



Effects of Applying Different Compounds from a Poultry Manure-based Compost on the Agro-morphological Parameters of Chili Peppers (*Capsicum chinense*)

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Authors' contributions

This work was carried out in collaboration among all authors. Authors KEY and AK carried out the fieldwork and laboratory work, performed the analyses, and wrote the article. Author BTJG supervised the entire process and made the necessary corrections. All authors read and approved the final manuscript.

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Abstract

This study aimed to evaluate the effects of three poultry manure-based compost formulations on the growth and yield of chili pepper (*Capsicum chinense*). A Fisher randomised complete block design was established with four treatments and four replicates from August to November 2022. The treatments comprised an unfertilised control (T0), direct application of solid compost (T1), and aqueous compost leachates collected after 5 days (T2) and 10 days (T3) of soaking in water. Plant survival, height, collar diameter, vigour index, and yield were assessed. Fourteen days after transplanting, survival rates were 75.00%, 94.53%, 85.15%, and 88.28% under T0, T1, T2, and T3, respectively. Plant height, collar diameter, and vigour index increased throughout the measurement period, with the strongest overall responses observed under T1. At 77 days after transplanting, plant height reached 46.49 cm under T1, compared with 42.24 cm under T2, 43.41 cm under T3, and 38.41 cm under T0. Yield was highest under T1 at 0.45 kg/plant (8.5 t/ha), followed by T3 at 0.38 kg/plant (6.8 t/ha), T2 at 0.35 kg/plant (6.1 t/ha), and T0 at 0.14 kg/plant (2.1 t/ha).

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Under the conditions of this study, direct solid-compost application produced the highest values for the measured agromorphological parameters and yield. The 10-day leachate generally performed better than the 5-day leachate, suggesting that soaking time in water may influence leachate performance.

Keywords: *Capsicum chinense*; poultry manure compost; compost leachate; soaking time; organic amendment; fruit yield.

1. Introduction

Market gardening is a dynamic source of food and income in many African cities (Onana, 2006; Segnou *et al.*, 2012). Chilli peppers, in particular, are essential to the daily diet of the Ivorian population (Kouassi Kouassi & Koffi-Nevry, 2012; Koffi *et al.*, 2021), but their estimated production of 32,900 tonnes per year is far from meeting the population's demand (Fondio *et al.*, 2015). Chilli pepper cultivation faces numerous constraints that lead farmers to use chemical inputs, which often deplete the soil without adequately limiting damage (Touré *et al.*, 2015). This has encouraged the adoption of other farming practices based, among other approaches, on organic fertilisers (Essehi *et al.*, 2016), particularly compost, as suggested by Koné *et al.* (2009).

Recent studies have shown that poultry manure and other compost-based organic amendments can improve pepper growth, yield, and selected soil fertility indicators, although responses differ with amendment type and management conditions (Rufa'i *et al.*, 2024; Rosyara *et al.*, 2025; Zhang *et al.*, 2023; Larkin, 2024).

However, composting is uncommon in Côte d'Ivoire, according to Ochou (2021). Owing to several difficulties associated with the method, farmers often apply organic fertiliser directly to the soil before planting; this practice can be harmful to plants and can result in very long mineralisation periods (Onana, 2006; Gomgnimbou *et al.*, 2019; Konate *et al.*, 2020). Therefore, alternative methods for composting organic matter are needed. Compost leachate appears to be a promising alternative because it may preserve major nutrients (nitrogen, phosphorus, and potassium) and trace elements in the raw digestate (M'Sadak & Elouaer, 2016), thereby promoting healthy chilli pepper development. However, the effectiveness of leachate in relation to its soaking time in water remains poorly understood in chilli pepper cultivation. In particular, comparative evidence on the direct application of solid poultry manure-based compost and leachates obtained after different soaking times in water is limited under the study conditions. Therefore, this study assessed the effects of three poultry manure-based compost formulations on the yield and selected agronomic parameters of chilli pepper (*Capsicum chinense*).

2. Materials and Methods

2.1 Materials

The study was conducted on the experimental plot of the Soil Science Department, located within the STRM Department of Félix Houphouët-Boigny University in Cocody, Abidjan Autonomous District. The site is located at 05°20'24'' N and 03°59'32'' W and is shown in Fig. 1.

The Abidjan Autonomous District is characterised by two rainy seasons (May–July and September–November), interspersed with two dry seasons. The region's vegetation consists of dense forests, subdivided into mesophilic and hydrophilic forests, which originally covered one-third of the territory (Sako & Beltrando, 2014; Kouassi *et al.*, 2019).



Fig. 1. Overview of the experimental plot

The topography is characterised by three main areas: the high plateaus (40–50 m and 100–120 m), represented by the hills of the Continental Terminal north of the Ebrié Lagoon; the mid-altitude plateaus, ranging from 8 to 12 m, which constitute the outcrops of the Quaternary coastal ridge; and the deep valleys, ranging from 12 to 40 m, originating in the north-central part of the area and cutting into the Tertiary high plateaus (Kouassi *et al.*, 2019). This topography creates the two main reservoirs of the sedimentary basin (Saley *et al.*, 2009): the Mio-Pliocene aquifer, also known as the Abidjan aquifer, and the Upper Cretaceous aquifer, in addition to a network of lagoons.

The geological context of the study area is that of the coastal sedimentary basin of Côte d'Ivoire. Lithologically, it is composed mainly of sand, clay, and ferruginous sandstone in the highlands. The soils encountered are primarily Ferralsols, Cambisols, Luvisols, Gleysols, and Arenosols (Dabin *et al.*, 1960; Kablan, 2017; Yoboué *et al.*, 2021).

The plant material used was chilli pepper (*Capsicum chinense*), known as Tropica Habanero and commonly called “Sent Bon” because of its aroma. This variety was chosen because it is less susceptible and considerably more resistant to humid tropical climates, and because it produces abundant, highly aromatic fruit. Its harvest cycle is 85 days after transplanting. Composted poultry manure, applied to the soil either directly or as an aqueous extract, was used as fertiliser.

2.2 Experimental Methodology

2.2.1 Experimental Setup

The experimental design was a randomised complete block design (RCBD) with four treatments and four replicates. Each experimental unit consisted of 32 plants. A 2 m buffer strip separated the experimental units, and another 2 m buffer strip separated the blocks. Three manure application treatments (T1, T2, and T3) were compared with the unfertilised control (T0), as shown in Fig. 2. The treatments were:

- T0 : No application ;
- T1 : Direct application by spreading ;
- T2 : Application of leachate from soaked manure compost for 5 days ;
- T3 : Application of leachate from soaked manure compost for 10 days.

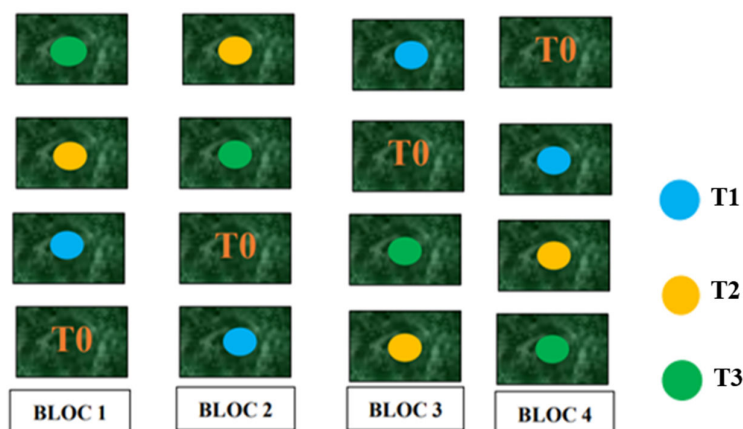


Fig. 2. Fisher block experimental setup

The use of four replications in this RCBD, dictated by the available experimental area (625 m²) and weekly monitoring of 512 plants for 77 days, resulted in 9 error degrees of freedom, below the 10-12 generally recommended in agronomic trials (Cochran & Cox, 1957; Gomez & Gomez, 1984). This limitation was mitigated by a multi-criteria and multi-date approach, including 12 measurement dates for growth parameters and four successive harvests, and by the consistent ranking of treatments (T1 > T3 > T2 > T0) across all five variables evaluated. This convergence strengthens the reliability of the results despite the limited error degrees of freedom.

2.2.2 Trial Procedure

2.2.2.1 Trial Period

The trial was conducted from August to November 2022, during which the measurements and treatments were applied for 77 days after transplanting.

2.2.2.2 Nursery Placement

The chilli pepper seeds were sown in cells at a rate of two seeds per pot and watered with clean water every two days. Almost all seeds germinated 14 days after sowing, representing a germination rate of approximately 90%, according to the counting method of M'Sadak and Elouaer (2016).

2.2.2.3 Transplanting

Transplanting took place one month after sowing in the nursery. The seedlings were spaced 0.5 m × 0.5 m apart, with two plants per planting hole for all treatments. Watering was carried out using a 12 L watering can at a rate of 12 L per micro-plot. Thinning was performed 15 days after transplanting to reduce the number of plants in each planting hole to one. Thus, each micro-plot contained 32 chilli pepper plants, giving a total density of 512 plants over the 625 m² experimental area.

2.2.2.4 Composting and Leachate Collection

The poultry manure was first composted in bags for at least two months. Then, 19.2 kg of poultry manure was weighed and added to 100 L of water to obtain a well-diluted compost tea that was safe for the plants. The leachate was then collected either 5 days after dilution for T2 or 10 days after dilution for T3.

2.2.2.5 Plot Treatment

For the direct manure-application treatment (T1), 19.2 kg of compost was weighed, incorporated into the soil 2 days before transplanting, and watered every 5 days with clean water.

The application rate was chosen based on research suggesting that an application of 20 t/ha of compost, or 2 kg/m², would improve soil structure and increase the soil's organic nitrogen content (Fondio *et al.*, 2009).

The compost leachate was applied to the soil 1 hour before transplanting and then every 5 days after transplanting, according to treatments T2 and T3. However, on the 30th and 60th days after transplanting, the leachate mixed with the residue was specifically applied to the soil according to the treatment type (T2 or T3). An insecticide and an acaricide were applied to each experimental unit, and regular manual weeding was carried out to reduce pest and weed pressure.

2.2.3 Data Collection

2.2.3.1 Survival Rate

Survival was observed from day 1 to day 14 after transplanting. It was determined as the ratio of the number of surviving plants to the total number of transplanted plants.

2.2.3.2 Measurement of Agro-morphological Parameters

Plant height and vigour index were the growth parameters measured in this trial. growth parameters were recorded weekly after transplanting until day 77.

Plant height (H), in cm, was measured with a ruler from the root collar to the point at which the petiole of the youngest fully open leaf joined the stem.

The diameter (D) at the root collar (mm) was measured using callipers. Plant circumference and height were measured to determine the vigour index (X) according to the method described by De Berchoux *et al.* (1986):

$$X = \log\left(\frac{C^2 \times H}{4\pi}\right);$$

X: Vigor index; C: Circumference; H: Height

All measurements were taken on four (4) plants selected from the centre of each individual plot.

2.2.3.3 Yield

Yield was calculated from the four measured plants. It was expressed per plant (kg/plant) and per unit area (t/ha) for each treatment. The reported yield represents the mean of four harvests conducted at 21-day intervals, from day 80 to day 142 after transplanting.

3. Results

3.1 Effect on Survival Rate

Fourteen days after transplanting, the survival rate exceeded 70% in all subplots, including the unamended subplots. The highest survival rate was observed under T1 (94.53%). Survival rates under T3 and T2 were 88.28% and 85.15%, respectively, whereas the unamended subplots had a survival rate of 75%. The treatment-wise survival rates are summarised in Table 1.

Table 1. Survival rate of chilli pepper plants 14 days after transplanting

Treatment	Compost formulation	Survival rate (%)
T0	No application	75.00
T1	Direct application of solid compost	94.53
T2	Leachate collected after 5 days	85.15
T3	Leachate collected after 10 days	88.28

