INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 13, No. 1, p. 102-110, 2018

RESEARCH PAPER OPEN ACCESS

Physico-chemical characteristics evaluation of termite dust and vegetal compost based substrates for a sustainable production of the pepper (*Capsicum annum* L.)

Bomisso Edson Lezin, Ouattara Généfol*, Kouamé Konan Didier, Bamba Mamadou, Tuo Seydou, Aké Séverin

[1]Laboratoire de Physiologie Végétale, UFR Biosciences, Université Félix HOUPHOUËT-BOIGNY de Cocody, Abidjan, 22 BP 582 Abidjan 22, Côte d'Ivoire

Article published on July 30, 2018

Key words: Compost, Growth, Pepper, Substrates, Termite dust.

Abstract

The aim of this study is to propose better substrates for the cultivation of pepper's nursery (*Capsicum annum* L.) as an alternative to expensive and non-ecological substrates. To achieve this, six substrates were made from ordinary soil, plantain peel compost and *cubitermes* termite dust. These are: ordinary soil (TV); plantain peel compost (CPB); ordinary soil + plantain peel compost (TV+CPB); ordinary soil + termite dust (TV+PT); plantain peel compost + termite dust (CPB+PT); ordinary soil + plantain peel compost + termite dust (TV+CPB+PT). The substrates have been physico-chemically characterized and their effects on the growth parameters of pepper plants have been evaluated. The physico-chemical characterization allowed to distinguish three types of substrates. The characteristics of the TV+CPB+PT, TV+CPB, CPB+PT substrates have been favorable for the initial growth of the pepper.

* **Corresponding Author:** Ouattara Généfol ✉ wattgene20@gmail.com

Introduction

The pepper (*Capsicum annum* L.) is a vegetable plant belonging to solanaceous weeds as the green pepper (CIRAD-GRET, 2002). It is used for its especially pungent fiery taste fruits. It is rich in calories, vitamin C and Calcium (USAID, 2006). Grown as vegetable crops for food and aromatic qualities of their fruits, the wide range of pepper varieties can be classified from sweet to pungent fiery taste according to SCOVILLE index (FAO, 2006). In cooking, pepper is used as condiment or directly as vegetable. In the food, drink and pharmaceutical industries, they are respectively the colours (Capsanthin and capsorubin) and the active ingredient (capsaicin) pepper extracts which are used (Bosland and Votara, 2001).

Pepper growing represents the second world gardening production after tomato and the best in terms of spices with a production of 33.3 million tons in 2011 (FAO, 2014).

Because of the economic, medicinal and food importance of the pepper, it is essential that a particular attention be paid to the improvement of its production, particularly the production of the plants in nurseries, the guarantee of success of any cultivation. The nursery allows to select healthy and strong plants for transplanting. The stimulation of the initial growth of the pepper can be done by the use of suitable growing (Pinners *et al.*, 1989). Cultivation substrates used in container are generally made of peat industry, vermiculite or forestry composts (M'sadak, 2013). However, the peat industry commonly used in the production of horticultural substrates is expensive and not easily renewable (Van Der Gaag *et al.*, 2007). In developing countries substrates are generally made of mineral soil, humus of forests, sand and manure (M'sadak, 2013). In addition of being potential sources of weeds and diseases, these substrates do not favor the standardization and improvement of plants production cultivation techniques. To deal with these constraints, numerous studies have been geared towards cultivation substrates research that could be acceptable socially, economically and ecologically for small producers of plants in nurseries (Herrera *et al.*, 2008).

The studies of M'sadak (2013) on the composting of forestry and agricultural wastes showed that these composted organic wastes produce excellent results in substrates manufacturing for plants in nurseries production. Furthermore, Inbar *et al.* (1993) reported the effectiveness of their use in mixture. In fact, by mixing compost and termite dust, Duponnois (2014) got a better development and a better tomato plants production. Moreover, termite dust associated with the fertilizer called NPK allowed to improve the production of cassava (Ballot *et al.,* 2016). The studies of Mokossesse *et al.* (2009) and those of N'diaye *et al.* (2003) on the *Cubitermes* termite dust highlighted a positive effect on the growth, development and symbiotic microflora performance.

The studies referred to above represent some contributions to the development of organic waste and termite dust in agriculture. In Côte d'Ivoire numerous green waste (peels, trunks, pods, branches, parches) rich in minerals especially the plantain peel (Biego *et al.*, 2010) are not yet promoted in compost. And the use of composts combined with other sources of modification such as termite dust has not been produced yet.

The current study is made on the assumption that the mixture of compost with plantain peel and *Cubitermes* termite dust allows to get substrates with physico-chemical characteristics favorable to the plants growth. It generally aims at improving the quality of substrates used for the production of pepper nursery. It will be specifically about the achievement of a physico-chemical characterization of different substrates and assess their effects on the germination and initial growth of pepper plants.

Material and methods

Site of the study

The experiments were carried out at Centre National de Floristique (CNF) of Université Félix Houphouët-Boigny, in Abidjan (in the southern forest of Côte d'Ivoire). The city of Abidjan is located in Côte d'Ivoire, 5° 17'- 5° 31' north and 3° 45'- 4° 31' west of the equator. The country's climate is Guinean (Akédrin *and al.*, 2011).

Material

The plant material was made up of SAFI variety pepper seeds from Centre National de Recherche Agronomique (CNRA), the national center of agricultural research. This variety has a production of 5 tons/ha and has a much appreciated taste and aroma.

The growth substrates used are combinations from ordinary soil plantain peel compost and *Cubitermes* termite dust. The ordinary soil was extracted in the fallow of the CNF (Centre National de Floristique), 20-60 inches deep and passed through a sieve with 2mm mesh. The plant compost used is made of plantain peel (epicarp). The adopted technique is the aerobic pits composting. The used *Cubitermes* termite dust was extracted at the top ant-hill in the forest of CNF.

In all, six substrates were evaluated:

- ordinary soil;
- plantain peel compost;
- ordinary soil (50%) + compost (50%);
- ordinary soil (90%) + termite dust (10%);
- plantain peel compost (90%) + termite dust (10%);
- ordinary soil (45%) + plantain peel compost (45%) + termite dust (10%).

Methods

Physico-chemical characterization of substrates

For identifying their pH, a mass of 5 g of each substrate was poured in 5ml of distilled water. The resulting mixture was agitated and left settle during 30 minutes, under regularly stirring. The values of water pH from substrate samples corresponding to those of the solutions were read with a pH meter, after electrodes calibration with a pH 4 acid solution. The evaluation of the pH was repeated three times for each substrate.

Levels of organic matters (OM) were determined in percentage (%) with the ignition loss method (CEAEQ, 2003) modified and adapted to our material. In order to do so, 5g of each substrate sample were raised to 70°C in the oven for 48 hours and calcined in a muffle furnace at 600°C for 5 hours. After cooling, the sample mass was determined. Four (4) repetitions were conducted for each substrate. The average levels of substrates organic matters were determined from the following formula:

$$\mathrm{OM}\ (\%) = 100 \times \frac{\mathrm{Pss} - \mathrm{Psi}}{\mathrm{Pss}}$$

With Pss: the dry substrate weight (g) and Psi: the incinerated substrate weigh (g).

Three types of substrates porosity as well were estimated in percentage (%). The parameters considered were determined from fuze wells cavity. Drain holes of the fuze wells cavity were obstructed and filled with water. That permitted to determine the volume VT of the holes. Then, three cavities of the emptied holes were filled with dry substrate. After that, water was poured on the whole surface of the filled cavities substrates saturation. An hour later, water was added in case of need (poured water quantity = pore volume: air and water). Then, drain holes were emptied and the water (volume of water collected = pore volume: air) that was flowing was collected from 5 to 10 minutes.

The measured variables are the total water quantity poured in the three cavities (VT), pore volume (VA) representing the poured quantity water and the gas phase volume (VR) which is the collected water quantity after the emptying of drain holes.

The different types of porosity were determined as follows:

- Full porosity Pa (%) = (VA/VT) x 100;
- Airing porosity Pa (%) = (VR/VT) x 100;
- Retention porosity Pr (%) = Pt – Pa.

Evaluation of substrates effect on pepper plants growth

The adopted experimental device was in randomized complete blocks with three repetitions. Each block was consisted of a hole. Six wells by cavity were filled with a substrate. To study the effect of substrates on the growth of pepper plants in nurseries, three seeds were planted by well, that means 18 seeds per substrate and repetition. The germination was followed during 21 days. After germination, the plants were separated in order to keep one per well, that means six per substrate and repetition. The follow-up of plants in nurseries lasted 45 days.

The measured parameters after the nursery phase were the height (cm), the stem diameter at the collar (mm), the number of leaves and lateral roots of pepper plants. In addition to these parameters, the robustness of pepper plants that correspond to the quotient of pepper plants height in their stem diameter was calculated in cm/mm.

Statistical analysis of the data

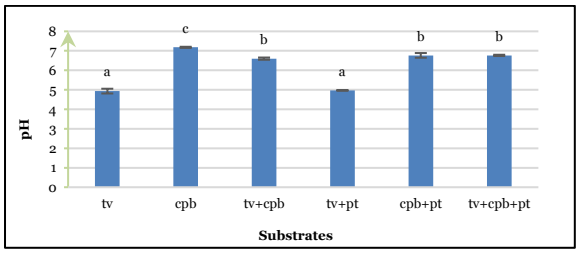
The statistical analysis of the data relating to the characteristics of substrates, and to the growth parameters of pepper plants involved an analysis of variance. In case of rejection of the null hypothesis (H0), the test of Newman-Keuls 5% threshold was carried out to classify averages into homogeneous groups. In addition, the principal component analysis (PCA) permitted to characterize substrates on the basis of their physico-chemical properties and the responses of pepper plants in terms of growth. All these tests were carried out with the software STATISTICA 7.1.

Results

Physicochemical characteristics of substrates

pH of substrates

The substrates pH values tested varied between 4 and 8. The analysis of variance followed with the multiple comparative test of Newman-Keuls 5% threshold permitted to classify them into three homogeneous groups. The first group composed of the plantain peel compost substrate CPB, is characterized with a high value of pH (7.3). The second group contains the substrates CPB+PT, TV+CPB+PT and TV+CPB with pH values of 6.5 and 7. The ordinary soil substrates TV and TV+PT with pH values less than 5 represent the third group (Fig. 1).



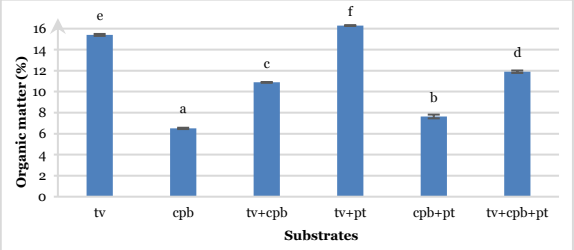
Bars topped with the same letters are not statistically different from 5% threshold

Fig. 1. pH values of growth substrates.

tv: ordinary soil; cpb: plantain peel compost; tv + cpb: ordinary soil (50%) + compost (50%); tv+pt: ordinary soil (90%) + termite dust (10%); cpb+pt: plantain peel compost (90%) + termite dust (10%); tv+cpb+pt: ordinary soil (45%) + plantain peel compost (45%) + termite dust (10%)

Organic matter levels of substrates

The levels of organic matter varied according to the substrates. The results of the statistical analysis indicate a significant difference (P < 5%) between recorded values. The TV+PT substrate differentiate itself with the highest value (16.29%). The lowest organic matter content (6.5%) was recorded in the CPB substrate (Fig. 2).



Bars topped with the same letters are not statistically different from 5% threshold

Fig. 2. Organic matter levels of growth substrates.

tv: ordinary soil; cpb: plantain peel compost; tv + cpb: ordinary soil (50%) + compost (50%); tv+pt: ordinary soil (90%) + termite dust (10%); cpb+pt: plantain peel compost (90%) + termite dust (10%); tv+cpb+pt: ordinary soil (45%) + plantain peel compost (45%) + termite dust (10%)

Porosities of substrates

Three types of porosities were analyzed. These are full, retention and airing porosities. All the substrates showed a total porosity of more than 50%. However, the statistical analysis permitted to differentiate two homogenous groups. For the retention porosity, the differences as observed between values according to substrates were statistically significant. The best values were recorded in the TV, TV+CPB, TV+PT and TV+CPB+PT substrates. Concerning the airing porosity of the substrates, all the values were less than 10%. Furthermore, no significant difference was observed between these latter porosity values (Table 1).

Table 1. Porosity of growth substrates.

Substrates	Full porosity (%)	Retention porosity (%)	Air porosity (%)
TV	59.25 b	54.89 c	4.36 a
CPB	50.23 a	45.55 a	4.68 a
TV+CPB	57.30 b	52.47 c	4.83 a
TV+PT	57.37 b	52.00 c	5.37 a
CPB+PT	51.07 a	45.17 b	5.90 a
TV+CPB+PT	58.48 b	51.66 c	6.82 a

In a column the averages followed with the same letters are not statistically different from 5% threshold.

TV: ordinary soil; CPB: plantain peel compost; TV + CPB: ordinary soil (50%) + compost (50%); TV+PT: ordinary soil (90%) + termite dust (10%); CPB+PT: plantain peel compost (90%) + termite dust (10%); TV+CPB+PT: ordinary (45%) + plantain peel compost (45%) + termite dust (10%)

Screening of substrates according to their Physico-chemical characteristics

The principal component analysis (PCA) carried out from some analyzed physico-chemical parameters indicate that the CPB substrate is characterized by a high pH (7.18) and low full porosity values (50.23), retention porosity (45.55) and organic matter content (6.5). The TV and TV+PT substrates, are characterized by high levels of organic matter, and have high values for the full and retention porosities. The TV+CPB+PT, TV+CPB and CPB+PT substrates are characterized by mean values for the whole analyzed parameters (pH : from 6.5 to 7; OM : 7.63% to 11.89% ; Pt : 51.07 to 58.48 ; Pr : 45.17 to 52.47; Pa : 40.83 to 6.82) (Fig. 3).

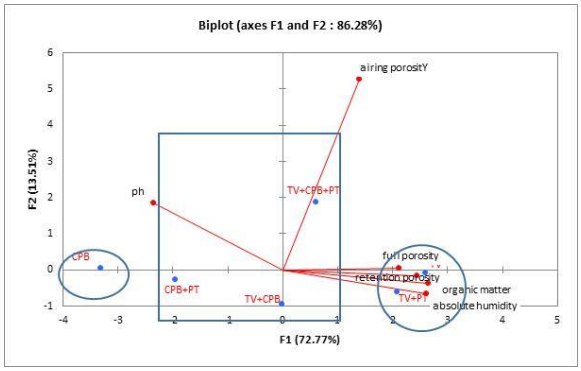


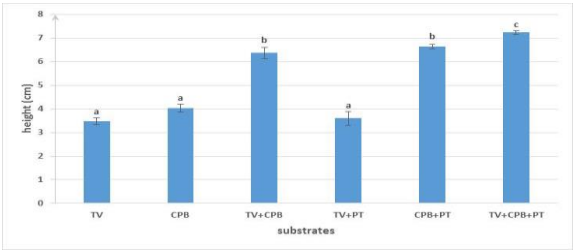
Fig. 3. Distribution of substrates according to their physico-chemical properties.

TV: ordinary soil; CPB: plantain peel compost; TV + CPB: ordinary soil (50%) + compost (50%); TV+PT: ordinary soil (90%) + termite dust (10%); CPB+PT: plantain peel compost (90%) + termite dust (10%); TV+CPB+PT: ordinary (45%) + plantain peel compost (45%) + termite dust (10%)

Effects of substrates on the growth of pepper plants in nurseries

Height of pepper plants

The analysis of pepper plants height permitted to classify the substrates into three homogenous groups. The TV+CPB+PT substrate whose plants are different with the greater height value (7.23 cm) represent the first group. It is followed by the TV+CPB et CPB+PT substrates group, that are characterized by plants having a height from 6 and 7 cm. The lower plants heights were recorded on the TV, TV+PT and CPB substrates with values less than 4 cm (fig. 4).



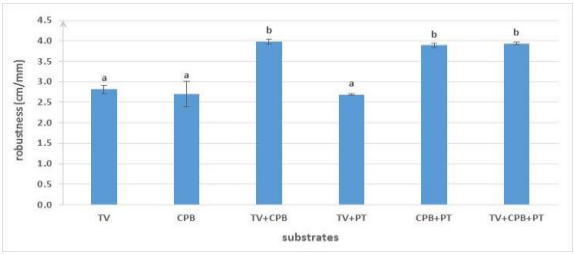
Bars topped with the same letters are not statistically different from 5% threshold.

Fig. 4. Height of 45 days pepper plants according to substrates.

TV: ordinary soil; CPB: plantain peel compost; TV + CPB: ordinary soil (50%) + compost (50%); TV+PT: ordinary soil (90%) + termite dust (10%); CPB+PT: plantain peel compost (90%) + termite dust (10%); TV+CPB+PT: ordinary (45%) + plantain peel compost (45%) + termite dust (10%)

Robustness of pepper plants

The analysis indicate two homogeneous groups of robustness in the plants cultivated on the substrates. The TV+CPB+PT, TV+CPB and CPB+PT substrates, have the plants with the higher values of robustness (almost 4 cm/mm) and the TV, TV+PT and CPB substrates have some robustness plants less than 3cm/mm (Fig. 5).



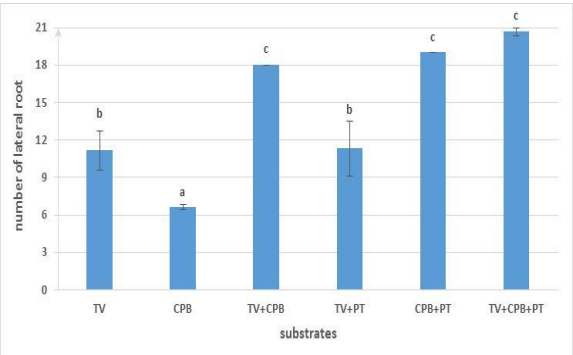
Bars topped with the same letters are not statistically different from 5% threshold.

Fig. 5. Robustness of 45 days pepper plants according to substrates.

TV: ordinary soil; CPB: plantain peel compost; TV + CPB: ordinary soil (50%) + compost (50%); TV+PT: ordinary soil (90%) + termite dust (10%); CPB+PT: plantain peel compost (90%) + termite dust (10%); TV+CPB+PT: ordinary (45%) + plantain peel compost (45%) + termite dust (10%)

Number of pepper plants' lateral roots

The analysis of obtained results indicate that the rooting of the plants is influenced by the type of used substrate. Thus, the best results were obtained in the TV+CPB+PT, TV+CPB and CPB+PT substrates that had plants with the largest average numbers of roots per plant (from 18 to 21). They are followed by the TV and TV+PT substrates whose plants had an average of 11 roots. The low numbers of lateral roots per plant were recorded on the CPB substrate (Fig. 6).



Bars topped with the same letters are not statistically different from 5% threshold.

Fig. 6. Number of lateral roots of 45 days pepper plants according to substrates.

