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Original Article

Assessment of the Combination of Different Measures of Biochar and Cow Dung on Cucumber Morphological Parameters in Glo-Djigbé, Benin

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Glo-Djigbé, Cucumber, Biochar, Cow dung, Chemical Fertiliser.

ABSTRACT

This research aims to determine the best combination of cow dung and biochar dosages that will enable good cucumber production under the ecological conditions of the Glo-Djigbé district. This will make it possible to satisfy the growing needs of the urban population for organic crops and so reduce the use of chemical products that are harmful to the environment and the health of consumers. To carry out this research, a randomised complete Fisher block design was fixed in the experimental stage with four (04) treatments and three (03) replications; corresponding to 12 plot units, each with a surface area of 6 m² including ten patches spaced 0.8 m apart from their centre. The treatments applied per plot are: T0 (no fertilizer input), T1 (50% biochar + 50% cow dung), T2 (75% biochar + 25% cow dung), T3 (25% biochar + 75% cow dung). The collected data were analysed with Excel 2010 spreadsheet and the Statistics software. The results show that the treatments having received fertiliser were the most successful in terms of all the highlighted parameters (length, girth, number, weight of harvested fruits and yield). The best results are obtained with treatment T1 (50% Biochar + 50% cow dung). This mixture was very favourable for cucumber production and could be substituted for chemical fertilisers for organic and ecologically profitable cucumber production.

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INTRODUCTION

The agricultural sector is a driving force behind the world's economic and social development. It is a source of income and employment for the majority of the world's population (Banza et al., 2019, p. 136-44). In Benin, agriculture employs about 70% of the active population and contributes nearly 23% to the formation of the Gross Domestic Product (GDP) (INSAE, 2015) cited by MAEP, 2017, p. 2). It is recognised as an imperative sector of activity for ensuring food sovereignty and then food and nutritional security. But nowadays, this agricultural production is facing colossal problems with the size of the Beninese population, which constantly increases, especially in the municipalities of Cotonou and Abomey-Calavi. The concentration of the population in these municipalities, respectively the first and second most populated in Benin, generates new needs in terms of food based on market gardening. The main vegetable crop most in demand by the populations of these municipalities is the cucumber, an exotic vegetable used not only in human food because of its organoleptic and nutritional quality but also in cosmetics and diet. Increasing this production remains the only possibility to satisfy the growing needs of the population. Therefore, market gardeners resort to an intensive system with high use of chemical fertilisers in order to maximise their yields and meet consumer demand perfectly.

However, the exclusive use of long-term chemical fertilisers leads to soil degradation and its surface tends to harden and form a crust (Lokossou et al., 2018, p. 12440 and 12443). Above all, it poses a problem with the quality of fruit intended for consumption and also causes soil acidification (Gomgnimbou et al., 2019, p. 12440 and 12443), air and water pollution by nitrates and phosphates, which could be the cause of eutrophication of water bodies. To these problems are added the population growth and land scarcity in the municipalities of Cotonou and Abomey-Calavi. Thus, it urges to use of available and low-cost organic fertilisers in this context of food insecurity, reduction of agricultural soil fertility and its scarcity, and the rising prices of chemical fertilisers on the markets (Useni et al. 2013, p. 6524) for organic and sustainable agriculture. Organic manures maintain or improve soil fertility with very good crop yields in a sustainable manner (Li et al., 2012; Khalid et al., 2014; Sikuzani et al., 2014)) quoted by Gomgnimbou et al. (2019, p. 2042).

Cow dung is one of the organic manures used to improve soil fertility. It contains nitrogen, phosphorus, potassium, and other elements necessary for plant growth (Nzambe et al., 2019, p. 61). Also, the addition of Biochar to the soil increases water retention capacity due to its porous surface offering micro-organisms hydration during dry periods or even within arid soils. A study by Yêmadjè (2016, p. 9) noted that the addition of Biochar in agricultural trials results in a 10% increase in crop yields. Sara (2015, p. 6)) also reported that one of the most attractive qualities of Biochar is undoubtedly its power to retain nutrients and thus increase soil fertility. For the latter, this amendment could be a solution to reduce the loss of nutrients through leaching. The current article is part of this dynamic by proposing the combination of cow dung and biochar, all organic fertilisers, in order to maximise the yield of the cucumber crop and maintain the biological and chemical balance of the soil for sustainable agriculture. Indeed, the objective of this research is to determine the best combination of cow dung and biochar dosages that will allow good cucumber production in terms of growth and development under the ecological conditions of the district of Glo-Djigbé.

