

RESEARCH PAPER

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Effects of an organic amendment based on biodigester effluent on cotton yield parameters in the Cascades region of Burkina Faso

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ABSTRACT

The present study aimed to explore the effectiveness of compost produced from biodigester effluent on the agronomic parameters of cotton in the Cascades region of Burkina Faso. To this end, the fertilizing value of composts produced from biodigester effluent was characterized. The effect of the compost on cotton yield parameters was evaluated using an experimental setup. The on-farm experiment was based on a Completely Randomized Block Design with six replications. Each block included five treatments: one exclusively mineral treatment, two treatments using compost alone, and two treatments combining compost and mineral fertilizers. In addition, the average weight of cottonseed per plant and the cottonseed yield were determined. The results showed relatively average contents of organic matter (20.95%), total phosphorus (0.30 g/kg), and total nitrogen (0.66%), as well as low levels of total potassium (0.62 g/kg) compared to FAO standards. Fertilization combining 5 t/ha of compost + 200 kg/ha of NPK was the one that produced the best results on the evaluated cotton yield parameters. The production of compost from biodigester effluent is a way to valorize household waste, plant debris, and animal manure to improve cotton yields while restoring soil fertility.

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INTRODUCTION

Burkina Faso's economy is heavily reliant on agriculture, like most countries located in the Sahel region, a type of agriculture generally characterized by low agricultural production (MAAH, 2018; GIZ, 2022). This low production can be explained by several constraints, including climate variability, declining soil fertility, land and environmental degradation, limited access to agricultural inputs, as well as unsustainable farming practices (Bamogo *et al.*, 2022; Zakaria *et al.*, 2024). Also, the results from the National Institute of Statistics and Demography revealed a significant increase in the Burkinabe population, following the general population census, which rose from 10,312,609 inhabitants in 1996 to 20,505,155 inhabitants in 2019 (INSD, 2013; INSD, 2022). This population growth leads to a high demand for food, making strategies for improving agricultural productivity essential. Thus, organic fertilization appears as an alternative for the improvement and sustainable management of soil fertility because it helps enhance the physical, chemical, and biological properties of the soil. Organic amendments such as compost not only help to rehabilitate and maintain soil quality and improve water retention, but also increase crop yields (Essy *et al.*, 2022; Hema *et al.*, 2023). However, the implementation of this solution poses some challenges due to the availability of organic fertilizers. In this context, it is important to explore and promote innovative technologies accessible to farmers that improve their access to organic fertilizers (Sakande *et al.*, 2022; Hema *et al.*, 2023). To this end, the biodigester is positioned as a tool of choice. It is a semi-buried structure with a fixed dome in the ground, designed to receive a mixture of animal excrement and water in order to produce a combustible gas (biogas) and a black-colored liquid called effluent (Sama and Thiombiano, 2012; Bamogo, 2014). The effluents from the biodigester are used in the compost production process. The overall objective of this work is to explore the effectiveness of compost produced from biodigester effluent on the agronomic parameters of cotton in the Cascades region of Burkina Faso.

MATERIALS AND METHODS

Presentation of the study area

This study was conducted in the Cascades region (Fig. 1). Located in the extreme west of the country, the Cascades region is bordered to the north by the Hauts-Bassins region, to the south by the Republic of Côte d'Ivoire, to the east by the Southwest region, and to the west by the Republic of Mali. The region is composed of two provinces that are Comoé and Léraba (Ouedraogo *et al.*, 2022; MEF, 2024). The activities were carried out in the Comoé province, specifically in the rural commune of Tiéfora, more precisely in the village of Kangounadeni. The Cascades region is a cotton-producing area, ranked as the fourth-largest cotton-producing region of the nation. The climate of the region is of the Sudanian-South type and is characterized by an average annual rainfall ranging from 800 to 1200 mm. This rainfall allows for the cultivation of a wide variety of crops and livestock farming. Since 2012, the region has experienced an increase in the production of cash crops. The agricultural soils are mainly lithosols, hardened leached tropical ferruginous soils, leached tropical ferruginous soils with spots and concretions, and hydromorphic soils. The dominant soils are slightly leached and leached ferruginous soils on sandy, sandy-clayey, and clayey materials, which are deep (INSD, 2022; MARAH, 2022).

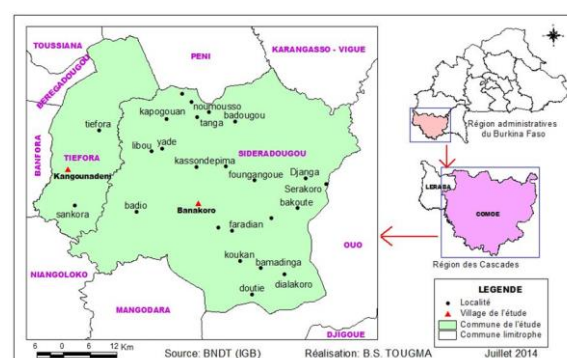


Fig. 1. Map of the study area

Materials

The cotton variety FK 37 (CC) was used as plant material. Cotton FK37 is a variety of African origin, known for its long fibers. This variety was chosen for the tests, not only because of its good response to

fertilizers but also because it is widely grown and promoted in the area (Koulibaly *et al.*, 2009). These cotton plants, with a growth cycle of about 150 days, have an upright habit with a potential seed cotton yield of 2.6 t/ha. Their cultivation area corresponds to a region with average rainfall exceeding 800 mm. As for the fertilizing material, improved compost based on effluent and mineral fertilizers, in particular NPK (14-23-14) and Urea (46%), were used during the trials.

Methods

Production of compost from effluent

The process of producing enriched compost from biogas digester effluents took place in several stages. The compost pit was filled with a series of successive layers of organic materials consisting of chopped straw, animal droppings, and biodegradable household waste.



Fig. 2. Mature compost made of effluent from the biodigester (Source : Sama and Thiombiano, 2012)

Each layer had an average thickness of between 20 and 30 cm. Each layer of organic material was covered with approximately 5 cm of effluent, corresponding to the liquid from the biodigester. About 5 wooden stakes were placed in the pit. These wooden stakes were shaken every morning to allow air to circulate. Once the pit was filled, it was covered with straw, and the contents were left to rest until the second pit was filled. As soon as the second pit is filled, the mixture from the

first pit, which has begun to mature, is emptied and placed in a shaded area with stakes always inserted, where the maturation will continue. After a period of two months, the process results in mature compost without any foul odor. This compost is characterized by a black color and a smell similar to that of fresh lowland soil. The original materials (straw and waste) are no longer recognizable as they are completely decomposed (Fig. 2).

Setup of the test

The experimental design used was a completely randomized block design, each block comprising five (5) treatments: T₁ (200 kg/ha NPK + 100 kg/ha Urea), T₂ (5 t/ha compost), T₃ (6 t/ha compost), T₄ (5 t/ha compost + 200 kg/ha NPK), T₅ (5 t/ha compost + 100 kg/ha Urea), and each repeated six (6) times. The dimensions of a block were 10 m in length and 10 m in width, giving a total area of 100 m². The blocks were separated from each other by a 2 m path, while a 1 m path separated the individual plots within a block. The dimensions of an individual plot were 10 m by 0.8 m, giving an area of 8 m². Table 1 shows the different experimental treatments. The preparation of the seedbed consisted of plowing the soil to a depth of 10 to 20 cm using an ox-drawn plow. The compost was applied before plowing and sowed at a spacing of 80 cm × 40 cm. The first weeding, followed by thinning to two plants per hill, took place 21 days after sowing. The second weeding occurred 41 days after sowing. No phytosanitary treatment was applied.

Table 1. Different treatments used

Designation	Treatments
T ₁	NPK (200 kg/ha) + Urea (100 kg/ha)
T ₂	Compost 5 t/ha
T ₃	Compost 6 t/ha
T ₄	Compost 5 t/ha + NPK (200 kg/ha)
T ