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RESEARCH ARTICLE

EFFECT OF SPENT MUSHROOM SUBSTRATE (OYSTER MUSHROOM SMS) ON THE GROWTH IN NURSERIES OF THE FRAKÉ (*TERMINALIASUPERBA*) AND THE FRAMIRÉ (*TERMINALIAIVORENSIS*) AT DALOA (CENTRAL WEST OF CÔTE D'IVOIRE)

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ABSTRACT

Fraké and Framiré are among the main timber products in West Africa. They are used extensively in carpentry and in pharmacopoeia. This work consisted in comparing the effect of different doses of organic fertilizers, particularly residual substrate to the production of oyster mushrooms on the growth and development of young plants of Fraké (*Terminaliasuperba*) and of Framiré (*Terminaliaivorensis*). To do this, direct seedling of Fraké and Framiré seed was carried out on various substrates consisting of five doses of this organic fertilizers (T0 = control, T1 = 10 t/ha, T2 = 30 t/ha, T3 = 40 t/ha, T4 = 60 t/ha) using a system of complete randomized blocks with three repetitions and two levels of factors. Plants were followed through of the plant growth parameters (stem height and diameter). Analyses of the results showed that in Fraké, all doses induces greater growth compared to the control (T0). The T4 dose (60 t.ha-1) was the most significant, with a dominant height of 14,70±1,57 cm and an average diameter of 3,88±0,12 mm at the last data (15th week after seedling). In Framiré, analyses of the results of all growth parametres studied were statistically insignificant (P≥0,05) at any doses level. In short, SMS appeared as an organic fertilizers capable to fertilizing the soils through its richness in organic matter and to positively influence growth of Fraké plants.

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INTRODUCTION

The forest surface in Africa adjoins 675 millions of hectares is 17% of the world forest area of which 95% represent the natural formations and 5% of the forest plantations (Kokutse, 2002; FAO, 2011). The increase constantly increasing of the needs made of wood of the driven African populations a more and more strong pressure on the woody resources. This situation results in a fragmentation of the natural formations (Adjossou, 2009). The skimming of the natural forests, the rarity and the disappearance of the value essences as the Fraké and the Framiré, dragged the reduction of the ecological continuity of the big biomes of the semideciduous forests of the forest zone from then on. The forest surface of the Côte d'Ivoirefor example, that added up to 16 million hectares in 1960, it is estimated today to about 2.5 million hectare (FAO, 2011).

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The surexploitation of the forest made of wood of work and woods of energy and the fires of bush is the reasons of this loss (FAO, 2009). In this context of deterioration, the satisfaction of the needs of the populations in woody forest products, pass by the restoration of the forests damaged (Kokutse, 2002) and the setting up of the artificial plantations (Adjonou, 2007). To arrive there, the creation of modern forest nursery enrolling in a lasting development context respectful of the environment proves to be necessary. Thus, the notion of a competitive agriculture to satisfy the increasing needs of the world population and to respect the environment, in order to confront the challenges. The recent research moved toward the adaptation of new techniques and process. Among them, one can mention the organic fertilization that results from the dating, that permits the biologic decomposition and the stabilization of the organic substrata (Mustin, 1987; Stofella & Kahn, 2001) while constituting one fashion of management of the organic garbage more respectful of the environment thus while encouraging ecological agricultural practices and especially like an aspect important of fertilization in lasting agriculture. Otherwise, the use of compost stays less in Côte d'Ivoire, notably in modern forest nurseries. Compost remains the substratum the more used for the production of the plantations, notably the non-standardized that present the characteristic physico-chemical mediocre and encourage the multiplication of the pathogenic having some repercussions on the young plantations since their setting in culture. From then on, the use of fertilizing organic proves to be to be an alternative to solve the crucial problem of the fertility of soils and to optimize the production of forest plantations. In addition, the biologic agriculture is recognized by the society like one fashion of production respectful of the environment. It appears therefore necessary to undertake the studies aiming to propose to the societies hired in the forestry notably the SODEFOR in Côte d'Ivoire and to the particular forest plantation producers the doses of fertilizing organic adequate to use to get optimal and less expensive productions. Specifically, the study aim to evaluate the effect of the different doses of organic fertilizer (SMS) on the parameters of growth of the Fraké *(Terminaliasuperba*) and the Framiré (*Terminaliaivorensis)*

MATERIELS

Experimental Site: The site of experimentation of the university Jean Lorougnon Guédé, in the city of Daloa, served to drive the experimentations. Daloa is a city of the Central west of the Côte d'Ivoire, in West Africa (Figure 1). County seat of the region of the High Sassandra, Daloa is situated to 383 km of Abidjan (economic capital). Its population in 2012, was estimated to 261789 inhabitants. It is also the 3rd city the more populated, after Abidjan and Bouaké (INS, 2015). The climate is the one of the domain Guinean, characterized by an equatorial régime and sube quatorial to two maxima rainfall. The month of June represents the peak of the big rainy season and the one of September, the peak of the small season. These two maxima separated more or less by one or two months rainy (Husk, 2005). The geological formations are essentially those of the Précambrien middle, dominated by the granites, to which are added some intrusions of shale and flysch. According to the studies achieved by Dabin and al. (1960), soils in the department of Daloa are fairly washed ferralitiques (or désaturés). The pedological characters present, a less acidic pH (5.3 to 6.5), a content in exchangeable bases more elevated (5 to 8 cmol.kg-1) and a distinctly more levated saturation rate (40 to 50%); a better evolution of the organic matter that stabilizes in a horizon humifère results from it, the C/N report is in general neighbor of 9 to 12 (Zro and al., 2016).

METHODS

Growth substrate preparation: The preparation of the growth substrate took place in two stepstages. The first consisted to the preparation of the substratum and the second to the preparation of the organic substratum. The substratum of growth has been gotten from the mixture of the organic substratum and the substratum to equivalent quantities in order to get a final substratum of 1g/phytocel.

Preparation of the substrates: The red earth appropriated on the site of the experimentation has been stocked to the ambient air on an awning, after sifter. The coarse elements that are there the plastic matters, the shards and other undesirable elements been extracted.

Preparation of the organic substratum: The obtaining of the SMS substrate follows a process that leaves from the preparation of the substratum for the culture of the mushroom until its withdrawal of the mushroom farm. The substratum for the culture of the mushroom is quite a mixture of sawdust of wood, of sound of rice and bicarbonate of calcium, the sprinkled of water, and put in dating during 45 days. The thus gotten substratum is deposited then in heat-resistant plastic sachets pasteurized to big fire during 2h30minute in metallic barrels, to rid it of the parasites. This substratum is inoculated by the spawn of the oyster mushroom for the production of carpophore. After a cycle of production, the vestigial substratum is put back in dating during one month for the organic manure production known under the term of spent mushroom substrate (SMS). In order to determine the quantity of organic substratum to apply to the different doses, we took into account the surface (S) of the basis of the containing (phytocels). A report has been established with the dose (kg/m2). The basis of the containing in the setting the survey had a shape a circular of 10 cm of diameter. The formula below was established, in order to determine the quantity of organic substratum by dose of fertilizing.

$$Q\ (g) = (S \times D)/10000$$

S: surface (m2) of the container, D: dose to apply in Kg, Q: quantity of organic substrate

Experimental design: The test has been carried with 300 phytocels under an ombre constructs to this effect according to a device in complete blocks randomized to three repeated. It is composed of 30 elementary plots, long of 1m and large of 0,5 m each. An elementary plot contains 10 phytocels of nurseries is a total of 300 phytocels. The blocks separated of 1 m one of the other, every block consists of 100 phytocels of which by elementary parcel (Figure 2).

Preparation of the plant material: The preparation of the plant material consisted in removing the wings that are on both sides of the seed of the Fraké and the Framiré before the date of setting in earth. Because of the thick character of the cockle of the seeds, we soaked them in water during 24hours to remove the dormancy. Have been withdrawn them and kept then at the free area during one half-day. A direct seedling of the seeds at the rate of a seed by phytocel has been made the morning early before the sunrise in order to keep the humidity inside the phytocels.A watering has been made before and after the seedling to encourage germination. An opening of 2 to 3 cm has been made in the phytocels before putting the seeds in the soil to facilitate germination.

