

Effect of the micro-organism-based biofertiliser Tokyo 8 on the growth and development of maize (*Zea mays* L.) in farmers' fields in southern Côte d'Ivoire

Summary:

The exclusive use of mineral fertilisers for production contributes to the destruction of certain microflora and microfauna in the soil, as well as reducing the organic matter content, which in turn reduces soil fertility. With the aim of finding an alternative to crop fertilisation on the farm, a micro-organism-based biofertiliser (Tokyo 8) was introduced and tested on maize crops. Three types of Tokyo 8 doses were tested: T2: Tokyo 8 diluted 50 times, T3: Tokyo 8 diluted 75 times and T4: Tokyo 8 diluted 100 times. In addition, two controls were tested, namely T0: control without fertiliser and T1: control with NPK 12-22-22 fertiliser. The trials were set up in a Fisher block design with three replicates. The results show that, like NPK, biofertiliser improves maize growth parameters and yield components. It provides the mineral elements required for maize growth and development. However, to be used effectively, Tokyo 8 biofertiliser needs to be diluted sensibly. A dilution of 75% seems to be the ideal for optimum use in maize crops.

Keywords: biofertilizer (Tokyo 8), micro-organisms, maize (*Zea mays*), Ivory Coast

1. INTRODUCTION

Maize, also known by its scientific name *Zea mays* L., is a tropical plant belonging to the Poaceae family, with the world's largest area of cultivation [1]. Maize plays an important role in maintaining food security. Maize grain is eaten in a variety of ways: cooked, grilled or in soup. It is also used to make biodegradable plastics, biofuels and even alcohol [2].

Maize is the world's most widely grown crop, with production estimated at 1,120 million tonnes for the 2019-2020 season [3](need update data from USDA and FAO?). Among cereals, it ranks third and first respectively ahead of wheat and rice in terms of cultivated area and production. Maize and oilseed grains are the most important source of food for humans. In many developing countries, it accounts for the bulk of people's diets [4].

In Côte d'Ivoire, maize is the second most widely grown cereal after rice[5]. Annual national maize production is estimated at around 600,000 tonnes, 60% of which comes from the savannah region, with a yield of 1.9 tonnes per hectare from a total planted area of 350,000 ha [6]. In our country, maize is essential for food security [7], and is also used in animal feed for poultry, pigs and cattle, and as a raw material in certain industries (brewing, soap production and oil production)[8].

However, maize yields in Côte d'Ivoire remain low and local production covers only 30% of consumption needs[9]. This low yield is due to a combination of factors[10], including, along with disease and pests, a decline in soil fertility[11]. This is mainly due to intensive cultivation and soil erosion. To overcome this major constraint to maize cultivation, farmers use mineral and organic fertilisers [12, 13, 14 and 15], but above all chemical fertilisers, which are known for their ability to improve crop yields. Unfortunately, chemical fertilisers are expensive and harmful to the environment and human well-being[16]. Given the decline

in soil fertility, the rise in the price of chemical fertilisers on the market and their harmful effects on the environment and human health, it is vital to look for alternatives that will enable sustainable agriculture. It is against this backdrop that the effect of a biofertiliser (Tokyo 8) has been assessed with a view to sustainable soil restoration.

The aim of this study is to contribute to sustainable maize production on the farm. More specifically, the aim is to assess the effect of the biofertiliser (Tokyo 8) on maize growth and yield.

2. STUDY AREA

The field trial was carried out at the Université Félix HOUPHOUËT-BOIGNY (UFHB) in Cocody (Abidjan) on the experimental plot of the Unité Pédagogique et de Recherche de Physiologie et Pathologie Végétales (UPR PPV). The plot is located in Abidjan, a city in the south of Côte d'Ivoire with geographical coordinates between latitudes 4°10 and 5°30 North and longitudes 3°50 and 4°10 West.

The relief varies between 0 and 300 m from the Gulf of Guinea, between latitudes 4°17N and 7°N and longitudes 2°40W and 8°40W. It is made up of Precambrian bedrock with a sedimentary cover of Upper Cretaceous-Quaternary age in the south-eastern part of the geological level. The soils found there are mainly ferrallitic and ferruginous, with some brown eutrophic tropical soils. By virtue of its geographical location, the Université Félix HOUPHOUËT-BOIGNY site belongs to a humid tropical climate zone characterised by a highly contrasting rainfall and temperature regime (Fig.1).

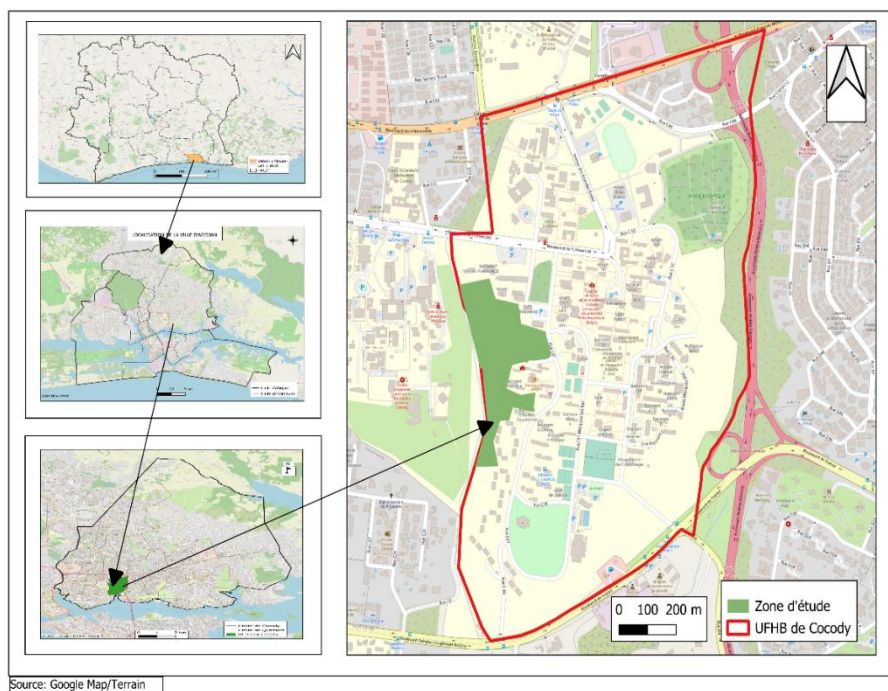


Fig.1. Map of the study area

Data of soil analysis in the study area should be presented here ?

