International Journal of Plant & Soil Science

26(1): 1-9, 2018; Article no.IJPSS.46147
ISSN: 2320-7035

Effects of Peat and Chiken Litter on Three Cultivars of Plantain in Plants Vivo: FHIA 21, PITA 3 and Horn 1

Francis Koffi Bedie[1], Louise Turquin[1*] and Deless Edmond Fulgence Thiemele[2]

[1]Laboratory of Plant Physiology, University Félix Houphouët-Boigny, Côte d'Ivoire.
[2]Station of Production of Plantain, Fruit and Citrus Plants of Azaguié, National Center for Agronomic Research (NCAR), Côte d'Ivoire.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2018/46147
Editor(s):
(1) Dr. L. S Ayeni, Adeyemi College of Education, Ondo State, Nigeria.
Reviewers:
(1) Georgiana Eurides de Carvalho Marques, Federal Institute of Education, Brazil.
(2) Ibrahim Yerima, University of Maiduguri, Nigeria.
Complete Peer review History: http://www.sdiarticle3.com/review-history/46147

Original Research Article

Received 11 October 2018
Accepted 22 December 2018
Published 11 January 2019

ABSTRACT

Aims: This study was carried out to test various substrates made of a mixture of earth with different proportions of organic fertilizing substances to improve the technique of mass production of plantain plantain material, and the multiplication of shelled strains (MSD).
Place and Duration of Study: The study of the growth and development of plantain cultivars FHIA 21, PITA 3 and Horn 1 was carried out in the region of Azaguié, at the production station of plantain banana (*Musa pardisiaca*) plants of the National Center for Agricultural Research (CNRA) under tunnel and shade for a period of 8 months.
Methodology: The substrates tested were chicken litter and peat mixed with soil in 25%, 50% and 75% proportions. Our study took place from March to November 2014.
Results: For tunnel results, S7 (soil 25% - mature chicken litter 75%) and S6 (soil 50% - mature chicken litter 50%) had positive impacts on the height of the three cultivars, particularly Horn 1 while the dry matter was improved by the substrate S1 earth (100%). The S7 substrate allowed good root production regardless of the cultivar and also increased root branching levels. Under the shade, substrates S7 and S6 negatively influenced the height. The number of roots and the degree

**Corresponding author: E-mail: lturquin@yahoo.fr;*

of branching of the roots were improved by the substrates S2 (50% earth - 50% peat) and S3 (25% earth - 75% peat). The amounts of dry matter fluctuated without any significant difference. The influence of the two environments on the development and growth parameters of the *in vivo* plants revealed that the highest values were obtained under tunnel with the exception of the dry matter.

Conclusion: This study confirmed that, there was influence of substrates on the growth and development of plantain banana plants. Substrate S7 gave the best result under tunnel and under shaded substrates S2 and S3. In both environments, S7 substrates had a positive effect on the number of roots emitted.

Keywords: Substrate; chicken litter; peat; growth; development; plantain banana.

1. INTRODUCTION

Plantain (*Musa* sp.) is the fourth-largest foodstuff in Côte d'Ivoire after rice, cassava and yams [1]. It is the main food source for more than 400 million people worldwide and particularly in tropical countries. World production is estimated at 35 Mt / yr and more than 1.4 Mt in Côte d'Ivoire [2]. The plant also represents a substantial source of income for many rural populations. Most banana cultivars produce asperm fruits. Their propagation is made from bayonet rejects [3] which constitute the classic planting material. This natural propagation pathway is slow and produces small quantity of suckers which get low phytosanitary quality [4]. This lack of plant material of satisfactory quality constitutes a major constraint for the extension and sustainability of banana plantations in many countries. Shelled strains (MSD), which activates latent buds and rapidly produces healthy and homogeneous plant material, may be a palliative. However this technique could be improved; the in vivo seedlings derived from MSD is influenced by the substrate used after weaning [5]; hence the interest of this study focused on the quest for an efficient substrate allowing better growth and harmonious development of plantain banana plants. Organic materials (chicken litter and peat) could improve the physicochemical properties [6] of the mixture on the one hand and, on the other hand, optimize the yield of the in vivo nursery plants.

2. MATERIALS AND METHODS

Our experiments were carried out in Azaguié in the Agnéby-Tiassa region, 40 km north of Abidjan, with coordinates 5 ° 35 'and 6 ° 15' north latitude and 3 ° 55 'and 4 ° 40 'west longitude. The soils are ferralitic (ferralsols) and the climate is humid tropical, Attiean type with two rainy seasons and two dry seasons. The long rainy season extends from May to mid-July; the small from mid-September to October. The long dry season starts in November and ends in April; the small covers the period from mid-July to mid-September. During the test, we recorded an average of 41 mm of rain in March.