TV: ordinary soil; CPB: plantain peel compost; TV + CPB: ordinary soil (50%) + compost (50%); TV+PT: ordinary soil (90%) + termite dust (10%); CPB+PT: plantain peel compost (90%) + termite dust (10%); TV+CPB+PT: ordinary (45%) + plantain peel compost (45%) + termite dust (10%)

Selection of the best growth substrates of pepper plants

The screening of growth substrates, with a principal component analysis carried out from growth parameters of pepper plants, permitted to classify them into two groups. A first group composed of TV+CPB+PT, CPB+PT and TV+CPB substrates is characterized by plants having the best values for the analyzed growth parameters (height, diameter, robustness, number of leaves and number of lateral root). A second group composed of the TV, TV+PT, CPB substrates. The plants cultivated on the substrates had the lower values for the whole growth parameters (Fig. 7).

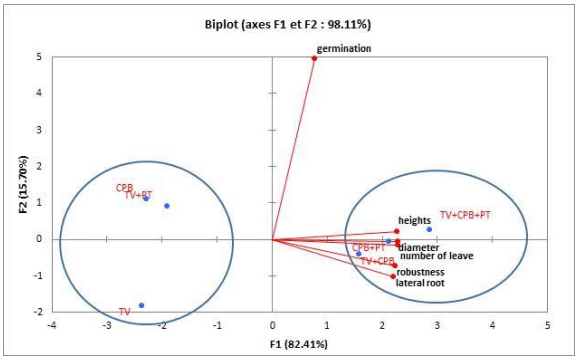


Fig. 7. Distribution of substrates according to growth parameters of pepper plants.

TV: ordinary soil; CPB: plantain peel compost; TV + CPB: ordinary soil (50%) + compost (50%); TV+PT: ordinary soil (90%) + termite dust (10%); CPB+PT: plantain peel compost (90%) + termite dust (10%); TV+CPB+PT: ordinary (45%) + plantain peel compost (45%) + termite dust (10%)

Discussion

The pH values of substrates varied from 4.93 to 7.18. However, the CPB, TV+CPB+PT, CPB+PT and TV+CPB substrates had some pH near 7. These substrates are made of plantain peel compost that could be rich in basic elements. According to Fellah (1979) pH values near 7 are desirable and suitable to all plant species. The studies of the same author also indicate that cultivation substrates with pH near 5 are favorable to the cultivation of white spruce. According to Lamhamedi *et al.* (2009) such a pH permits to make more available most of necessary mineral elements to the plants. Pinners *et al.* (1989) said that the optimum acidity of the substrate for pepper cultivation is near a pH from 6.5 to 7. These values are suitable to those recorded in the TV+CPB+PT, CPB+PT, TV+CPB substrates.

The full porosity values obtained are more than 50% and those of airing porosity are less than 10% in all the analyzed substrates. These values suggest that the substrates are favorable to a water conservation, a circulation of liquid and a suitable rooting of the plants as mentioned in the studies of Baize and Jabiol, (1995).

Moreover, plants in nurseries on the TV+CPB+PT, CPB+PT and CPB+TV substrates, generally had, the best growths of pepper plants (height, robustness,

rooting). These results were consolidated with those of the principal component analysis (PCA), carried out on the basis of growth parameters, that permitted to classify the substrates into two groups. The TV+CPB+PT, CPB+PT and CPB+TV substrates, characterized by the best values for the whole growth parameters (height, collar diameter, robustness, number of leaves, rooting), were different from the TV, CPB and PT+TV substrates. These results could be explained by the components quality of each single substrate and their characteristics. The substrates that had the best growths contain CPB, used in association with other components whereas the CPB used alone did not permit to obtain plants with high growth. This suggests that one of the best ways to optimize the potential of the CPB is to use it in combination. This result supports the one of Duponnois (2014) who associated compost and termite dust to obtain a better growth and production of tomato plants. The presence of PT in some of the substrates that had a favorable effect on the growth consolidate the results of N'Diaye *et al.* (2003) that indicated the use of enriched substrate with *Cubitermes* termite dust has a positive effect on the plant growth.

In addition, the TV+CPB+PT, CPB+PT, CPB+TV substrates which had the best growth, were different with some good average physico-chemical characteristics ($6.5 < pH < 7$, full porosity > 50%). This result indicates that for an optimal initial growth of pepper plants, we need a favorable porosity of substrates in addition to the pH recommended condition by Pinners *et al.* (1989). The TV+CPB+PT substrate, that has proved to be the most favorable to the growth of pepper plants, in addition to have a full porosity more than 50%, is characterized by the higher airing porosity. According to the studies of Landis (1990) the porosity of cultivation substrate is regarded to be among the key factors of the plants morphological quality. It directly influences the whole plants root functions, particularly the absorption of water and mineral elements. The respiration or oxygen level, in the substrate is necessary, because the roots need oxygen for the respiration and growth. Abourouh *et al.* (1995) throughout their studies indicated that the lack of ventilation of certain substrates very often causes a mortality of the roots generally preceded by phyto-pathogen fungi such as *Phytophthora*. According to these authors a good plant nursery substrate must have a good porosity, a sufficient quantity of specific humidity and a good organic matter level. The obtained results relating to organic matter and types of porosity are proved by those of these authors.

According to Lamhamedi *et al.* (1997) the ratio of robustness: height/diameter expressed in (cm/mm) should be less than 7 for quality plants produced in nursery. The quality of the used compost and the one of the termite dust can explain the obtained results on the TV+CPB+PT, CPB+PT, CPB+T substrates. M'sadak *et al.* (2013) recorded an improvement in height and diameter and therefore the ratio *acacia cyanophylla* robustness on the substrates made of sieved compost in a nursery off the ground. Ballot *et al.* (2016), after their studies, obtained an improvement of the cassava growth by using the termite dust as fertilizer. Mokossesse *et al.* (2009) also demonstrated fertilization effect of the termite dust on growth parameters of acacia in pot. According these authors, the termite dust (soils) is rich in ammoniacal nitrogen and also in nitric nitrogen, carbon and available phosphorous as well as savannah sandy soil.

Conclusion

This study is mainly concerned with an indirect evaluation relating to physiological parameters (germination, height and diameter growth, number of leaves and lateral roots) of pepper plants produced on various cultivation substrates. It consisted in developing cultivation substrates from plantain peel and *cubitermes* termite dust compost, and evaluating the effects of their physico-chemical characteristics on the pepper nursery development.

According to the obtained results, the TV+CPB+PT substrate led to the most satisfactory growth of pepper plants. The CPB+TV and CPB+PT substrates can be considered among the best in terms of plants vegetative parameters. Considering all the results, the plantain peel compost enriched with ordinary soil

or/and the termite dust constitute an alternative substrate to the least available and expensive substrates for the small producers. You just need to properly adjust the ratio of mixture to ensure a suitable physical quality, necessary basis to help the good start of plants growth.

References

Abourouh M, Lamhamedi MS, Fortin JA. 1995. Techniques de mycorhization en pépinière des plants forestiers. Centre national de la recherche forestière de Rabat, Maroc 38.

Akédrin TN, N'guessan K, Aké-Assi E, Kassi NJ, Ake S. 2011. Evaluation des effets comparatifs de 11 Légumineuses herbacées ou subligneuses sur la croissance du maïs, Journal of Applied Biosciences **37,** 2468-2476.

Baize D, Jabiol B. 1995. Guide pour la description des sols. Edit. INRA, Paris, Impri. Louis. Jean 98.

Ballot C, Wango S, Atakpama W, Semballa S, Zinga I, Batawila K, Akpagana K. 2016. Amélioration des rendements de la culture du manioc (*Manihot esculenta* C.) par les terres de termitières dans la zone de savane de Damara en République Centrafricaine), Marché des Sciences Agronomique Vétérinaire **4(2),** 40-53.

Bosland P, Votara EJ. 2001. Peppers: vegetable and spice capsicums. NW State University, USA. CABI Publishing, Wallinford, UK, 216.

CEAEQ. 2003. Détermination de la matière organique par incinération : Méthode de la perte au feu (PAF), MA. 1010-PAF1. Édition: 2003-03-27. Ministère de l'environnement du Quebec 9.

CIRAD-GRET. 2002. Mémento de l'agronome. Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), Groupe de Recherche et d'Echange Technologique (GRET). Edition du GRET, Edition du CIRAD, Ministère française des Affaires étrangères 24-25.

Duponnois R. 2014. Utilisation de poudre de termitière comme bioengrais en maraîchage. In: Agricultures familiales. Les Dossiers d'Agropolis International **19,** 27-63.

FAO. 2006. Commodity highlight: chili peppers. In « Vegetables and Melons VGS **313,** 23.

FAO. 2014. FAOSTAT Database. Food and Agriculture Organization, Roma, Italy. Available online at www.fao.org.

Fellah A. 1979. Problème des mélanges en pépinières forestières, les effets de l'utilisation d'un compost. Thèse foresterie, I.N.A d'Alger EL HARACHE 45.

Herrera F, Castillo JE, Chica AF, López Bellido L. 2008. Use of municipal solid waste compost (MSWC) as a growing medium in the nursery production of tomato plants. Bioresources. Technol **99,** 287-296.

Inbar Y, Chen Y, Hoitink HAJ. 1993. Properties for establishing standars for utilization of compost in container media, In: Hoitink HAJ, Keener HM (Eds). Science and engineering of compostiong: design, environemental, microbiological and utilization aspects. Renaissance Publication, Worthington, OH 668-694.

Lamhamedi M, Renaud M, Desjardins P, Veilleux L. 2009. Mise à l'échelle opérationnelle du traitement hâtif de jours courts sur la morpho-physiologie et l'insuffisance racinaire des plants d'épinette noire (1+0) produits en tunnel. Mémoire de recherche forestière n° 154. Direction de la recherche forestière, Ministère des Ressources naturelles et de la Faune, Gouv. Québec. Québec 23.

Lamhamedi MS, Fortinn JA, Ammari Y, Ben Jalloun S, Poirier M, Fecteau B, Bougacha A, Godin L. 1997. Évaluation des composts, des substrats et de qualité des plants (*Pinus pinea*, *Punis halepensis, Cupressus sumpervirens* et *Quercus suber*) élevés en conteneurs. Projet Bird 3601. Rapport technique : Exécution des travaux d'aménagement de trois pépinières pilotes en Tunisie. Direction Générale des Forêts, Tunisie et Pampev Internationale Ltée, (Canada) 121.

Landis TD. 1990. Containers and growing media, vol. 2. The container tree Nursery Manual. Agric. Handbk 674. Washington, DC. US. Department of Agriculture forest service 41-85.

M'sadak Y, HamdI W, Zaalani Ch. 2013. Production et croissance des plants d'Acacia sur des substrats à base de tamisat de compost dans une pépinière hors sol (Tunisie). Institut Supérieur Agronomique de Chott-Mariem, Université de Sousse – Tunisie. *R*evue Agriculture **6,** 29-34.

Mokossesse jA, Lepage M, Josens G. 2009. Croissance en pots de quatre espèces végétales sur des substrats enrichis avec la terre de termitières de *Cubitermes*. Tropicultura **27(3),** 168-175.

N'diaye D, Duponnois R, Brauman A, Lepage M. 2003. Impact of a soil feeding termite, Cubitermes niokoloensis on the symbiotic microflora associated with a fallow leguminous plant Crotalaria ochroleuca. Biol. Fert. Soils **37,** 313-318.

Pinners E, Dekker E, Amati M. 1989. La culture de la tomate, du piment et du poivron. Wageningen: AGROMISA 8.

USAID. 2006. Activité de renforcement de la commercialisation agricole en Guinée. USAID du peuple américain **29,** 36.

Van Der Gaag DJ, Van Noort FR, Stapel-Cuijpers LHM, Dekreij C, Termorshuizen AJ, Van Rijn E, Zmora-Nahum Sh, Chen Y. 2007. The use of green waste compost in peat-based potting mixtures: Fertilization and suppressiveness against soilborne diseases, Scientia Horticulturae **114,** 289-297.