IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 5 Issue 11, November 2018
ISSN (Online) 2348 – 7968
www.ijiset.com

Influence of Biofertilizers (*Azolla Filiculoides* And Compost) On The Growth And Productivity Of Two Varieties Pepper (*Capsicum Annum*) In The Locality Of Daloa (Côte D'ivoire).

Mambé Auguste-Denise BOYE[1], Noël GROGA[2], Valère KOTCHI[3] et Paule Ayefemi Doriane DJIKENNOU[4]

[1]Professor, Department of Agroforestry, University Jean Lorougnon Guédé, Daloa, Côte d'Ivoire
[2]Assistant professor, Department of Agroforestry, University Jean Lorougnon Guédé, Daloa, Côte d'Ivoire
[3] Assistant professor, Department of valorization and research, University Jean Lorougnon Guédé, Daloa, Côte d'Ivoire
[2]Assistant, Department of Agroforestry, University Jean Lorougnon Guédé, Daloa, Côte d'Ivoire

*bmambeaud@gmail.com

Abstract
The low productivity of crops is a problem faced by gardeners in our country. The lack of sufficient resources for the purchase of fertilizers and their scarcity on the market and the lack of information on other means or technical cheaper to increase crop productivity are the basis of this situation.
This study was conducted to evaluate the effect of two biofertilizers *A.filiculoides* and compost on the parameters of vegetative growth and production of two varieties of Cheyenne Sunny and hot peppers. The test was conducted according to a device consisting of three randomized complete block with 3 replicates. Each repetition includes 6 treatments including 2 control treatments without organic fertilizers. The blocks are spaced from each other of 0.70 m. The spacing between the elementary parcels is 0.50 m.
Results showed better growth in stem height, collar diameter, and a good performance with the biofertilizer *Azolla filliculoïdes* especially in the variety Sunny. Increased leaf area was obtained with an amendment made to the compost precisely at the Cheyenne variety.*Azolla filiculoides* under the conditions of this trial was of great potential for improving the availability of nutrients in soil and was able to provide the amount of nutrients for growing peppers without the addition of mineral fertilizers.

Keywords: biofertilizers; *Azolla filiculoides*;

compost; chilli pepper

1. Introduction

Horticultural crops in rural, peri-urban and urban areas are a dynamic source of food and income in many African cities. Chili in particular is a vegetable plant, which belongs to the family of Solanaceae as well as pepper. The Capsicum spp pepper is one of the top 40 vegetable species produced worldwide (Lebeau, 2010). It has been the subject of an important selection work that has led to the multitude of varieties currently known and whose flavor ranges from very mild to very spicy. Global chilli production has been assessed by FAO at more than 31 million tonnes (FAO, 2014). At 500,000 and 110,000 tons / year, Nigeria and Ghana are the largest pepper producing countries in West Africa. In Côte d'Ivoire, with an estimated production of 32 900 tonnes / year, peppers are the main vegetables consumed and grown with okra, tomato and aubergine. It is used in food and traditional medicine by the populations for its high capsaicin content (Koffi-Nevry et al., 2012, Kouassi, 2012, Koffi et al., 2014)). This hot pepper principle consists of a yellowish oil with a hot flavor. In addition, chilli is also rich in minerals, vitamins A and C necessary for the proper functioning of the body (El-Ghoraba et al., 2013). In economic terms, prices per kilogram of peppers constantly high in the markets (between 505 and 722 F / kg in December 2012 in the markets of Bouaké) offer opportunities for improving income for producers (Fondio et al., 2015). However, in order to increase yield, the use of mineral and / or organic fertilizers is necessary. Mineral or chemical fertilizers are sometimes imported, expensive and rarely available and their use pollutes the air, disturbs the soil balance and contaminates groundwater (Cisse, 2000). To protect health and the environment organic farming is a way to explore. This favors the use of biofertilizers (less expensive and easy to obtain) and contributes to the enrichment of the soil leaving no toxic residues on the products. The objective of this study is to contribute to the improvement of chilli production through the use of biofertilizers.