Collection of the data: The collection of the data has been done on a sample of 90 plantations at the rate of 3 plantations by elementary parcel. The data collected to the level of the plantations are about the height and the diameter of the plantations.

Height and leaves numbers: The mean height of the plantations has been measured every other week (of the 5ième to the 15ième week after seedling).

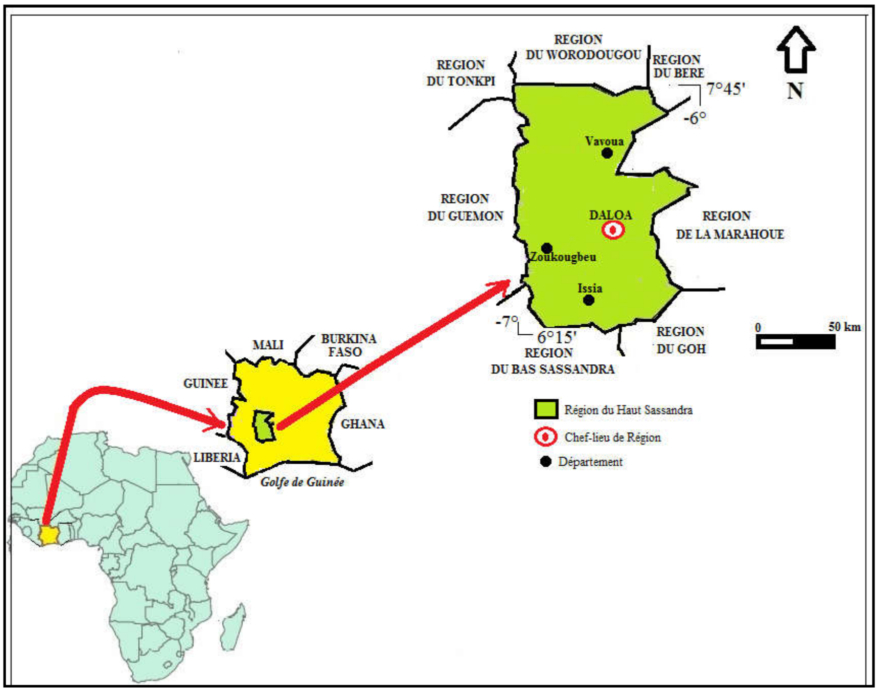
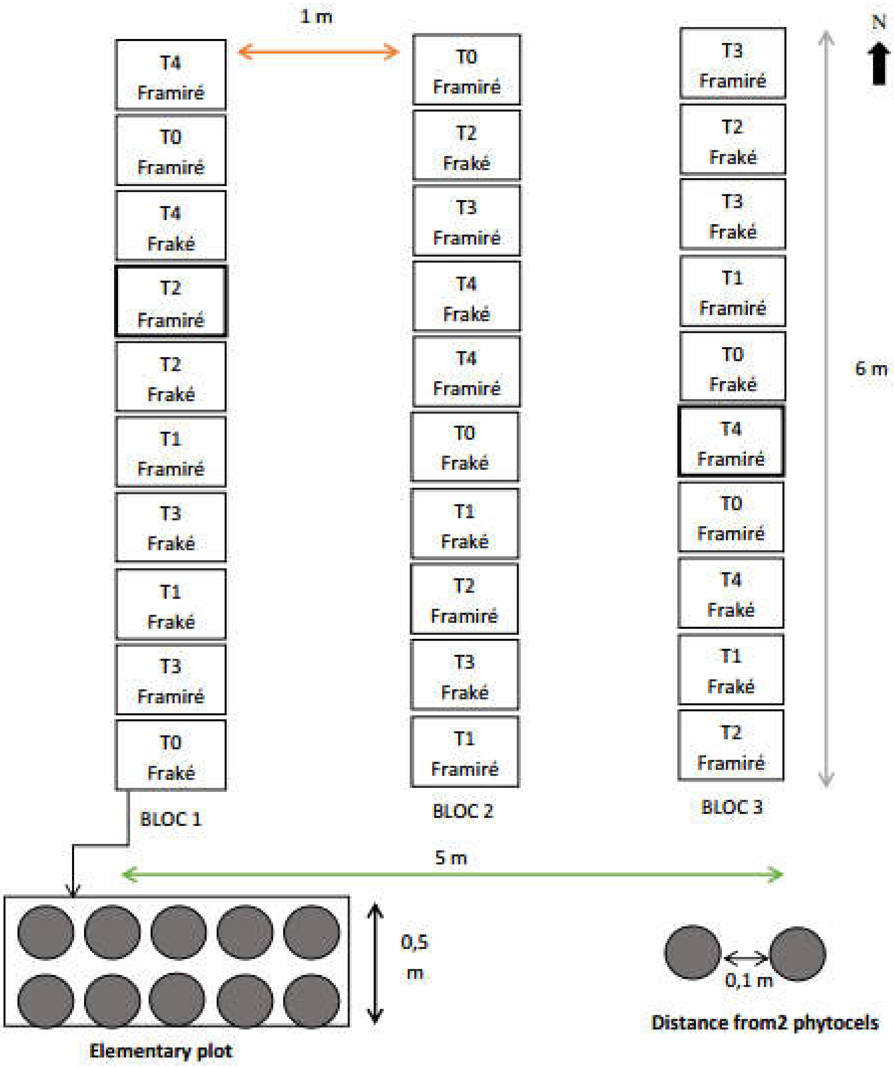


Figure 1. Location of the region of the upper Sassandra (INS, 2015)



T0 : control T1 : 10t/ha, T2 : 30t/ha, T3 : 40t/ha, T4 : 60 t/ha

Figure 2. Experimental design

Tableau 1. Height mean comparison according to different treatments

	Height (cm)					
	5 SAS	7 SAS	9 SAS	11 SAS	13 SAS	15 SAS
Framiré						
T0	3.66±0.38^{a}	4.63±0,51^{a}	5.47±0.65^{a}	6.17±0.93^{a}	7.23±1.63^{a}	8.07±1.25^{a}
T1	3.36±0.95^{a}	4.07±1,12^{a}	5.37±0.93^{a}	6.60±0.87^{a}	8.17±0.67^{a}	9.10±0.75^{a}
T2	3.40±0.56^{a}	4.30±0,44^{a}	5.70±0.72^{a}	6.87±1.05^{a}	7.77±0.68^{a}	8.07±0.51^{a}
T3	2.66±0.83^{a}	3.40±1,05^{a}	4.60±1.35^{a}	6.00±1.00^{a}	7.63±0.45^{a}	9.30±1,68^{a}
T4	2.86±0.31^{a}	3.57±0,40^{a}	4.50±0.20^{a}	5.57±0.23^{a}	7.33±0.71^{a}	9.03±1.40^{a}
prob	0.428^{ns}	0.331^{ns}	0.305^{ns}	0.437^{ns}	0.783^{ns}	0.581^{ns}
Fraké						
T0	3.5±0.27^{a}	3.97±0,25^{c}	4.47±0.45^{c}	5.00±0.26^{d}	5.90±0.30^{c}	7.00±0.20^{c}
T1	3.5±0.38^{a}	5.53±0,06^{ab}	5.83±0.15^{bc}	6.63±0.21^{cd}	7.53±0.21^{bc}	9.63±0.32^{bc}
T2	3.7±0.12^{a}	5.70±0,35^{ab}	6.20±0.20^{abc}	8,30±0.62^{bc}	9.03±0.25^{b}	10.53±0.30^{bc}
T3	4±0.15^{a}	5.95±0,07^{ab}	6.90±0.14^{ab}	9.20±0.99^{b}	10.05±0.64^{ab}	12.00±0.71^{ab}
T4	3.8±0.15^{a}	6.60±0,44^{a}	8.30±0.95^{a}	10.67±0.90^{a}	12.57±1.36^{a}	14.70±1.57^{a}
prob	0.053^{ns}	0.000**	0.0000**	0.000**	0.000**	0.000**

*In the same column, each value followed by the same later are not significantly different(T0 :control, T1 : 10t/ha, T2 : 30t/ha, T3 : 40t/ha, T4 : 60t/ha). ns : non significant ; * : significant ; ** : highly significant ; SAS : week after semi, prob probability*

Tableau 2. Mean comparison of the stem diameter

	Stem diameter (mm)					
	5 SAS	7 SAS	9 SAS	11 SAS	13 SAS	15 SAS
Framiré						
T0	0.81±0.20^{a}	1.11±0.08^{a}	1.21±0.05^{a}	1.37±0.06^{a}	1.57±0.12^{a}	1.70±0,05^{a}
T1	0.75±0.10^{a}	1.03±0.14^{ab}	1.18±0.07^{ab}	1.43±0.24^{a}	1.45±0.14^{a}	1.84±0,18^{a}
T2	0.58±0.06^{a}	0.84±0.11^{bc}	1.06±0.09^{b}	1.21±0.09^{a}	1.42±0.09^{a}	1.77±0,28^{a}
T3	0.73±0.19^{a}	0.93±0.07^{ab}	1.17±0.03^{ab}	1.33±0.19^{a}	1.52±0.34^{a}	1.84±0,07^{a}
T4	0.55±0.12^{a}	0.79±0.08^{c}	1.00±0.11^{b}	1.10±0.14^{a}	1.28±0.17^{a}	1,64±0,20^{a}
Prob	0.168^{ns}	0.015*	0.023*	0.140^{ns}	0.241^{ns}	0.569^{ns}
Fraké						
T0	1.1±0.06^{a}	1.12±0.04^{f}	1.21±0.02^{e}	1.35±0.02^{e}	1.49±0.03^{c}	1.65±0,10^{c}
T1	1.11±0.04^{a}	1.21±0.02^{ef}	1.32±0.06^{cd}	1.47±0.07^{cd}	1.60±0.03^{c}	1.86±0,18^{b}
T2	1.14±0.05^{a}	1.33±0.05^{c}	1.49±0.07^{bc}	1.71±0.08^{bc}	1.86±0.11^{b}	2.47±0,30^{a}
T3	1.16±0.10^{a}	1.49±0.09^{b}	1.76±0.10^{b}	2.06±0.12^{b}	2.25±0.08^{b}	3.36±0,28^{a}
T4	1.13±0,05^{a}	1.76±0.04^{a}	2.14±0.06^{a}	2.57±0.18^{a}	2.91±0.34^{a}	3.88±0,12^{a}
Prob	0.897^{ns}	0.000**	0.000**	0.000**	0.000**	0.000**

*In the same column, each value followed by the same later are not significantly different(T0 :control, T1 : 10t/ha, T2 : 30t/ha, T3 : 40t/ha, T4 : 60t/ha). ns : non significant ; * : significant ; ** : highly significant ; SAS : week after semi, prob probability*

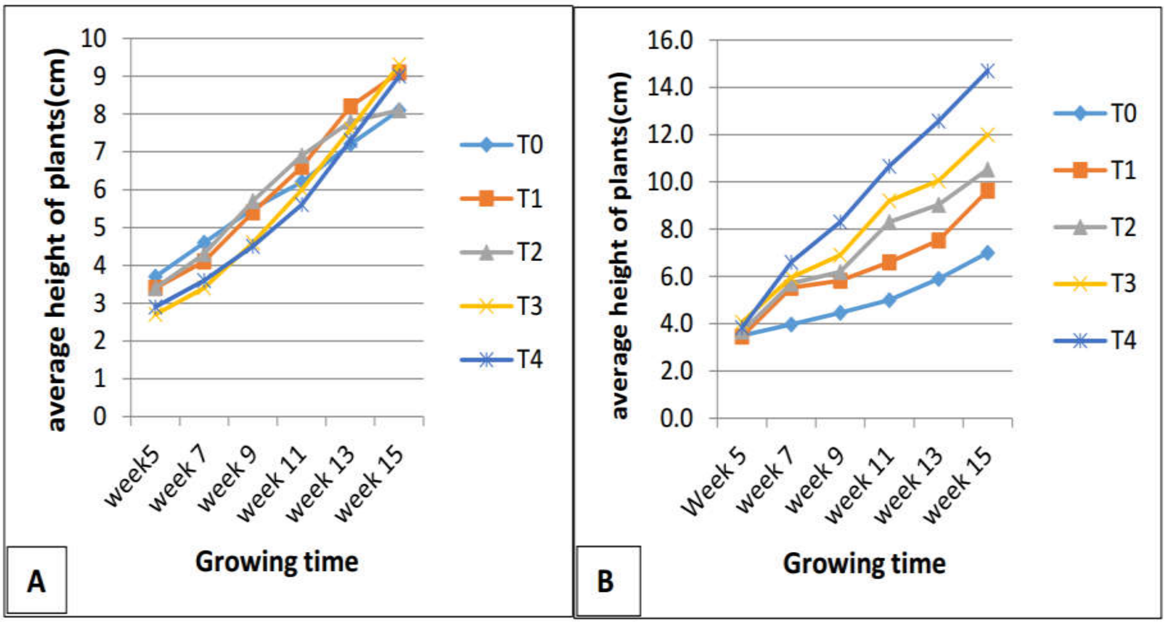


Figure 3. Effect of organic fertilizer on the height growth of Framiré (A) and Fraké (B)

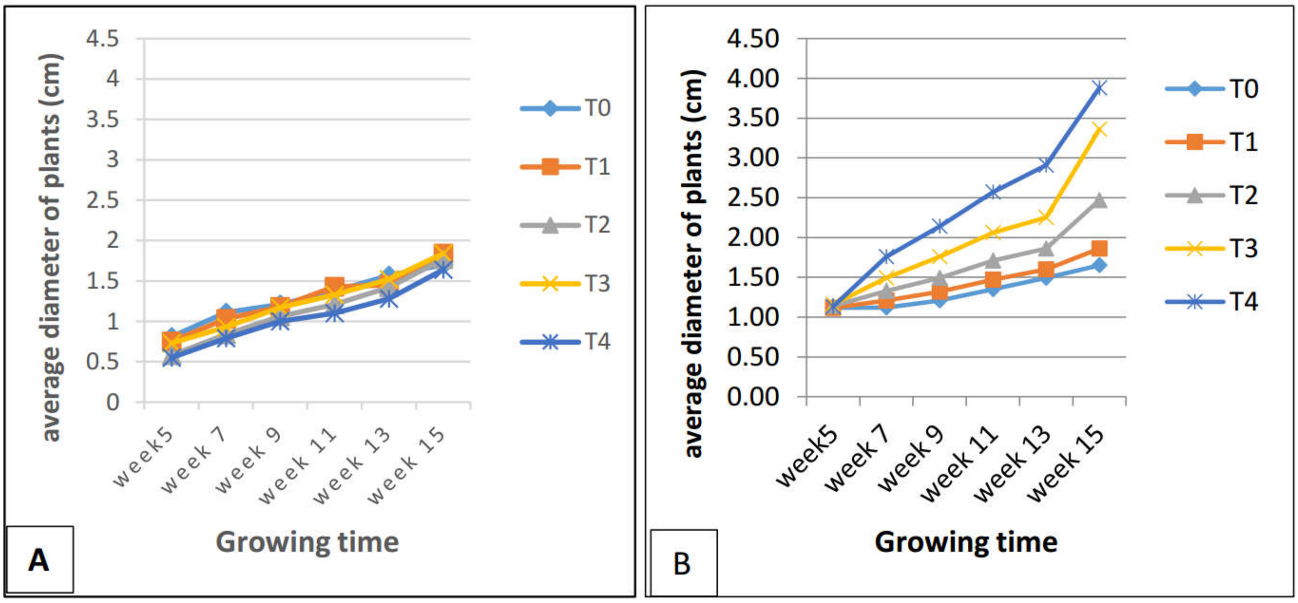


Figure 4. Effect of organic fertilizer on the stem diameter of Framiré (A) and Fraké (B)

Diameter of the stem: The diameter of the stem has been measured from the 5ième to the 15ième week after seedling on the same plantations. The measures of the diameter of the main stems have been made with the help of a foot to slide. A measure has been made to the level of collar of the stem (Dm1) and below the last leaves appeared (Dm2). An average has been established from these two measures.

Treatment and analysis of the data: An analysis of variance (ANOVA) has been done on the data of height and diameter with the software STATISTICA version 7.1. Also, the test of multiple comparison of Student-Newman-Keuls (SNK) has been used to classify the different treatments by homogeneous group when the ANOVA reveals a meaningful difference to the probability of 5% of confidence level.