3. MATERIALS AND METHODS

3.1 Material

3.1.1 Plant material

The experiment focused on the LG501 hybrid maize variety (Should indicate single-cross, three-way or double-cross hybrids ? just say LG501 maize hybrid that is enough, do not say hybrid maize variety, because variety refers to open pollinated maize variety, not hybrid). It has a development cycle of 90 days and a yield of 7 t/ha. It originates from Limagrain, a group of semi-processing cooperatives.

3.1.2 Fertilisers used

The fertilisers used are shown in Fig.2. The synthetic fertiliser NKP (12-22-22) usually applied in the field for market gardening, vegetables and maize was used as a reference control.

Biofertilisant Tokyo 8 is a formulation of micro-organisms, enzymes and trace elements and nutrients. It was tested at 3 doses obtained by dilution to 50, 75 and 100%. It is already being used in Ghana and Liberia, and is currently being tested in Côte d'Ivoire and Guinea.



Fig.2. Fertilisers used

Description of Biofertilizer Tokyo 8 should include its composition of micro-organisms, enzymes, trace elements and nutrients, and manufacturer's instruction for users. Similar description for the synthetic fertiliser NKP (12-22-22) is more specific as possible. Do not place the picture of fertilizer bag in this article. Because they look like advertisement for the manufacturer.

3.1.3 Technical equipment

The technical equipment used in this study consisted mainly of tools and instruments required for growing, maintaining and observing plants in the field and in the laboratory. Items such as machetes, a decameter, ropes, stakes and a backpack sprayer were used to set up and care for the plants. Observations and measurements were made using a variety of tools, including a tape measure, a calliper, a 30 kg weighing scale of a specific brand, transparent polyethylene plastic bags, permanent markers and a digital camera.

3.2. METHODS

3.2.1 Experimental design

The experimental design was a Fisher randomised complete block design. The factor studied was the dose of biofertiliser with three (3) treatments and three (3) replications. The experimental plot was 14 m long and 11 m wide, i.e. an area of 154 m². The distance between the blocks was 2 m, and that between the individual plots 1 m (Fig.3). Each individual plot had an area of 6 m².

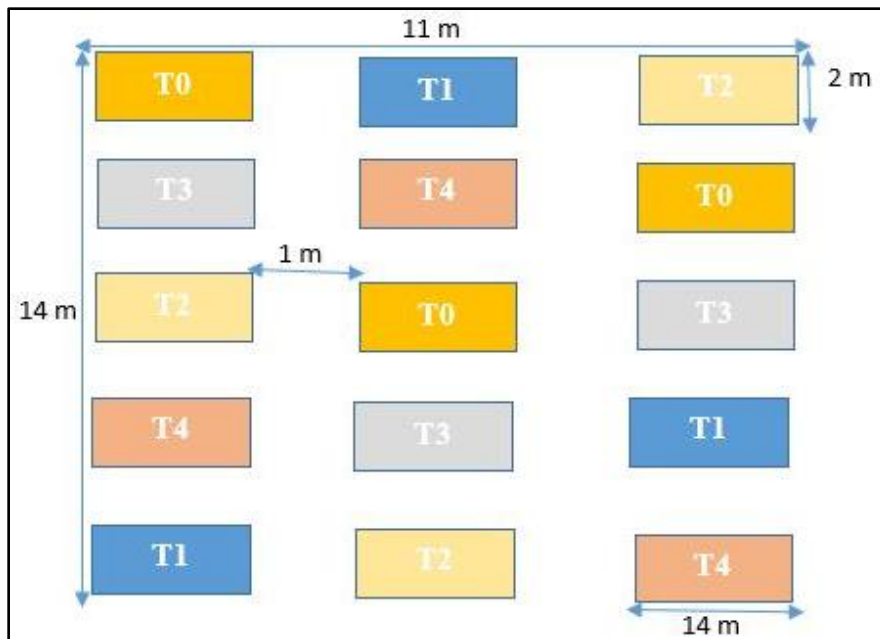


Fig.3. Experimental set-up

T0 : control without fertiliser ; *T1* : control with NPK 12-22-22 fertiliser ; *T2* : Tokyo 8 diluted 50 times ; *T3* : Tokyo 8 diluted 75 times ; *T4* : Tokyo 8 diluted 100 times

3.2.2 Setting up and running the trial

The previous crop in the experimental plot was fallow. As a result, the plot was prepared before the trial was set up. This involved clearing the land and ploughing to a depth of 15-20cm. The experimental layout was then laid out. Each micro-plot consisted of 4 rows, each bearing 52 bunches (Should be minimum 6 rows, more rows are better in fertilizer experiment, because border rows effect a lot to experiment error. Another attention is how to maintain uniform plant density from emergence to harvest, otherwise effects a lot to error of experiment). Sowing was carried out after a useful watering of 45 l of water per micro plot. Sowing was carried out manually, with two seeds per plot. Fertiliser was applied 15 and 35 days after sowing. Weeding was carried out before each application. A total of three doses of Tokyo 8 biofertiliser were tested in comparison with NPK (12- 22- 22) at a dose of 150 kg/ha and an untreated control. The biofertiliser doses were obtained by diluting the recommended dose of 1 ml/m². The dilution factors were 50, 75 and 100%. Thus, 6 ml of biofertiliser were placed in a beaker and then water was added until a volume of 900, 1350 and 1800 ml was reached for the 50, 75 and 100% dilutions respectively. This quantity of spray mixture was

then put into a sprayer and applied to the microplots concerned. The biofertiliser was applied by sprinkling at the foot of the plants, while the NPK fertiliser was applied by spreading at the foot of the maize plants. The biofertiliser was applied to the plants by foliar spraying. Phytosanitary treatments based on cypercal (50ml/7.5l of water) were carried out to reduce attacks by the armyworm.

