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Effect of bokashi fertilizer and banana peel slurry on certified pepper seed production in Benin

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Abstract

The pepper (*Capsicum frutescens* L.) is one of the most widely consumed fruiting vegetables in Benin. However, its production is faced with numerous problems, including declining yields and poor farming practices. The aim of this study was to produce certified pepper seed using organic fertilizers in the commune of Kétou. The study took place on the application farm on the Akpotokou university campus. A Randomized Complete Block design with three replicates and three treatments was used. The treatments were: a relative control (T0: 1 kg NPK two weeks after transplanting, 1 kg Urea+K_2SO_4 four weeks after transplanting); bokashi fertilizer (T1: 30 kg bokashi per plot unit each month) and slurry from banana peel (T2: 1/2 liter of slurry from banana peel per plot unit). A dose of 300 g of a compost was applied to all treatments two weeks before transplanting. Results showed that organic fertilization with bokashi significantly ($P < 0.01$) improved pepper plant growth compared with other fertilizers.On the other hand, organic fertilization with banana peel slurry produced the exact same number of fruit as bokashi, while chemical fertilization produced fewer fruit than the other two. Slurry and bokashi gave the highest fruit yields (2.8 t/ha and 2.7 t/ha respectively). The highest seed weight of 10 fruits was obtained in plants fertilized with bokashi (5.53 g). This study shows the contribution of organic fertilizers (bokashi or slurry) to better certified pepperproduction.

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Introduction

Market gardening is an important source of food and one of the most income generating activities in Benin (Adjatini*et al.*, 2019). In recent years, the market gardening sector in Benin has experienced a boom, making it an important activity in agriculture, trade and the processing of agricultural products (Bastin and Fromageot, 2007). Market garden crops represent an important and varied source of food that complements well the dietary needs of populations whose essentially staple diet is carbohydrates, constituting the main energy elements (Yolou *et al.*, 2015). The market growing sector generally includes the production of fruit, leaf and root vegetables but pepperis one of these vegetables. Indeed, it is a fruiting vegetable cultivated throughout the world, and is of vital importance in the human diet (Dias *et al.*, 2013). The world's main producers of fresh peppers are China and Turkey (1.7 million tons). According to Djebbour and Kebala (2017), pepper cultivation now extends to all inhabited continents and comprises two components: pepper-vegetable and pepper-condiment processed into powder; these are expressed in tons of dry matter. The *Capsicum*genus of peppers, native to the humid tropics of Central and South America, belongs to the Solanaceae family and includes peppers of great economic value (Menichini *et al.*, 2009).

In Benin, the income generated by this market gardening activity enables several hundred families to meet their daily needs (Houssou, 2014). Despite the economic, food and medicinal importance of pepper, its supply remains below demand, particularly during the April to July period (Kpadonou*et al.*, 2010). Pepper cultivation is subject to a number of constraints that limit yield, including the use of degenerate varieties due to self-seeding, loss of soil fertility and difficulties in accessing certified seeds (Kpadonou*et al.*, 2010).

The problem of declining soil fertility is a concern both for farmers, who are faced with the high cost of inputs, and for researchers whose work aims to find strategies for maintaining and restoring soil fertility for intensified agricultural production (Biaou*et al.*, 2017). However, given the limited financial means of Beninese farmers and the high cost of fertilizers, the contribution of chemical fertilizing elements remains limited or inappropriate in the production of vegetable crops. Yields decline after a few years due to the degradation of soil properties (Pamalba*et al.*, 2019). In this context, the use of organic fertilizers is essential and they can help to modify the plant microclimate, which in turn can optimally improve soybean production (Wijayanto *et al.*, 2016). Organic matter can improve fertility, structure and will indirectly retain aggregation and porosity of the soil, which means it will maintain the soil's capacity to hold water (Biaou*et al.*, 2017). Panday *et al.* (2024) and Tsvetkov *et al.* (2018) revealed that organic farming generally reduces the risk of negative environmental effects more than conventional farming methods.

That organic farming is well suited to improve soil fertility and nutrient management significantly on the farm level. Tsvetkov *et al.* (2018) reveal that organic farming has a greater positive impact on biodiversity conservation. Annunziata and Vecchio (2016) demonstrated that organic farming had a positive impact on public health, the environment, and rural communities' economic and social well-being. Both rich and developing countries can benefit from organic agricultural techniques which protect the environment and improve biodiversity while consuming less energy and emitting fewer greenhouse gases (Stockdale *et al.*, 2001). Increase in organic matter content of the soil will increase ability of the soil to absorb and exchange soil nutrients.