2.1 Plant Material

Our plant material consisted of 2-month-old plantain banana plants of a local cultivar Horn 1 and two hybrids, PITA 3 and FHIA 21.

2.2 Methods

The substrates tested for the evolution of the plants were composed of black forest soil, peat and chicken litter. The black forest soil and peat were sieved through a sieve with 1 mm diameter mesh and then sterilized for 4 hours in a wood fire before use. Litter of mature and non-mature chickens were used as is. In 2200 ml containers, the substrates were primed. They were obtained by a mixture of the basic constituent, the black earth of forest with various proportions of organic residues including the peat or litter of chickens: a volume of black earth for a complementary fraction of organic substance to test to the unit according to the formula: $V_{substrate} = V_{x\ earth} + 1/x\ V_{organic\ subs}$ and recorded in Table 1. The substrates were put in 700 ml nursery pots for testing and arranged under tunnel and shade. The banana bulbs of the local cultivars Horn 1 and hybrids, PITA 3 and FHIA 21 having flowered after 7 months of planting, were collected, trimmed, shelled and the apical meristem was destroyed to stimulate the growth of dormant lateral buds. Then they were soaked in a solution of fungicide (Banko plus) at the concentration of 0.1 g / l for 30 s to remove any fungi and put in tunnel culture where the internal temperature oscillated between 30°C and 35°C and relative humidity, Hr = 87.75, with daily watering. Two months later, the developed rank I buds were scarified to favor the release of the rank II buds. These were carefully separated from the explant without damaging the emergent

Table 1. Composition of substrates

Substrates	Components			
	Earth (%)	**Peat (%)**	**Non-mature chicken litter (%)**	**Mature chicken litter (%)**
S1	100	0	0	0
S2	50	**50**	0	0
S3	25	**75**	0	0
S4	50	0	**50**	0
S5	25	0	**75**	0
S6	50	0	0	**50**
S7	25	0	0	**75**

buds with a scalpel two months later. These plants were rootless, their mass was between 3 to 15 g and had 2 to 4 leaves. Then they were transplanted into the pots filled with substrates. Our study took place from March to November 2014.

2.2.1 Experimental apparatus

The experimental setup consisted of a randomized complete block with three variables. Experimental variable A (banana cultivars with 3 modalities: PITA3, FHIA 21 and Horn 1). Experimental variable B (environments with 2 modalities: greenhouse and shade house) and experimental variable C (substrates with 7 modalities) (Table 1). In a given environment, we had 39 treatments, 3x13. Each treatment was the subject of 10 repetitions corresponding to the number of experimental units, ie: 3x13x10=390 experimental units per environment. Watering of the plants was done every 2 days.

2.2.2 Parameters studied

The evolution of the plants was observed every week for 8 months and concerned the following parameters.

2.2.2.1 Height

It was measured once a week after transfer of the seedlings from the collar to the v-neck formed by the last leaf and the cigar.

2.2.2.2 Dry matter content, number and degree of root branching

At the end of the test the rate of dry matter was determined after drying the fresh roots in an oven at 60°C for 3 days according to the following formula: Qs = Ms x 100 / Mf, the amount of roots and the degree of root branching were enumerated.

2.2.3 Statistical analysis

All the results obtained were analyzed with the STATISICA 7.1 software. An analysis of variance incorporating the Newman-Kheuls post ANOVA tests was performed when there was a difference between the averages of the treatments.

3. RESULTS AND DISCUSSION

The results show the effect of substrates on the evolution of FHIA 21, PITA 3 and Horn 1 juvenile plantain in both environments.

3.1 Effect of Substrates on the Evolution of Banana Plantain Plants under Tunnel

3.1.1 Height

The size of the in vivo plants was higher for the three cultivars in the plants grown on the S7 substrate (8.8 cm) followed by the S6 substrate (7.4 cm) (Fig. 1). Thus, the sizes reached on the S7 substrate by the cultivars FHIA 21 (7.1), PITA 3 (9.2) and Horn 1 (10.2) are higher than those of the plants on the substrate S6 FHIA 21 (5, 6 cm), PITA 3 (5.5 cm) and Horn 1 (10.5 cm). Plants of substrate S1 (3.9) had the smallest size. The variety Corne 1 had the highest growth.