3.2.3 Data collection

Observations focused on measurements of agro-morphological parameters and yield components of maize plants. The quantitative variables were measured on twenty (20) marked plants selected at random (Should be consecutively) from each microplot. Observations were made every week from 30 DAS until flowering began.

3.2.4 Agro-morphological parameters

Measurements were taken on 5 plants per row selected at random (consecutively is better) on each elementary plot and in each block, i.e. a total of 20 plants per microplot. Some characteristics were selected from among the maize descriptors. Plant height was measured with a tape from the crown to the stem apex 50 cm above the ground. This was done every week until flowering. The number of leaves was determined by counting them every week. Stem diameter was also measured using a caliper at the neck of the plants.

These data were used to calculate the vigour index (IV) according to the equation in [17] :

$$IV = \text{Log} [(H \cdot C^2) / 4\pi],$$

Where π is the constant 3.14; IV :Vigour index; H: Plant height; C: Plant circumference.

3.2.5 Yield components

3.2.5.1 Flowering

As soon as the first male flowers (panicle) and female flowers (ear) appeared, i.e. 52 days after sowing, the number of flowers that appeared was counted on all the plants. They were assessed by counting the flowers every two days, which made it possible to calculate the number of days at 50% male flowering and female flowering.

3.2.5.2 Fresh yield

At harvest, the fresh yield was assessed. To do this, the two central linesrows of each microplot, bearing a total of 15 plants, were harvested. The number of ears and the mass of each ear were determined. The number of ears per m² was calculated by dividing the number of ears by the area harvested. Similarly, the average ear mass was calculated by dividing the total ear mass by the number of ears. The yield induced by each treatment was calculated by dividing the total mass of ears by the area harvested.

Method for measurement of dry grain yield (14% moisture) needs to mention here.

3.2.5.3 Data analysis and processing

All the data collected was entered using Excel. An analysis of variance (ANOVA) was performed using Statistica software version 7.1. The Newman Keul test was used for the

comparison of means to establish the significance of differences between treatments at the 5% threshold.

3.2.6. Time of experiment ?

4. RESULTS

4.1 Effect of biostimulant doses on maize agro-morphological parameters

4.1.1 Changes in plant height as a function of treatment

Changes in average plant height as a function of treatment and time after sowing are shown in Fig.4, which shows that average plant height increased sharply over time, regardless of treatment. The average height ranged from 18.97 to 23.13 cm at week 1, and by week 4 had risen to values ranging from 86.99 to 111.17 cm. However, the average plant height in treatments T1 and T3 was higher throughout the evaluation period.

The average height of the maize plants obtained at the end of the observations varied significantly from one treatment to another. Treatment T1 (NPK fertiliser) produced the highest heights, with an average height of 58.77 cm. On the other hand, treatments T2 and T4 (Tokyo 8 diluted 50 and 100%) showed low heights with mean heights of 45.23 and 46.19 cm respectively. Treatments T0 (no fertiliser) and T3 (biofertiliser diluted 75%) gave intermediate heights with mean heights of 52.66 and 54.64 cm respectively (Fig.5).

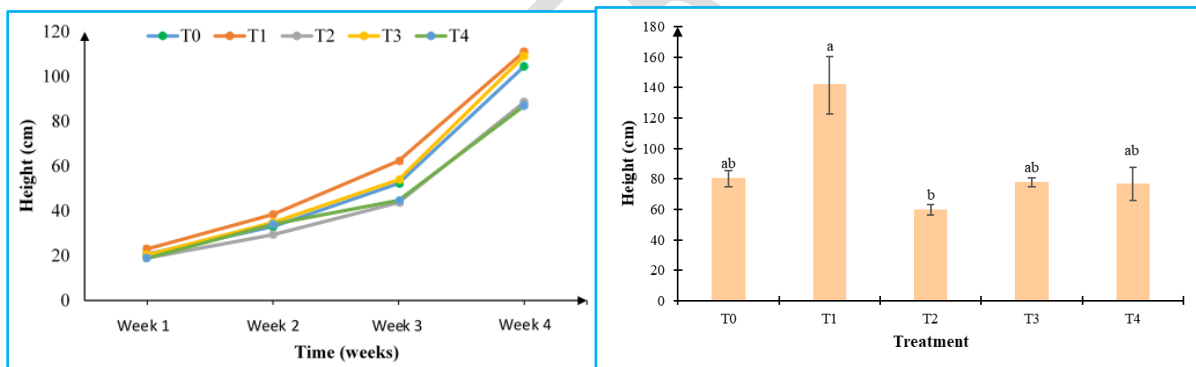


Fig.4. Height versus time curve Fig.5. Plant height as a function of treatment

T0: control without fertiliser, **T1:** control with NPK 12-22-22 fertiliser, **T2:** Tokyo 8 diluted to 50%, **T3:** Tokyo 8 diluted to 75%. **T4:** Tokyo 8 diluted to 100 ; Error bars with the same letters are statistically identical according to the N-Keuls test with a threshold of $\alpha=0.05$.

4.1.2 Changes in plant diameter as a function of treatments

At the end of the observations, a significant difference was recorded between the stem diameters obtained on the treatments. Treatment T1 (NPK fertiliser) produced the largest diameter with an average of 17.66 mm. The smallest diameters were observed in treatments T2, with averages of 14.23 (Fig.6). Treatments T0, T3 and T4 produced statistically identical intermediate diameters.

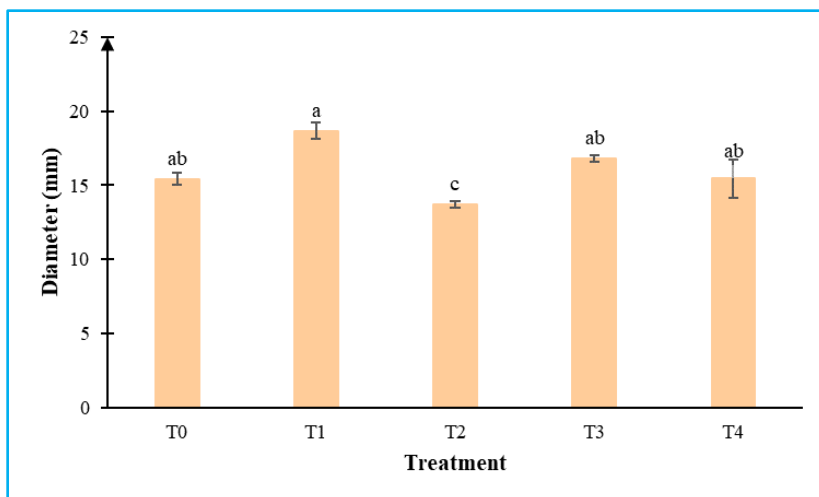


Fig.6. Effect of treatments on plant diameter

T0: control without fertiliser, **T1:** control with NPK 12-22-22 fertiliser, **T2:** Tokyo 8 diluted to 50%, **T3:** Tokyo 8 diluted to 75%. **T4:** Tokyo 8 diluted to 100; Error bars with the same letters are statistically identical according to the N-Keuls test with a threshold of $\alpha=0.05$.

