Agricultural Sciences, 2025, 16(10), 1086-1099
https://www.scirp.org/journal/as
ISSN Online: 2156-8561
ISSN Print: 2156-8553

Evaluation of the Effectiveness of a Biodegradable Organic Fertilizer Based on Neem (*Azadirachta indica*) 'BioNeem+' on the Agronomic Performance of Amaranth (*Amaranthus cruentus*) Cultivated in the Municipality of Abomey-Calavi

Wilfried Emmanuel Epiphane Seton[1], Armelle Sabine Yelignan Hounkpatin[1,2*], Hervé Kouessivi Janvier Bokossa[2], Saturnin Hounsou[1]

[1]Pluridisciplanary Research Laboratory for Technical Education (LARPET), University of Sciences, Technologies, Engineering and Mathematics of Abomey (UNSTIM), Abomey, Benin
[2]Laboratory of Hygiene, Sanitation, Toxicology and Environmental Health (HECOTES), Interfaculty Center for Training and Research in the Environment for Sustainable Development (CIFRED), University of Abomey-Calavi, Abomey-Calavi, Benin
Email: *harmelle2011@gmail.com

How to cite this paper: Seton, W.E.E., Hounkpatin, A.S.Y., Bokossa, H.K.J. and Hounsou, S. (2025) Evaluation of the Effectiveness of a Biodegradable Organic Fertilizer Based on Neem (*Azadirachta indica*) 'BioNeem+' on the Agronomic Performance of Amaranth (*Amaranthus cruentus*) Cultivated in the Municipality of Abomey-Calavi. *Agricultural Sciences*, **16**, 1086-1099.
https://doi.org/10.4236/as.2025.1610062

Received: August 21, 2025
Accepted: October 6, 2025
Published: October 9, 2025

Abstract

Problem Statement: Despite their importance for vegetable production, liquid organic fertilizers remain underutilized, even though they offer an alternative to the high cost of mineral fertilizers on the market. Amaranth cultivation in Benin is carried out with the use of synthetic fertilizers, resulting in harmful consequences for soil quality and public health. **Methodology**: This research aims to evaluate the effectiveness of a liquid organic fertilizer made from Neem (*Azadirachta indica*) on the agronomic performance of amaranth (*Amaranthus cruentus*) grown in the commune of Abomey-Calavi. To conduct this research, a Fisher block design was set up at the experimental station with four (04) treatments and three (03) replications, corresponding to twelve (12) plot units, each with an area of 2 m^2. The treatments applied were: T0: Absolute control (no fertilizer input); T1: Plants treated with a dose of 10% in 90% of water; T2: Plants treated with a dose of 20% in 80% of water; T3: Plants treated with a dose of 30 in 70% of water. Data collected on growth parameters (number of leaves, height, collar diameter) and yield at the first and second harvests were subjected to Poisson linear regression analysis and ANOVA using R software. **Results**: The results of this study showed that the treatments receiving liquid organic fertilizer were the most effective across all parameters considered (number of leaves, height, collar diameter, and fresh weight yield). The best results were obtained with treatment T2, with 20% of liquid organic fertilizer.