Plant size values showed highly significant differences between substrates (F=9.22, dd1=12 and P<0.001) (Table 2).

3.1.2 Dry matter content

Dry matter observations revealed that the in vivo plants grown on the S1 substrate (7.9%) obtained the highest solids content followed by those of the S2 substrate (7.6%) and the lowest on the S7 substrates (6.3%); S6 (6.5%) and S5 (6.2%) (Fig. 2a). The values were, on substrate

S1 with Horn 1 (8.5%), with FHIA 21 (7.8%). The dry materials showed significant differences between the substrates (F=2.45, ddl=12 and P<0.05) (Table 2).

3.1.3 Number of roots

The amount of roots varied according to the substrates. Root emission (Fig. 2b) showed that the plants of the S7 substrates (5.8 6) produced the greatest amount of roots: FHIA 21 (5), Horn 1 (7) and PITA 3 (7). It is followed by S2 (5.16) and S5 (5). The largest amount of Horn 1 roots is observed on the substrates mentioned. Lowest on S4 substrates (3.8).Variance analysis of root amounts revealed highly significant differences between the substrates (F=2.45, ddl=12 and P <0.001); (Table 2).

3.1.4 Branching level

Root branching was high on S7 substrate (3) followed by S6 (3) as opposed to S1 (1,9), S2 (2,1) and S4 (1,9) substrates (Fig. 2c). The values were: FHIA 21 (3), PITA 3 (4) and Horn 1 (3) on the S7 substrate. On the substrate S6. The 3 cultivars produced the same number of roots: FHIA 21, PITA 3 and Horn 1 (3).

Root ranks showed highly significant differences between substrates (F=7.25, ddl=12 and P<0.001); (Table 2).

3.2 Effect of Substrates on the Evolution of Young Plantain under Shade

3.2.1 Height

The size of the in vivo plants showed that the highest size was observed on the substrate S3 (5 cm) followed by the substrate S2 (4.7 cm) and the lowest on the substrates S4 and S5 (2.4 cm) (Fig. 3). On the S3 substrate, the sizes reached by cultivars were for FHIA 21 (5.3 cm), PITA 3 (5.29 cm) and Horn 1 (3.9 cm); and on the substrate S2 FHIA 21 (5.2 cm); PITA 3 (3.9 cm) and Horn 1 (5.0 cm). The cultivar Horn 1 (5.29 cm) had its greatest height on S2 and FHIA 21 (5.3 cm) on both substrates S2 and S3. The size of the plants showed a highly significant difference between the substrates (F=5.09, ddl=12 and P<0.001) (Table 3).

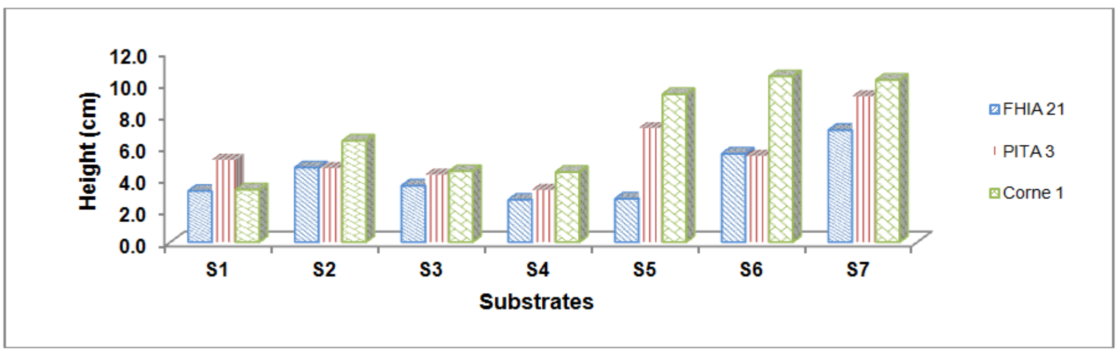

Fig. 1. Effect of substrates on the growth of FHIA 21 plantain banana plants, PITA 3 and Horn 1 under tunel

Table 2. Impacts of substrates on the evolution of vivo plants under tunnel

Substrates	H	Qs	R	Dr
S1	3,9 cd	7,9 a	4,6 ab	1,9 c
S2	5,3 bc	7,6 ab	5,1 ab	2,1 c
S3	4,2 bcd	7,3 ab	4,6 ab	2,6 ab
S4	3,6 d	7,1 ab	3,8 b	1,9 c
S5	5,7 b	6,2 b	5,0 ab	2,4 bc
S6	7,4 a	6,5 b	4,8 ab	2,8 ab
S7	8,8 a	6,3 b	5,8 a	3,0 a