2. Material and methods

2.1 Material

The plant material consists of peppers (*Capsicum annum*.) Of F1 variety Sunny and Cheyenne.
The fertilizing material consists of two types of organic fertilizers:
- the compost used is a mixture of chicken droppings, sawdust white, pulp of
coffee and charcoal.
- *Azolla filiculoides* comes from a shallow bottom on the road to Issia more precisely a
Zakoua.
The study was conducted in an experimental phase at the University Jean Lorougnon Guede site in Daloa, in the western center of the Haut Sassandra region. This locality is characterized by a ferralitic type soil and a dense semi-deciduous forest (Figure 1).

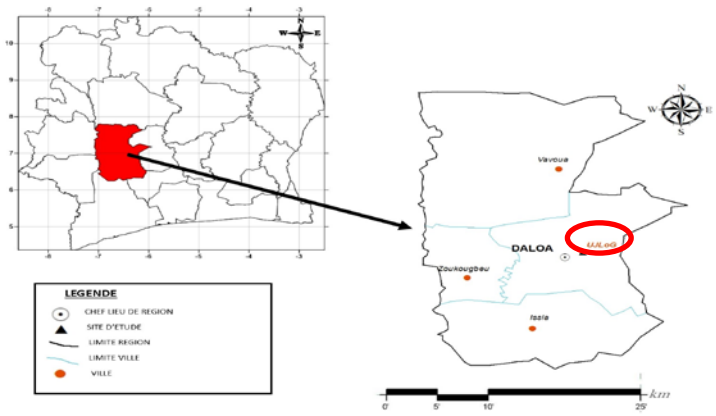

Figure 1: Study site

2.2 Methods

2.2.1 Preparation of the compost

The preparation of the compost required the use of 100 kg of chicken manure, 50 kg of white sawdust, 35 kg of coffee pulp and 100 kg of charcoal. Half of each quantity was spread on a black tarpaulin in succession (sawdust, droppings, charcoal, coffee pulp) and mixed. The other half was added to the mixture and then 180L of water was poured gradually to obtain a homogeneous heap. The mixture obtained was stored for 1 month in a black tarpaulin.
Establishment of the culture of *Azolla filiculoides.*

kg of chicken dung added to 5L of ordinary water and let stand for 2 days in the shade.

As for the culture of *Azolla filiculoides* 125 L of ordinary water were poured into the pit and 6 L of droppings were added. The medium thus prepared to serve as 125g culture medium of *Azolla*. 500 g *Azolla* of fresh mass kneaded in 15 L of water were used for the preparation of
liquid azolla. This allowed the fertilization of the boards.

2.2.2 Experimental apparatus

After 42 days in the nursery the plants were removed and transplanted according to a completely randomized device with 6 treatments repeated 5 times. Each repetition constituting a block. The length of an elementary parcel was 2 m 60 and the width of 0.50 m. The distance between blocks was 0.70 m.

For the cultivation of *Azolla filiculoides* pits 3 m long, 1 m wide

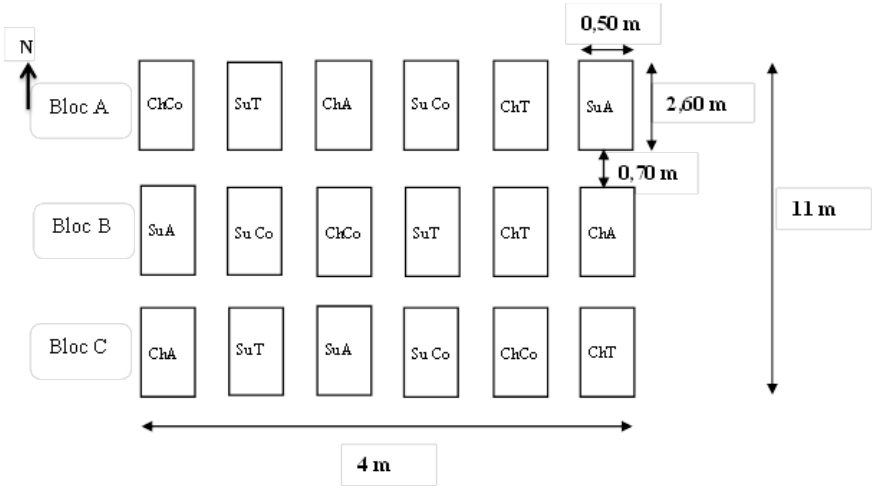

Figure 2: Experimental device

ChT : Variété Cheyenne + sans engrais (Témoin); SuAF : Variété Sunny +*Azolla filiculoïdes*; ChAF : Variété Cheyenne + *Azolla filiculoïdes*; SuCo : Variété Sunny+ compost ; ChCo : Variété Cheyenne + compost

2.2.3. Conduct and follow-up of the experiment

2.2.3.1 Establishment of the nursery

For the conduct of this experimentation a nursery was set up in the period of December and January and lasted 42 days. A board with an area of 2m2 was made to receive the nursery. A contribution of 1kg of chicken dung was brought 2 weeks before semi. The semi was made in a continuous and homogeneous line.

2.2.3.2. Establishment of the culture

For the preparation of the plot an area of 44 m2 was cleared to accommodate the nursery with a deep plowing of 30 cm deep for this purpose boards 2 m 60 long, 0.5 m wide and 30 cm high have been made.

Transplanting consisted of transplanting the seedlings from the nursery to the area prepared for this purpose and only the most vigorous plants were selected. It was 0.5 m apart between the plants. The plants were buried to the neck in the substrate (the earth) followed by watering. Manual and daba weeding is done once every two weeks until the end of the experiment to avoid weed competition. Ordinary water was provided by watering when needed.

2.2.3.3. Fertilization of planks

It was made with organic fertilizers (*Azolla filiculoides* and compost). Chicken droppings were used as bottom fertilizer on all plots. Biofertilizer (Azolla) was applied weekly for the first 4 weeks. The first intake was made one week after transplanting. Each contribution consisted of pouring 0.25 liters of *Azolla filiculoides* per board, or about 50 ml per pepper plant in the Sunny variety as in the Cheyenne variety. The compost was made following the same methodology except that it was used at the rate of 1 kg for a variety, ie 0.33 kg per board or 66 g. Both biofertilizers (*Azolla* and Compost) were applied simultaneously on the same day. However, the witnesses of the different varieties did not undergo any treatment.

2.2.3.4. Colette data

Data collection focused on growth and production parameters. It started 2 weeks after transplanting for growth parameters and 1 month after fertilization (with fruiting) production parameters. The data collection ended at the first harvest.

Measurement of growth parameters: The number of leaves (NF) was counted on each chili plant. The height of the stem (HT) is determined using a double decimetre and was measured for each plant and for each type of treatment. Height measurements were taken on the main stem from the soil surface to the apex of the plant. The collar diameter (DC) was determined using a caliper and measurements were taken at the base of the plant stem. The diameter (mm) was measured for each plant and for each type of treatment. The leaf area (cm2) was determined by the length and width of the leaves according to the following formula (Spagnolelli & Qualset 1990).

Leaf area (SF) = L x l x 0,607

L= Length of leaves in cm.
L= leaf width in cm.
0,607 = regression coefficient of the surface

Measurement of yield parameters: The production parameters concerned the number of fruits, the mass of fresh fruit and the yield. Fruit harvesting started 44 days after transplanting. The yield obtained is from the first harvest and last for 2 days. The fruits harvested from each chili plant were counted and then weighed using a scale. The yield (t / ha) was determined according to the following formula:

$$R = \frac{M}{S} \times 10^{-2}$$

R : yield in t / ha
M : fruit mass
S : surface in ha

2.3. Statistical analysis

The collected data was processed using the STATISTICA version 7.1 software. The one-way analysis of variance allowed the averages to be compared and the turkey HSD test at the 5% threshold allowed the averages to be classified into homogeneous groups.

3. Results

3.1. Influence of biofertilizers on vegetative growth parameters of Sunny and Cheyenne pepper varieties.

3.1.1 Number of sheets

The number of leaves of plants for the varieties Sunny (40.39 ± 39.10) and Cheyenne (39.11 ± 44.82) is higher on the plot amended with *Azolla filiculoides* followed by the plants of the plot amended with compost (38.47 ± 38.43 for the Cheyenne variety and 30.75 ± 30.11 for the Sunny variety) (Table III). However, the difference in the number of leaves for these different treatments is statistically insignificant in both varieties ($p = 0.20$).

3.1.2. Height

However, the treatments revealed a very highly significant difference ($p < 0.001$) on the height of chilli plants. In the Sunny variety, height growth was significantly higher in the A. filiculoides-amended plot (17.00 ± 5.02 cm) than in the composted plot (14, 82 ± 4.93). Unlike the Sunny variety, the height of Cheyenne pepper plants is statistically identical on the different plots treated.

3.1.3. Leaf area

Similarly, the various amendments made increased the leaf area of the plants very significantly ($p < 0.001$). This difference was observed in both Sunny and Cheyenne varieties. It appears that the highest leaf area (13.63 ± 7.34 cm2) was obtained from chili seedlings of the Cheyenne variety that received compost (Table III). With an *Azolla*-based amendment, the leaf area of chilli was 12.53 ± 4.61 cm2 and 8.26 ± 5.01 cm2 respectively for Sunny and Cheyenne. Comparison of the two control treatments revealed that the Sunny variety had a large leaf area than the Cheyenne variety.

3.1.4. Neck diameter

Finally, regarding the neck diameter of the pepper plants, the statistical tests revealed a very highly significant difference ($P < 0.001$) between the different treatments. Indeed, the diameter at the neck of chilli plants varied from one treatment to another. The difference was significant between treatments in the Sunny variety and not significant in Cheyenne. The largest neck diameter (4.40 ± 1.38 mm) was observed in the Sunny variety on *A. filiculoides* treated chilli plants. The neck diameter of compost-treated peppers was 3.55 ± 1.21 mm and 3.19 ± 1.23 mm respectively for the Sunny and Cheyenne varieties. In addition, the smallest neck diameter (2.83 ± 1.20 mm) was obtained with Cheyenne at plants treated with A. *filiculoides*. Comparison of the two controls concluded that the Sunny variety exhibits better thickness growth compared to the Cheyenne variety. The analysis of this parameter shows that the highest collar diameter was obtained in the Sunny variety fertilized with *A. filiculoides*

Table 1: Influence of biofertilizers on vegetative growth of Sunny and Cheyenne peppers

Treatments	NF	HT(Cm)	SF(Cm^2)	DC (mm)
SuT	28,33 ± 23,62[a]	15,62 ± 4,58[bc]	10,95 ± 4,40[a]	3,51 ± 1,03[b]
SuAF	40,39 ± 39,10[a]	17,00 ± 5,02[c]	12,53 ± 4,61[ac]	4,40 ± 1,38[c]
SuCo	30,75 ± 30,11[a]	14,82 ± 4.93[b]	10,86 ± 3,89[a]	3,55 ± 1,21[b]
ChT	30,88 ± 25,35[a]	9,17 ± 3,18[a]	7,46 ± 3,73[b]	2,77 ± 0,96[a]
ChAF	39,11 ± 44,82[a]	10,14 ± 3,52[a]	8,26 ± 5,01[b]	2,83 ± 1,20[a]
ChCo	38,47 ± 38,43[a]	9,70 ± 3,65[a]	13,63 ± 7,34[c]	3,19 ± 1,23[ab]
F	**1,48**	**43,04**	**14,69**	**16,60**
P	**NS**	**<0,001**	**<0,001**	**<0,001**

For each average, values with the same letters (a, b, c) on the same column are not significantly different at the 5% threshold.

Légende : NF : Nombre de feuilles ; HT : Hauteur de tiges ; SF : Surface foliaire ; DC : Diamètre au collet ; SuT : Variété Sunny + sans engrais organique (Temoin) ; SuAF : Variété Sunny + *Azolla filiculoïdes* ; SuCo : Variété Sunny + compost ; ChT : Variété Cheyenne + sans engrais (Temoin) ; ChAF : Variété Cheyenne + *Azolla filiculoïdes* ; ChCo : Variété Cheyenne + compost

3.2. Influence of biofertilizers on production parameters of Sunny and Cheyenne peppers.

3.2.1 Number of fruit

Statistical analysis revealed that the different biofertilizers significantly increased ($p < 0.01$) the number of fruits at harvest of the different treatments (Table 2). Comparison of the controls showed that the Cheyenne variety was more productive (number of fruits) than the Sunny variety on the parcel amended with A. filiculoides. The mean number of Cheyenne and Sunny fruit in the controls was 52.50 ± 37.85 and 38.19 ± 19, respectively. However, no significant difference was found between the Sunny-control treatments, Sunny - compost; between Cheyenne - witness, Sunny - Azolla, Cheyenne - compost. From the Table analysis, it can be seen that the application of A. filiculoides to the pepper resulted in a high average fruit number for both Cheyenne (66,19 ± 29,06) and Sunny variety (58.75 ± 21.62). The compost yielded an average fruit count of 60.44 ± 23.26 for the Cheyenne variety and 38.50 ± 20.30 for the Sunny variety.