Presentation of the Research Framework

The experimental site is located in Glo-Djigbé, one of the districts of the municipality of Abomey-Calavi. This district is located between 6°31' and 6°35' of North latitude and 2°15' and 2°30' of East longitude (*Figure 1*) and has an area of approximately 100.79 Km² (INSAE, 2014). It is characterised by a sub-equatorial climate marked by two rainy and two dry seasons. The

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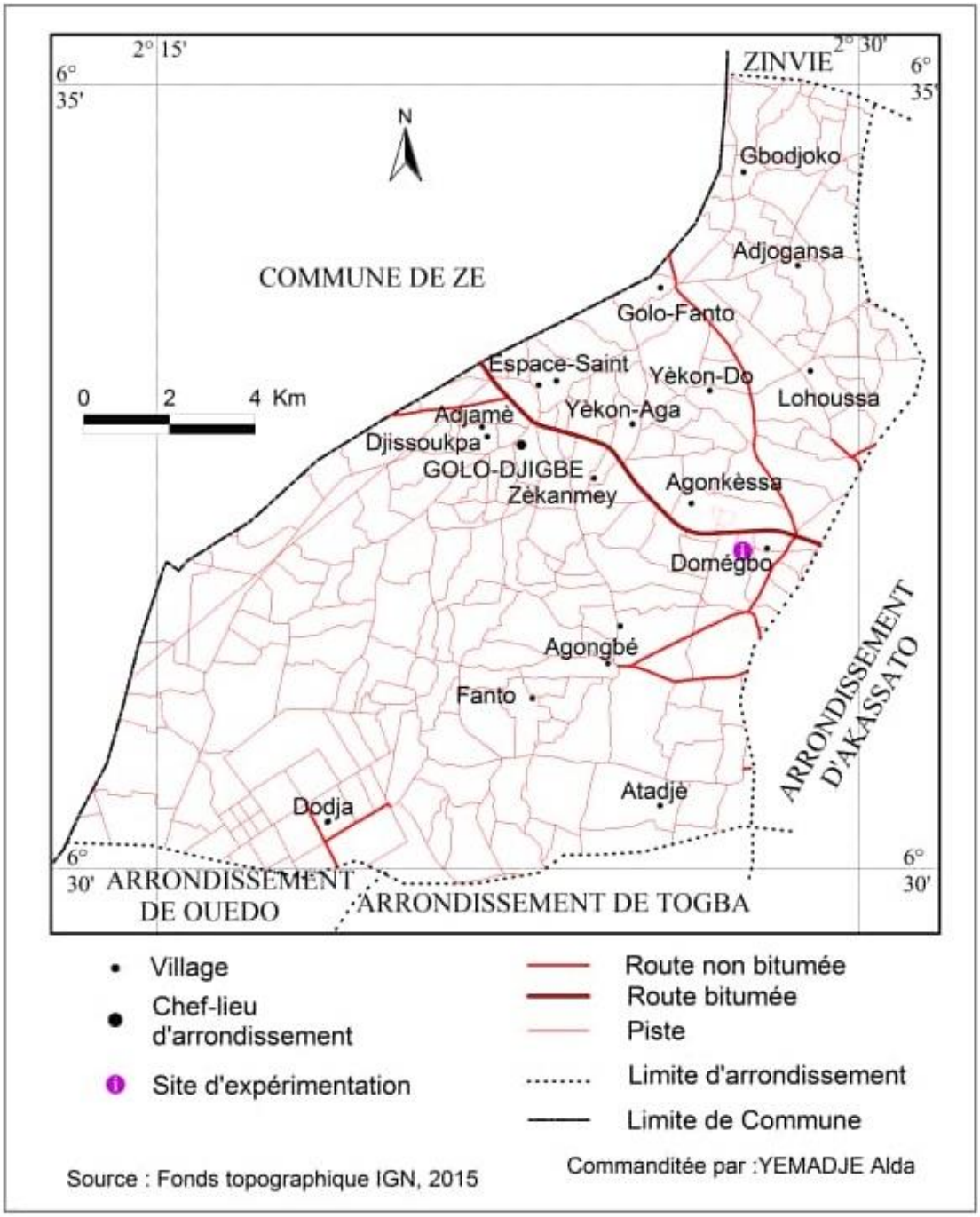
average annual rainfall of 1200 mm, offers immense agricultural opportunities. The average temperature is about 27.2 °C. The moisture content is always high at 60-80%, with maxima at the time of heavy rainfall. These soils are very loose on the surface, well-drained, and have good physical characteristics that allow good development of cucumber cultivation. It is approximately twenty-seven kilometres from the municipality of Cotonou and 15 kilometres from Abomey-Calavi. Its proximity to the two municipalities is recognised as a major issue in terms of low-cost organic waste supply (cow dung, agricultural waste and biomass and then household solid waste). This waste is the raw material for the manufacture of Biochar. Also, the position of this district will solve the problems of crop rot and reduce the cost of transport. All these factors will be an advantage for the consumer, who will have quality crops at a lower cost, and for the market gardener who will make a maximum profit.