Keywords

Amaranthus cruentus, Agroecological, Liquid Organic Fertilizer, Land Management

1. Introduction

Food security remains a central priority for all governments and development partners in a context marked by increasing demographic pressure, climate change, and the rising cost of inputs [1]. Enormous food needs affect about two billion people, with diets poor in energy, proteins, and micronutrients [2]. West Africa is not spared from this situation, which weakens households and reduces life expectancy [3]. In the Republic of Benin, agriculture as a whole accounted for about 26.3% of GDP in 2023 [4]. The total production of vegetable crops was estimated at 668,590 tons, representing about 5.7% of the total food crop production [5]. It should also be mentioned that the use of mineral fertilizers is not always effective in the context of sustainable peri-urban agricultural production. The main reasons are, on the one hand, the decline in the production capacity of urban soils due to the application of high doses of chemical fertilizers to meet the growing demand of the market, and, on the other hand, the unbearable financial burden in vegetable production [6]. The degradation of vegetable soils persists in Benin, due to the lack of in-depth knowledge among vegetable farmers regarding the values of organic fertilizers and their transformations [7]. This situation impoverishes agricultural production systems and reduces their capacity to meet the needs of the population. However, organic fertilizers, through their beneficial effects on the physico-chemical and biological properties of the soil, and thus on plant growth, could enhance the effectiveness of modest doses of mineral fertilizers [8]-[10]. According to [11], residues from agriculture and livestock are initially considered as waste that pollutes the environment. However, [12] considers organic waste as essential means nowadays used in integrated systems for the development of agriculture in many Asian and African countries. Moreover, several studies in Benin have shown the beneficial effects of using different types of organic fertilizers on vegetable crops. Among these studies is that of [13], who, by applying poultry litter and composted small ruminant droppings to amaranth, reported that its productivity was more effective under poultry litter than under droppings, at a dose of 20 $t \cdot ha^{-1}$. Amaranth is widely grown and consumed. It is an integral part of dietary habits and is present in many traditional dishes. It constitutes a source of income for many farmers and traders and is rich in essential nutrients, notably vitamins A and C, iron, and calcium, making it a food of choice in combating deficiencies.

Its regular consumption helps improve the nutritional status of populations, particularly in areas where access to a diversified diet is limited [14]. However, it faces poor land management practices, which subsequently lead to soil nutrient depletion [15]. It is in this context that the use of liquid organic fertilizers with dual action (fertilization + phytosanitary treatment) proves necessary for the production of short-cycle crops, notably amaranth.

2. Materials and Methods

2.1. Study Area

The work was carried out during the rainy season, allowing the benefit of natural humidity. It was conducted on the "AGRI-BIO SERVICE" farm located in the municipality of Abomey-Calavi, specifically in the district of Togba. The site is situated in the village of Houeto. Located in the Atlantique department, the district of Togba covers an area of 200 km². It lies between 6˚22' and 6˚30' North latitude and between 2˚15' and 2˚22' East longitude. The climate of the area is subequatorial, with two dry seasons (mid-December to mid-March and mid-August to mid-September) and two rainy seasons (mid-March to mid-July and mid-September to mid-December). The average annual rainfall is around 1,200 mm, with 700 to 800 mm falling during the first rainy season and 400 to 500 mm during the second rainy season. The average monthly temperatures range between 27 and 31 degrees Celsius [16]. Most of the territory of the municipality of Abomey-Calavi is occupied by ferralitic soils and sandy soils. Highly flood-prone hydromorphic soils are found only in a small part of the northern territory [16].

2.2. Plant Material Used

The plant material consisted of seedlings from an improved certified variety of amaranth. It was the SUPER GIANT variety, with a 31-day growth cycle, obtained from the LIVING SEED seed center. This variety was selected based on its organoleptic and agronomic qualities, as well as its availability in seed distribution outlets. **Figure 1** shows the material (*Amaranthus cruentus*) used as the basis for the experiment.

Figure 1. Amaranth seeds.

2.3. Organic Materials Used

The organic material consisted of manure made from poultry droppings, cattle urine, and neem leaves. Both the urine and the poultry droppings used were obtained from nearby household farms. Figures 2-4 present the organic materials used for the implementation of the experiment.

Figure 2. Poultry manure.

Figure 3. Cattle urine.

Source: Seton, 2025.

Figure 4. Neem leaves.

3. Experimental Design and Treatments

The experiment consisted of transplanting seedlings of the SUPER GIANT amaranth variety and monitoring them under a completely randomized block design (CRBD) or Fisher block design with three replications. Each replication or block was composed of four (4) plot units or treatments, giving a total of twelve (12) plot units. The blocks were separated by a distance of 1 m, and the plot units within the same block were spaced 0.5 m apart. The experimental field covered an area of 8 m × 5.5 m, for a total of 44 m^2. The elementary plots measured 2 m × 1 m, *i.e.*, 2 m^2 each. The factor under study was a liquid organic fertilizer with three (03) application rates (10% in 90% of water; 2% in 80% of water; 30% in 70% of water). **Figure 5** illustrates the experimental design as well as the distribution of the different treatments applied during the trial.

T0: Control plants without any liquid organic fertilizer (absolute control);

T1: Plants receiving liquid organic fertilizer at the rate of 10% in 90% of water;

T2: Plants receiving liquid organic fertilizer at the rate of 20% in 80% of water;

T3: Plants receiving liquid organic fertilizer at the rate of 30% in 70% of water.

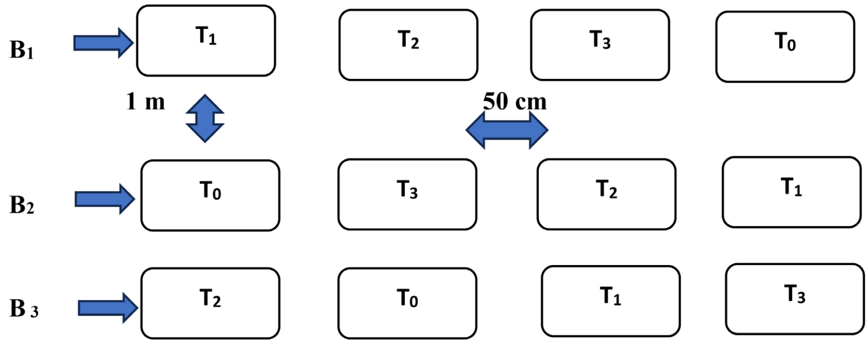


Figure 5. Experimental setup.

3.1. Process of Obtaining Neem-Based Liquid Organic Fertilizer

3.1.1. Reception of Raw Materials

This step involves gathering the various ingredients used in the preparation of the liquid organic fertilizer, including:

1) 10 kg of neem leaves.
2) 100 L of water.
3) 5 L of cattle urine.
4) 5 kg of poultry manure.
5) 1 kg of corn flour.
6) 1 kg of ripe fruit.
7) 1 barrel of 100 L.
8) 1 jute sack.
9) Soil clod.
10) A rope.
11) A stick.

3.1.2. Preparation of the Liquid Organic Fertilizer

This step consists of mixing the different ingredients to obtain an organic solution that will be used for crop fertilization. The procedure is as follows:

1) Take a non-metallic barrel containing 90 L of water.
2) Take another barrel containing 5 L of water.
3) Pour the 5 L of urine into the second barrel.
4) Add the recycled corn flour to the solution.
5) Add 1 kg of well-mashed ripe fruit.
6) Add the 5 kg of poultry manure.
7) Add two handfuls of soil into the solution.
8) Stir the solution to ensure homogeneity.
9) Pour the obtained solution into the 90 L of water.
10) Add the neem leaves into the solution.
11) Stir the mixture with a stick.
12) Place the solution in the shade.
13) Stir three times a day to ensure proper fermentation and a uniform mixture.
14) Cover the solution with a jute sack and secure it with a rope.

15) Stir the solution clockwise.

3.1.3. Usage

1) The solution is ready after seven (07) days when a whitish layer appears, indicating proper fermentation.

2) Apply the solution to the plot 1 - 2 weeks before sowing or transplanting.

3) Apply either as a foliar spray or directly at the base of the plants.

3.2. Selection, Seed Sowing and Seedling Transplanting

Sowing was carried out by broadcasting using 20 g of seeds of the SUPER GIANT variety. It was performed on a bed of 5 m² (dimensions: 5 m × 1 m). Before sowing, the bed was treated with a solution made from neem leaves and hortis in order to prevent attacks from soil fungi and bacteria.

After sowing, mulching with palm fronds was applied to conserve soil moisture. Regular watering was carried out twice a day, then reduced after seedling emergence. Young amaranth seedlings, aged two weeks and four days, were transplanted onto 2 m² plots (2 m × 1 m) at a spacing of 0.20 m × 0.20 m (between plants and rows). This corresponds to a density of 250,000 plants/ha and 50 plants per plot unit. Figure 6 presents the procedures for the establishment and transplanting of young amaranth seedlings.

