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Evolution of *Lippia multiflora* Biomass by the Fertigation Technique on a Ferralsol in the South of Côte d'Ivoire

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Abstract

In order to domesticate *Lippia multiflora* for its perpetuation, study was carried out at the National Center of Floristics (CNF) of the University Félix Houphouët Boigny of Côte d'Ivoire. The objective of this work is to estimate the biomass of *Lippia multiflora* (Verbenaceae), called "savannah tea", under the effect of urea diluted in water (fertigation) over time on a ferralsol in southern Côte d'Ivoire. The trial was set up in a completely randomized Fisher block design with three replications. *Potted Lippia multiflora* plants received two doses of urea T1 (0.5 g) and T2 (1 g) previously diluted 1 liter of water and a control treatment T0 without urea addition. The effects of these different doses on the growth parameters of *Lippia multiflora* were compared with each other using analysis of variance to assess the growth parameters of the plant. The observations were made on the average height of the plants in centimeters (cm), the average diameter of the stem, the average number of leaves and roots. From the results obtained, the contribution of urea influenced the growth of *Lippia multiflora* because different from those of the T0 control. It appears that the application of urea T1 (0.5 g) best promotes the growth of *Lippia multiflora*.

Keywords: *Lippia multiflora*, domestication, soils, urea, fertigation, Côte d'Ivoire

1. Introduction

Soil contains chemicals elements that plants need for growth and development. However, tropical soils are generally degraded and nutient poor due to misuse (Roose, 2015; Monroe *et al.*, 2018). This leads to low crop productivity in the absence of low use of mineral and organic fertilizers (Vanlauwe *et al.*, 2010; Gerstenmier & Choho, 2015) in countries where farmers live in extreme poverty. However, these nutrients, which are lacking in tropical soils, are necessary for flourish (Lessard *et al.*, 2018; Tchaniley *et al.*, 2020). Indeed, nitrogen for example, is one of the essential chemical elements in the nutrients of plant and its deficit in soil can be filled by fertilization or amendement. Mineral fertilization has encountered shortcomings in its application and significant nitrogen losses have been noted, negatively affecting crop yields (Saïdou *et al.*, 2014; Macauley & Ramadjita, 2015). Fertigation, wich consists of the addition of soluble mineral fertilizer previously dilued in irrigation water, could limit the use of nitrogenous fertilizers in order to increase yields and meet the challenge of sustainability in plantations (Ilunga *et al.*, 2018; Ganyo *et al.*, 2018; Siene *et al.*, 2020). Thus, the use of urea on soil containing *Lippia multiflora* did not affect the quality of *L. multiflora* leaves (Kané *et al.*, 2010). So, it should be noted that water remains an essential element for plant growth (Skhiri, 2017). Indeed, *Lippia multiflora* is one the main aromatic plants whose leaves with many virtues are dried and then marketed by women (N'guessan, 2012). Its leaves are used for the production of natural substances or active ingedients (Diomandé *et al.*, 2014; Soro *et al.*, 2015; Soro 2016). These are therapeutic properties (Gandonou *et al.*, 2018; Masunda *et al.*, 2020; Samba *et al.*, 2021; Ngaibi *et al.*, 2021). The regular drink of *L. multiflora* in the form of herbal tea is remedy against high blood pressure, malaria, colds, coughs, but also against febrile and flu attacks and diarrhea (Etou-Ossibi *et al.*, 2016; Abena *et al.*, 2017). *Lippia multiflora* is so used for its anti-inflammatory, relaxant and sedative effects (Abena *et al.*, 2017; Mebarki, 2021). It also has pesticidal (Sirima *et al.*, 2020) and artisanal (Atanasso *et al.*, 2017). In addition to its therapeutic virtues, the socio-economic importance of this plant is proven at national and regional levels. For these virtues, it is important to domesticate this plant which is still product of recolt. While the development and yield of a crop are closely linked, among other things, to soil fertility, the application of a method to increase the productionof *L. multiflora* to facilitate its domestication is urgent. It's in this perspective that study "Evolution of the biomass of *L. multiflora* by the fertigation technique" was initiated. Thus the present study aims to determine the effect of urea on the biomass yield of *L. multiflora* during its growth.

2. Materiel and Methods

2.1 Study Area

The National Floristic Center is located within Felix Houpouet Boigny University of Abidjan. The limits of the Center are to the north by the boulevard François Mitterand and to the south by the Faculté of Law of the University. It is located west of the ravine separating the Cocody Campus and the Riviera Golf; east of District. The center is located between 5°20′9″ and 5°20′8″ North longitudes and 3°59′1″ and 3°59′0″ West latitudes (Kouamé, 2013), (Figure 1).