Therefore, the application of inorganic fertilizer would be more efficient due to the released nutrients will be absorbed by the organic matters and become available for the plants, so that the plants will grow and develop optimally, as well as produce high yields (Wijayanto*et al.*, 2016). The aim of this study is to evaluate the effect of two organic fertilizers (bokashi and banana peel slurry) on the production of certified pepper seed.

Materials andmethods

Study area

The present study was carried out in the Akpotokou village, municipality of Ketou (Fig. 1). Thismunicipality is located at the northern end of the Plateau department, between latitudes 7°10' and 7°41'17" North and longitudes 2°24'24" and 2°47'40" East (INSAE, 2016). It covers an area of 2,183 km² according to the 4th General Population and Housing Census in Benin (MPD, 2019). The climate is tropical with a bimodal rainfall regime composed of two nuances: a long rainy season, a short dry season, a short rainy season and a long dry season.

The average annual rainfall is about 1073 mm in 365 days (Boko *et al.*, 2021). The two maxima of this regime are centered on June and September.

The vegetation is characterized by wooded savannahs of *Daniella oliveri*, *Lophira lanceolata*, *Parkia biglobosa* and forests (KetouDogo) covering around forty-seven thousand hectares (Boko *et al.*, 2021).

The soils are impoverished, weakly desaturated and indurated, and are associated with vast sheets of ferruginous cuirass bearing sparse vegetation (MPD, 2019).

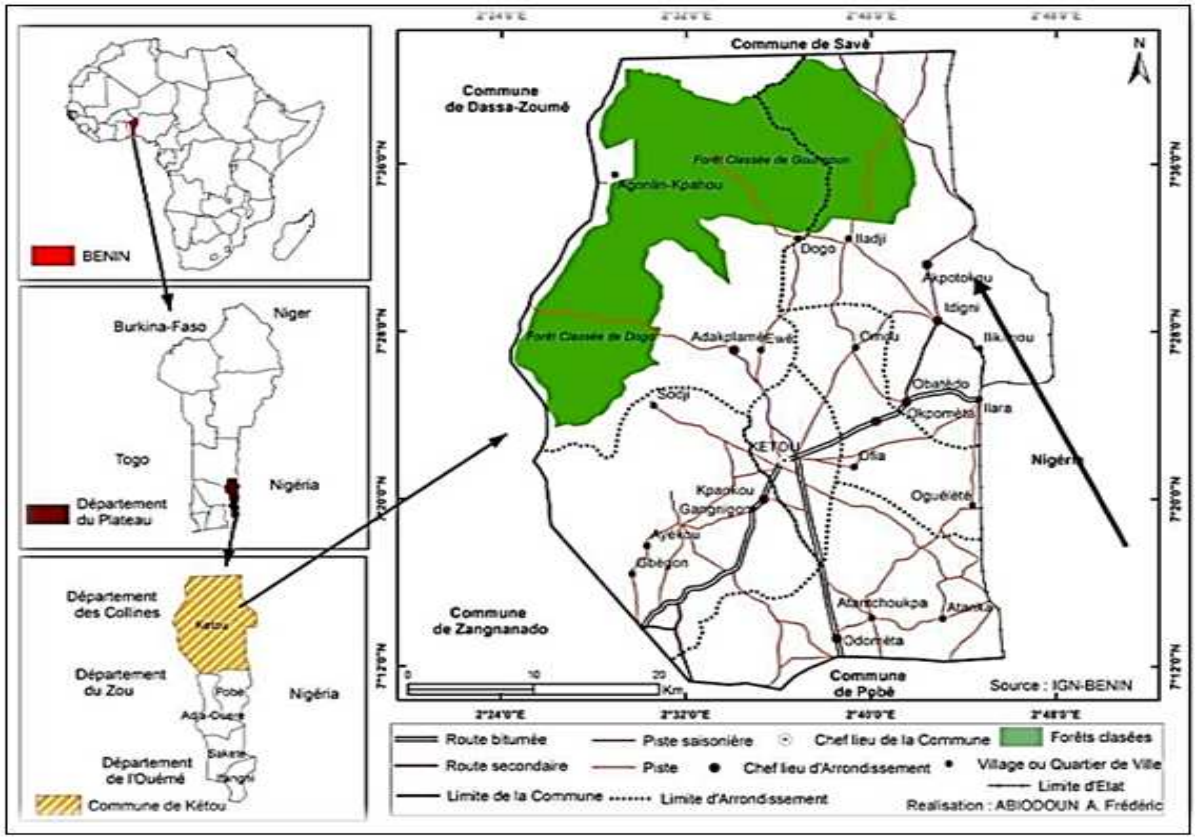

Fig. 1. Map of the study area.