Note: Source: Seton, 2025.

Figure 6. Establishment of the nursery and transplanting operation.

3.3. Application of Liquid Organic Fertilizer

The study was conducted through the application of an organic fertilizer (liquid organic fertilizer) supplied in split doses throughout the production cycle. Fertilizer application was carried out every eight days until the end of the cycle. With a total of three applications before the first harvest and two applications before the second harvest. For this operation, 10% of liquid organic fertilizer was diluted in 90% of water in a watering can for Treatment 1 (T1). For Treatment 2 (T2), 20% of liquid organic fertilizer were diluted in 80% of water, and finally, Treatment 3 (T3) received 30% of liquid organic fertilizer diluted in 70% of water at the same time. The concentrations of 10%, 20%, and 30% of BioNeem+ were selected to evaluate the response of amaranth to different application levels. The objective was to determine the fertilizer dose that would be most effective in improving growth and yield, while also identifying a potential optimal application threshold. **Figure 7** presents the dilution process of the liquid organic fertilizer.

Note: Source: Seton, 2025.

Figure 7. Dilution of the liquid organic fertilizer.

4. Data Collection

Croissance

1) Growth Parameters

The growth parameters evaluated in this trial were: plant height (measured from the collar, at soil level, to the tip of the last leaf), collar diameter (measured at the boundary between the underground and aerial parts), and number of leaves (determined by counting all green leaves on a plant). Measurements were taken on 12 plants (4 plants per row) randomly selected from the three central rows of each plot unit (excluding border rows). These growth parameters were recorded every seven (07) days after the application of liquid organic fertilizer.

2) Yield

The main parameter measured for yield evaluation was the fresh biomass of the aerial part of the plant. Two (2) successive harvests were carried out: the first, four (04) weeks after transplanting, and the second, seven (07) weeks after transplanting. Fresh biomass was assessed at both the first and second harvests. Harvesting was performed by cutting the plants 10 cm above the soil surface, and the harvested material was weighed using a digital scale.

3) Statistical Data Analysis

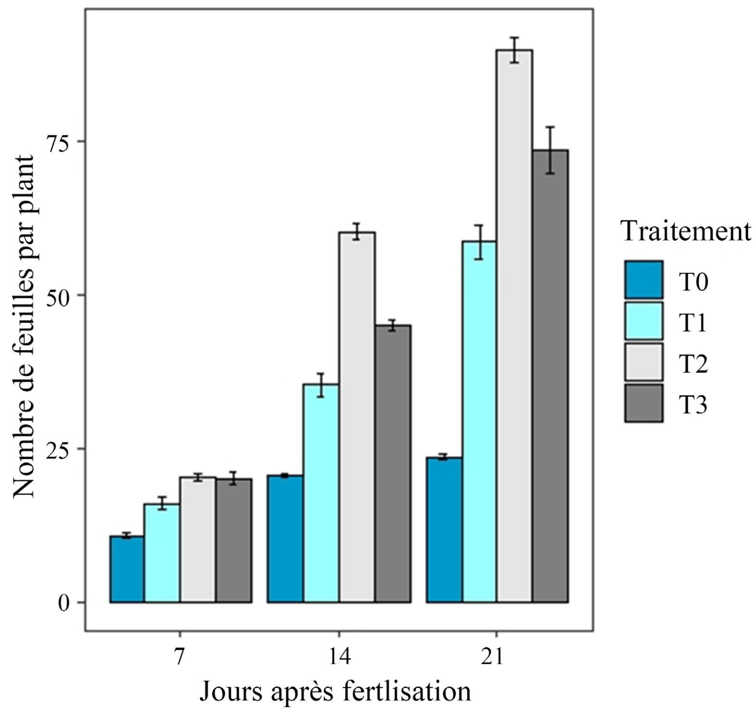
The data on the number of leaves were subjected to Poisson linear regression analysis, while those related to plant height, collar diameter, and fresh weight of harvested vegetables were subjected to one-way ANOVA after verifying the assumptions of application (normality and homogeneity of variances). All analyses were performed using R software.