Figure 1: Geographical location of the district of Glo-Djigbé



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MATERIAL AND METHODS

Plant Material

The plant material consists of cucumber seeds (*Cucumus sativus* L.), Long Market variety (*Plate1*).

Plate 1: Cucumber fruits and seeds (Cucumus sativus L.)

These seeds (Figure) are NANDINI 732 F1. They are more widely grown in the research area and have dark green, elongated fruits of about 25-30 cm in length.

Materials Used for Biochar Production

Several materials are used in the biochar manufacturing process. These are:

- raw materials (maise spat, groundnut husks and rice husks),
- the carbonizer which has been used for thermal decomposition of the raw material in an oxygen-poor environment,
- of the mill which allowed the char obtained to be reduced to powder after carbonisation,
- a container for mixing the char to obtain the Biochar.

Equipment Used for Measurements

These are the tape measure, the string which are used to make the seedpods and then a scale to weigh the quantity of biochar and cow dung and the crops.

Data collection sheets for the parameters studied.

Fertilisers - The fertilisers used are cow dung and Biochar.

Method - The method essentially boils down to the collection, the processing of data, and then the analysis of the results.

Data Collection

Data Collected

The data collected are both quantitative and qualitative. They cover:

- Physical data: this includes rainfall, humidity, temperature, and soil data,
- Data about the morphological parameters of the cucumber: length, circumference, number, the weight of harvested fruits and yield.

Data Collection Tools and Techniques

Tools - This is the data collection sheet that served as a medium for recording data from cucumber sowing to harvest.

Documentary Research

The documentation consisted of investigations at the level of research centres and institutions

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whose fields of activity are related to the current research theme. There is a considerable contribution from websites that made it possible to obtain digital works in addition to these research centres and institutions. In these various information centres and on the internet, the documents (dissertations, theses, reports, articles, journals) have been of considerable help. They provided knowledge about the research area and a better understanding of the production system for cucumber cultivation, the techniques for making and applying Biochar and cow dung.

Cultural Techniques

Several cultural operations were carried out as part of the preparation of the land. These included: demarcation of the land, mowing, grubbing, cleaning, setting up the experimental device, and applying the different combinations of cow dung and Biochar.

Experimental Set-Up and Treatment (Application of Organic Fertilisers)

The experimental device of the trial is the Fisher design with four (04) treatments per block and three (03) replications corresponding to twelve (12) plot units, each having an area of 6 m². Aisles of 0.5 m were observed between the plots and 1 m between blocks. Zai patches are 40 cm in diameter and 15 cm deep. Each plot unit consists of 10 pits spaced 0.8 m apart from their centres. The treatments applied are as follows:

T0: Control treatment with no fertiliser input,

T1: 50% biochar (0.6 kg) + 50% cow dung (0.6 kg),

T2: 75% biochar (0.9 kg) + 25% cow dung (0.3 kg),

T3: 25% (0.3 kg) biochar + 75% cow dung (0.9 kg)

The 1.2 kg of organic fertiliser combination was determined in relation to the amount needed for one cucumber plant per plot. The fertiliser mix was watered for a fortnight before sowing. This will ease the decomposition of the cow dung and its incorporation into the Biochar, which in turn will capture the necessary nutrients and gradually distribute them to the cucumber plants.