Experimental and trial setup

The experimental setup was a Complete Randomized Block consisting of three treatments and three replicates. There were a total of nine 16m² (4m x 4m) elementary plots. Each elementary plot was made up of twenty-five bunches at a spacing of 0.80m between rows and 0.80m between bunches, with one plant per bunch, giving a density of 15,625 plants per hectare. A 1m alley between elementary plots and 1m between blocks with a 1m wide firewall all around the plot were respected.

TPS long pepper variety was used and the plants of certified pepper seed were transplanted rigorously one month two weeks after sowing. Transplanting was carried out in honeycomb plates. Two weeks before transplanting, all elementary plots received compost. The three treatments were: a relative

control (To: 1/3kg NPK two weeks after transplanting, 1/3kg Urea+K_2SO_4 four weeks after transplanting); bokashi fertilizer (T1: 10 kg bokashi per plot unit each month) and banana peel slurry (T2: 1/6litreof banana peel slurry per plot unit).

Bokashi production process begins with making a solution which is a mixture of Effective Microorganisms-4 (EM-4), molasses/sugar and water, with a ratio of 1:1: 1 (v : v : v). Bokashi basic materials (especially plant materials), are cut into small pieces, and then the material is evenly mixed with rice bran on dry floor. Furthermore, the bokashi base material is slowly and gradually watered with a solution of EM-4 to form dough. The good dough is if clenched by hand, then there is no water coming out, also when the fist is released then the dough re-inflates (water content of about 30%). Next, the dough is laid on the floor as high as 15-20 cm. Mound is then covered with a sack or a plastic tarp over 1-2 weeks. During the process, the material temperature is maintained between 40-50°C. If the material temperature exceeds 50°C, then the cover sack is opened and dough material is inverted, then mound is closed again.

Ripe organic banana peels, scissors, a knife, a bowl and water were used to make the slurry. Preparation began by cutting the banana peels into small pieces. They were then mixed with water in a bowl. The bowl was covered and the mixture macerated for 48 hours. Finally, after 48 hours, the solution was filtered, the peel debris removed and the ready banana peel slurry put into small cans for storage.

Fertilizer application dates were well defined. However, 15 days before transplanting, all plots received compost at a dose of 300 g per holeas a base dressing. On 15 and 45 days after transplanting (DAT), crowns were made on the plot units of treatment T1 to accommodate bokashi at a dose of 400 g per plant. For treatment T2, banana peel slurry was applied to the three elementary plots of this treatment at a frequency of 7 days beginning 15th DAT, using a sprayer containing a solution of ½ liter of slurryin one liter of water.

Throughout the experiment, a number of maintenance tasks were carried out to ensure the smooth running of the experiment. These included watering, weeding and hoeing to eliminate weeds, making crowns to distribute water and fertilizers, and using neem oil for phytosanitary treatments. Watering is carried out twice a day, in the morning and evening respectively, and weeding is carried out whenever necessary. Three weedings were also carried out on the 15th, 45thand 60th DAT respectively to eliminate weeds.

Data collection

Growth data such as pepper plant height, pepper plant collar diameter, number of branches were collected at the maturity. In addition, number of flowers per plant, date of 50% flower appearance, date of 50% fruit appearance were collected.To this end, six plants were randomly selected from the three rows within each plot unit, taking into account the border effect. For the yield parameters, fruit yield and seed weight of 10 fruits were collected.

Statistical analysis

Statistical analyses were performed using R software version 4.4.1. The one-way analysis of variance (ANOVA), considering fertilizer type, was performed for data collected. Before running ANOVA, variance homogeneity was tested. The Student Newman-Keuls test was performed to compare differences in means among treatments at the 5%.

Results

Effect of fertilizers on the growth of pepper plant

Fig. 2, 3 and 4 show respectively the height, the collar diameter and the number of branches perpepper plants according to the fertilizers types. The analysis of variance showed that the treatments significantly influenced the height growth of pepper plants ($P<0.001$). The results of Fig. 2 showed that there was no significant difference between the control treatment (To) and the treatment with the mixture of compost and banana peel slurry (T2).