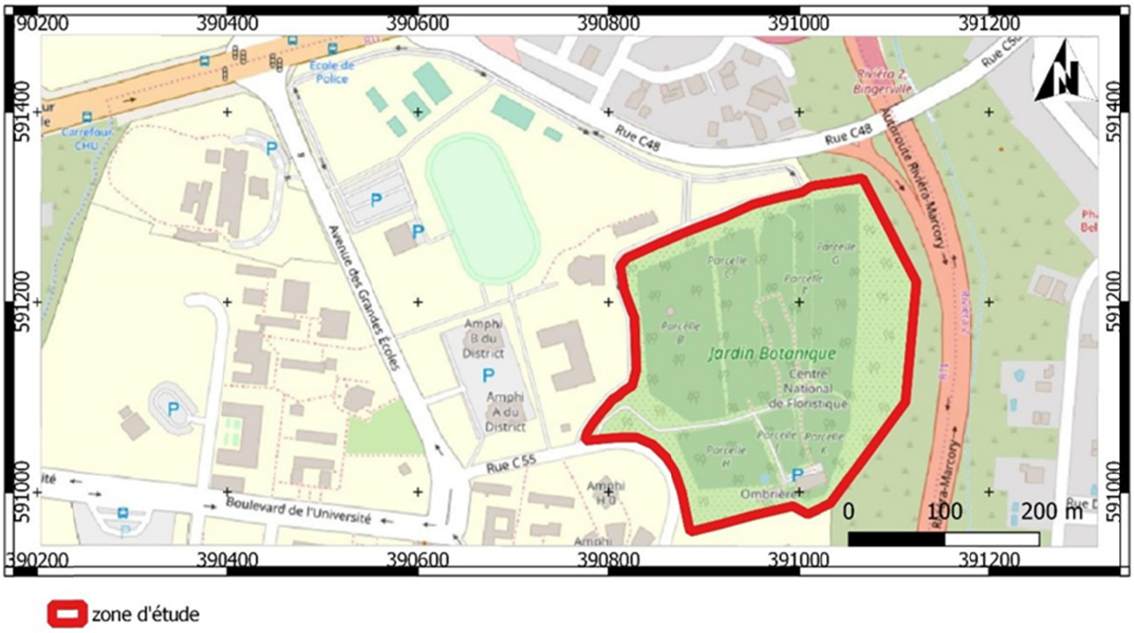

Figure 1. Geographical location of the CNF

2.2 Soil Characteristics of the Study Site

Soils of Abidjan, including those of the CNF are mostly ferralsols (Ouattara 2016) and have a shallow humus horizon in District (Guillaumet and Adjanohoun, 1071). This part is reworked soils, that is to say with a gravelly or thick granular horizon. It occupies the the more or less undulating contours resulting from granites and shists, particularly in the north- east part of District where the CNF is located. The soil in the study area is very acidic (Pitta 2017).

2.3 Plant Material

The plant material consists of seeds of *Lippia multiflora* collected from wild plants (Figure 2).

Figure 2. *Lippia multiflora* seed microscopic view (G × 2.9) (Alui, 2009)

2.4 Input

The input used is urea (CH_4N_2O), a fertilizer very rich in nitrogen and completely soluble in water. It acts less quickly than nitrates and effects lasts longer (Figure 3).

Figure 3. Urea

2.5 Experimental Design

Study was carried out under controlled conditions in May 2021 for 60 days. The installation of the device began with manual clearing with a machete. The construction of the shelter was done on an area of 16.5 m² (5.5 m × 3 m). Seeds were sown on the fly on a germinator filled with potting soil and covered with straw for three (03) days, then watered after emergence every two (02) days for one month. After a month sowing, transplanting was carried out in plastic pots measuring 8.5 cm in height and 10 cm in diameter previously filled with 1 kg of soil from the CNF, potting soil was added to this soil. The type of device used for the trial plot is a complete randomized block with (03) treatments T0 (0 g Urea), T1 (0.5 g Urea) and T2 (1 g Urea) with three (03) repetitions (R1, R2, R3). Dose of 35 mL of water was brought every 02 days in the morning before sunrise (Figure 4).

2.5 Growth Parameters Observed

Parameters observed are number of roots, number of leaves, height of plants and diameter of the stem. These observations and measurements were made on the plants at 45 days after transplanting (45 DAT) and 52 days after transplanting (52 DAT).

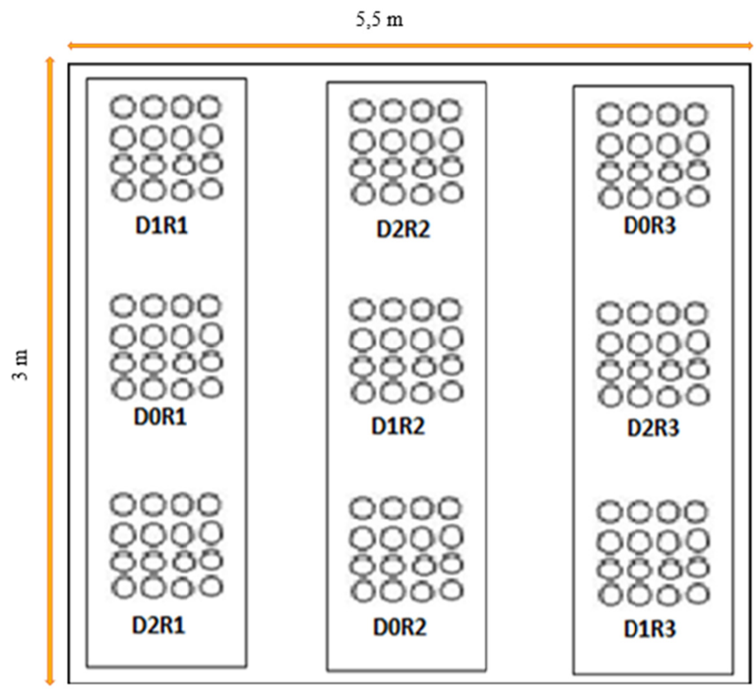

Figure 4. Experimental design

3. Result

3.1 Growth of Parameter of L. multiflora Having Received Urea, 45 Days After Transplanting (45 DAT)

3.1.1 Number of Root

Study of number of roots of plant, 45 days after transplanting, shows that the volume of the roots has statistically varied from treatment to another. Analysis of the data shows that the contribution of the dose of urea had a significant effect on the number of roots ($p = 0.022$). This number varied from an average of 18 for the T0 treatment and to 27 for the T1 treatment (Figure 5).

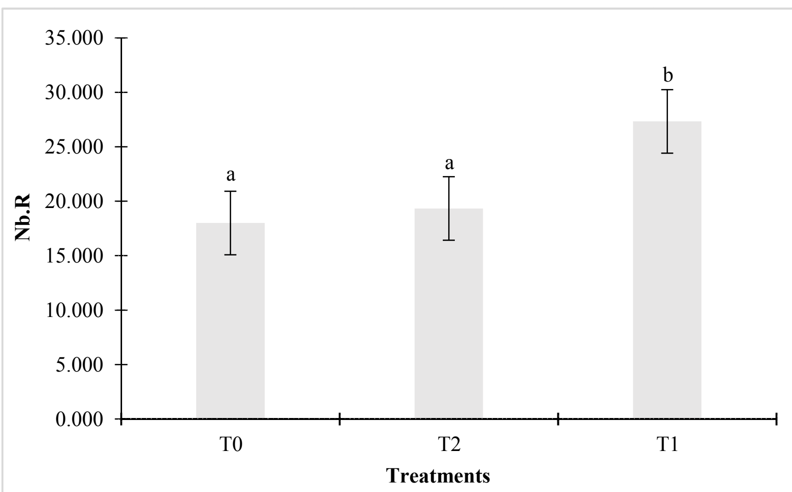

Figure 5. Variation in number of *L. multiflora* roots according to the treatments 45 DAT

3.1.2 Plant Height (cm)

Figure 6 shows the evolution of the height of *L. multiflora* plants having received or not urea. At 45 DAT, result indicate that the supply of urea had a significant effect on the height growth of the plant ($p = 0.024$) and there is a difference between the treatment (T0, T1, T2). Plant height increased from 2.76 cm for the T0 control treatment to 3.43 cm for the T1 treatment (0.5 g).

3.1.3 Number of Leaves

The data shows us a variation accordind to the effect of of the doses of urea provided on the number of leaves produced per plant. Statistical analysis shows us that treatment with urea had a highly significant effect on the number of leaves produced ($p = 0.005$). This increase in the number of leaves is higher for treatment T1 (0.5 g urea) with 9 leaves (Figure 7).

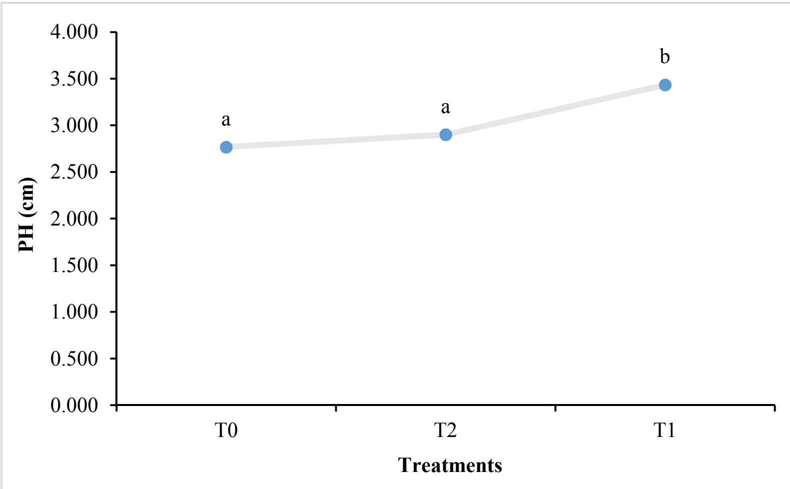

Figure 6. Evolution of the height of *L. multiflora* according to the contribution of urea at 45 DAT

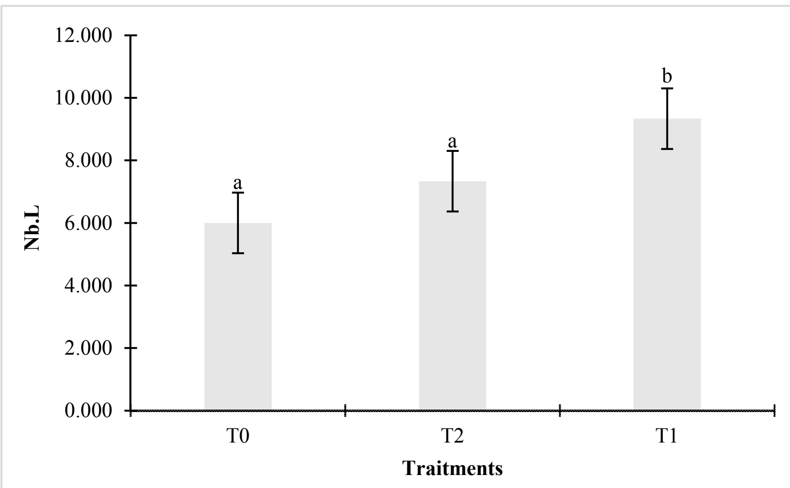

Figure 7. Evolution number of the leaf of *L. multiflora* according to the contribution of urea at 45 DAT

3.1.4 Stem Diameter (mm)

Data of 45 DAT shows variation in diameter of the accordind to the treatments. Data analysis shows that there is no sinificant difference between the treatments applied ($p = 0.562$) in Figure 8.