5. Results and Discussion

5.1. Results

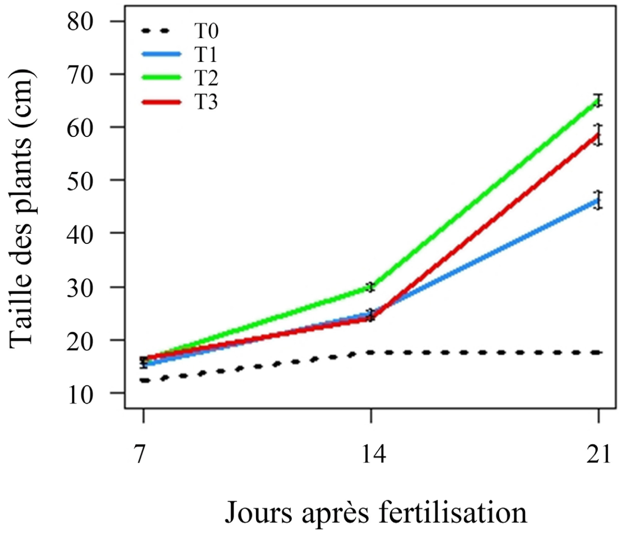
Results of the generalized linear Poisson model showed that treatments and time had a highly significant effect (P < 0.001) on the number of leaves produced by amaranth. Graph 1 illustrates the effect of liquid organic fertilizer and time on the number of amaranth leaves under the different treatments.

The lowest number of amaranth leaves was observed in the control plots that did not receive liquid organic fertilizer (about 38 to 58 times lower) compared to the plots treated with the different doses of liquid organic fertilizer. Moreover, no significant difference was observed between the plots treated with 20% of liquid organic fertilizer in 80% of water and those treated with 30% in 70% of water per plot unit (treatments T2 and T3), which were both significantly different from the plots treated with 10% in 90% of water (treatment T1). However, although there was no significant difference between treatments T2 and T3, treatment T2 numerically favored higher leaf production in amaranth cultivation (Graph 1).



Graph 1. Number of leaves produced according to the different liquid organic fertilizer treatments and time.

The results of the analysis of variance (ANOVA) showed that treatments and time had a highly significant effect (P < 0.001) on plant height. Graph 2 shows the height of amaranth plants according to the effect of liquid organic fertilizer applied through the different treatments.



Graph 2. Plant height according to the different liquid organic fertilizer treatments and time.

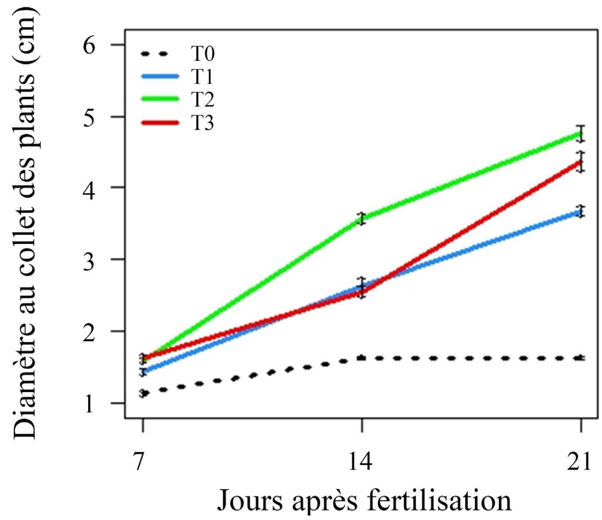
The lowest plant heights (25 to 55 times lower) were observed in the untreated control plots compared to those of the plots treated with liquid organic fertilizer at different doses. Moreover, no significant difference was observed between the plots treated with 20% of liquid organic fertilizer in 80% of water and those treated with 30% in 70% of water per plot unit (treatments T2 and T3), which were both significantly different from the plots treated with 10% in 90% of water (treatment T1). However, although there was no significant difference between treatments T2 and T3, treatment T2 progressively favored greater plant height growth in amaranth (Graph 2).