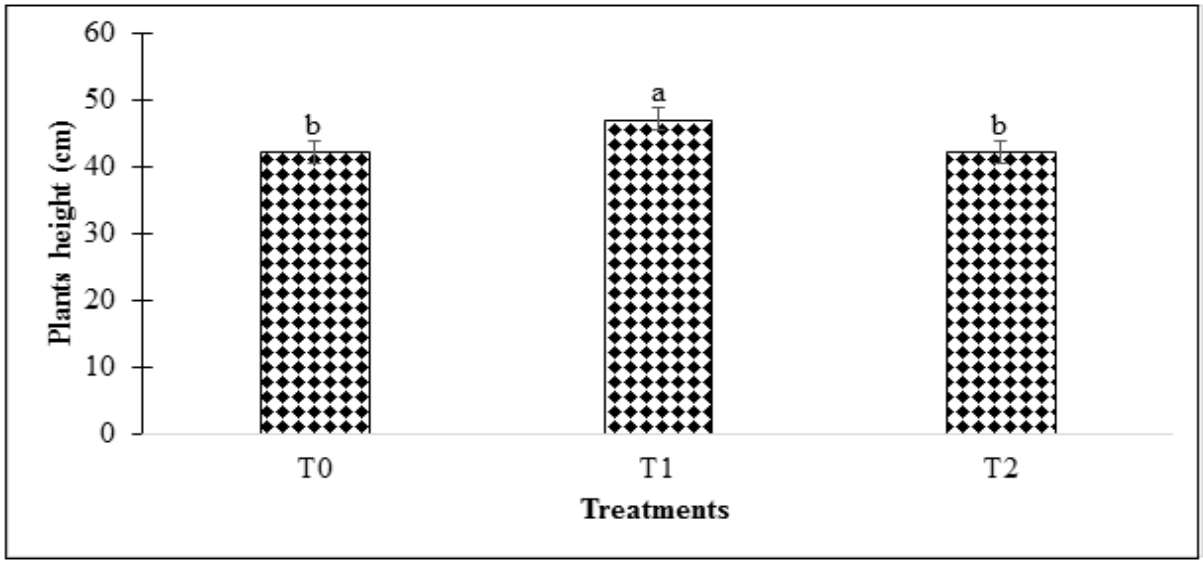

Fig. 2. Height of pepper plants according to the fertilizers types.

Legends: To =Control; T1 = bokashi fertilizer; T2 = banana peel slurry.

Means followed by the same alphabetical letter are not significantly different (P > 0.05) according to the Student Newman-Keuls test.

The height of pepper plants fertilized with the compost and bokashi mixture (47.16 cm) was significantly higher (P<0.05) than that of the To and T2 treatments (42.22 cm). The analysis of variance showed that treatments had a significant influence on the diameter at the crown of pepper plants (P<0.05). The results of Fig. 3 showed that there was no significant difference (P>0.05) between the control treatment (To) and the treatment with the mixture of compost and banana peel slurry (T2).

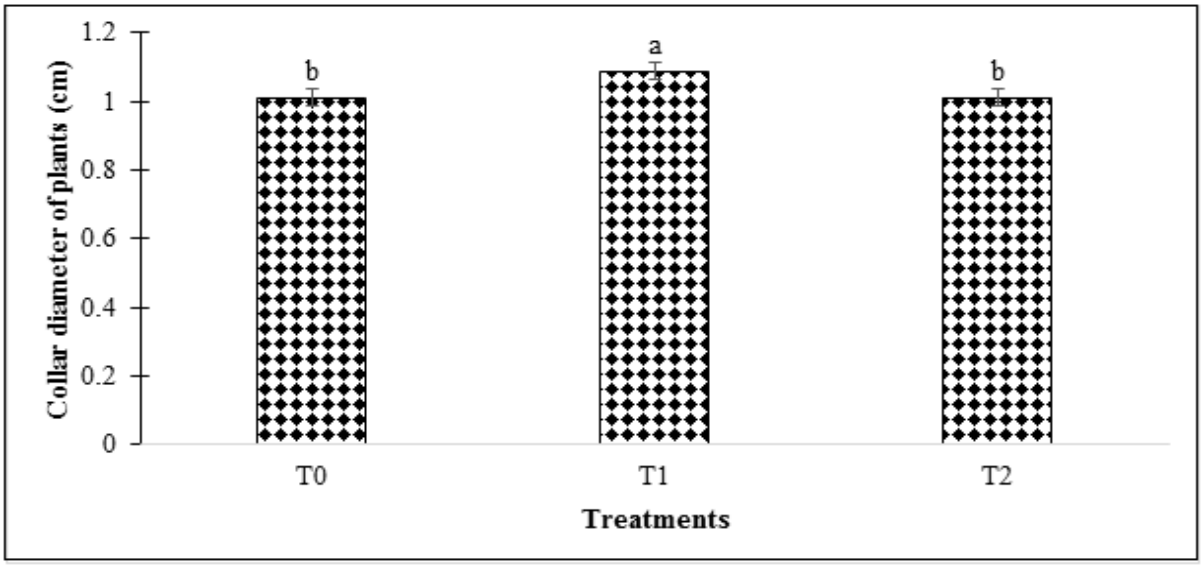

Fig. 3. Collar diameter of pepper plants according to the fertilizers types.