Seedling

Sowing was carried out on August 24, 2021, corresponding to the fourteen (14) days after planting the fertilisers (Biochar and cow dung). The first emergence took place three days and the rest six days after sowing. The plants were staked as soon as the first tendril appeared on the plant by erecting a 2 m long stick that acted as a stake for the tendrils. Flowering started 21 days after sowing.

Maintenance and Phytosanitary Treatment

The maintenance work included: watering (twice a day in the morning and evening), cleaning the edges of the pots (three times during the experiment), hoeing (every three days), weeding (14 days after sowing), staking (18 days after sowing) and topping (37 days after sowing).

As for the phytosanitary treatment, neem oil was used (2 L of water for 125 ml of neem oil plus ½ quantity of the small pouch of Omo Klean, all in 16 L of water). The first treatment took place three weeks after sowing and the rest every week until 35 days after sowing when the first fruits appeared.

Collection and Measuring of Parameters

The experiment lasted 45 days. The first harvest took place on day 40, the second on day 43 and the last on day 45. A total of three passes were made. The harvested fruits were immediately measured and weighed (*Plates 2* and *3*).

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Plate 2: Measurement of harvested fruit

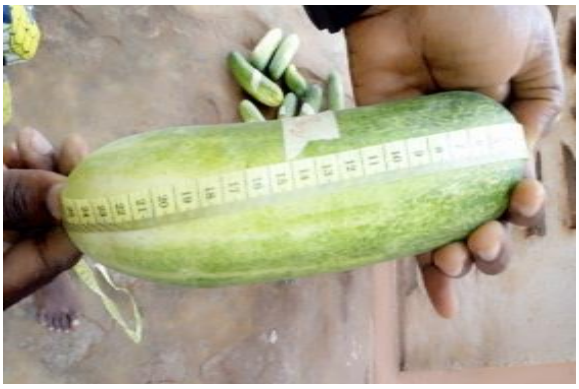

Plate 3: Weighing of harvested fruit

Data Processing and Result Analysis

The collected data were processed with an Excel spreadsheet to make the descriptive statistics. Means, variances, and coefficients of variation were carried out. The coefficient of variation was used to check the homogeneity of the variances in order to assess the level of significance of the differences observed in the effectiveness of the treatments applied to the parameters studied. This spreadsheet was also used to produce tables, graphs, and curves. The maps were made using Arc-View software. The analysis of the results was descriptive, analytical, and comparative.

RESULTS

Effect of various doses of fertiliser combination (biochar and cow dung) on fruit length and girth. *Table I* shows the averages of the parameters (length, girth) on ten cucumber plants (average of three replications) and the coefficient of variation per treatment.

Table 1: Average parameters (length, girth) of harvested cucumbers and coefficient of variation by treatment

Treatments	Average parameters (length, girth) of harvested cucumbers and coefficients of variation by treatment			
	Average fruit length (cm)	CV (%)	Average fruit circumference (cm)	CV (%)
T0	22,3	6,37	17,38	9,04
T1	27,5	14,81	20,56	8,88
T2	25,5	5,82	19,69	4,65
T3	22,3	3,92	19,60	9,40

Source: Field, October 2021

Table I shows that the coefficients of variation of the different treatments are low. Thus, the performance of the treatments on fruit length and girth did not differ. The efficiency of the treatments applied to these parameters is then similar. However, the average values of the length and girth parameters of the harvested cucumbers seem to vary between treatments (*Figures 2* and *3*).