The averages followed by the same letter in the same column are not significantly different at the 5% level. H: height, Qs: dry matter content, R: number of roots, Dr: degree of root branching

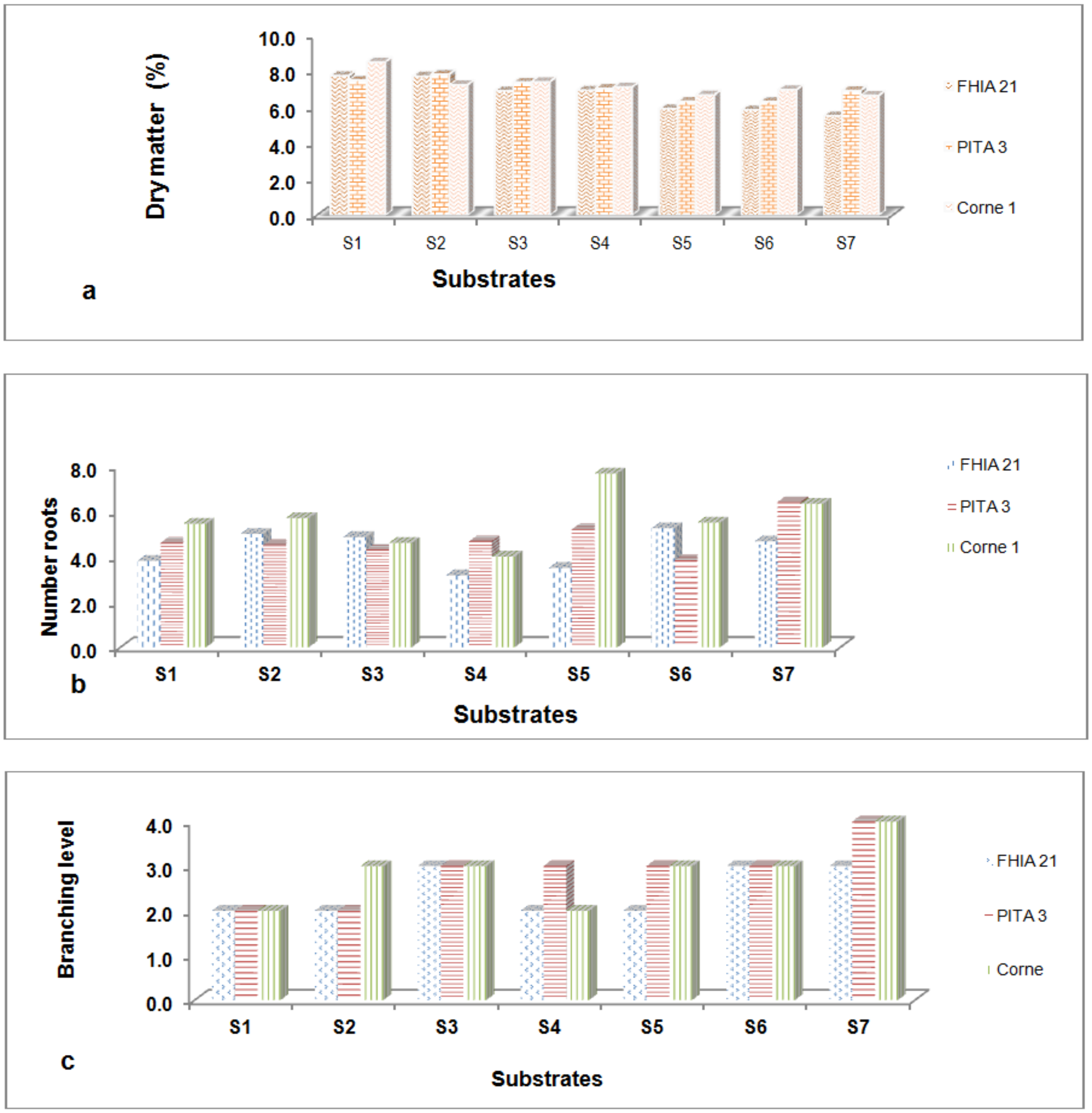

Fig. 2. Effect of substrates on the development of plantain FHIA 21, PITA 3 and Horn 1 under tunnel

a: dry matter content, b: number of roots emitted, c: degree of root branching

Table 3. Effect of substrates on the growth of FHIA 21 plantain plants, PITA 3 and Horn 1 under shade

Substrates	H	Qs	R	DR
S1	3,0 bc	8,5 a	2,2 bc	1,6 c
S2	4,8 a	9,8 a	3,6 a	2,4 a
S3	4,7 a	7,2 a	3,9 a	2,4 a
S4	2,4 c	10,1 a	2,1 c	1,9 bc
S5	2,4 c	9,4 a	2,8 abc	1,7 bc
S6	3,1 bc	8,5 a	3,0 abc	1,6 c
S7	3,7 ab	7,7 a	3,3 ab	2,0 b

The averages followed by the same letter in the same column are not significantly different at the 5% level.
H: height, Qs: dry matter content, R: number of roots, Dr: degree of root branching

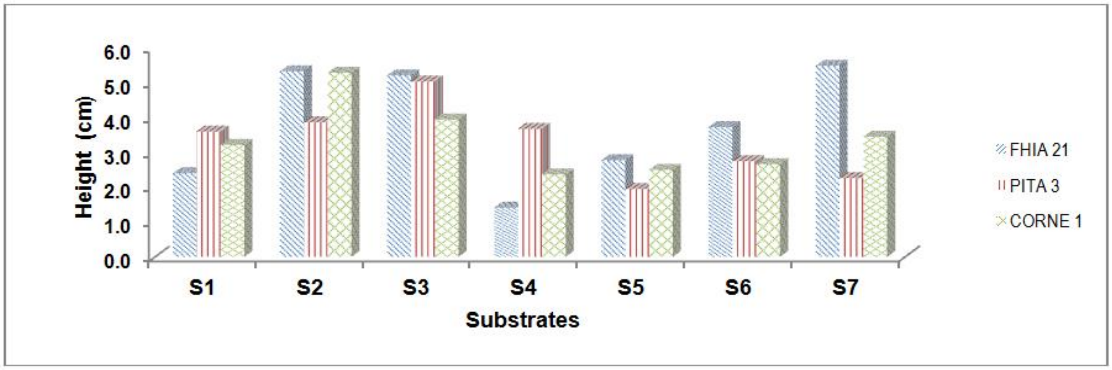

Fig. 3. Effect of substrates on the growth of FHIA 21 plantain banana plants, PITA 3 and Horn 1 under shade

3.2.2 Dry matter content

At the end of cultivation, the dry matter content of the plants of the three cultivars was determined (Fig. 4a). The quantities of dry matter fluctuated without any significant difference (Table 3).

3.2.3 Emission of roots

The results revealed a variability in the amount of roots released depending on the substrates.They were more numerous on S3 and S2 substrates followed by S7 plants and the minimum values on S1 (2.2) and S4 (2.1) (Fig. 4b). The number of roots obtained per variety was on the substrate S3, FHIA 21 (5,6), Horn 1 (3,4) and PITA 3 (3), on the substrate S2, Horn 1 (4,2), FHIA 21 (3,7) and PITA 3 (2,9) and on S7, FHIA (5), PITA 3 (2,8), Horn 1 (3). Root amounts revealed highly significant differences between the substrates (F=3.82, ddl=12 and P<0.001); (Table 3).

3.2.4 Degree of root branching

Root branching levels were strong and identical on substrates S3 and S2 (2,4) (Fig. 4c). We observed by variety: Horn 1 (2,6); FHIA 21 (2,4) and PITA 3 (2,2) on the substrate S2 and on the substrate S3 FHIA 21 (2,6); PITA 3 (2.5) and Horn 1 (2.2). The seedlings of the S1 (1,6) and S6 (1,6) substrates had the lowest values: Horn 1 (2,6) on the substrate S2 and FHIA 21 (2,6) on the substrate S3. Branching levels showed highly significant differences between substrates (F=7.62, ddl=12 and P <0.001); (Table 3).

3.3 At the Level of Both Environments

The degree of root branching and the number of roots are greater on substrates S7 under tunnel and substrates S2, S3 under shade. Finally, the comparison of the environments revealed a superiority of all the parameters of growth and development of the plants of the tunnel with the exception of the quantity of dry matter. Indeed, the analysis of the influence of the two environments on the development and growth parameters of the FHIA 21, PITA 3 and Horn 1 plantain (Table 4), showed significant differences. The highest average of the height (7.48 cm), the degree of branching (3) of the number of roots (5) was obtained under tunnel. As for the quantity of dry matter, the highest rate (9.50%) was recorded under the shade.