3.2.2. Fruit mass

For the mass of fruit harvested, the statistical analysis revealed a significant difference ($p = 0.02$) between the different treatments applied (Table 2). The comparison of the controls showed that the Sunny variety gave a mass of harvested fruits superior to that of the Cheyenne variety treated with Azolla. The highest average fruit mass (255.56 ± 110.72 g) was recorded for treatment with *A. filiculoides* on the Sunny variety. However, no significant difference was found in Sunny - control, Cheyenne - *Azolla*, Sunny - compost and Cheyenne - compost treatments.

3.2.3. Yield

From a performance point of view, the statistical tests revealed a significant difference between the different treatments ($p < 0.05$). Sunny - *Azolla* treatment is significantly different from Cheyenne - control treatment. However, no difference was found in Sunny - control, Cheyenne - *Azolla*, Sunny - compost and Cheyenne compost treatments. The plants treated with A. *filiculoides* of the Sunny varieties had a high yield (10.22 ± 4.43 t / ha) compared to the compost (7.59 ± 4.67 t / ha) for the Sunny variety and (6, 39 ± 2.79 t / ha) for the Cheyenne variety. In comparison with controls, the Sunny variety is more productive than the Cheyenne variety with a yield (fruit mass) of 10.22 ± 4.43 t / ha (Table 2). This study shows that treatments with *Azolla filiculoides* have resulted in better fruit mass yield with the Sunny variety.

Table 2: Influence of biofertilizers on the production of Sunny and Cheyenne peppers

Treatments	Number of fruits	Mass of fruits (g)	Yield (t/ha)
SuT	38,19 ± 19^{a}	169,44 ± 96,40^{ab}	6,78 ± 3,86^{ab}
SuAF	58,75± 21,62^{ab}	255,56 ± 110,72^{b}	10,22 ± 4,43^{b}
SuCo	38,50± 20,30^{a}	189,81 ± 116,71^{ab}	7,59 ± 4,67^{ab}
ChT	52,50 ± 37,85^{ab}	132,31 ± 106,63^{a}	5,29 ± 4,27^{a}
ChAF	66,19 ± 29,06^{b}	179,69 ± 90,99^{ab}	7,19 ± 3,64^{ab}
ChCo	60,44 ± 23,26^{ab}	159,63 ± 66,77^{ab}	6,39 ± 2,79^{ab}
F	**3,27**	**2,77**	**2,77**
P	**0,009**	**0,02**	**0,02**

For each average, values with the same letters (a, b, c) on the same column are not significantly different at the 5% threshold.
Légende : NF : Nombre de feuilles ; HT : Hauteur de tiges ; SF : Surface foliaire ; DC : Diamètre au collet ; SuT : Variété Sunny + sans engrais organique (Temoin) ; SuAF : Variété Sunny + Azolla filiculoïdes ; SuCo : Variété Sunny + compost ; ChT : Variété Cheyenne + sans engrais (Temoin) ; ChAF : Variété Cheyenne + Azolla filiculoïdes ; ChCo : Variété Cheyenne + compost

4. Discussion

The different biofertilizers significantly induced an increase in the height of the stem, the leaf area and the diameter at the neck of chilli plants.

The analysis of the results shows that A. filiculoides and compost induced an increase not only in the height of the stalks of the pepper plants but also their neck diameter in the Sunny variety. However, the highest values were obtained with the biofertilizer A. filiculoides. This growth is justified by the fact that *A. filiculoides* has provided a significant amount of nitrogen and phosphorus, the main plant growth factors. These elements are essential for the growth and development of plants and act immediately on the development of foliage and the production of plants in culture (Brasset & Couturier, 2005). *Azolla* is home to a cyanobacterium of the genus *Anabeana* that has the property of fixing nitrogen, that is to say transform the atmospheric nitrogen and make it assimilable to the plant. These results are similar to those of William (2003) who reveals that an excess of nitrogen stimulates an exuberant growth of the aerial part, thus favoring an increase in the ratio of leafy stems / roots and heights of the plants. However, these results corroborate those of Bikela (2007) who asserts that baselle *(Basella alba* var alba) plants fertilized with *Azolla cristata* excellent in thickness. Stevenson (1986) has similarly argued through his work, which has shown that nitrogen promotes the use of carbohydrates, stimulates development and root activity, thus promoting the export of other mineral elements and the plant growth.