The results of the analysis of variance showed that treatments and time had a highly significant effect ($P < 0.001$) on the collar diameter of amaranth plants. Graph 3 illustrates the effect of liquid organic fertilizer on the collar diameter of amaranth plants under the different treatments.

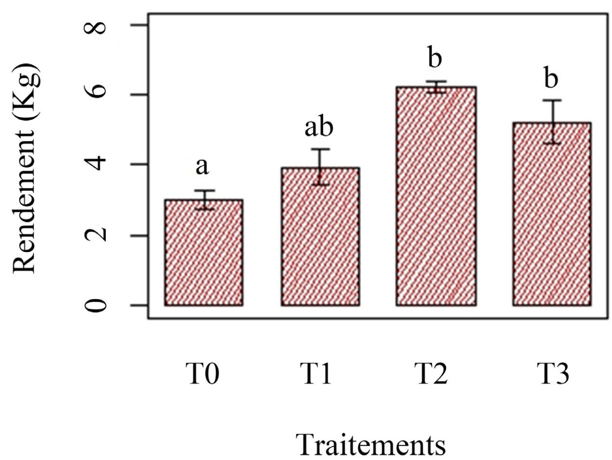
The smallest collar diameters of the plants were observed in the untreated control plots (about 2 to 3 times smaller) compared to those of the plots treated with liquid organic fertilizer at doses of 10% in 90%of water, 20% in 80% of water, and 30% in 70% of water per plot unit (T1, T2, and T3) at the 21st day after fertilization. Moreover, no significant difference was observed between the plots of Treatments T2 and T3. Nevertheless, the plants in Treatment T2 showed relatively larger collar diameters (Graph 3).

The results of the analysis of variance showed a significant effect ($P < 0.001$) of treatments on the fresh weight of harvested amaranth. Figure 4 presents the graphical data of fresh biomass of amaranth plants in response to the different liquid organic fertilizer treatments applied.

The fresh weight of amaranth plants was significantly lower in the untreated control plots (1 to 2 times smaller) than in the plots treated with liquid organic fertilizer at the different doses (T1, T2, T3). Moreover, no significant difference was observed between the plots of treatments T2 and T3. Although there was no significant difference between T2 and T3, treatment T2 resulted in a greater increase in the fresh weight of amaranth (Graph 4).



Graph 3. Stem diameter of the plants according to the different liquid organic fertilizer treatments and time.



Graph 4. Fresh vegetable yield of amaranth according to the different liquid organic fertilizer treatments.

5.2. Discussion

The growth parameters studied were plant height, collar diameter, and number of leaves. For all three variables, the results showed significant differences between the plots treated with liquid organic fertilizer and the control plots. Although no significant difference was observed between the plots receiving 20% and 30% doses (T2 and T3), the application of 20% of liquid organic fertilizer had a positive influence on the studied growth parameters. The number of leaves produced by amaranth was significantly increased under liquid organic fertilizer.

These results are consistent with [17], who reported that urine-based fertilizer production tests are highly advanced in Switzerland, as these liquid fertilizers contain all the essential substances for plant growth: nitrogen, phosphorus, and potassium, as well as trace elements such as iron, zinc, and boron, which strongly contribute to proper plant development. The use of liquid organic fertilizer promotes increased leaf production in amaranth cultivation, as the fertilizer is easily absorbed by the plants. These findings align with several studies demonstrating the positive effects of foliar fertilization on crop growth and development ([18]-[21]).

Liquid organic fertilizer effectively stimulates plant height growth. Being rich in nutrients such as potassium (K), it favors the vertical growth of amaranth plants. Studies by [22] showed that potassium increases plant size. The fertilizer also promotes radial growth of the plants. According to [23], nitrogen (N) is the main nutrient responsible for the quantitative growth of plants. Furthermore, research by [13] revealed that nitrogen is the most critical nutrient for amaranth growth.