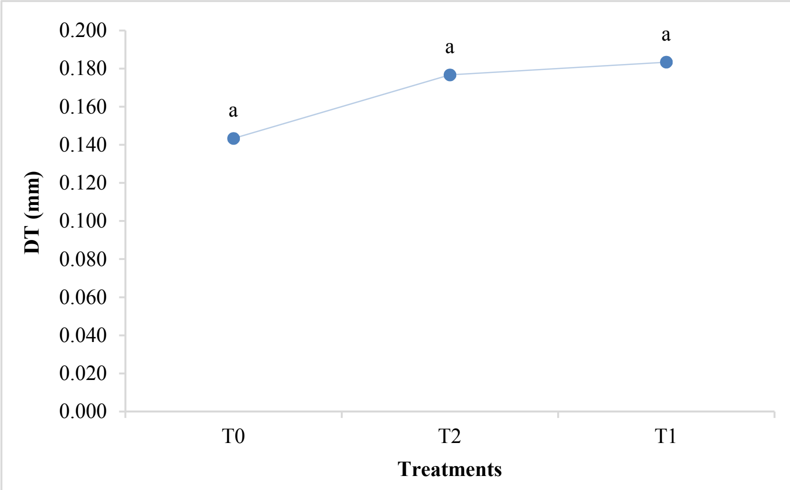

Figure 8. Evolution in stem diameter of *L. multiflora* as a function of urea supply at 45JAR

3.2 Urea Treatment on L. multiflora Growth 52 Days After Transplanting (52 DAT)

3.2.1 Number of Roots

Analysis of the data in (52 JAR) shows high number of roots in treatments T1 and T2. We note mean value of 34.33 roots for the T2 treatment and 36.33 roots for the T1 treatment. Statistical analysis of data shows that urea application has a significant effect on number of root growth ($p = 0.033$). The lowest value is noted for the control treatment T0 with 26.33 (Figure 9).

3.2.2 Plants Height (cm)

Analysis of the data reveals difference between the different treatments applied. This difference is higher for the T1 treatment, which increases from 3.43 cm (45 DAR) to 6.16 cm (52 DAR). The treatments had significant effects on plant height growth (Figure 10).

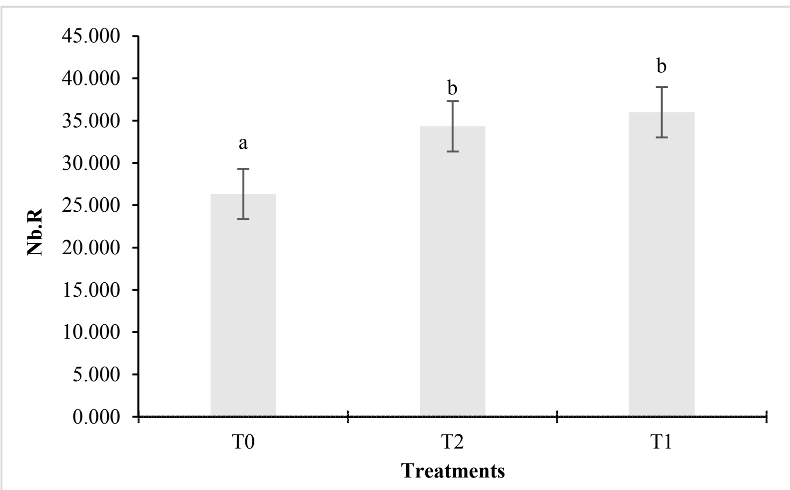

Figure 9. Variation in number of root of *L. multiflora* as a function of urea supply at 52DAT

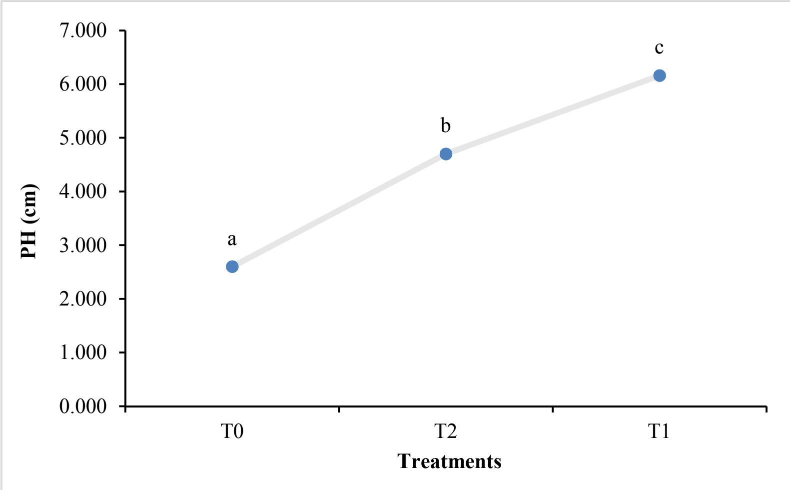

Figure 10. Evolution in height of *L. multiflora* as function of urea application at 52DAT