The leaf surface is a factor of good photosynthesis; the more it increases, the greater will be the production of 02 by the resulting photosynthetic activities and the consequent synthesis of C6H1206 Mondjalis & Ilunga (2015). The various amendments made significantly increased the leaf area of chilli plants. Comparison of the 2 control treatments revealed that the Cheyenne variety has a large leaf area than the Sunny variety. At the end of our experiment, it appears that compost fertilization proved to be more effective in terms of leaf area in the Cheyenne variety. These results are consistent with those of Nguo et al. (2016) who deduce from their experimentation that cow dung favored the highest value of the leaf area of eggplant plants. This would be due to the amount of mineral elements that would be found in these organic fertilizers. Indeed, the phosphorus content of compost is an important element for fruit production (FAO, 2000).

The application of *A. filiculoides* on chilli resulted in a higher average number of fruits in the Cheyenne and Sunny varieties. These results are consistent with the findings of Diara (2000) who showed that the use of *A. pinnata* increases the yield of rice grain in Senegal. The results from our study showed that the various amendments made significantly increased the number of fruits of the chilli varieties used. Fondio et al. (2013) confirm this by showing that the different organic fertilizers have significantly increased the number of tomato

fruits. The Cheyenne variety yielded more fruit than the Sunny variety compared to their controls. In contrast to the number of fruits, the results from our study showed that the different organic fertilizers increased the yields (fruit mass) of the pepper. Dobermann & Fairhurst (2000) state that nitrogen fertilization affects all the parameters that contribute to good yield. The different biofertilizers applied to the chilli varieties made it possible to assess the fruit mass yield at the chilli plants fertilized with *A. filiculoides*. The positive role of *Azolla*, demonstrated by the results obtained in this trial, is consistent with that of Bikela (2007) who recorded increases in yields of *Basella* alba var. alba, compared to pig manure, chicken manure and urea after, the application of *Azolla cristata*. These results are consistent with those of Lumpkin-Plucknet (1982) who deduce that *A. pinnata* is a green manure that significantly increases the yield of rice. Bationo et al. (1998) state that nitrogen is a limiting factor for yields, and good nitrogen nutrition is expressed by a spectacular yield; therefore, nitrogen is considered the pivot of fertilization (Betrand & Gigou, 2000). This increase in yield takes place because of the permanent availability of nitrogen assimilable to the rice plant as shown by the work of Maria Andrea et al. (2007). The assimilable nitrogen allows growth and increases yield as shown by the yields at harvest.

5. Conclusion

This work allowed to experiment the action of *Azolla filiculoides* and compost on the growth and production of pepper. At the end of this study, it was found that all biofertilizers used for this test significantly increased stem height, neck diameter, mass and fruit count. Azolla and compost biofertilizers have proven effective, but *Azolla* has been shown to be more effective for both vegetative organ growth and productivity. *Azolla*, by its richness in nutriment thus demonstrated its capacity to increase the output of the pepper. The work has therefore shown that the *A. filiculoide*s biofertilizer gave a better yield in terms of fruit mass with the Sunny variety and this variety is more productive than the Cheyenne variety.

6. References

[1] A. Bationo, S. Koala and E. Ayuk. Soil production for cereal production in Sahelo-Sudan zone and recovery of natural phosphates. Cahiers Agriculture, 1998, 7 (5): 365-371.

[2] R. Betrand & J. Gigou. The fertility of tropical soils. Paris, Edition Maisonneuve, Larose, 2000, 397 p.

[3] Bikela N.A. Comparative test of the fertilizing quality of Azolla Cristata and other manures (droppings, slurry and urea). Bachelor of Science, Higher Pedagogical Institute, Gombe Kinshasa, 2007, 30 p.

[4] T. Brasset & C. Couturier. Management and valorization of ashes of wood boilers. Spreading in the forest, Environment and Energy Management Agency, 2005, 7 p.

[5] I. Cisse. Use of pesticides in the horticultural production system in the Niayes area: the products and their impact on the water table, PhD Thesis, UCAD, 2000, 187p.

[6] H.F. Diara. The use of Azolla as a green manure in West African rice farming WARDA - Saint-Louis Regional Station, Senegal, 2000, 10 p.

[7] A. Doberman & T. Fairhurst. Nutrients Disorders and Nutrients Management. International Plant Nutrition Institute; 2000, 191p.

[8] A.H. El-Ghoraba, Q. Javedb, F.M. Anjumb, S.F. Hamedc and H.A. Shaabana. Pakistani Bell Pepper (Capsicum annum L.): Chemical Compositions and its Antioxidant Activity. International Journal of Food Properties, 2013, 16 (1): 18-32

[9] FAO. Fertilizers and their use - A pocket guide for extension officers. Fourth edition. FAO, Rome, 2000, 34p

[10] FAO. FAOSTAT Database. Food and Agriculture Organization, Roma, Italy. 2014, Available online at URL: www.fao.org.

[11] Fondio Lassina, Djidji A Hortense, N'gbesso François de Paul Mako and Kone Daouda. Evaluation of nine varieties of tomato (Solanum Lycopersicum L.) in relation to bacterial wilt and productivity in southern Côte d'Ivoire, 2013, 1086 p.

[12] L. Fondio, J.C. N'zi and K. Kobenan. Agronomic and health behavior of new chilli lineages (Capsicum sp) in southern Côte d'Ivoire. Journal of Applied Biosciences, 2015, 92: 8594 - 8609

[13] A.C. Koffi, R. Koffi-Nevry, K.C. Kouassi and Y.G. Loukou. Activity of extracts of six varieties of pepper (Capsicum) used in Ivory Coast. J. Appl. Biosci., 2014, 82: 7379-7888.

[14] R. Koffi-Nevry, C. Kouassi, Z. Nanga, M. Koussémon and G. Loukou. Antibacterial activity of two bell pepper extracts: Capsicum annum L. and Capsicum frutescens. Int.J. Food Prop., 2012, 15: 961-971.

[15] C. Kouassi. Bioactive potential and antimicrobial activity of chilli varieties (Capsicum) grown in Côte d'Ivoire. Doctoral thesis; University

of Abobo-Adjamé, Abidjan, Ivory Coast, 2102, 161 p.
[16] A. Lebeau. Resistance of tomato, eggplant and Ralstonia solanacearum pepper: interaction between Resistance broodstock and bacterial diversity, characterization, 2010
[17] T.A. Lumpkin & D.L. Plucknett. Azolla as a green manure. Westview Tropical Agriculture Series, Westview Press, Boulder Co, USA.1982, 230 p
[18] K. Maria Andrea, L.G. Paul and Vlek. Azolla, a technique to improve the efficiency of use of nitrogen. Agriculture & Rural Development, Zentrum fur Entwicklungsforschung (Center for Development Studies) Bonn, Germany, 2017.
[19] P. Mondjalis & C. Ilunga. Comparative test on the application of biofertilizers and fertilizers of the NPK (17-17-17) and urea type on the development of the QPM3 leaf area, 2015, p45
[20] B. P.Nguo, W. Godefroid and S. T. Seburiri. Effect of different organic fertilizers on eggplant cultivation in sake (RD Congo), 2016, pp. 117
[21] J. F. Stevenson. Cycles of soil: carbon, nitrogen, phosphorus, sulfur, micronutrients. John Wiley & Sons, New York, 1986.
[22] G. William. Plant Physiology, Editions De Boeck University, rue des Minimes 39, B-1000 Brussels, 2003, 110-115p.

Mambé Auguste-Denise BOYE is professor of plant physiology since 2018 in the department of agroforestry, he is the Director of Research at the University Jean Lorougnon Guédé, has several publications on plantain, rice, pepper and cocoa
Noël GROGA is assistant professor of plant biology since 2015 in the agroforestry department, he has several publications on plant ecology et their distribution.
Valère KOTCHI is assistant professor in pedology since 2015 in the department of agroforestry, his research concern the importance of soil constitution in plant nutrition
Paule Ayefemi Doriane DJIKENNOU is assistant of plant physiology, Department of Agroforetry in University Jean Lorougnon Guédé