4.1.3 Changes in maize plant leaf emission as a function of treatment

Fig.7 shows the evolution of ~~plant leaf emission~~ full maize plant leaves as a function of ~~treatment and time~~. This figure shows that ~~full leaves emission~~ increased slightly with time, whatever the treatment. The greatest number of leaves was recorded in treatments T0, T1 and T3 over the entire observation period. T2 and T4 induced the lowest number of leaves in weeks 1 and 3. At the end of the observations, data analysis showed no significant difference ($p > 0.05$) between treatments. The number of leaves emitted was 11.25, 11.01, 10.98, 10.38 and 10.31 respectively for treatments T0, T1, T2, T3 and T4 (Fig. 8).

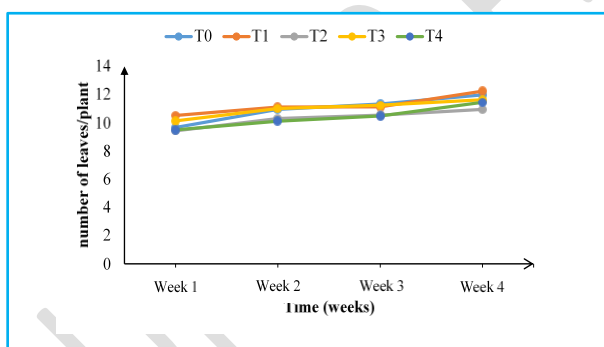


Fig.7. Evolution of the number of leaves as a function of time

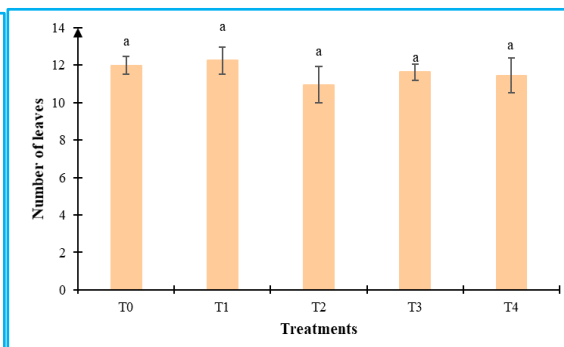


Fig.8. Effect of treatments on the number of leaves emitted

T0: control without fertiliser, **T1:** control with NPK 12-22-22 fertiliser, **T2:** Tokyo 8 diluted to 50%, **T3:** Tokyo 8 diluted to 75%. **T4:** Tokyo 8 diluted to 100; Error bars with the same letters are statistically identical according to the N-Keuls test with a threshold of $\alpha=0.05$.

4.1.4 Vigour index as a function of treatment

Analysis of variance of the data revealed significant differences between treatments in terms of vigour index. The most vigorous plants were observed in treatment T1, with an average index of 3.05. On the other hand, the least vigorous plants were observed in treatments T2 and T4, with averages of 2.72 and 2.77 respectively. Treatments T3 and T0 recorded intermediate vigour indices of 2.91 and 2.90 respectively (Fig.9). **T0 should be least vigorous ? why in intermediate vigorous ?**

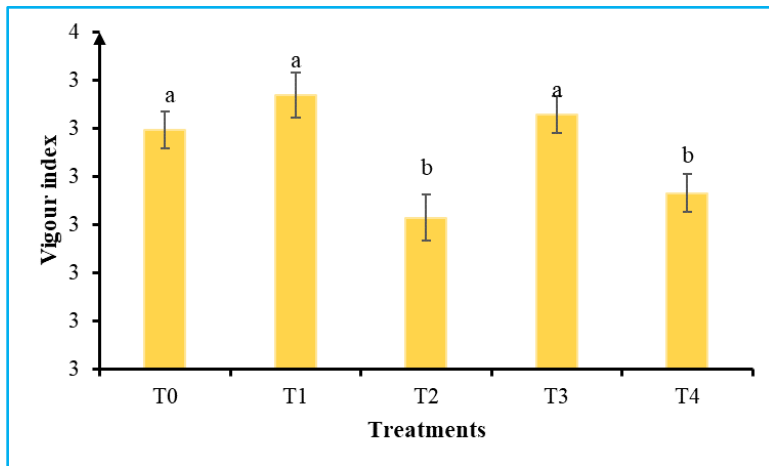


Fig.9. Effect of treatments on vigour index

4.2 Effect of treatment on yield components

4.2.1 Evolution of flowering of plants according to treatments

The first male and female flowers were observed on days 52 and 56 respectively after sowing. The rate of male flowering increased slightly until day 54 and then sharply until the end of the observations. Treatment T1 induced the highest rates of male flowering throughout the observation period. It was followed by T3 and then T0. Treatments T2 and T4 induced the lowest flowering rates. At the end of the observations, the male flowering rate was 78, 62, 57, 43 and 41% for treatments T1, T3, T0, T4 and T2 respectively. However, analysis of variance showed no significant difference ($p > 0.05$) between treatments (Fig.10 and 11).