3.4 Discussion

Under tunnel, the S7 substrates (25% soil - 75% mature chicken litter) and S6 (50% soil - 50% mature chicken litter) favored good elongation of the plants. The height of the in vivo plants was 8.8 cm on S7 and 7.4 cm on S6. This good growth of the plants observed on this substrate could be explained by the large amount of nitrogen released by the mature hen litter. Bhattacharya and Taylor [7] have shown that nitrogen from droppings was 20-45% of the dry matter and Useni et al. [8] showed that nitrogen promotes maize growth. Our results corroborate those of [9] who reported the positive effect of droppings on the growth of coconut plants. The mature litter would be favorable to the production of vivo plants. Optimal root development was obtained on S7 substrates. The hen litter significantly improved the structure and texture of the mixture. These physical properties influence the availability of oxygen, water and mineral elements for plants [10]. Vartanian [11] showed that the number of roots depended on the moisture and porosity of the culture medium; the more humid and aerated the environment, the more roots there are. The mature litter has benefited from the direct influence of the tunnel environment, especially, humidity and high temperatures. The latter activate the rate of degradation of hen litter in humus, then in minerals.

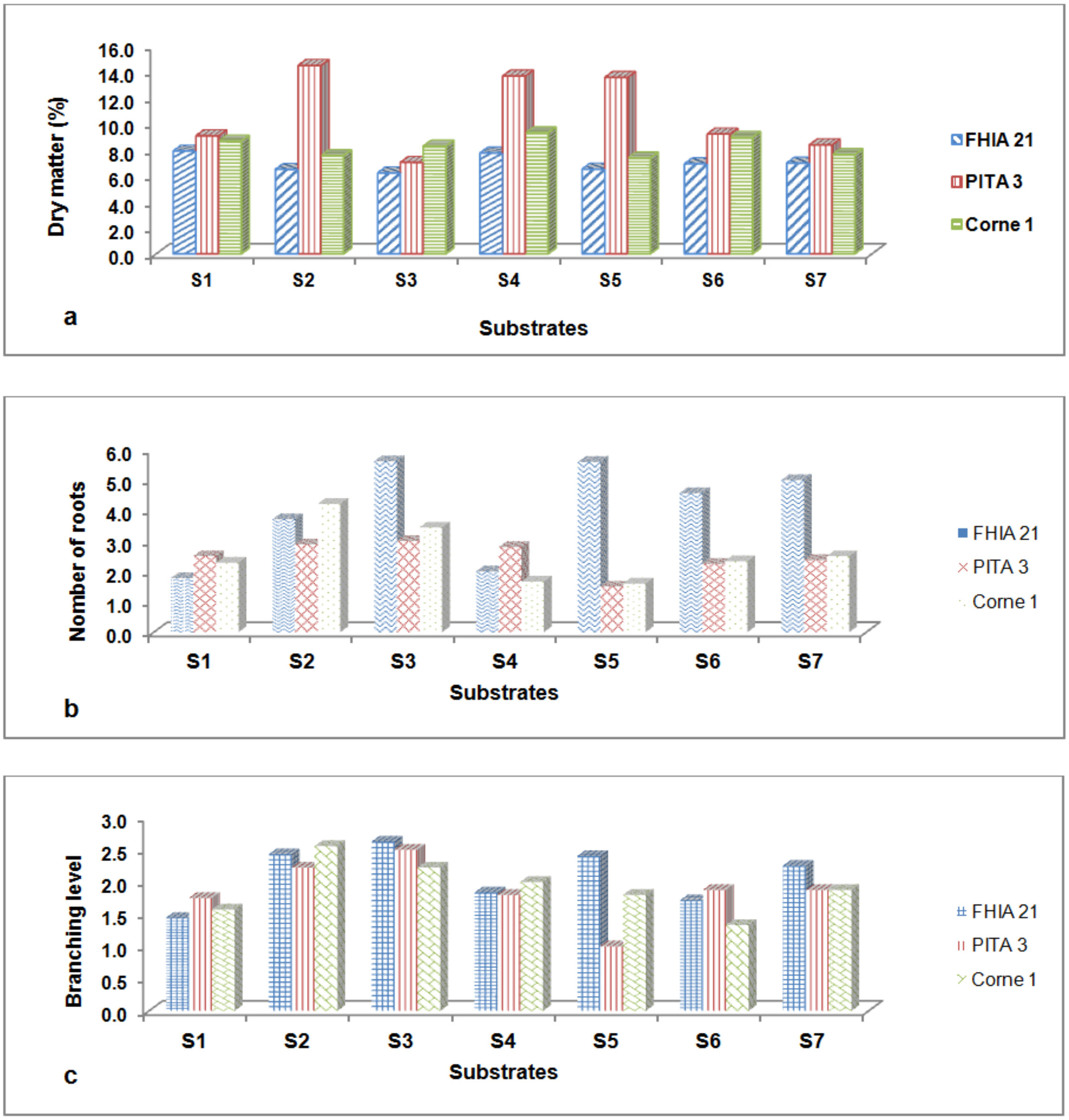

Fig. 4. Effect of substrates on the development of plantain banana plants FHIA 21, PITA 3 and Horn 1 under shade

a: dry matter content, b: number of roots emitted, c: degree of root branching

Table 4. Comparison of the influence of the two environments on the plants

Environments	H	Qs	Roots	Dr
Shade	3,59 b	8,62 a	3,05 b	1,97 b
Tunnel	5,30 a	7,15 b	4,79 a	2,33 a

The averages followed by the same letter in the same column are not significantly different at the 5% level. H: height, Qs: dry matter content, R: number of roots, Dr: degree of root branching

The effect of hen litter at 75% (S7) was better on height growth, with the exception of the amount of dry matter. The in vivo seedlings used were rootless and their recovery would have required the presence of important mineral elements that released the mature hen litter at this proportion. These results were contrary to those of [5], whose work has shown that the mixture of black soil and henhouse litter in proportions (50/50), better promotes the growth and development of vivo plants of plantain.