Similarly, the results on fresh weight yield of amaranth plants at physiological maturity revealed significant differences depending on the doses applied. The highest yields were obtained with the liquid organic fertilizer at a 20% dose (T2), which is consistent with the work of [24], who tested a combination of urine and poultry manure as fertilizer for amaranth in Mexico. His results showed that the combination of urine and poultry manure produced the highest yield, 2350 kg/ha.

Overall, the 20% dose of liquid organic fertilizer (T2) demonstrated the most beneficial effects on the agro-morphological parameters and yield of amaranth compared to the control plot.

Despite the positive results obtained with BioNeem+, this study has some limitations. First, no baseline soil analysis was conducted prior to the experiment, which prevents a precise understanding of the initial nutrient status and may influence the interpretation of the fertilizer's effectiveness. Second, the exact chemical composition of BioNeem+ was not determined, limiting the understanding of the mechanisms through which the fertilizer affects amaranth growth and yield. These limitations suggest that future research should include baseline soil analysis and a detailed quantification of the fertilizer's composition to improve reproducibility and result interpretation.

6. Conclusion

In summary, this study contributed to improving the agronomic performance of amaranth by utilizing liquid organic fertilizer through liquid fertilization within the framework of sustainable and environmentally friendly agriculture. At the end of the study, it was observed that the application of liquid organic fertilizer at a dose of 20% improved amaranth yield. It also showed positive effects of this fertilizer, at this dose, on agro-morphological parameters such as leaf number, plant height, and collar diameter. Thus, the 20% dose of liquid organic fertilizer is recommended as a replacement for chemical fertilizers to enhance the agroecological production of amaranth. However, further research on its insecticidal and fungicidal effects would be necessary to draw a more comprehensive conclusion regarding the dual action of the liquid organic fertilizer.

Acknowledgements

Our sincere thanks go to the rectoral team of UNSTIM, whose Student Technological Innovation Support Funds enabled us to carry out this BioNeem + innovation.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Kwadjo, K.E., Kra, K.D., Douan, B.G., Angoua, K.H. and Doumbia, M. (2018) Insects of Voandzou (*Vigna subterranea* (L.) Verdc., Fabaceae) Stocks in the Abidjan District (Côte d'Ivoire). *Revue de l'Environnement et de la Biodiversité—PASRES*, **2**, 32-41.

[2] FAO (2016) Legumes: Seeds for a Sustainable Future. https://doi.org/10.4060/i5528f

[3] FAO (2015) The State of Food Insecurity in the World. 62.

[4] Institut National de la Statistique et de la Démographie (INStaD), Republic of Benin (2024) Report on Macroeconomic Indicators.

[5] Directorate of Agricultural Statistics (DSA), Ministry of Agriculture, Livestock and Fisheries (MAEP) (2025) Cited in a Submission to SBSTA/SBI of the UNFCCC.

[6] Gomgnimbou, A.P.K., Bandaogo, A., Coulibaly, K., Sanon, A., Ouattara, S.H. and Nacro, B. (2019) Short-Term Effects of Poultry Manure Application on Maize (*Zea mays* L.) Yield and Chemical Properties of a Ferralitic Soil in the Sudanian Zone of Burkina Faso. *International Journal of Biological and Chemical Sciences*, **13**, 2041-2052.

[7] Ahouangninou, C. (2013) Sustainability of Vegetable Production in Southern Benin: An Ecosystem Approach Trial. Master's Thesis, University of Abomey-Calavi.

[8] Jama, B., Palm, C.A., Buresh, R.J., Niang, A.I., Gachengo, C. and Nziguheba, G. (2000) Tithonia as a Green Manure for Soil Fertility Improvement in Western Kenya: A Review. *Agroforestry Systems*, **49**, 201-221.

[9] Uyo Ybesere, E.O. and Elemo, K.A. (2000) Effect of Inorganic Fertilizer and Foliage of Azadirachta and Parkia Species on Early Maize Productivity. *Nigerian Journal of Soil Research*, **1**, 17-22.