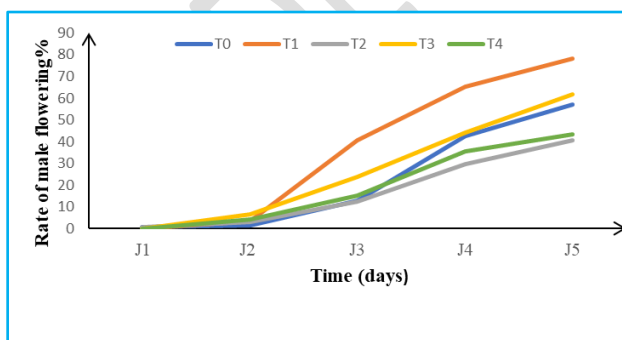


Fig.10. Male flowering rate as a function of time

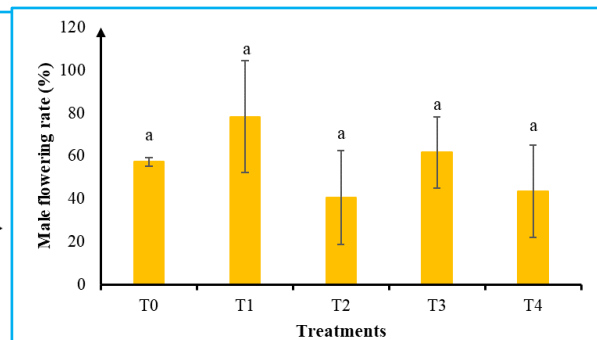


Fig.11. Male flowering rate as a function of treatment

T0: control without fertiliser, **T1:** control with NPK 12-22-22 fertiliser, **T2:** Tokyo 8 diluted to 50%, **T3:** Tokyo 8 diluted to 75%. **T4:** Tokyo 8 diluted to 100 ; **J1,2,3 ;4,5 :** Day 1,2,3 ;4,5 ; Error bars with the same letters are statistically identical according to the N-Keuls test with a threshold of $\alpha=0.05$.

In the case of female flowers, the rate of flowering increased sharply over time. Treatment T1 recorded the highest flowering rate over the entire observation period. It was followed by treatment T3 and then the control T0. The female flowering rates observed in treatments T4 and T2 were below those of the control.

At the end of the observations, the female flowering rate was 23, 21, 17.14 and 9% respectively on treatments T1, T3, T0, T4 and T2. However, analysis of variance showed no significant difference ($p > 0.05$) between treatments (Fig.12 and 13).

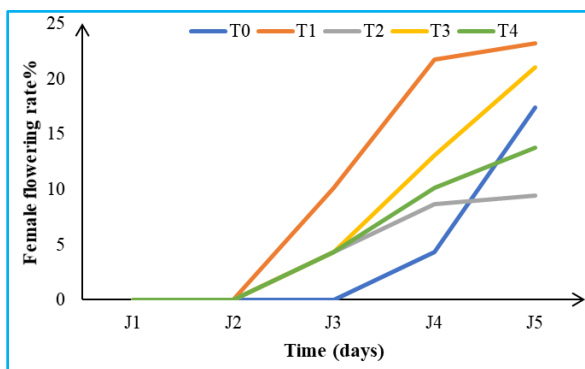


Fig.12. Female flowering rate as a function of time

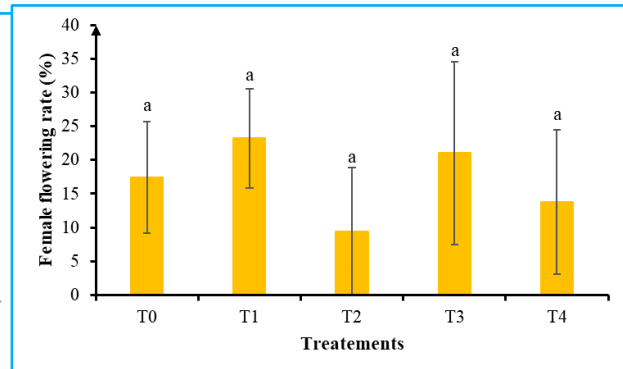


Fig.13. Female flowering rate as a function of treatment

T0: control without fertiliser, **T1:** control with NPK 12-22-22 fertiliser, **T2:** Tokyo 8 diluted to 50%, **T3:** Tokyo 8 diluted to 75%. **T4:** Tokyo 8 diluted to 100 ; **J1,2,3 ;4,5 :** Day 1,2,3 ;4,5 ; Error bars with the same letters are statistically identical according to the N-Keuls test with a threshold of $\alpha=0.05$.

4.2.2 Number of fresh ears as a function of treatment

The number of ears per plant (per plot ?, check it please) varied significantly from one treatment to another. Treatment with T1 induced the highest number of ears with an average of 24.67. The lowest number of ears was recorded in the untreated control with an average of 16.3. Treatments T3 and T4 induced ear numbers very close to those of T1. Treatment T2 produced an ear number very close to that of T0 (Fig.14).

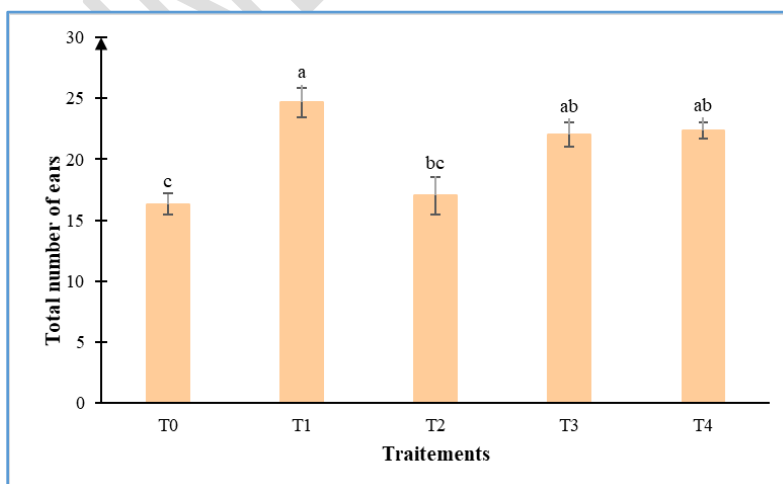


Fig.14. Number of spikes as a function of treatment

T0: control without fertiliser, **T1:** control with NPK 12-22-22 fertiliser, **T2:** Tokyo 8 diluted to 50%, **T3:** Tokyo 8 diluted to 75%. **T4:** Tokyo 8 diluted to 100 ; Error bars with the same letters are statistically identical according to the N-Keuls test with a threshold of $\alpha=0.05$.