3.2.3 Number of Leaves

Data shows a variation in the number of leaves according to the doses of urea applied. It can be seen that the urea doses applied had a significant effect on the average number of leaves produced ($p = 0.010$). This increase was highest for T1 treatments, which went from 9.33 in (30 DAT) to 12.00 (52 DAR) and from 7.33 (45 DAT) to 11.33 for T2 treatment (1 g urea). The smallest increase in leaf number observed was for the T0 (0 g) control treatment which varied from 6.00 in 45 DAT to 8.00 in 52 DAT (Figure 11).

3.2.4 Stem Diameter (mm)

The analysis of data indicates that there is no significant difference between treatments T0 and T2 applied, but for treatment T1, difference in stem diameter is observed with 0.21 mm. The stem diameter changes with the dose of urea applied (Figure 12).

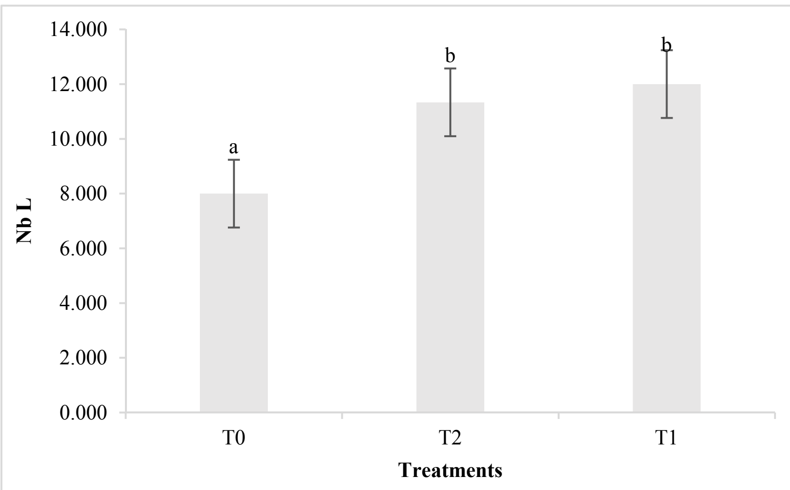

Figure 11. Evolution of the number of leaves of *L. multiflora* according to the treatments at 52DAT

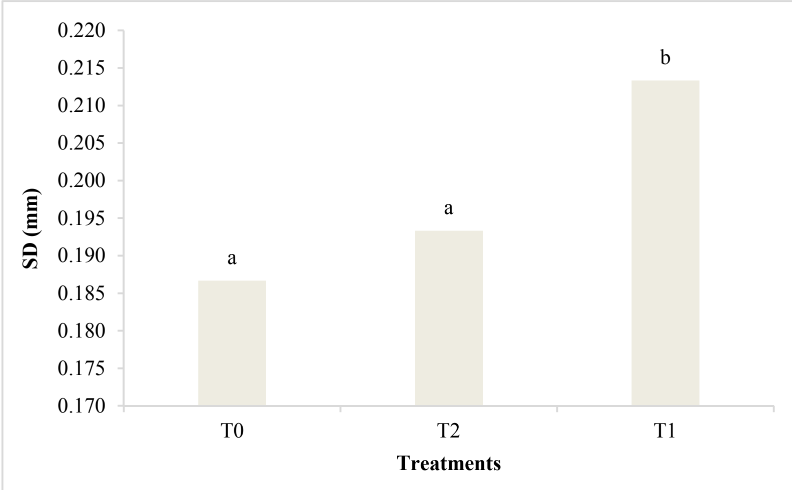

Figure 12. Evolution of stem diameter of *L. multiflora* according to treatments at 52DAT

3.2.5 Fresh Matter Mass (g)

The analysis of data shows evolution of the weight of the fresh material at level of treatments T1 and T2. We note the highest value for the T1 treatments with 0.70 g and the lowest for the T0 treatments with 0.08 g. Statistical analysis of our data shows urea addition had significant effect on fresh matter production ($p = 0.013$) (Figure 13).

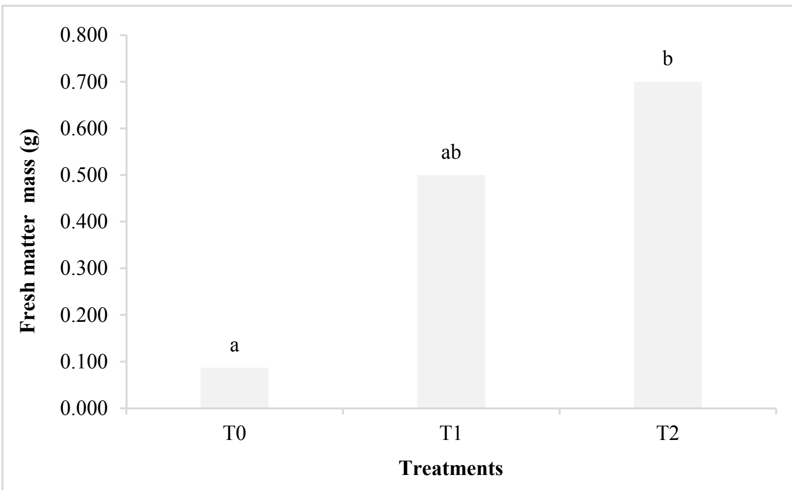

Figure 13. Evolution in fresh matter mass of *L. multiflora* as function of urea supply

