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# Effects of Different Doses of Compost on the Productivity of Corn (*Zea mays L.*) in the towns of LomÉ and Kara in Togo

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**Abstract** The objective of this study is to evaluate the effectiveness of composts on the productivity of maize (Zea mays L.) by identifying the optimal dose to obtain maximum productivity. The compost used was produced from fermentable fractions of household waste from the city of Lomé. A device in randomized complete blocks with two repetitions comprising five doses of compost (To = control, T1 = 25 t. ha-1, T2 = 50 t. ha-1, T3 = 75 t. ha-1, T4 = 100 t. ha-1) was used. The treatment with compost have been done on elementary plots of 10 m2 each. Sowing is done in three rows of 25 feet each. On each line, the maize plants are separated by 0.20 m and the lines are spaced 0.80 m apart. The average density is 75000 feet per hectare to ensure good ventilation. The results obtained showed that the yield increased according to the doses of compost provided but decreased from 50 t. ha-1. There is therefore a compost use limit of between 25 t. ha-1 and 50 t. ha-1. Maize farmers could use compost for sustainable and effective fertilization to increase their production while preserving soil quality.

***Keywords:*** *compost, effects, optimal, corn, productivity*

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## 1. Introduction

In Togo, where agriculture plays an essential role in the national economy, improving the production of corn, one of the country's most important crops, is a strategic priority. The raw spreading of solid waste as an amendment in urban and peri-urban agriculture is a fairly widespread practice in Togo. In the case of corn cultivation, an activity in high demand to respond effectively to urban food demand, waste is often used in its raw state as an organic amendment, even though this practice is detrimental to soil quality. cultivated, that of water and can alter the quality of the environment. Furthermore, the FAO emphasizes that the decline in land productivity in most African countries is the result of demographic pressure which is growing faster than in other regions. Added to this are poor land management practices subsequently leading to depletion of soil nutrients [1]. However, the quantities of nutrients present in the soil during the crop cycle determine the quality of mineral nutrition of plants and largely the yields quantity of crops. The soil nutrient balance in tropical regions is the most negative in the world given the high aggressiveness of rains, high temperatures and low pH levels [2]. Also, it must be recognized that the use of urban solid waste in its raw state in agriculture affects the quality of the growing environment and agricultural production and could subsequently affect the health of consumers. Faced with these socio-economic and environmental issues, it becomes imperative to look for other sources of nutrients that can enable sustainable agriculture of qualitative and quantitative production. To compensate for the decline in crop yields, several avenues can be considered: fertilization mineral by chemical fertilizers, organic fertilization [3,4] the practice of crop associations, crop rotations and crop rotations [5]. However, the use of mineral fertilization could have a financial impact that agricultural producers in the towns of Lomé and Kara cannot bear, while the implementation of rotations and crop rotations requires mastery of particular techniques. Several studies indicate that the addition of organic amendments by producers is an alternative for crop management aimed at reducing or eliminating synthetic inputs [6]. These amendments improve soil quality and reduce losses due to plant pests, reduce environmental pollution and increase harvest and yields. More particularly, composts are rich in nutrients and recent research has demonstrated that additions of these products increase the levels of organic matter in the soil, the cation exchange capacity, the biomass of microorganisms and their activities. The use of compost from this waste offers a doubly advantageous opportunity: it contributes to the reduction of solid waste in urban areas while providing a rich source of nutrients for agricultural soils. Studies carried out in a natural environment have shown that the addition of organic amendments to poor and acidic soils makes it possible to provide the nutrients necessary for the nutrition, growth and production of cultivated plants [7,8,9]. The importance of organic matter in plant production and following the high prices of synthetic fertilizers which make them inaccessible to the majority of farmers on the one hand and the demographic growth which results in a high demand for foodstuffs of on the other hand, the present study tests the hypothesis according to which the addition of compost would be an inexpensive alternative to corn cultivation in the edapho-climatic conditions of Lomé and Kara. This study therefore aims to evaluate the effects of different doses of compost on corn productivity in two localities in Togo: Kara and Lomé. By identifying the optimal dose, we seek to optimize corn yield while minimizing potential environmental impacts associated with excessive compost use.

# 2. Experimental Works

## 2.1. Location of the Expérimental Sites

This study was carried out on two sites, one in Lomé and the other in Kara. That of the city of Lomé is at the coordinates 1°13' 58" EAST, 6°12'7" NORTH and at an altitude of 37.35 m and that of the city of Kara is at the coordinates 1° 11' 36 .40" EAST, 9° 32' 31.91" NORTH and at an altitude of 277 m. The town of Kara is located approximately 415 km north of Lomé, the capital of Togo. Sites $S_1$ and $S_2$ are located respectively in an experimental field at Kégué in Lomé and in an experimental field on the Kara University site in Kara. The Lomé site is located in an urban environment and that of Kara in a peri-urban area. The Lomé site previously received organic fertilizers such as manure, dried fecal sludge and others. That of Kara is supposed to be natural because it was previously exploited by a farmer in the region who testifies to having never used organic or mineral amendments. The soils of the plots selected for the tests as well as the composts used were analyzed beforehand to determine whether they could be used for quality food production. These two study sites are subject to a tropical climate. The Lomé site is marked by the rhythm of two rainy seasons: the first rainy season goes from the end of March to mid-June and the second, smaller one, which goes from mid-September to the end of October. And the Kara site is marked by a rainy season which goes from March to October.

On average the temperature in Lomé is 26.6°C and the average annual precipitation is 1131 mm. For the town of Kara, the average temperature is 27.2° C and the annual precipitation is 1215 mm. These climatic conditions are favorable for the cultivation of corn, which is a main food crop in Togo and which is cultivated favorably between 800 to 1500 mm of water per year.

## 2.2. Plant Material

Corn variety “IKENE 9449-SR” with yellow grains is used. It is a tropical crop native to Central America [10] widely cultivated in Africa. The seeds come from the Institute of the Togolese Agronomic Council (ICAT). IKENE is a variety having a vegetative cycle of 90 to 100 days with an average productivity of 3 to 4 t. $ha^{-1}$ in Burkina Faso [11], 2 and 3 t. $ha^{-1}$ in Côte d'Ivoire according to Agence Nationale d'Ivoire. 'Support for Rural Development.

**Figure 1.** Corn cobs at maturity

## 2.3. Physico-chemical Characteristics of Site Soil and Compost

The determination of the physicochemical and agronomic properties of the soil on the site was carried out before applying the compost. Soil samples are taken to a depth of 0 - 20 cm at 2 m intervals on a 20 m transect at various locations on the site. These samples, dried and sieved at 2 mm, are used for analyses. The compost was produced from the fermentable fractions of municipal solid waste. The analyzes concern pH, organic matter, total organic carbon, total nitrogen, phosphorus.

### 2.3.1. Determination of pH and Electrical Conductivity of Compost

The pH and electrical conductivity are determined on solutions prepared in a solid/liquid ratio equal to 1/2.

The compost-distilled water mixture is kept stirring continuously for one hour on an orbital rotation table in order to facilitate contact between the solid phase and the liquid phase [12,13]. The pH of the samples is directly measured using a Hanna pH/EC/TDS-meter brand multifunctional pH meter.

### 2.3.2. Determination of Organic Matter (OM) and Total Organic Carbon (TOC)

The organic matter (OM) content was determined using the loss on ignition method [14]. The total organic carbon content of the soil is determined by potassium permanganate oxidizability using the Walkley and Black method [15].

### 2.3.3. Determination of Total Soil Phosphorus Content

The total phosphorus content of the samples is determined in the minerals obtained by the colorimetric method at a wavelength of 420 nm. Absorbance is measured using a T90+UV/Vis Spectrometer. A mixture of acidified solution A of ammonium molybdate $(NH_4)_6Mo_7O_{24}$, $4H_2O$ and solution B of ammonium metavanadate $NH_4VO_3$ was used [16].

### 2.3.4. Determination of Total Nitrogen Content (NTK) of Soil Samples

The total nitrogen content (NTK) of the samples is determined using the Kjeldhal method as described by the Association of Official Analytical Chemists [16].