[10] Kitabala, M.A., Tshala, U.J., Kasangij, A.K.P., Mulang, T.S., Kamana, N.L. and-Nyembo, K.L. (2016) Integration and Use of Human Feces Residues for Improving Soil Chemical Fertility and Maize (*Zea mays* L.) Production in Lubumbashi (DR Congo). *Journal of Applied Biosciences*, **108**, 10480-10490.

[11] Nzila, J.D., Watha-Ndoudy, N. and Ntangou, M. (2007) Impact of Organic and Mineral Fertilization on Vegetable Crop Production (*Basella alba* and *Amaranthus cruentus*) on Sandy Soils in the Brazzaville Region (Congo). CRCRT, 87-88.

[12] Mbogning, J.B. (2000) Effect of Organic and Mineral Fertilization on the Growth and Yield of Three Varieties of African Nightshade (*Solanum scabrum*) in Dschang. University of Dschang.

[13] Koussihouèdé, H.K.I., Assogba-Komlan, F., Aholoukpè, N.S.H. and Amandji, G.L. (2016) Comparative Influence of Poultry Litter and Composted Small Ruminant Manure on Amaranth (*Amaranthus cruentus* L.) Productivity on Ferruginous Soils in Southern Benin. *Bulletin de la Recherche Agronomique du Bénin* (*BRAB*), **80**, 14-23.

[14] FAO (2017) Urban Agriculture. http://www.fao.org/urban-agriculture/en/

[15] Henao, J. and Baanante, C.A. (2006) Agricultural Production and Soil Nutrient Mining in Africa: Summary of IFDC Technical Bulletin. IFDC, 75.

[16] INSAE and RGPH4 (2013) Census Mapping.

[17] Bonvin, C., Etter, B., Udert, K.M., Frossard, E., Nanzer, S., Tamburini, F., *et al.* (2015) Plant Uptake of Phosphorus and Nitrogen Recycled from Synthetic Source-Separated Urine. *AMBIO*, **44**, 217-227. https://doi.org/10.1007/s13280-014-0616-6

[18] Chiţu, V., Coman, M., Bulgaru, L. and Chiţu, E. (2002) Effects of "Calmax" and "Nutri Vit" Foliar Fertilisers on Plant Growth and Strawberry Fruit Quality. *Acta Horticulturae*, 475-480. https://doi.org/10.17660/actahortic.2002.594.61

[19] Toscano, P., Godino, G., Belfiore, T. and Bricolli-Bati, C. (2002) Foliar Fertilization: A Valid Alternative for Olive Cultivar. *Acta Horticulturae*, 191-195. https://doi.org/10.17660/actahortic.2002.594.20

[20] Bly, A.G. and Woodard, H.J. (2003) Foliar Nitrogen Application Timing Influence on Grain Yield and Protein Concentration of Hard Red Winter and Spring Wheat. *Agronomy Journal*, **95**, 335-338. https://doi.org/10.2134/agronj2003.3350

[21] Yorinori, M.A., Klingelfuss, L.H., Paccola-Meirelles, L.D. and Yorinori, J.T. (2004) Effect of Time of Spraying of Fungicide and Foliar Nutrient on Soybean Powdery Mildew. *Journal of Phytopathology*, **152**, 129-132. https://doi.org/10.1111/j.1439-0434.2003.00810.x

[22] Stephanie, P.T., Lance, G.B. and Ted, W.V. (2005) Irrigation Management Guide. Irrigation Industry Association of British Columbia, Ministry of Agriculture, Food and Fisheries, 7.

[23] Bruno, S. (2009) Technical Itinerary. Fruit and Vegetable, 15.

[24] Clark, G.A. (2003) A Test of the Production of Organically Fertilized Amaranth in Tehuixtla, Morelos, Mexico. 43. https://www.gwp.org/globalassets/global/gwp-cacena_files/en/pdf/esr2.pdf