this organic biofertilizer. Indeed, Vermicompost tea vermiwash which is an aqueous extract of vermicompost, collected in the presence of a rich population of earthworms, contains several enzymes, plant growth hormones, vitamins as well as macro and micronutrients which quickly provide nutrients to the plant during its development cycle [٢٠]. This good availability of nutrients must have strengthened the vigour of the rootstocks by allowing them good adhesion with the scion, which favoured the resumption of the physiological process [١١, ٢١]. Vermicompost tea Vermiwash applied to plants was less harmful with low plant mortality rates. However, vermicompost caused more mortality of rubber plants. These plant mortality rates observed with vermicompost could be explained by the high dose of vermicompost given to the plants. Our work agrees with Essehi [٢٢, ٢٣, ٢٤, ٢٥, ٢٦, ٢٧]. Indeed, these authors showed that increasing doses of organic manure, particularly compost in bags intended for nurseries, could increase the mortality rate, making these doses harmful to the plants.

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التعليق [DS٢١٣]: [٢٢, ٢٣,٢٤,٢٥, ٢٦, ٢٧] .These references are located at the end of the reference list. These references are recent.

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٥. CONCLUSION

The results obtained in this study showed that the use of organic~~bio~~fertilizers (vermicompost and Vermicompost tea ~~vermiwash~~) promotes good radial development with optimal monthly growth of rubber plants. The nutritional values of these two have enabled many rubber plants to reach the diameter required for grafting in record time. Furthermore, the probability of success in grafting rubber plants in bag nurseries was good for Vermicompost tea ~~vermiwash~~, with mortality rates less than ٢٠٪. The good expression of Vermicompost tea ~~vermiwash~~ in this study indicates that this biofertilizer could be used as a substitute or in combination with mineral fertilizer, commonly applied in rubber tree nurseries in Ivory Coast. The adoption of Vermicompost tea ~~vermiwash~~ in rural areas could also contribute to reducing environmental degradation. However, before any popularization of Vermicompost tea ~~vermiwash~~ and even vermicompost which was the best organic fertilizer in this study, an economic study must be carried out on production costs and gains after the sale of the nursery plants.

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