RESULTS

Heightmean of the plants: The Figure 3 showed that the growth in height of the Fraké (B) and of the Framiré (A) increased meaningful way of the fifth week to the fifteenth week. She varied on average from 2 to 9 cm for the Framiré and 3 to 15 cm for the Fraké. Concerning the Framiré, the curves nearly presented the same shape with middle heights identical whatever is the treatment. On the other hand at the Fraké, the curves of growth differed according to the treatments. The T2 treatments, T3 and T4 led more important growths in relation to the control (T0). The T4 treatment leads the most important growth. The analyses of variance of the data on the height, of the 5ième to the 15ieme week after seedling showed that the application of 0kg of organic fertilizer on the Framiré presented no significant effect (Pr> 0.05). At the Fraké, the application of organic fertilizer had a meaningful effect (Pr<0.05) on the height of the 7ième to the 15ième week (Table 1). Different homogeneous groups have been observed to the level of the middle height of the Fraké. The T4 dose (60 t.ha-1) proved to be the more efficient. The recorded dominant height was of 14.70 cm.

Diameter of the stem: It was evident from the figure 4 that the growth in thickness of the stem of the Fraké and the Framiré evolves from the 5ième week to the 15ième week. It varied from 0.5 to 1.6 mm for the Framiré and 1 to 3 mm for the Fraké. At the Framiré, the curves of evolution have present the same shape nearly with middle diameters identical whatever is the treatment. On the other hand at the Fraké, the curves of evolution varied from a treatment to another. The T2 treatments T2, T3 and T4 led more important growths in relation to control (T0). The T4 treatment led the most important growth. The analyses of variance of the data on the height, of the 5ième to the 15ieme week after seedling showed that the application 0 kg of organic fertilizer on the Framiré presented no meaningful effect (Pr> 0.05). At the Fraké, the application of organic fertilizer had a highly meaningful effect (Pr<0.001) on the growth in thickness of the stems diameterof the 7ième to the 15ième week (Table 2). The T4 dose (60 t.ha-1) proved to be the most meaningful, one recorded a middle diameter dominating 3.88±0.12 mm to the last hold of data (15ième week after seedling).

DISCUSSION

Our survey was about the assessment of the effect of spent mushroom substrate of the production of mushroom pleurotes (SMS) on the growth of the Fraké (*Terminali asuperba*) and of the Framiré (*Terminaliaivorensis*) in nursery. The results gotten with the increasing doses of compost on the plantations didn't prove to be statically different in relation to the witness since the first taken of data, that is to say 5ième weeks after seedling. To this date, all doses of fertilizing had the same effect so much on the young plantations of Framiré and Fraké on the height of the stem that on the diameter. Indeed, the studied parameters of growth proved to be statically identical (p>0.05) in relation to the witness. According to Bacyé (1993), it would explain itself by the fact that after germination, the brought organic matter was not decomposed enough (mineralized) for the liberation of the nitric nitrogen. In addition, nitrogen in compost is brought under organic shape, what requires a transformation of the organic nitrogen in mineral nitrogen for a good assimilation by the plant(Cobo and al., 2002). However, to the level of the diameter of the stem and the stem, it takes out again a meaningful effect between the treatments (p <0.05).

We can note a proportional increase of these parameters studied by the contribution of the organic matters. The maximal dose fixed by this survey that is T4 (60 t.ha-1) appeared highly meaningful. These results are different from those carried by Kitabala and al. (2016) on the effect of different doses of compost on the production and the profitability of the tomato (*Lycopersicon Mill esculentum*) in the city of Kolwezi, Province of the Lualaba (Congo). Indeed, compost used by these authors was essentially the droppings of chicken. Thus, they observed that the output in fruit of tomato increases by the contribution of the organic matters, but decreases beyond 30 t.ha-1. The positive role of the residues of the mushroom production on the parameters of vegetative growth, demonstrated by the results gotten in this test, is confirmed by other authors as Dayegamiye and al. (2004) that recorded meaningful increases of the outputs of the barley, compared to the witness, after application of the mixed muds and manures.