4.2.3 Average fresh ear weight by treatment

The average mass of the ear was 0.24, 0.25, 0.21, 0.20 and 0.20 kg respectively for treatments T1, T2, T3, T4 and T0. However, analysis of the data revealed no significant differences. (Fig.15)

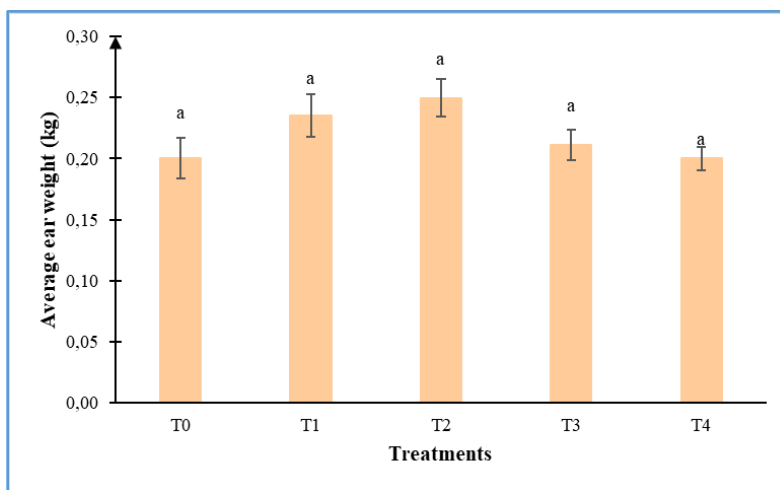


Fig.15. Average ear weight as a function of treatment

T0: control without fertiliser, **T1:** control with NPK 12-22-22 fertiliser, **T2:** Tokyo 8 diluted to 50%, **T3:** Tokyo 8 diluted to 75%. **T4:** Tokyo 8 diluted to 100 ; Error bars with the same letters are statistically identical according to the N-Keuls test with a threshold of $\alpha=0.05$.

The Fig.15 means soil fertility is fertile. So average fresh ear weight is no different among T0, T1, T2, T3 and T4?

4.2.4 Yield in kg/ha as a function of fresh treatment

The **fresh** yields obtained from the different treatments are shown in Figure 16. Analysis of variance revealed a significant difference ($p < 0.05$) between treatments. Treatment with T1 produced the highest yield, with an average of 18888.89 kg/ha. By contrast, the lowest yield was recorded for treatment T2 with 7933.33 kg/ha. Treatments T3, T4 and T0 recorded intermediate yields with 14888.89, 14833.33 and 14000 kg/ha respectively. (Fig.16)

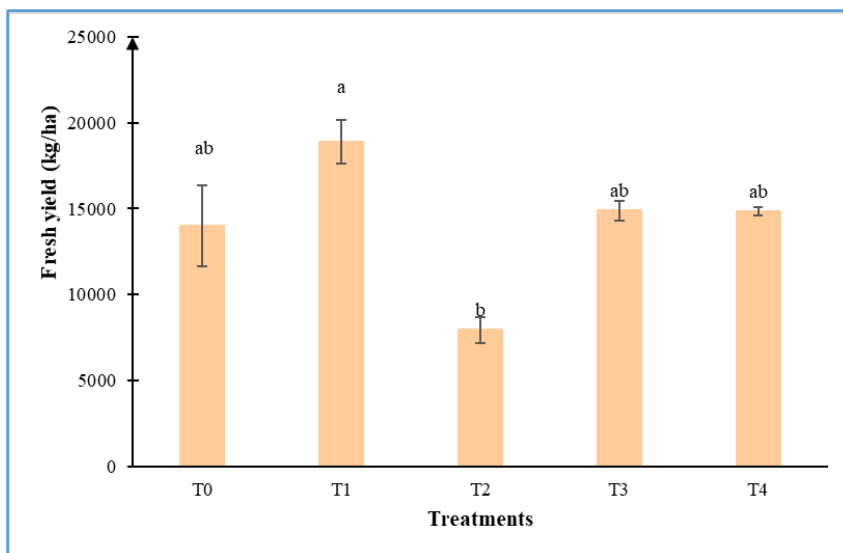


Fig.16. Fresh yield as a function of treatment

T0: control without fertiliser, **T1:** control with NPK 12-22-22 fertiliser, **T2:** Tokyo 8 diluted to 50%, **T3:** Tokyo 8 diluted to 75%. **T4:** Tokyo 8 diluted to 100; Error bars with the same letters are statistically identical according to the N-Keuls test with a threshold of $\alpha=0.05$.

4.2.5 Dry yield in kg/ha as a function of treatment (Should be tone/ha ???)

The mass grain yield (kg/ha) of dry maize kernels without ears was a function of treatment (Fig.17). Analysis of variance revealed a significant difference ($p < 0.05$) between treatments. Treatments T1 and T3 gave the highest yields, with an average of 2.98 and 2.63 kg/ha respectively (kg/ha ?). By contrast, the lowest yield was recorded in treatment T2 with 1.8 kg/ha. Treatments T0 and T4 recorded 2.04 and 2.17 kg/ha respectively (kg/ha ?).