3.2 Effect on Plant Height

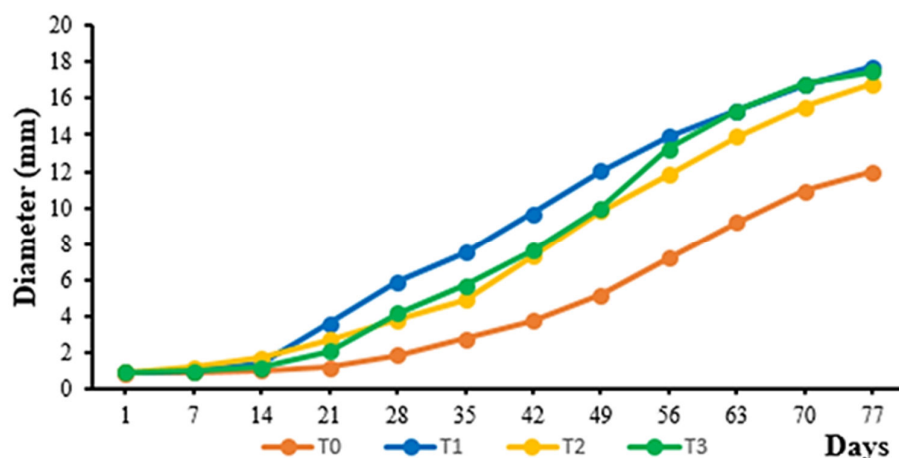
The exact plant-height values reported in the manuscript are summarised in Table 2. This table shows the change in plant height under all treatments. Overall, plant height increased from day 1 to day 77 after transplanting. However, from day 1 to day 14, the height of treated plants was virtually the same as that of control plants, with an average height of 2.6 cm per plant across all treatments. From day 21 to day 77, treated plants were significantly taller than untreated plants. Plants under T1 increased from 5.82 cm on day 21 to 46.49 cm on day 77. Under T2 and T3, plant heights increased from 4.98 cm on day 21 to 42.24 cm and 43.41 cm on day 77, respectively. Untreated plants (T0) increased from 4.36 cm on day 21 to 38.41 cm on day 77.

Table 2. Plant height at the reported assessment points under each treatment

Treatment	Days 1–14 mean height (cm)	Day 21 (cm)	Day 77 (cm)
T0	2.60	4.36	38.41
T1	2.60	5.82	46.49
T2	2.60	4.98	42.24
T3	2.60	4.98	43.41

3.3 Effect on Collar Diameter

Fig. 3 shows the change in plant collar diameter under all treatments. Overall, collar diameter increased from day 1 to day 77 after transplanting. This increase became more pronounced from day 21 onwards, at which point the collar diameters of treated plants increased from 3.9 mm to 17.74 mm on day 77 under T1, from 2.7 mm to 17.49 mm under T2, and from 2.08 mm to 17.70 mm under T3. From day 63 onwards, the collar diameters of plants under T1 and T3 were practically identical.

**Fig. 3. Evolution of collar diameter over time according to treatment**

3.4 Effect on Vigour Index

The vigour indices under T1, T2, and T3 increased significantly from the beginning to the end of the measurement period and were higher than those under T0. From day 56 onwards, the indices for T1, T2, and T3 were virtually identical (Fig. 4).

3.5 Effect on Yield

Overall, yield was higher in treated plants (T1, T2, and T3) than in untreated plants (T0). The highest yield was obtained under T1 (0.45 kg/plant or 8.5 t/ha), followed by T3 (0.38 kg/plant or 6.8 t/ha) and T2 (0.35 kg/plant or 6.1 t/ha). Untreated plants (T0) yielded 0.14 kg/plant or 2.1 t/ha. The treatment-wise yield values are summarised in Table 3.

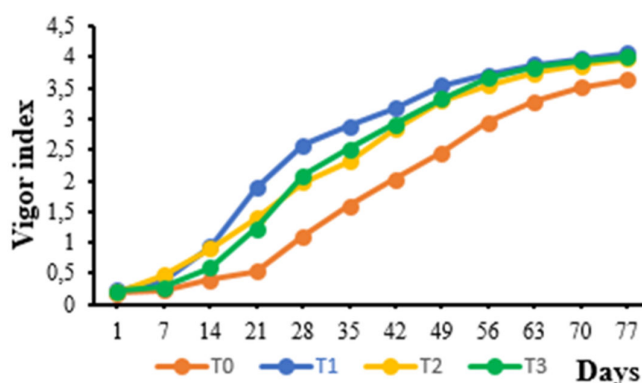


Fig. 4. Evolution of the vigor index over time according to treatment

Table 3. Chilli pepper yield under the four compost treatments

Treatment	Compost formulation	Yield (kg/plant)	Yield (t/ha)
T0	No application	0.14	2.1
T1	Direct application of solid compost	0.45	8.5
T2	Leachate collected after 5 days	0.35	6.1
T3	Leachate collected after 10 days	0.38	6.8

4. Discussion

4.1 Effect of Compost on Growth Indicators

Under all treatments, the survival rate exceeded 70%, as also observed by Segnou *et al.* (2012). According to these authors, this may be explained by the fact that improved chilli pepper varieties, such as the variety used in this experiment, have undergone genetic modification and are less susceptible to soil-borne pests.