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Figure 2: Length of fruit harvested per treatment

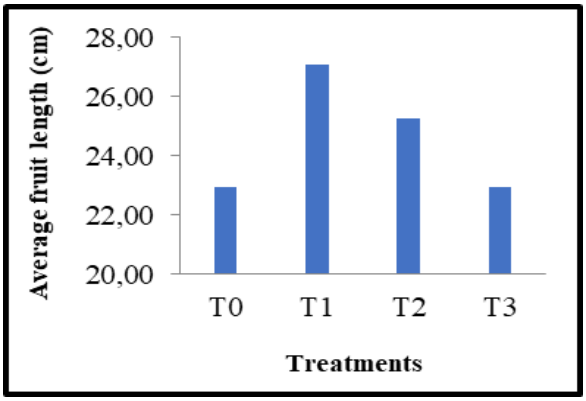
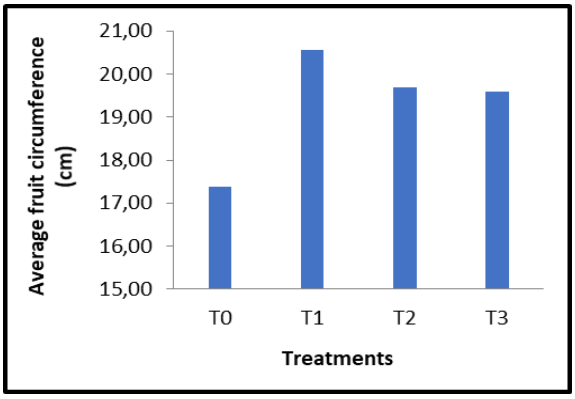


Figure 3: Circumference of harvested fruit per treatment



Source: Field survey, October 2021

T0: Control treatment without fertilizer input, **T2:** 75% biochar + 25% cow dung, **T1:** 50% biochar + 50% cow dung, **T3:** 25% biochar + 75% cow dung.

Figure 2 and *3* shows that the treatments with the highest average values are T1 and T2. On the other hand, treatments T0 and T3 have the lowest average values, respectively, 22.3 cm for fruit length and 17.38 and 19.60 cm for girth. In order of importance, treatment T1 (50% Biochar + 50% cow dung) is in the lead with average values of 27.07 cm for length and 20.56 cm for circumference. This treatment is therefore the most efficient on the length and circumference parameters of the harvested cucumbers.

Influence of different doses of the fertiliser combination (Biochar and cow dung) on the number, weight, and yield of fruits. The averages of the parameters (number of fruits, fruit weight and yield) on ten cucumber plants (average of three replications) and the coefficient of variation per treatment are recorded in *Table 2.*

Table 2: Average of parameters (number of fruits, fruit weight and yield) of harvested cucumbers and coefficient of variation by treatment

Treatments	Average of parameters (number, weight, fruit yield) harvested and coefficient of variation per treatment					
	Average number of fruits	CV (%)	Average fruit weight (g)	CV (%)	Average yield (Kg/ha)	CV (%)
T0	02,89	27,06	276,08	15,37	414,5	35,98
T1	05,00	10,00	452,58	10,13	672,4	32,76
T2	04,22	45,52	420,81	12,81	630	34,40
T3	04,33	34,62	366,39	08,44	547	32,42

Source: Field survey, October 2021

The analysis of the coefficients of variation (*Table 2*) shows that the effectiveness of the treatments on the number of fruits and the yield is very different and very significant between treatment T1 (50% Biochar + 50% cow dung) for the fruit number parameter and not very significant for the yield parameter compared to the other treatments. The highest average values are of five (05) fruits with a yield of 672.4 Kg/ha noted in treatment T1 (50% Biochar + 50% cow dung). The lowest values were recorded for treatment T0 (control without fertiliser) with average values of about three (03) fruits for a yield of 414.5 kg/ha. This reflects the high efficiency of treatment T1 compared to the other treatments.

The coefficients of variation are generally low as far as the fruit weight parameter is concerned. Thus, the efficiency of the treatments on fruit weight did not differ. Nevertheless, the average values of this parameter tend to vary in relation to the different treatments applied (*Figure 4*).