Legends: To =Control; T1 = bokashi fertilizer; T2 = banana peel slurry.

Means followed by the same alphabetical letter are not significantly different (P > 0.05) according to the Student Newman-Keuls test.

The diameter of pepper plants fertilized with the compost and bokashi mixture (1.1 cm) was significantly greater (P<0.05) than that of the To and T2 treatments (1.01 cm).

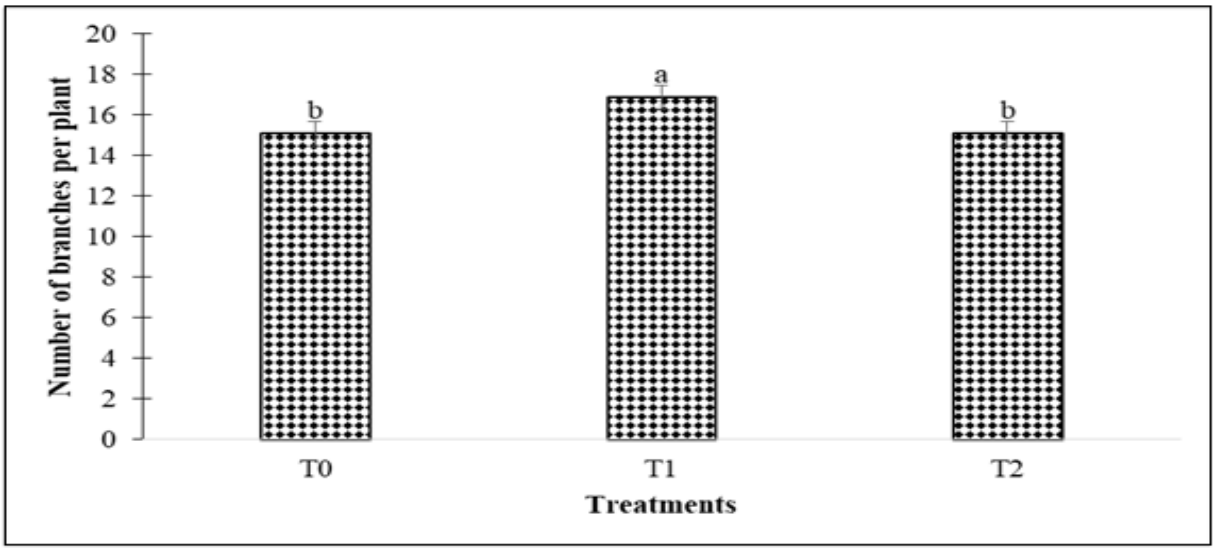

Fig. 4. Number of branches perpepper plant according to the fertilizers types.

Legends: To =Control; T1 = bokashi fertilizer; T2 = banana peel slurry.

Means followed by the same alphabetical letter are not significantly different (P > 0.05) according to the Student Newman-Keuls test.

The analysis of variance showed that treatments significantly influenced the number of branches in pepper plants (P<0.05). The analysis of the Fig. 4 showed that there was no significant difference between the control treatment (T0) and the treatment with the mixture of compost and banana peel slurry(T2). Pepper plants fertilized with the compost mixture and Bokashi had a significantly higher (P<0.05) number of branches (17) than those in treatments To and T2 (15).