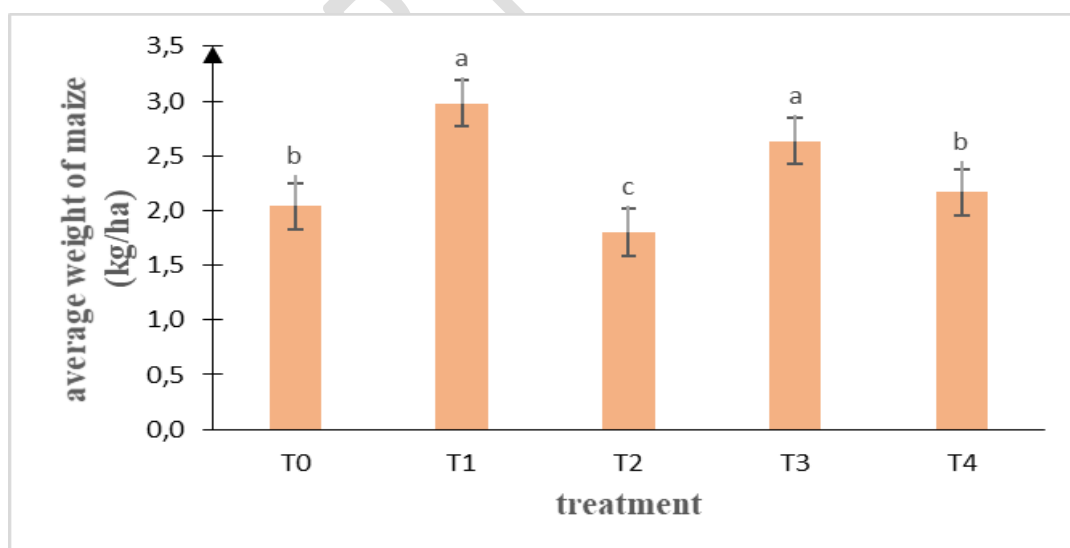


Fig.17. Dry yield as a function of treatment

T0: control without fertiliser, **T1:** control with NPK 12-22-22 fertiliser, **T2:** Tokyo 8 diluted to 50%, **T3:** Tokyo 8 diluted to 75%. **T4:** Tokyo 8 diluted to 100; Error bars with the same letters are statistically identical according to the N-Keuls test with a threshold of $\alpha=0.05$.

In grain yield of maize, shelling percentage is very important criteria indicating stress tolerance at kernel setting period for final harvest yield. If you have this kind of data, please supplement them.

4.2.6 Correlation between growth parameters and yield components

Principal component analysis (PCA) was carried out on the data collected on the growth parameters and yield components of maize after application of the different doses of Tokyo 8 biofertiliser. These were mean height, diameter, number of leaves, vigour index, male and female flowering rate, number of ears, mean ear weight and fresh yield (**why not included dry grain yield ?**). The results showed that axes 1 and 2, which express 91.1% of the inertia, were sufficient to characterise the variables studied. All the variables were strongly positively correlated with axis 1, with the exception of yield and number of ears. The latter were strongly positively and strongly negatively correlated respectively with axis 2, which accounts for 30.74%. Height, diameter, vigour index and the percentage of female and male flowers were strongly correlated with each other. The dispersion of the treatments revealed four homogeneous groups. Treatments T1 and T3 produced the best maize growth and yield. Treatment T2 recorded the lowest values and treatments T0 and T4 recorded intermediate values. (Fig.18 and 19)

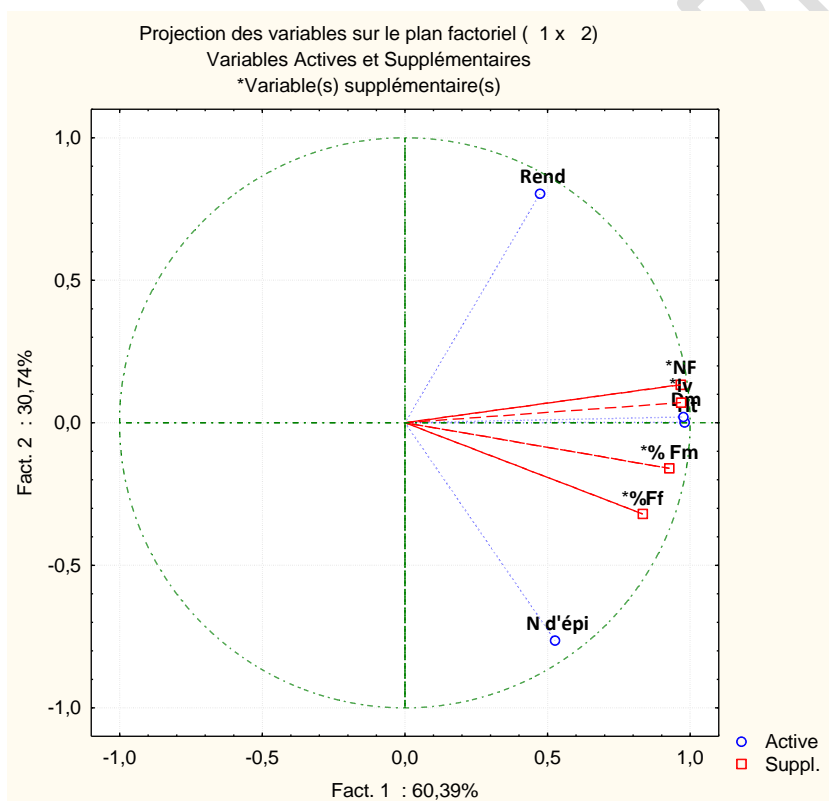


Fig.18. Correlation circle according to PCA of treatments

Ha: height; *Dm*: diameter; *iv*: vigour index, *Ff*: female flowers; *Fm*: male flowers; **Rend**: yield; *N'épi*: number of ears

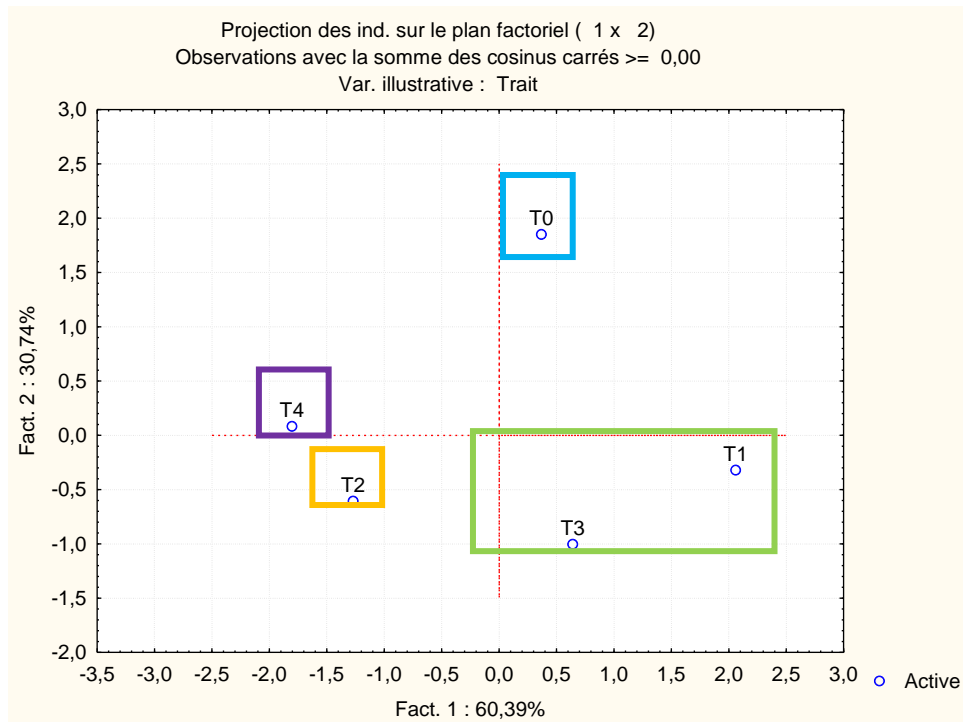


Fig.19. Dispersion of treatments

T0: control without fertiliser, T1: control with NPK 12-22-22 fertiliser, T2: Tokyo 8 diluted to 50%, T3: Tokyo 8 diluted to 75%. T4: Tokyo 8 diluted to 100 ;

5. DISCUSSION

Chemical fertiliser produced the best growth and yield in maize. This is because the chemical fertiliser provided the plants with the mineral elements required for optimum growth and development. It is rich in nitrogen, phosphorus and potassium, the levels of which correspond to the needs of the maize crop. This supply of mineral elements that can be directly assimilated by the plant in sufficient quantities is responsible for the rapid growth and good development observed. Our results are in line with those of [18], who showed that plant nutrition and nitrogen fertilisation are essential factors in determining the yield and quality of agricultural production in tropical environments. According to the work of [19] and [20], the nitrogen (N), phosphorus (P) and potassium (K) contained in chemical fertilisers are involved throughout the plant development cycle. As a result, their absence can lead to unsatisfactory development and yields [18] (But the result of fresh ear weight is no different in this experiment ? not yet explained ?)

The effects of the various fertilisers on growth parameters were remarkable. The Tokyo 8 biofertiliser improved the growth of the maize plants compared with the untreated control. This result could be explained by the composition of this biofertiliser. It is composed of mineral elements such as nitrogen (no data of composition for this biofertilizer ?), which would have played an active role in the vegetative growth of the maize. Our results are in agreement with those of [20] who showed that nitrogen is a determining factor in plant growth and the determination of plant yield. Also, [21] showed that biofertilisers have the necessary mineral elements for the growth and development of field crops such as maize.

Tokyo 8 biofertiliser is also rich in enzymes and microorganisms. These would have stimulated mechanisms to improve the bioavailability of nutrients in the soil; qualitatively modify soil microbial communities (new equilibrium) and increase soil microbial activity favourable to good plant development. Our results corroborate those of [22], who showed that biofertilisers also improve soil structure by simulating microbial activities and nitrogen uptake by plants by modifying their morphological and physiological characteristics.

As with the growth parameters, the Tokyo 8 biofertiliser applied to the crop led to an improvement in the components of maize development and yield. This result could be justified on the one hand by the good growth induced by the biofertiliser. Our observation is in line with that of [23], who highlighted the improvement in maize yield by four types of organic fertiliser through the good growth induced by them. Thus, good plant growth is a prerequisite for good crop yields. Tokyo 8 biofertiliser also contains micro-organisms. According to the work of [24], micro-organisms release gibberellin into the environment, which is involved in bud initiation, stem growth, flowering, the breaking of seed dormancy and fruit growth. All these results prove that Tokyo 8 biofertiliser is an organic fertiliser that is very rich in the mineral elements essential for healthy plant development.

The biofertiliser diluted to 75% gave (fresh or dry grain ?) yields similar to those of the chemical NPK fertiliser (12 22 22). The 50% dilution slowed down maize plant growth and significantly reduced yields. As for the 100% dilution, it induced growth and yield very close to that of the control. These results show that Tokyo 8 biofertiliser needs to be diluted carefully if it is to be effective. A dilution of 75% seems to be the most suitable for improving the effectiveness of Tokyo 8 biofertiliser in maize crops. This result is similar to those obtained by [25] in tomato crops using seaweed-based biofertilisers. These authors showed that these biofertilisers were effective from the 50% dilution, whereas the 25% dilution was ineffective.

The fact that the Tokyo 8 biofertiliser diluted to 75% induced growth and yield close to that of the NPK chemical fertiliser shows that its composition is sufficient to ensure optimal nutrition of maize plants. Our results are in agreement with those of [26] who show that foliar spraying of a seaweed extract (SE) biofertiliser improved the yield of baby lettuce under low nitrogen conditions. However, unlike chemical fertilisers, which have a negative impact on the environment, plants and human health, biofertilisers have the advantage of improving physico-chemical properties and boosting beneficial soil micro-organisms (no data supporting for this comment ?). According to the work of [27], biofertilisers improve microbial activity or the physico-chemical properties of the soil, enabling organic compounds to be degraded more effectively.

6. CONCLUSION

This study was carried out with the aim of contributing to sustainable maize production on the farm. To this end, the biofertiliser Tokyo 8 was tested in comparison with the chemical fertiliser NPK 12 22 22 and a control. The results showed that, like NPK, the biofertiliser improves maize growth parameters and (dry grain ?) yield components. It provides the mineral elements (No data for this remarks ?) required for maize growth and development. It also stimulates improved bioavailability of nutrients in the soil, as well as the microbiological activity in the soil that underpins the plant's development (No data for this conclusion ?). However, for Tokyo 8 biofertiliser to be used effectively, it must be diluted carefully. A

dilution of 75% would appear to be ideal for optimum use in maize crops. Tokyo 8 biofertiliser diluted to 75% induces vegetative growth and maize yields very close to those of chemical NPK fertiliser. It could be used to enrich the soil.

In view of this study, it would be advisable to :

- Test the Tokyo 8 biofertiliser on other crops grown by farmers.
- Evaluate the effect of the biofertiliser in combination with NPK
- Test the biofertiliser in other localities.

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