The positive effects of compost used (SMS) on the agronomic parameters of the two studied species, has been raised by some authors at various plant species. Indeed according to Aggelides&Londra (2000); Devisscher, (1997), the mature compost permits the improvement of the physicochemical properties and biologic of soils and therefore the development of the cultures. Compost enriches soils in organic matter and in nitrogen, in particular under assimilated shapes for the plants (Devisscher, 1997; Korboulewsky and al., 2001). According to Hussain and al. (1999), the use of the products to basis of efficient microorganism improves the quality of soils, the growth, the output and the quality of the cultures. By their research on the diversity of the microorganisms in the substrata of plantproduction Higa (1994) showed that compost to efficient microorganism basis, to the picture of the SMS has for vocation to fertilize soil, to assure a food and a diversification of the soil microorganisms and to encourage the detoxification of soil and to guarantee an immediate availability of the nourishing elements necessary to the development of the plants. Steward (1995) and of Steward and al. (1997) showed also that the application of substratum of mushrooms exhausted to soil entailed an increase of the output of the potato.

Chang &Yau (1981); Iwase and al. (2000) observed that compost used of *Volvariellavolvacea* added to soil increased the output of tomatoes of 7 times and the outputs of lettuce of soy and radish of 2 times each. Besides, they observed that the addition of compost of *Agaricus* to soil produced better outputs in cabbage, cauliflower, beans and celery in relation to the addition of poultry manure to soil. The worn-out compost is considered like a source of formation of humus and, it is known that humus provides to the plants of the micronutrients, improve the ventilation of soils, their capacity of retention in water and contribute to the maintenance of the soil structure.
For the Framiré, the T1 dose (10t/ha) corresponds to the dose that was the most representative to the level of the studied parameters. The T4 dose (60t/ha) didn't give any better results. Some similar results have been observed by Mora and al. (2010) at the end of their tests of efficiency of a compost to basis of urban loss on the tomato where the dose 45t/ha led lower outputs of the dose 30t/ha. However, the good development of the plantations of Framiré without contribution of fertilizing reveals the good quality of soil. He/it also translates the fact that the Framiré is little demanding concerning nutriments. It is confirmed by the results of Voh (1998), Olowe & Busari (2000) and Muhamman and al. (2009) for experimentations on some soils. These authors showed that with the quality of soil, some such cultures the sesame presented non meaningful answers in spite of the contributions of mineral manures. According to Ahmad and al. (2011) the genetic character would explain the differences to the level of the species for the same dose of fertilizing.

Conclusion

This work had for general objective to improve the sylvan productions particularly the case of the *Terminalia superba* and *Terminaliaivorensis* while testing several doses of organic fertilizer notably: spent mushroom substrate(SMS) on the growth parameters of the young plantations of these two species in nursery. It is also aimed to determine the dose of optimal compost in terms of growth on the two studied species among five doses: T0 (control), T1 (10t/ha), T2 (30t/ha), T3 (40t/ha), and T4 (60t/ha). The analyses of the results carried by our survey showed that: Concerning the Fraké, all doses lead more important growths in relation to the control (T0 = 0 t.ha-1). The T4 dose (60 t.ha-1) proved to be the most meaningful, one recorded a dominant height of 14,70±1,57 cm and a middle diameter of 3,88±0,12 mm, Against a height of 7±0,20 cm and a diameter means of 1,65±0,10 cm at witness, to the last hold of data (15ième week after seedling). Concerning the Framiré, the evolutionary curves of growth of the all studied parameters of growth nearly proved to be identical whatever the doses is.

This survey proved that the worn-out compost coming from mushroom farm (SMS) could constitute a real alternative to the fertilization of the forest soils destined to the production of plantations. Her especially interesting than the adoption of stamps to basis of vestigial substratum of mushroom could permit the lasting increase of the productions at a time sylvan particularly the case of the Fraké and the reduction of the pollution of the environment. So the forest sector will be able to enroll in an agriculture respectful of the environment. Relatively to the gotten results, we recommend to the societies hired in the forestry notably the SODEFOR in Côted'Ivoire and to the producers of forest plantations for the production of the young plantations of Fraké in nursery, the use of spent mushroom substrate (SMS) at the dose of (60t/ha) to promote plant growth.

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