Under shade, the height of the in vivo plants was higher on the substrates S3 (50% earth - 50% peat) and S2 (25% earth - 75% peat). The mixture of peat with the ground would have allowed the plants to dispose of the nutritive elements necessary for their growth.

The effectiveness of peat was due to its ability to increase cation exchange capacity (CEC) [12]. These results are similar to those of [13] which obtained in one year, after culture on peat substrates, beech plants of large size. Moreover, the peat in addition to being light, has good porosity and good water retention capacity; which would have allowed the mixture to have a good structure and to maximize the availability of mineral elements in the rhizosphere [14].

Our experiments also showed that the amount of roots and the degree of roots were numerous on substrates S2 (50% earth - 50% peat), S3 (25% earth - 75% peat). Peat has improved the physical structure of these substrates by increasing aeration of the pore space [15]. Aeration of the substrate at a sufficient level is an essential condition for root development [16]. These results obtained with peat are in agreement with those of [17] who found that germination rates in *Prosopis africana* were higher (100%) when sand was used as a growing medium. In the same sense, Baali-Cherifd et al. [18] showed that germination of *Olea laperrinei* seeds is better in the substrate containing sand and the potting soil. Djellabi et al. [19] report, the beneficial effect of peat on the qualitative aspect of woody plants produced in the nursery.

In both environments, the degree of branching and the amount of roots were greater on substrates S7 under tunnel and substrates S2, S3 under shade. The formation and development of the lateral roots would be related to the size of the plants. This corroborates the idea of [20] which states that the lateral roots make it possible to build the root system and to increase the absorption surface and the volume of substrate exploited. The comparison of the two environments also showed a greater accumulation of dry matter under shade. Like all living things, plantain needs water for its survival, a warm environment, as it is a plant in the humid tropics that thrives at moderate or moderate temperatures [21]. The small amount of dry matter under tunnel could be explained by the fact that in this environment, there is a hygrometry close to saturation and a high temperature therefore conditions favoring an intense metabolism. Starch (abundant solid organic matter) from photosynthesis is rapidly hydrolysed into soluble carbohydrates to meet the energy needs of the plant during biochemical reactions.