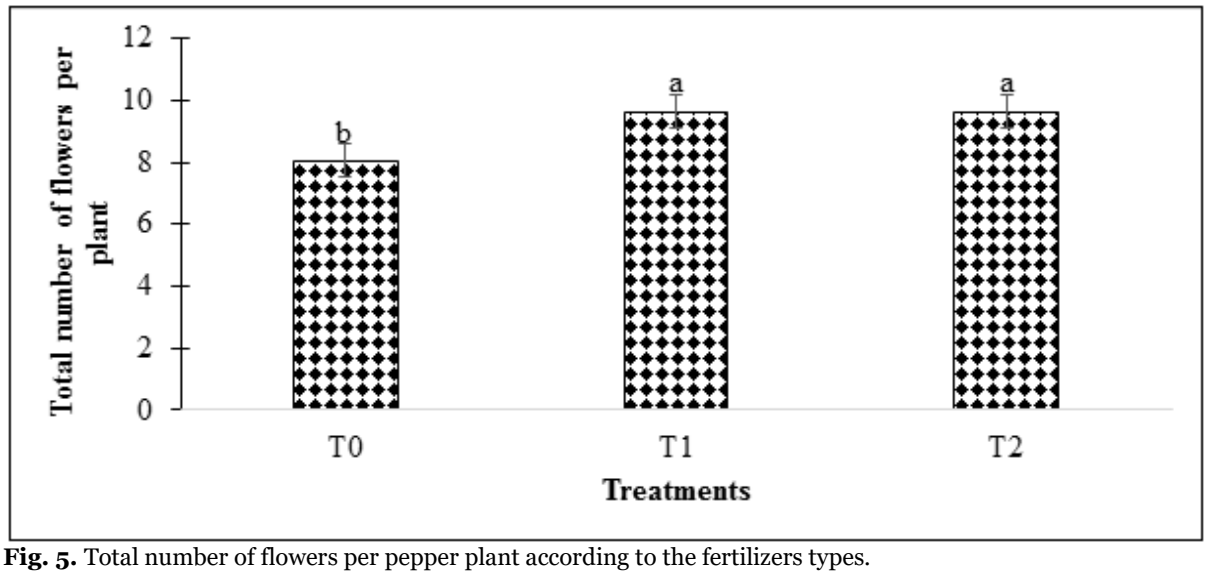

Fig. 5. Total number of flowers per pepper plant according to the fertilizers types.

Legends: To =Control; T1 = bokashi fertilizer; T2 = banana peel slurry.

Means followed by the same alphabetical letter are not significantly different (P > 0.05) according to the Student Newman-Keuls test.

Effect of fertilizers on phenological parameters of pepper plants

Fig. 5 and 6 showrespectively the total number of flowers and the dates of appearance of 50% flowers and 50% fruits per pepper plant. The analysis of variance showed that treatments has significantly

influence (P<0.05)on the number of flowers per plant and the date of 50% of flowers and 50% of fruits appearance in pepper plants. The analysis of these figures showed that there was a significant difference(P<0.05) between the control treatment (T0) and the other treatments. Plants in the control treatment had an average of eight flowers per plant, while plants in the other treatments had an average of ten flowers per plant (Fig. 5).

Also, it was found that pepper plants fertilized with chemical fertilizers had a two-day delay in the appearance of 50% of flowers and 50% of fruit compared with the other treatments (Fig. 6).

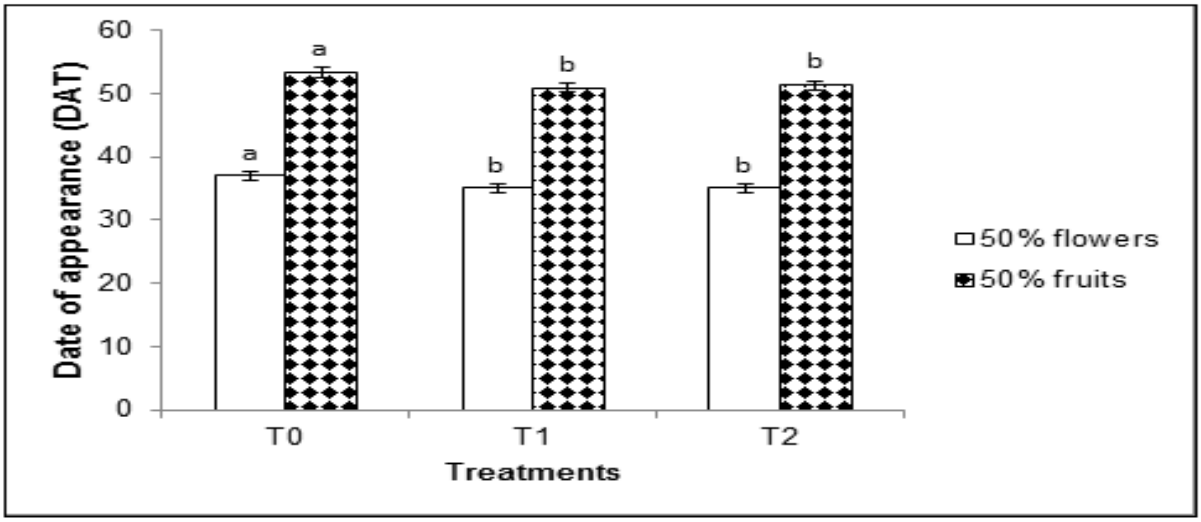

Fig. 6. Date of appearance of 50% flowers and 50% fruits per pepper plant according to the fertilizers types.
Legends: T0 =Control; T1 = bokashi fertilizer; T2 = banana peel slurry.
Means followed by the same alphabetical letter per parameter are not significantly different (P > 0.05) according to the Student Newman-Keuls test.