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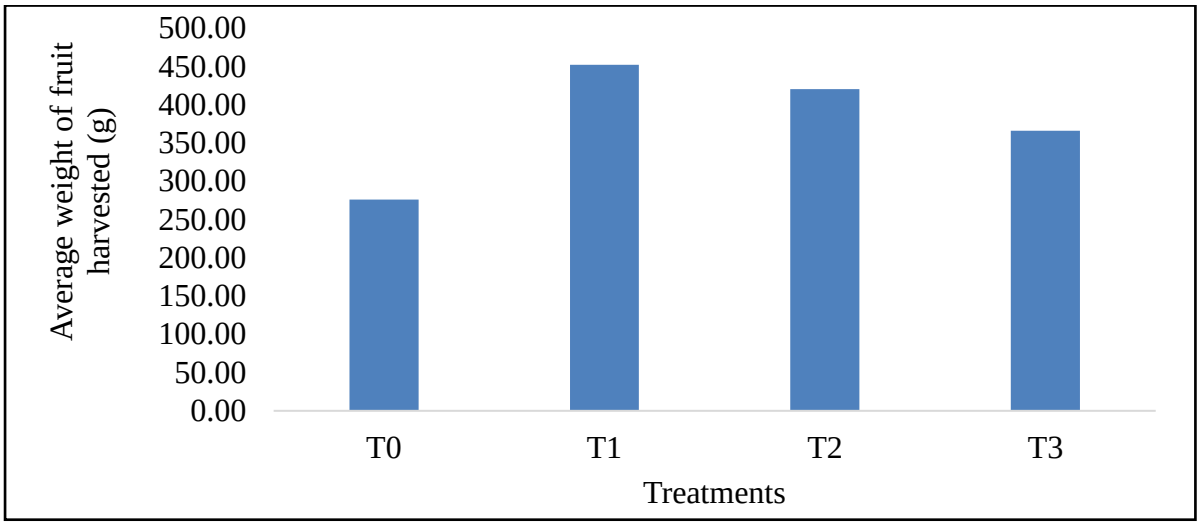
Figure 4: Average fruit weight per treatment of harvested fruit per treatment



Source: Field survey, October 2021

T0: Control treatment without fertilizer, **T2:** 75% biochar + 25% cow dung, **T1:** 50% biochar + 50% cow dung, **T3:** 25% biochar + 75% cow dung.

Figure 4 shows that the weight of the fruits is moderately high, i.e., 452.58 g in treatment T1 (50% Biochar + 50% cow dung) and very low (276.08 g) in treatment T0 (control without fertiliser). Also, it should be noted that treatments T2 (75% Biochar + 25% cow dung) and T3 (25% Biochar + 75% cow dung) come respectively after T1 with average fruit weight values of 630 g and 547 g.

DISCUSSION

The results show that the performance of the treatments on the length and girth of cucumbers did not differ. So, the efficiency of these treatments on the parameters is similar. However, it can be seen that the average values of these parameters tend to vary in relation to the different treatments applied. It results from figures 3 and 4 that the treatments with the highest average values are T1 (27.5 cm for length and 20.56 cm for girth) and T2 (25.25 cm for length and 19.69 cm for girth), and the lowest are T0 and T3 with average values of 22.3 cm for fruit length and 17.38 and 19.60 cm for girth respectively. T1 treatment (50% Biochar + 50% cow dung) is the most efficient and T0 treatment (control treatment without fertiliser) is the least efficient on the length and circumference parameters of the harvested cucumbers. This can be justified by the availability of essential mineral elements in organic fertilisers and the property of Biochar which favours the retention of soil moisture and the progressive distribution of nutrients to the plant according to its needs during its vegetative cycle for its good growth.

Yêmadjè (2016 p. 9) also pointed out that the addition of Biochar to soil increases water retention capacity due to its porous surface providing micro-organisms hydration during dry periods or even within arid soils. Likewise, Downie et al. (2012) reported that the low density of Biochar reduces soil mass density which simplifies the penetration of plant roots into the soil for better development. This observation is in line with the results of this research as the treatments with a high dose of biochar T1 (50% biochar + 50% cow dung), and T2 (75% Biochar + 25% cow dung) have the best performance. The results in this research corroborate with those of Mukendi et al. (2017, p. 10577) who reported in a study on maise productivity that plots that received organic fertilisers exhibited high growth vigour in height, crown diameter as well as the number of leaves compared to the average of the control plots without fertiliser application. These authors also mentioned that the maise under fertiliser gave a greater length and number of rows than the maise of the control treatment. Also, P. Levasseur (1998); K. J. Kouakou et al. (2019) reported that increasing doses of manure promote cucumber length growth.