4. CONCLUSION

This study confirmed the influence of substrates on the growth and development of plantain banana plants. Substrate S7 gave the best result under tunnel and under shaded substrates S2 and S3. In both environments, S7 substrates had a positive effect on the number of roots emitted. Producers of the in vivo plants could use these mixtures of 25/75 and 50/50 peat muck soil and mature chicken litter under 25/75 soil and peat moss. These biodegradable substrates could be recommended to planters for the establishment of banana plantations especially for a healthy environment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. ANON1 (Anader). The partner: food production: A national issue. Binding Bulletin of the National Agency for Rural Development. 2009;15:12.
2. ANON2 (Faostat). United Nations Organization for Agriculture and Food. Economic and Social Department. The Statistics Division. 2008;11.
3. Turquin L, Aké S, Anno AP. Effects of auxin derivatives on the production of Plantain cv Horn 1 in Côte d'Ivoire, Science and technology, Natural Sciences and Agronomy. 2007;29(1-2):105-115.
4. Koné T, Koné M, Koné D, Kouakou TH, Traoré S, Kouadio YJ. Effect of photoperiod and vitamins on micropropagation of plantain. Journal of Applied Biosciences. 2010;26:1675-1686.

5. Mayeki PJ, Biyo'o NM, Ngnigone CE, Molouba F, Demikoyo D, Mibemu S, Effa B. Influence of substrate composition on the weaning of plantain banana plants. (*Musa sp*.). Sciences Sud. 2010;3: 1-16.
6. Soltner D. The basics of plant production. The soil and its improvement, 23rd Eds. Poitier (France): Agricultural Science and Technology. 2003;1:472.
7. Bhattacharya AN, Taylor JC. Recycling animal vaste as a feed stuff are view. J Anim Sci. 1975;41:1438-1457.
8. Useni SY, Baboy LL, Nyembo KL, Mpundu MM. Effects of combined biofuels and inorganic fertilizers on the yield of three varieties of *Zea mays* L. grown in the Lubumbashi region. J. Appl. Biosci. Flight. 2012;54:3935-3943.
9. Zadi M. Effect of two types of organic fertilizer on the growth and development of Coconut (*Cocos nucifera* L.) Hybrid PB 113+ in nurseries. Memory of DEA. Félix HOUPHOUËT-BOIGNY University. 2013; 80.
10. Allaire-Leung SE, Caron J, Parent LE. Changes in physical properties of peat substrates during plant growth. Can. J. Soil Sci. 1999;79:137-139.
11. Vartanian N. Morphological diversity of the root system in relation to edaphic moisture. C. R. Seminars of the Root Study Group. October 1974 Nancy; October 1975, Grenoble. T 2. 1975;166-179.
12. Djeke DM, Angui TKP, Kouadio YJ. Decomposition of crushed cocoa hulls in the ferralitic soils of the Oumé zone, west-central Côte d'Ivoire: Effect on the chemical characterization of soils. Biotechnol. Agrono. Soc. Environ. 2011; 15(1):109-117.
13. Le Tacon F. Research better conditions of production of beech plants. French Forestry Journal. 1974;4:299-305.
14. Delran S, Garbaye J, Le Tacon F. Rapid production of leafy plants on peat. French Forestry Journal. 1975;6:436-448.
15. Hannah J. Good tree growing practices in forest nurseries. Practical guidelines for research nurseries. Technical Manual. World Agroforestry Center (ICRAF). 2006; 3:93.
16. Da Silva FF, Wallach R, Chen Y. Hydraulic properties of *Sphagnum peat* moss and tuff (scoria) and their potential effects on water availability. Plant Soil. 1993;154: 119-126.
17. Ahoton LE, Adjakpa JB, M'po Ifonti M'po et Akpo EL. Effect of seed pretreatment on the germination of *Prosopis africana* (Guill, Perrot and Rich.) Taub., (*Caesalpiniaceae*). Tropicultura. 2009; 27(4):233-238.
18. Baali-Cherifd, Kara-Mostefa-Khelil L, Zemit O, Meghaouia, Sahki A, Bouguedoura N. Study of some biological aspects of the Laperrine olive tree (*Olea laperrinei*) with a view to setting up an ex situ bank. In: Ilizi W, ed. Rediscover and reinvent silviculture in arid zones. Djanet: CRSTRA-INRF. 2000;82-89.
19. Djellabi A, Chouial A, Bezzaz F, Kahia F. Test of making peat-based culture substrates in the production of forest seedlings in an above-ground nursery. The Algerian Forest, Special Issue: New Techniques for Producing Seedlings in the Nursery. 2004;20-23.
20. Becel C. Root growth in peach orchard. Influence of water distribution in soil and availability of carbon assimilates. Thesis of the Academy of Aix-Marseille. University of Avignon and the Countries of Vaucluse. 2010;143.
21. Budju IKE, Gradua. Evolution and characterization of *Mycosphaerella sp* symptoms on plantain in the Kisangani Region. Online Memory. 2008;8.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/46147