### 2.3.5. Determination of Trace Metal Element (TME) Content

The content of trace metal elements (Cd, Cu, Ni, Pb, Zn) in soil and compost samples is determined in the mineralized material. Mineralization is carried out by oxidation using concentrated nitric and perchloric acids according to A.S.Baker and R.L.Smith, J., from 1974. The equipment used is an Agilent Technology brand Flame Atomic Absorption Spectrophotometer (240 FS AA) automated which uses a mixture of air and acetylene. The determination of the MTE contents of the samples is made from the calibration curves drawn using the standard solutions of each metal and is read directly on a computer.

## 2.4. Description of the Experimental Device

The experimental design includes five plots of 10 $m^2$ of different treatments, designated by T0, $T_1$, $T_2$, $T_3$ and $T_4$, with the quantities in tonnes per hectare ($t. ha^{-1}$) applied as follows: 0 $t. ha^{-1}$, 25 $t.ha^{-1}$, 50 $t.ha^{-1}$, 75 $t.ha^{-1}$ and 100 $t.ha^{-1}$ respectively. Plots are arranged in randomized blocks separated by two meters from each other, with each block containing the five treatments repeated three times. The plots are spaced one meter from each other and the control plot T0 two meters from the others in order to minimize the influence of the compost on this plot. The field system is the same on both sites during all phases. On the Lomé site, the aim is to compare the performance of crops with different doses of compost under two situations: firstly, under controlled water supply and then, under natural climatic conditions. On the other hand, on the Kara site, this is an approach taking into account variations in sowing dates practiced by local farmers. It is therefore necessary to compare the performance of crops with different sowing dates with an application of compost at varying doses.

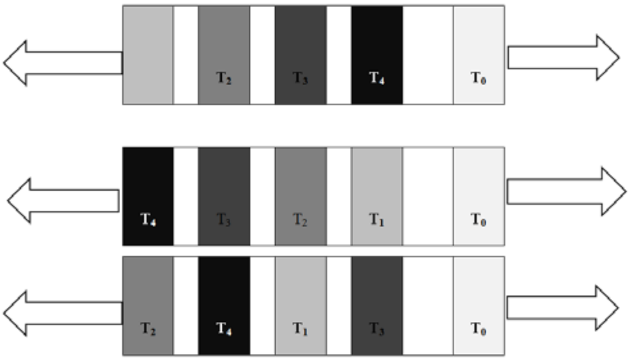


**Figure 2.** Experimental setup for agronomic trials on the Lomé and Kara site

On the Kara site, a second device identical to the first was created for a second series of tests on corn. This series also targets an effect of late sowing. Corn sowing method and monitoring Direct online sowing was carried out for all experiment stations. Three lines of 5 m length separated by 0.80 m from each other were sown. On each row, the corn plants are spaced 0.20 m apart. A total of 25 plants are planted per row, which corresponds to 75 plants of corn per 10 $m^2$ bed, or a density of 75,000 plants of corn on average per hectare. The seeds are planted 2 by 2 and at least five days after germination, weeding is done in order to allow one plant per pocket to evolve. The five boards were seeded on April 30 in Lomé and June 6 in Kara for the first series. The beginning of June is the start of major plantings in the Kara region. A second series of sowing took place on June 29 on the Kara site in order to also evaluate the effect of the compost in the event of late sowing. Sowing takes place after two weeks of compost spreading according to the advice of agronomists in order to avoid non-germination in case the compost was not sufficiently mature before spreading.

## 2.5. Maintenance of Elementary Plots (boards)

In order to protect the crops from wandering animals, the experimental plots were fenced using barbed wire. On the Lomé site, water monitoring is carried out in the event of no rain. The quantity of water provided is 100 L per bed morning and evening or 200 L per day until the ears mature. For natural climatic conditions, crops are left to the sole water care of rain. Weeding takes place every two weeks to make the soil aerated and loose even if there is not enough grass under the plants.

## 2.6. Measuring the Quantity Harvested and Calculating the Yield Per Hectare

The harvested ears are counted, dried and then hulled. The grains are dried until a constant mass is obtained. A one-gram sensitivity scale made it possible to weigh the quantity harvested in grams. The yield is expressed in tonnes per hectare by the relation (1).

$$\eta = \frac{A}{1000\mathcal{R}} \times G \quad (1)$$

with

- √ A: the total mass of tomatoes harvested (kg)
- √ $\mathcal{R}$: the number of corn plants per block
- √ 1000: the conversion factor in tonnes
- √ G: the number of corn plants per hectare.

The different rates of increase in production of the different doses compared to the T0 control were then calculated in order to ensure the effect of doses on the increase in productivity. This rate is given by relation (2).

$$K = \frac{(\mathbf{Ti} - \mathbf{T0})}{\mathbf{T0}} \times 100 \quad (2)$$

with i = (1, 2, 3, 4).

Finally, the calculation of the rate of increase in productivity between the different coupled doses with a view to identifying the optimal dose was made by the relation (3).

$$\in = \frac{(\mathbf{Ti} - \mathbf{Ti} - 1)}{\mathbf{Ti} - 1} \times 100 \quad (3)$$

with i = (2, 3, 4)

## 2.7. Statistical Analysis of Data

The raw data collected were processed by analysis of variance (ANOVA) with post hoc test (DUNCAN test at the 5% probability threshold) for the comparison of the means of the factors studied (productivity as a function of compost doses and depending on the conditions) and their interactions using **Rstudio** software version 4.4.3.

# 3. Results and Discussion

## 3.1. Physico-chemical Characteristics of the Soil

**Soil content of total carbon (TC) and total nitrogen (NTK)**

The results of the total carbon (CT), total nitrogen (NTK) dosages show higher percentages of these parameters in the amended plots and the substrate compared to the control plot (Table 1).

We obtain a little more than 1.5 times total carbon in the amended soil on the Lomé site and 2.33 times on the Kara site than in the control soil. The high total carbon content of the amended soil samples is due to the richness in TC of the spread waste. Indeed, faecal sludge and household waste contain a significant fraction of organic matter. However, the OM content remains lower than the OM content of fertile soils which is between 4 and 8% [17]. In addition, an organic amendment significantly improves the nitrogen fraction in the soil, 1.5 times higher than in the control soil on the Lomé site and 5 times higher on the Kara site. Note that in Kara, the amended soils are more enriched in CT than in Lomé. This situation is linked to the nature of the organic substrates used at each site. Indeed, in Kara we use more cow dung while in Lomé we use more fecal sludge. Cow dung comes from the digestion of food ingested by cows. These foods contain more carbon due to their plant origin. The total nitrogen content increases more than 4 times compared to the controls. This would be due to the fact that cow dung has a plant origin. The total nitrogen contents are almost equal in the control soils in Kara and Lomé (0.07% and 0.08% respectively); which confirms that the addition of organic waste modifies the nitrogen content of the soil. The increase in nitrogen content is similar to that in carbon in the amended soil. Nitrogen content is an essential factor for good agricultural production.

## 3.2. Soil Content of Total Phosphorus ($P_2O_5$) and Assimilable Phosphorus ($HPO_4^{2-}$)

The soil contents of total phosphorus ($P_2O_5$) and assimilable phosphorus ($HPO_4^{2-}$) are given in Table 2. An organic amendment is an important source of phosphorus. The assimilable fraction of the amended soil is more than three times that of the control soils in Lomé. This high fraction could ensure good crop development and will lead to good crop yield. Adding organic manure to the soil helps improve its agronomic properties (availability of nitrogen and phosphorus), which are essential elements for crop development.

The ratio between the contents of the amended soils and the control soils is around 14 for total phosphorus and around 15 for assimilable phosphorus on the Kara site. Additions of cow dung contribute to considerably improving the total carbon, total nitrogen, total phosphorus and assimilable phosphorus contents of soils. However, it is important to ensure that the use of organic waste as agricultural amendments does not affect the quality of agricultural soils. This quality may be linked to their trace metal element (TME) content.

## 3.3. Soil and Substrate Contents of TME Study Sites

The substrate taken in Lomé is the one which contains the highest concentrations of MTE compared to the almond soils and the control from the same site. This site also has the highest concentration of zinc compared to the Kara site with 1653 mg/kg of dry soil. After the substrate come the amended soils (Table 3). The copper, zinc and leads contents of the control soil comply with the standards for unpolluted soils. In the amended soil, we observe that the lead content is below the standard for unpolluted soils. There is therefore no lead pollution at the moment but lead contamination would probably be of anthropogenic origin given that its content in the spread substrate (faecal sludge) is sufficient to influence that in the exposed soil. The zinc and copper contents of the polluted soil are within the range of their standard in unpolluted soils.

We note that the TME contents of the polluted site are proportional to their content in the substrate. We can therefore conclude that the fecal sludge spread on the Lomé site contributes to the pollution of this site in TME. This pollution could affect the quality of agricultural production intended for human consumption and thus represent a danger for consumers. To compensate for this, the use of compost must be considered, hence the importance of this study. But you also need to know the characteristics of the composts to use.

**Table 1. Total carbon of amended soil and control soil of the sites**

| | Lomé | | | Kara | | |
|---|---|---|---|---|---|---|
| Parameters | Amended soil (T) | Control soil ($T_0$) | $T/T_0$ | Amended soil(T) | Control soil ($T_0$) | $T/T_0$ |
| CT (%) | 0.88 | 0.58 | 1.5 | 1.75 | 0.75 | 2.33 |
| NTK (%) | 0.12 | 0.08 | 1.5 | 0.3 | 0.06 | 5 |

*The contents are expressed as percentages (%). Amended means that the plot received organic matter and control corresponds to a plot that did not receive organic matter.*

**Table 2. Total phosphorus and assimilable phosphorus in site soils**

| | Lomé | | | Kara | | |
|---|---|---|---|---|---|---|
| Phosphorus (ppm) | Amended soil (T) | Control soil ($T_0$) | $T/T_0$ | Amended soil (T) | Control soil ($T_0$) | $T/T_0$ |
| $P_2O_5$ | 450 | 175 | 2.57 | 1100 | 75 | 14 |
| $HPO_4^{2-}$ | 175 | 48 | 3.645 | 300 | 20 | 15 |

**Table 3. Soil contents of the Lomé site in TME and certain standards (mg/kg DM)**

| | Lomé | | | Kara | | |
|---|---|---|---|---|---|---|
| TME | Amended soil | Control soil | Substrat | Amended soil | Control soil | AFNOR Standard NFU 44 - 041 |
| Cu | 25 | 6 | 200 | 62 | 8 | 100 |
| Zn | 75 | 25 | 1653 | 15 | 5 | 300 |
| Pb | 45 | 3 | 40 | 11 | 7 | 100 |
| Ni | 17 | 3 | 26 | 15 | 6 | 50 |
| Cr | 32 | 28 | 72 | 62 | 30 | 150 |

**Table 4. Physicochemical characteristics of compost (pH, MO, TOC, $P_2O_5$, NTK)**

| pH (water) | OM (% de MS) | TOC (% de MS) | P $P_2O_5$ (mg/g) | N (NTK en %) |
|---|---|---|---|---|
| 9.9 | 20.4 | 11.8 | 12.3 | 0.9 |

## 3.4. Physico-chemical Characteristics of Compost

The physicochemical characteristics are recorded in Table 4 [18].

The pH is slightly alkaline (pH 9.9) like most urban waste composts [19-22]. The alkaline pH could be linked to the ash content in household waste [22] and this value could also induce a loss of nitrogen in the form of ammonia during composting [22]. It provides favorable conditions for improving biological properties and reduces the availability of trace cations from the soil that can be harmful to the plant in an acidic environment. The organic matter (OM) content is 20.40% in dry mass of compost. The organic matter in compost is a reserve of nutrients which are released into the soil during their mineralization. This content is low, however it complies with European ecolabel standards which place the OM content ≥ 20%. This OM rate is also lower than those obtained by Kolédzi in 2011 [20]. Compost is in fact a product rich in organic matter and also in mineral compounds (N, P, K, etc.). The TOC rate of the compost is 11.8% by dry mass of the compost. The total phosphorus content (mg $P_2O_5$/g) of dry matter is 12.3 mg $P_2O_5$/g. This value is higher than that obtained by Kolédzi in 2011 [22]. This difference could be justified by the improvement of composting techniques given that these composts are produced by the same composting platform. Indeed, the total phosphorus rate is in the range of 0.286 to 0.613% by dry mass of the compost which is consistent with the rate of other composts located between 0.2 – 0.5% of the dry mass of waste compost urban [23-28].

The total nitrogen content (NTK) expressed as a percentage of N is in the range of 0.9% of dry mass of compost. This low value could be linked to a loss of nitrogen in ammonia form during composting. Several authors have shown that total nitrogen generally represents 1 to 4% of the total dry mass of compost, and is composed of less than 10% mineral nitrogen [25-31]. The C/N ratio controls the microbiological balance of the soil. It is 13.11 for the compost used for the experiment. The compost is mature according to the C/N criterion and could be applied to the soil for improved food production. All waste compost is likely to contain trace metallic elements (TME), hence their search in the compost used. Table 5 shows their content.

**Table 5. Compost content in TME (Cu, Ni, Cd, Pb) and the NFU 4446051 standard in mg/kg**

| MTE | Zn | Cu | Ni | Cd | Pb |
|---|---|---|---|---|---|
| mg/Kg | 169 | 18 | 8 | 2 | 20 |
| NFU 4446051 | 600 | 300 | 60 | 3 | 180 |

All concentrations of trace metal elements are lower than their permitted value according to the AFNOR NFU 444 6051 standards for composts intended for agricultural use. Their application to the soil for corn production poses no environmental or public health problems. Indeed, their richness in OM on the one hand would allow the formation of an organometallic complex which would allow the fixation of TMEs, thus making them less available for plants [32].

### 3.5. Corn Productivity at the Kara Site

**Table 6. Evaluation of the effectiveness of increasing doses of compost on yield on the Kara site**

| Doses (t.ha-[1]) | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ |
|---|---|---|---|---|---|
| **Early seed** | 2.53 ± $0.35_d$ | 4.83 $\pm 0.03_c$ | 5.42± $0.10_b$ | 6.52± $0.33_a$ | 6.51 ± $0.17_a$ |
| **Late seed** | 2.57± $0.29_e$ | 3.2± $0.15_d$ | 4.57± $0.26_c$ | 5.60± $0.22_b$ | 6.11± $0.18_a$ |

*T0 is the control soil having received no dose of compost, T1 soil treated with 25 tonnes of compost per hectare, T2, soil treated with 50 tonnes of compost per hectare, T3, soil treated with 75 tonnes of compost per hectare and T4 , soil treated with 100 tonnes of compost per hectare. Means ± standard deviation. The different letters indicate significant differences after the DUNCAN test.*

Table 6 shows that in the Kara region, the addition of compost induces significant variabilities in the yield values ($p<0.05$). The average productivity varies between 2.53 and 6.51 in semi-early season (June 6) while in semi-late season (June 29) this variability is between 2.57 and 6. 11t.ha$^{-1}$. In each case, we see that the highest yield comes from the $T_4$ dose (100 t. ha$^{-1}$) and is low from the $T_0$ dose (control). The analysis of variance shows a significant effect between the different treatments. Note also that productivity increases with the increase in the dose of compost. The different yields in (t. ha$^{-1}$) are better than the national yield according to the Directorate of Agricultural Statistics, Informatics and Documentation (DSID) which indicates that the average corn yield is 1.23 t.ha$^{-1}$ in 2021. The productivities of $T_3$ and $T_4$ treatments are similar to those obtained at the global level which indicates 5,878 t. ha$^{-1}$ according to (FAOSTAT) in 2021. For the corn sector, the country wants to increase the production of 1.2 to 06 tonnes of corn per hectare, extend the cultivable area to 35,000 hectares for a yield of 211,000 tonnes of grain corn. Compost could help to partly achieve this objective. The recovery of waste in agriculture makes it possible to clean up the environment while improving the soil in order to increase the yields of food crops.

### 3.6. Influence of the Period (seasons) on Corn Productivity

For sowing in the Kara region, the ANOVA table returns a p-value (around $3.45 \times 10^{-5}$) less than 5%. We can therefore consider that there is a very highly significant effect of the "Season" factor. Calculating the increase rates would make it possible to highlight the effect of the different doses on maize productivity in the Kara context. The different rates are recorded in Table 7.

**Table 7. Rate of increase in maize productivity of treatments compared to $T_0$**

| Dose ($T_i$) | | $T_1$ | $T_2$ | $T_3$ | $T_4$ |
|---|---|---|---|---|---|
| $K = \frac{(Ti-T0)}{T0} \times 100$ | **Early seed** | 109.5 % | 135.65 % | 183.48 % | 182.61 % |
| | **Late seed** | 24.51 % | 77.95% | 117.52% | 137.16% |

*$T_0$ is the control soil having received no dose of compost, $T_1$ soil treated with 25 tonnes of compost per hectare, $T_2$, soil treated with 50 tonnes of compost per hectare, $T_3$, soil treated with 75 tonnes of compost per hectare and $T_4$, soil treated with 100 tonnes of compost per hectare.*

Between $T_0$ and $T_1$, productivity increased by 109.5%, for the early season semi and by 24.51% for the late semi, between $T_0$ and $T_2$. It experienced an increase of 135.65% and 77.95%, thus showing the beneficial effect of a higher dose. Between $T_0$ and $T_3$, we observe an increase of 183.61% for the early season semi and 117.52% for the late semi, which suggests that this dose continues to improve productivity and between $T_0$ and $T_4$, productivity increased only by 182.61% for early sowing and 137.1% for late sowing, thus demonstrating a possible limit in the application of compost for corn cultivation. It should be noted that sowing at the start of the season gives a much better increase than sowing late. The compost has had all the time and water necessary to release the nutrients essential to the crops when sowing is done on time and this could justify these differences. These percentage increase rates highlight the increasing effectiveness of treatments as doses increase. They reinforce the conclusions of the study on the positive impact of different doses on corn productivity in Kara in Togo. However, calculating the rate of increase in corn productivity relative to the different doses apart from the control is necessary to identify the optimal dose for maximum productivity. The results of the calculations are shown in Table 8.

**Table 8. Rate of increase in tomato productivity between the different treatments**

| Dose ($T_i$) | | $T_1$ | $T_2$ | $T_3$ | $T_4$ |
|---|---|---|---|---|---|
| $\in = \frac{(Ti-Ti-1)}{Ti-1} \times 100$ | **Early seed** | | 12.20 % | 20.29 % | 15.46% |
| | **Late seed** | | 42.81% | 22.46% | 9.11% |

For semi at the start of the season, we notice an increase in productivity of 12.20% and 42.81% for semi late between $T_1$ and $T_2$, of 20.29% for semi at the start of the season and 22.46% for the semi-late between $T_2$ and $T_3$. This indicates that the positive effect of compost is even more pronounced when a high dose is used. However, between $T_3$ and $T_4$, there is a drop of approximately 15.46% for the semi early in the season and an increase of 9.11% for the late semi. This can mean that when a certain compost dose is exceeded, it can cause negative effects on crop growth, perhaps due to nutrient starvation or other factors. The addition of compost seems to have a positive effect on the productivity of crops, particularly corn, with a more marked improvement at high doses up to a certain threshold. However, excessive use of compost can lead to decreased productivity, highlighting the importance of finding the right balance for optimal results. The optimal dose of compost according to these results would be between 25 and 75 tonnes of compost per hectare ; the dose of 100 tonnes per hectare appears to be an excessive dose.

### 3.7. Corn Productivity on the Lomé Site

Average yields in Lomé under controlled water conditions vary from 2.23 to 7.83 and those under natural conditions vary between 2.67 and 6.81. It appears from the analysis of variance that the yield was influenced by the doses of compost applied ($p < 0.05$) whatever the hybrid or natural conditions. In each case, we see that the highest yield comes from the $T_4$ dose (100 $t.ha^{-1}$) and is low from the $T_0$ dose (control). The analysis of variance shows a significant effect between the different treatments. Note also that productivity increases with the increase in the dose of compost. The recovery of waste in agriculture makes it possible to clean up the environment while improving the soil in order to increase the yields of food crops.