The same remarks were made about the number, weight, and yield of cucumbers. The effectiveness

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of the treatments on the number of fruits and yield are very different. The analysis of the coefficient of variation shows a very significant difference between the T1 treatment for the number of fruits parameter and not very significant for the yield parameter compared to the other treatments. The highest average values for the number of fruits and yield were found in the treatments that received organic fertilisers and the lowest in the T0 treatment (control without fertiliser). In addition, treatment T1 performed better than the other treatments. Contrary to these parameters, the effectiveness of the treatments on fruit weight did not differ. It seems to be homogeneous for all treatments. Thus, the treatments did not have a significant effect on the weight of the cucumbers. However, the average values obtained seem to vary in relation to the different treatments applied (*Figure 4*). The higher average values are observed in the treatments that had fertiliser applied. It should also be noted for this parameter that treatment T1 (50% biochar + 50% cow dung) has the most dominant average values and is therefore the most effective.

These results are in line with those of Yêmadjè (2016, p. 9) who noted that the addition of Biochar leads to a 10% increase in crop yields in agricultural trials. Ognalaga et al. (2017) cited by Tanzo et al. (2021, p. 204) came to the same results. They found an increase in cassava tuberous root yield with cow dung input of about 88% compared to the control. Tanzo et al. (2021 p. 204) study also showed that improving cucumber yield depends on the application of both mineral and organic manure. With regard to the weight parameter, Mukendi et al. (2017, p. 10578) in another study reported that the average corn grain yields obtained under various fertilisers, regardless of their nature, showed a significantly higher gain in weight than the control. It should be noted from this research that the treatments that received fertilisers were the most effective in terms of all the parameters highlighted. In order of efficiency, treatment T1 (50% biochar + 50% cow dung) is in first position, followed by treatment T2 (75% biochar + 25% cow dung) and T3 (25% biochar + 75% cow dung) is in third position. Indeed, the high efficiency of T1 compared to T2 can be explained by the low quantity of cow dung which seems to reflect the low level of nutrient reserves in the soil. The opposite is true for treatment T3 (25% Biochar + 75% cow dung), where the small amount of Biochar available does not play its role in capturing the mineral elements in the cow dung and then retaining the moisture in the soil.

The beneficial effect of Biochar on yields has been attributed to the improvement of physical soil conditions such as water retention (Tryon, 1948) cited by Sara (2015, p. 9) and direct nutrient supply (Gaskin et al., 2010) cited by Yêmadjè, (2016 p. 34). This idea joins that of Sara (2015, p. 6) who addressed the same issue by showing that biochar amendment allows for to improvement of soil properties. These authors also pointed out that one of the most attractive qualities of Biochar is undoubtedly its ability to retain nutrients and thus increase soil fertility. For the latter, this amendment could be a solution to reduce the loss of nutrients by leaching. Also, its combination with other organic fertilisers could go some way to solving the problem of soil depletion or impoverishment that the use of Biochar alone could cause in the long run.

CONCLUSION

The application of the combination of different measures of Biochar and cow dung in cucumber production has a beneficial effect on the growth, development, and yield components of the cucumber crop. Of the treatments carried out, only those having received fertiliser inputs (a combination of Biochar and cow dung) were the most successful. They significantly influence the parameters (number of fruits and yield). For the other parameters (length, girth, and weight of the fruits), the average values tend to vary with the different treatments applied. The best combination is the T1 treatment (50% Biochar + 50% cow dung). It was the most effective in cucumber production in the trials and resulted in significant yields in quality and quantity. Thus, its promotion will be an asset to optimise organic and ecologically profitable cucumber production. This will help to alleviate the environmental and health problems caused by the excessive use of chemical fertilisers in agricultural activities in general and market gardening in particular.

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