Effect of fertilizers on pepper yield parameters

Fig.7 and 8 show respectively the fruit yield and seed weight of 10 fruits according to fertilizer type. The results of the analysis of variance showed that the treatments had a significant effect (P<0.05)on fruit yield and seed weight. Indeed, it was found that the bokashi and banana peel slurrytreatments gave the highest yields compared with the mineral fertilizer treatment (Fig. 7). In addition, the bokashi treatment gave a higher seed weight than the other two (Fig. 8).

Discussion

Effect of fertilizers on the growth of pepper plant

The results of the present study have shown that bokashi is more effective on different vegetable growths, as demonstrated by several authors. Following the example of Konan*et al.* (2024), according to whom this bokashi fertilizer is suitable for market gardening and vegetable gardening, as it improves soil fertility and plant productivity, especially for vegetables. The use of bokashi to improve plant growth and productivity confirms the findings of Konan*et al.* (2024). Following the work of the present study, analysis of data relating to the height growth of peper plants showed that plants fertilized with chemical fertilizers, bokashi and banana peel slurrysignificantly influenced the height growth of pepper plants.However, the plants with the lowest heights were those treated with chemical fertilizer and those treated with banana peel slurry. It was observed that plants treated with bokashi had the greatest height. In addition, the diameter of pepper plants fertilized with the compost mixture and bokashi was significantly greater than that of other fertilizers. As far as the number of branches on pepper plants is concerned, plants treated with bokashi have the highest number of branches. However, peppers treated with chemical fertilizers and those treated with banana peel slurryhad the same number of branches.

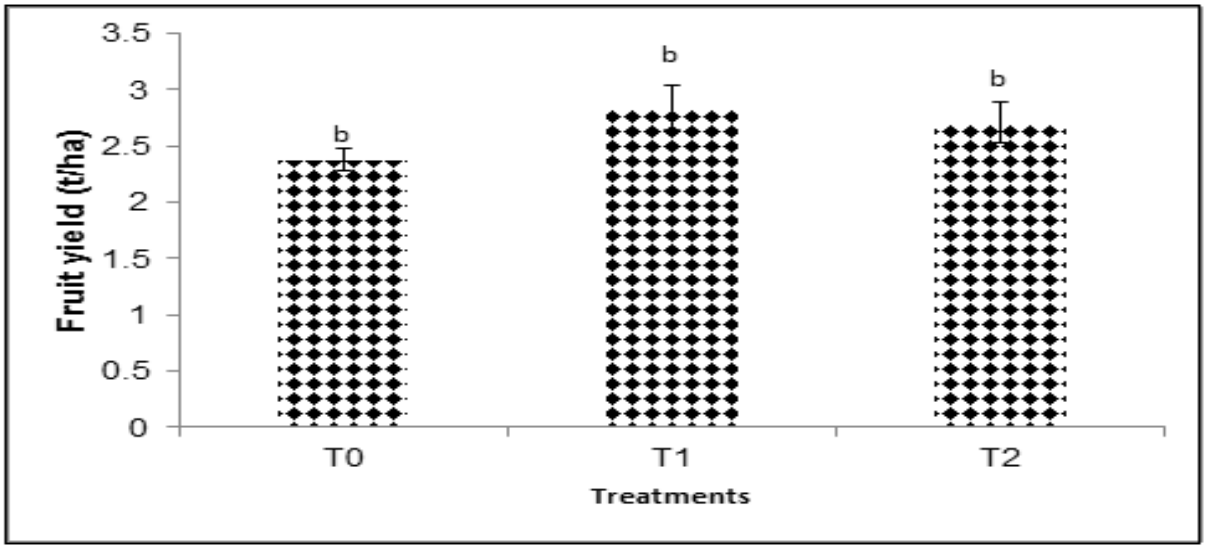

Fig. 7. Fruit yield pepper according to the fertilizers types.

Legends: To =Control; T1 = bokashi fertilizer; T2 = banana peel slurry.

Means followed by the same alphabetical letter are not significantly different (P > 0.05) according to the Student Newman-Keuls test.

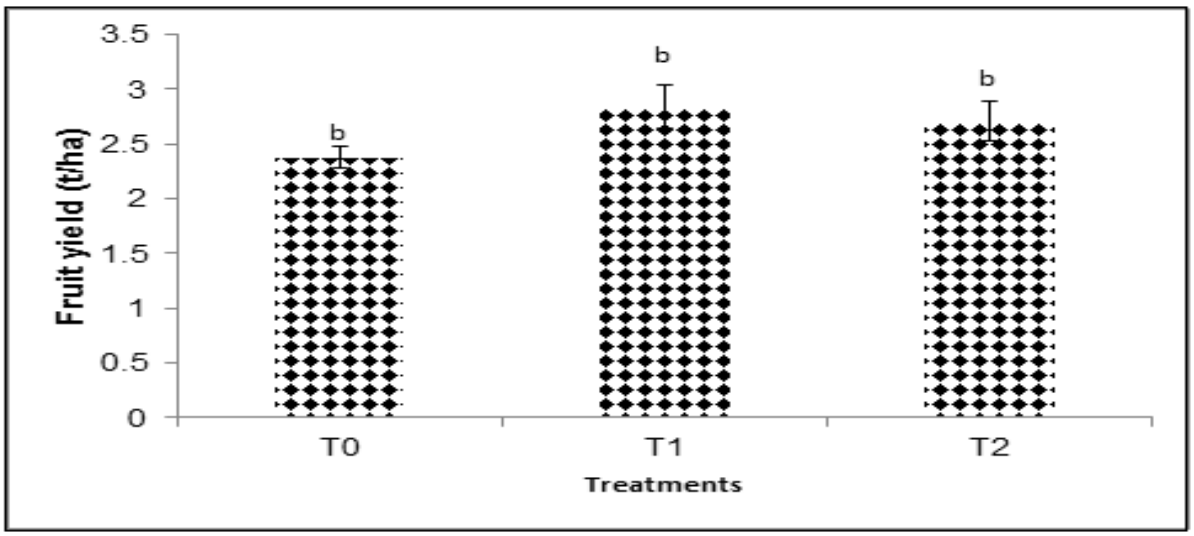

Fig. 8. Seed weight of ten fruits according to the fertilizers types.

Legends: To =Control; T1 = bokashi fertilizer; T2 = banana peel slurry.

Means followed by the same alphabetical letter are not significantly different (P > 0.05) according to the Student Newman-Keuls test.

This significant increase in the number of branches observed at T1 is consistent with the differences in height and diameter previously observed. These results are in line with those of Sawadogo *et al.* (2019), who showed that bokashi contributes to the growth and development of market garden plants, particularly vegetables. These observed results are thought to be due to the early maturity of bokashi, which promotes rapid mineralization of organic matter, releasing high nitrogen content into the soil (Ouedraogo *et al.*, 2022).

Effect of fertilizers on phenological and yield parameters of pepper

The results of the present study showed that the number of flowers in the control treatment was lower than in the other treatments, and that there was a slight delay in the appearance of 50% of flowers and

fruits. With regard to the number of fruits produced by pepper plant at 52 days after transplanting, the results showed that there was no significant difference between the treatment based on a mixture of compost and bokashi (T1) and the treatment with a mixture of compost and banana peel slurry(T2). These two treatments enabled the pepper plants to have the highest number of fruits at 52 days after sowing (8), compared with 7 fruits in the control treatment (T0).With regard to fruit yield and seed weight of 10 fruits, the results showed that bokashi and banana peel slurry gave the highest yields compared with the mineral fertilizer treatment. The bokashi treatment gave a higher seed weight than the other two. These results coincide with those of Panday *et al.* (2024), who reported that the use of organic fertilizers such as bokashi resulted in significantly higher yields than chemical fertilizers. Studies by Gourlez (2022) have also shown that organic fertilizers can contribute to plant nutrition and production. Therefore, organic farming has a big potential to significantly enhance the provision of important ecosystem services necessary for the resilience of the food supply and the sustainability of farming systems (Giri and Pokhrel, 2022). Blundell *et al.* (2020) reported that the increased biodiversity and abundance of beneficial predators, as well as changes in plant nutrient content, have been primarily attributed to the decreased insect pest populations observed on long-term organic farms.Thus, organic fertilizers can induce better productivity in market garden produce such as pepper.

Conclusion

The present study highlighted the effect of different types of organic fertilizers such as bokashi and banana peel slurry on the production of certified TPS long pepper seeds. The results showed that bokashi is the most effective organic fertilizer for the production of certified TPS long pepper seeds. Indeed, bokashi can not only improve yields in certified pepper seed production, but also contribute to more sustainable and resilient agriculture. However, further research is needed to further explore the economic and environmental aspects of this practice in certified seed production to support wider adoption by seed growers.

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