In this study, the measured growth parameters, including plant height, stem diameter, and vigour index, indicated substantial plant growth following the application of organic amendments. Ngoyi *et al.* (2020) similarly reported that organic amendments supported the growth of potato plants (*Solanum tuberosum*). According to Kouadio *et al.* (2018), the organic matter supplied by compost increases the soil's water- retention capacity. This increased water availability may have contributed to improvements in these parameters.

Compared with the control and compost leachates, solid compost had the greatest effects on chilli pepper growth parameters. Direct application of solid compost contributed substantially to increases in height, stem diameter, and vigour index by enhancing the soil's water-retention capacity, unlike the liquid compost treatments. In this respect, direct manure application may help to combat soil-surface degradation and improve soil porosity and structure. The fine soil fraction, particularly clay and organic matter, contributes to the retention and bioavailability of essential plant nutrients (Barnard *et al.*, 2025). This suggests that the proportion and quality of clay influence nutrient sorption capacity and accumulation in the soil. However, the lower effectiveness of the liquid compost treatments may have resulted from the leaching of nutrients that were not immediately absorbed by the chilli pepper plants because of the soil's high sand content (silty-sandy texture). Our results show that solid compost and liquid compost can act differently and have complementary effects, as also shown by the studies of Hibar *et al.* (2006) and Mouria *et al.* (2010).

Among the measured parameters, T3, which involved the application of leachate from compost soaked for 10 days, produced better results than T2, which involved the application of leachate from compost soaked for 5 days. This suggests that the duration of compost immersion in water positively influences nutrient availability in the soil and, consequently, for the plant. Direct application of solid compost (T1) produced the best results across all measured parameters compared with the compost-leachate treatments (T2 and T3). Because the study was conducted during a rainy period, nutrients applied through the compost-leachate treatments may have been leached by infiltrating water, thereby affecting the results obtained under these treatments.

4.2 Effect of Compost on Yield

Yields varied among treatments. Plots treated with T1 (8.5 t/ha) produced the highest yield, followed by T3 (6.8 t/ha), T2 (6.1 t/ha), and T0 (2.1 t/ha). According to the theoretical yield indicated on the seed packaging, chilli pepper (*Capsicum chinense*) should yield between 6 and 7 t/ha. Thus, only the plot not fertilised with compost yielded below this range. The high yield under T1 suggests that a substantial application of organic fertiliser supports the growth of chilli pepper plants. This response may be explained by the high biological activity following the application of solid poultry manure, which promotes decomposition and makes nutrients available in the soil. This is consistent with Kouadio *et al.* (2018), who reported that organic inputs stimulate microbial biomass, the living component of soil organic matter.

However, the lower yields produced by liquid compost than by solid compost may be attributable to the leaching of chemical elements during rainfall in the experimental period. These results are similar to those of Fondio *et al.* (2015), who found that differences among chilli pepper lines in vegetative development resulted from differences in their ability to adapt to the environment. The more favourable the growing medium, the greater the plant development. The rapid height growth of plants treated with solid compost may have contributed to their higher yield through the production of numerous fruit-bearing branches. In agreement with Raturi *et al.* (2019), plant height is an important parameter because taller plants may develop more branches and fruits, ultimately increasing chilli pepper yield.

5. Conclusion

This study evaluated the effects of different forms of poultry manure-based compost on chilli pepper yield and selected agronomic parameters. The survival rate under solid compost (T1) was 94.53%, whereas the rates under the five-day (T2) and ten-day (T3) leachate treatments were 85.15% and 88.28%, respectively. T1 produced the highest yield (8.5 t/ha), compared with T2 (6.2 t/ha), T3 (6.8 t/ha), and T0 (2.1 t/ha).

Treatment T1 may therefore be the most suitable of the tested treatments for chilli pepper cultivation on silty-sandy soils such as the soil used in this study. For the leachate treatments, the results indicate that performance improved with a longer residence time in water.

This study deserves to be replicated, by increasing both the number of treatments and blocks, on different soil types in tropical environments and across different seasons to provide a more comprehensive assessment of the effects of leachate on the measured chilli pepper parameters.

6. Limitation

This study was conducted at a single site during one rainy-season period, which limits the extent to which the findings can be generalised to other soils and seasons. Growth and yield measurements were based on four selected plants per plot, and only two leachate residence times were evaluated. Rainfall during the trial may also have influenced nutrient leaching and the relative performance of the liquid treatments. In addition, the study did not report complementary soil or leachate nutrient analyses that could clarify the mechanisms underlying the observed treatment responses.

Declaration of AI Use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. Grammarly and ChatGPT were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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