4. Discussion

Results obtained indicate that the addition of urea had positive impact on growth parameters of *L. multiflora*. Indeed, urea supply had impact on the growth of *L. multiflora*, the plants that received urea had higher parameters than the T0 control that did not receive urea as demonstrated by the work of Ilunga *et al.* (2018) and Nsiku *et al.* (2019) on maize on Ferralsol in DRC, the work of Ganyo *et al.* (2018) on lettuce and the work of Tchaniley *et al.* (2020) on sorghum. This shows the nutrient poverty of the control plot. Results show that T1 treatment (0.5 g) promoted plant growth compared to T2 treatment (1 g), which suggests that this dose is the one that promotes optimal growth of *L. multiflora*. T2 dose (1 g) would be considered limiting. For stem height, statistical analyses show that there is significant difference between the average heights obtained with the different doses of fertilizer applied. Results show the clear importance of the contribution of urea, Stevenson 1994 approached in the same direction through his work which proved that nitrogen supports the use of carbohydrates which stimulate the development and the root activity thus supporting the export of the other mineral elements and the growth of plants. Treatment T1 has the highest average plant height of 3.33 cm (45 DAT) and 6.17 cm (52 DAT). On the other hand, treatment T0 had the lowest average plant height of 2.70 cm (45 DAT) and 2.90 cm (52 DAT). These results confirm those of Nyembo *et al.* (2012) who showed that the large plant height observed on the plots fertilized with mineral fertilizers would be more related to the amount of nitrogen applied. With regard to the number of leaves, the analysis of variances reveals that there is a significant difference between treatments, with a statistically identical average value for treatments T1 and T2, respectively 12 and 11 (52 DAT); this increase in the number of leaves in relation to the dose of urea applied is linked to the growth in plant height. These results are in agreement with the work of Kouakou (2013) who showed that the more the plant evolves in height, the more leaves it produces. For the diameter of the stem the statistical analysis of our results indicates that there is no significant difference according to the treatments (45 DAT) however we note a slight evolution of it (52 DAT) which is 0.21 cm. Regarding the number of roots, the results show a significant difference depending on the treatments. T1 treatments present the high number of roots which is 27 (45 DAT) and 36 (52 DAT), on the other hand for T0 and T2 the data show that there is no significant difference we note average values respectively of 19 and 18 (45 DAT).

5. Conclusion

Objective of the study was to determine effect of urea on the development of *Lippia multiflora*. Study conducted at the National Floristic Center of the Felix Houphouet Boigny University contributed to a knowledge of the response of *L. multiflora* to chemical fertilizer. The study highlighted the evolution of growth parameters following the different treatments. Concerning the growth characteristics of *Lippia multiflora* we can say that the quantity of urea brought to the plant has an impact on the development of the various agronomic parameters. Indeed, during our study, we could notice that an average quantity of urea favors the development in length, in number and in volume of the growth parameters. This allows us to affirm that our hypotheses are verified:

- Application of urea affects the growth of *L. multiflora*.
- Dose of urea influences the production of fresh material.

Growth characteristics at the root level showed that the highest growth rates were observed with the 0.5g urea doses. On the other hand T0 control treatments gave the lowest growth rates. This root development influenced by the amount of urea applied had an impact on the growth of the aerial parts of *Lippia multiflora*. Growth of the aerial parts evolves in the same order of growth as the roots under the influence of the dose of fertilizer applied to the plant. We can therefore say that *Lippia multiflora* is a plant that requires an adequate amount of urea for it to give better yields.

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References

Abena, A. A., Etou Ossibi, A. W., Gouolally, T. N., Okemy, A., & Ouamba, J. M. (2017). Étude monographique de *Lippia multiflora* Moldenke (Verbenaceae). *Phytothérapie, 15*, 27-32 https://doi.org/10.1007/s10298-016-1025-8

Atanasso, J. A., Chadare, F. J., Padonou, E. A., Ahouansinkpo, E., Oura, K., Houehanou, T., Assogbadjo, A. E., Glele Kakaï, R., & Sinsin, B. (2017). Habitats and utilizations of *Lippia multiflora* moldenke: local perception of four ethnic groups from Benin (West Africa). *Agronomie Africaine, 29*(2), 111-120.

Diomandé, L. B., Kanko, C., Tia, E. V., Kone, B., & Yao-Kouame, A. (2014). Occurrence et composition chimique de l'huile essentielle des feuilles de *Lippia multiflora* M. (thé de savane) selon le pH, les teneurs en Carbone, en Azote et Phosphore du sol en zones de savane guinéenne en Côte d'Ivoire. *Afrique Science, 10*(4), 93-108.

Etou Ossibi, A. W., Elion Itou, R. D. G., Morabandza, C. J., Nsonde Ntandou, G. F., Nzonzi, J., Ouamba, J. M., & Abena, A. A. (2016). Effets de l'extrait hydroéthanolique de *Lippia multiflora* Moldenke sur le coeur isolé de crapaud. *Int. J. Biol. Chem. Sci., 10*(6), 2617-2636. https://doi.org/10.4314/ijbcs.v10i6.17

Gandonou, C. D., Tokoudagba, J.-M., Houngbeme, A. G., Chodaton, M. D., & Ahissou, H. (2018). Antiradical activity and determination of phenolic compounds of extracts of *Lippia multiflora* (Verbenaceae): A plant traditionally used against arterial hypertension in Benin. *International Journal of Current Research, 10*(10), 74039-74043. https://doi.org/10.24941/ijcr.32498.10.2018

Ganyo, K. K., Muller, B., Gaglo, E. K., Guissé, A., Cissé, N., & Adam, M., (2018). Optimisation du NPK et urée basée sur les informations climatiques pour accroitre la production du sorgho en zones soudano-sahéliennes du Sénégal. *Journal of Applied Biosciences, 131*, 13293-13307. https://doi.org/10.4314/jab.v131i1.5

Gerstenmier, A., & Choho, T. (2015). Fourniture d'intrants agricoles. *Document de Référence "Nourrir l'Afrique"* (p. 23). Dakar, Sénégal.

Guillaumet, J. L., & Adjanohoun, E. (1971). La végétation de la Côte d'Ivoire. *Le milieu naturel de la Côte d'Ivoire* (pp. 157-263). ORSTOM, Paris, France.

Ilunga, T. H., Banza, M. J., Lukusa, M. L., Mukunto, K. I., Malonga, H. L., Kanyenga, L. A., & Nyembo, K. L. (2018). Influence du moment d'application du NPK sur la croissance et le rendement du maïs (*Zea mays* L.) installé sur un ferralsol. *Journal of Applied Biosciences, 127*, 12794-12803. https://doi.org/10.4314/jab.v127i1.4

Kane, F., Yao-Kouame, A., Konan, A. A., & N'guessan, A. K. (2010). Dosage de quelques composantes biochimiques des feuilles de *Lippia multiflora* (Verbenacee) a deux stades de développement et qualité des infusions, en fonction de la dose d'urée. *Agronomie Africaine, 22*(3), 227-235.

Kouakou, K. E. (2013). *Caractérisation physico-chimique et aptitude à la culture de Lippia multiflora moldenke (verbenaceae) des sols des sites expérimentaux d'Azaguié (zone de foret) et de Blé (zone de savane) en côte d'Ivoire* (p. 61, Mémoire de Master en Sciences de la Nature de l'Université Nangui Abrogoua, Abidjan).

Lessard, J., Bilodeau, G., Champagne, B., & Lemaire, É. (2018). *Guide de la gestion de la croissance des fines herbes et des transplants de légumes en serre* (p. 46). Institut Québécois du Développement de l'Horticulture Ornementale (IQDHO).

Macauley, H., & Ramadjita, T. (2015). *Les cultures céréalières: Riz, maïs, millet, sorgho et blé: Plan pour la transformation de l'agriculture africaine* (Document de reference). Centre International de Conférences Abdou Diouf, Octobre 21-23, 2015, Dakar, Sénégal. https://doi.org/10.4236/ahs.2013.23020

Masunda, A. T., Inkoto, C. L., Masengo, C. A., Bongili, S. B., Basilua, J.-P. K., Legbiye, E. M., Ngbolua K.-T.-N., & Mpiana, P. T. (2020). Traditional uses, Physical properties, Phytochemistry and Bioactivity of *Lippia multiflora* Moldenke (Verbenaceae): A Mini-review. *Discovery Phytomedicine, 7*(1), 19-26. https://doi.org/10.15562/phytomedi cine 114

Mebarki, A. (2021). *Potentiels antioxydant et anti-inflammatoire de Lippia multiflora en vue de la prévention du syndrome métabolique* (Thèse de doctorat en Sciences des aliments et nutrition, Montpellier).

Munroe, J., Brown, C., Kesse, C., Verhallen, A., Lauzon, J., & O'Halloran, I. (2018). *Manuel sur la fertilité du sol* (p. 256). Université de GuelphTom Bruulsema, International Plant Nutrition Institute Dale Cowan, AGRIS Co-operative.

Ngaibi, J., Taiwe, G. S., Njapdounke, J. S. K., Bigued, N. Y., Neteydji, S., & Bum, E. N. (2021). Potential of an aqueous extract of *Lippia multiflora* Moldenke (Verbenaceae) in the treatment of anxiety disorders: Possible involvement of serotoninergic transmission. *GSC Biological and Pharmaceutical Sciences, 14*(03), 277-289. https://doi.org/10.30574/gscbps.2021.14.3.0079

N'guessan, K. A. (2012). *Domestication et valorisation du thé de savane (L. multiflora Moldenke, Verbénaceae) en Côte d'Ivoire: Incidence de la densité de plantation et du type de semence sur le rendement et les composantes du rendement du thé de savane, cultivé dans les écosystèmes forestier (Azaguié) et savanicole (Toumodi) et sur les caractéristiques du sol* (p. 181, Thèse Unique de Doctorat, Université F.H.B. de Cocody, Abidjan, Côte d'Ivoire).

Nyembo, K. L., Useni, S. Y., Mpundu, M. M., Bugeme, M. D., Kasongo, L. E., & Baboy, L. L. (2012). Effets des apports des doses variées de fertilisants inorganiques (NPKS et Urée) sur le rendement et la rentabilité économique de nouvelles variétés de *Zea mays* L. à Lubumbashi, Sud-Est de la RD Congo. *Journal of Applied Biosciences, 59*, 4286-4296.

Nsiku, D. N., Mbeyame, C. A., & Mudimbiyi, P. (2019). Effets des doses croissantes d'azote et de phosphore sur deux variétés du maïs (*Zea mays* L. var Mudishi1 et Pan53) dans les conditions édapho-climatiques de Kinshasa. *Revue Africaine d'Environnement et d'Agriculture, 2*(1), 52-59.

Ouattara, S. F. P. (2016). *Diversité et densité des espèces de bois d'œuvre inscrites sur la liste rouge de l'UICN, dans l'arboretum du Centre National de Floristique de l'Université Félix Houphouët-Boigny d'Abidjan*

(Côte d'Ivoire) (p. 387). CNF, UFR Biosciences, Université Félix Houphouët-Boigny, Côte d'Ivoire. https://doi.org/10.19044/esj.2019.v15n36p213

Pitta, A. M. C. (2017). *Evaluation des apports atmosphériques dans un écosystème forestier urbain: Cas du centre national de floristique (CNF) de Cocody* (p. 74). Mémoire de Master de Pédologie, UFR Sciences de la Terre et des Ressources Minières, Université de Félix Houphouet Boigny Abidjan-Cocody, Côte d'Ivoire.

Roose, E. (2015). *Restauration de la productivité des sols tropicaux et méditerranéens, contribution à l'agroécologie* (p. 547). IRD Editions Institut de Recherche Pour le Developpement Montpellier, Juillet.

Samba, N., Aitfella-Lahlou, R., Nelo, M., Silva, L., Coca, R., Rocha, P., & Rodilla, J. M. L. (2021). Chemical Composition and Antibacterial Activity of *Lippia multiflora* Moldenke Essential Oil from Different Regions of Angola. *Molecules, 26*, 1551-28. https://doi.org/10.3390/molecules26010155

Saidou, A., Gnakpenou, K. D., Balogoun, I., Hounnahin, S. R., & Kindomihou, M. V. (2014). Effet de l'urée et du NPK 15-15-15 perlés et super granulés sur la productivité des variétés de riz IR841 et NERICA-L14 en zone de bas-fond au Sud-Bénin. *Journal of Applied Biosciences, 77*, 6575-6589. https://doi.org/10.4314/jab.v77i1.13

Siené, L. A. C., Doumbouya, M., Traore, M. S., Conde, M., N'guettia, T. V. F., & Koné, M. (2020). Effet de quatre types de fertilisants sur la croissance et la productivité de deux génotypes de maïs (*Zea mays* L.) en cas d'un semis tardif à Korhogo au Centre-Nord de la Côte d'Ivoire. *Int. J. Biol. Chem. Sci., 14*(1), 55-68. https://doi.org/10.4314/ijbcs.v14i1.6

Sirima, A., Sereme, A., Sereme, D., Koïta, K., Nana, T. A., & Sawadogo, M. (2020). Effets de quatre huiles essentielles sur la croissance mycélienne radiale d'un isolat de *Alternaria* sp. au Burkina Faso. *Int. J. Biol. Chem. Sci., 14*(3), 762-771. https://doi.org/10.4314/ijbcs.v14i3.10

Skhiri, A. (2017). *Les bases de l'irrigation, Calcul des besoins en eau* (p. 106). Editions Universitaires Européennes.

Soro, L. C. (2016). *Caractérisation biochimique et activités biologiques des feuilles de Lippia multiflora Verbenaceae "théier de savane" cultivé en milieux forestier et savanicole de Côte d'Ivoire* (p. 204, Thèse de Doctorat, Nutrition et Sécurité Alimentaire, Université Nangui Abrogoua, Abidjan).

Soro, L. C., Grosmaire, L., Ocho-Anin Atchibri, A. L., Munier, S., Menut, C., & Pelissier, Y. (2015). Variabilité de la composition chimique de l'huile essentielle des feuilles de *Lippia multiflora* cultivées en Côte d'Ivoire. *Journal of Applied Biosciences, 88*, 8180-8193. https://doi.org/10.4314/jab.v88i1.5

Stevenson, F. J. (1994). Humus chemistry. *Genesis, Composition, Reactions*. New York, USA: John Wiley & Sons Inc. https://doi.org/10.4236/jep.2011.24038

Tchaniley, L., Ayisah, K. D., & Dewa, K. K. A. (2020). Effet de la combinaison des fertilisants organiques et minéraux (NPK 15-15-15 et urée) sur le rendement de la laitue (*Lactuca sativa* L.) dans le sud du Togo. *J. Appl. Biosci., 151*, 15540-15549. https://doi.org/10.35759/JABs.151.3

Vanlauwe, B., Bationo, A., Chianu, J., Giller, K. E., Merckx, R., Mokwunye, U., … Sanginga, N. (2010). Integrated soil fertility definition and management: Operational consequences for implementation and dissemination. *Outlook Agric., 39*, 17-24. https://doi.org/10.5367/000000010791169998

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