**Table 9. Evaluation of the effectiveness of increasing doses of compost on yield on the Lomé site**

| Doses ($t.ha^{-1}$) | $T_0$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ |
|---|---|---|---|---|---|
| Hybrid conditions | 2,23 ± 0,16d | 4, 6± 0,16c | 7,2 ± 0,17b | 7,4 ± 0,08ab | 7,83 ± 0,11a |
| Natural conditions | 2,67 ±0,2d | 4,71 ± 0,03c | 5,54 ± 0,05b | 6,76 ± 0,04a | 6,81 ± 0,12a |

*$T_0$ is the control soil having received no dose of compost, $T_1$ soil treated with 25 tonnes of compost per hectare, $T_2$, soil treated with 50 tonnes of compost per hectare, $T_3$, soil treated with 75 tonnes of compost per hectare and $T_4$, soil treated with 100 tonnes of compost per hectare. Means ± standard deviation. The different letters indicate significant differences after the DUNCAN test.*

### 3.8. Influence of Water Conditions on corn Productivity

We also observe that in Lomé the "condition" factor has a very highly significant effect with a p-value = 0.00181. Water control in agriculture could allow production all year round and have good productivity Calculating the increase rates would make it possible to highlight the effect of the different doses on maize productivity in the context of Lomé. The different rates are recorded in Table 10.

In Table 10, the effect of water is noticed. The more the plot is watered, the more it generates a large increase in production ranging from 100% to 240%. In the conditions we also observe a growth in productivity from 76.12% to 155.62%. These observations indicate that with compost we obtain a very significant increase in production. With these rates of increase we notice that there is no difference between the values obtained between $T_0$ and $T_3$ on the one hand and $T_0$ and $T_4$. This suggests to us that the optimal dose would be between 25 to 75 tonnes per hectare. In order to identify this dose on the basis of production growth, let us use the relationship between production growth and dose.

Table 11 provides information on these different reports.

Table 11 shows that under the same conditions, ɣ increases from $T_1$ to $T_2$ for the case of Lomé in hybrid conditions but decreases in natural conditions. Similarly in the natural conditions of Kara ɣ also decreases. From this observation, we could say that the optimal dose to obtain maximum productivity is 25 tonnes of compost per hectare. In addition, for economic and environmental reasons, the treatment of 25 tonnes per hectare could be recommended to producers. Compost could also therefore be a remedy for crops in the context of climate change. In fact, compost enriches the soil with organic matter that can serve as a water stock, which is crucial in periods of drought or climatic irregularity, it also allows the storage of carbon in the soil, thus acting as a carbon sink, which is very important for climate change mitigation. Finally, composting reduces greenhouse gas emissions.

## 4. Conclusion

The study demonstrated that composting is a viable solution for increasing corn production in Lomé, the capital of Togo, and in Kara in the interior of the country. Compost characteristics play a crucial role in improving soil fertility and crop growth. By identifying the optimal dose of compost, this research provides practical information to farmers to optimize their production while preserving natural resources.


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**Table 10. Rate of increase in maize productivity of treatments compared to $T_0$**

| Dose ($T_i$) | | $T_1$ | $T_2$ | $T_3$ | $T_4$ |
|---|---|---|---|---|---|
| $K = \frac{(Ti - T0)}{T0} \times 100$ | **Hybrid conditions** | 100% | 213.04 % | 221.74% | 240.00 % |
| | **Natural conditions** | 76.12% | 107.86% | 153.19% | 155.62% |

**Table 11. rate of increase in corn productivity per kg of treatments compared to $T_0$**

| Dose ($T_i$) | | | $T_1$ | $T_2$ | $T_3$ | $T_4$ |
|---|---|---|---|---|---|---|
| $\gamma = \frac{1}{Ti}\frac{(Ti - T0)}{T0} \times 100$ | Lomé | **Hybrid conditions** | 4% | 4.26 % | 2.95% | 2.40 % |
| | | **Natural conditions** | 3.04% | 2.16% | 2.04% | 1.55% |
| | Kara | **Early seed** | 4.38% | 2.71 % | 2.44 % | 1.83 % |
| | | **Late seed** | 0.98% | 1.56% | 1.57% | 1.37% |

*Ti = (25 $t.ha^{-1}$, 50 $t.ha^{-1}$, 75 $t.ha^{-1}$, 100 $t.ha^{-1}$) doses in tonnes per hectare*
*ɣ= rate of increase in corn productivity per kg compared to $T_0$*

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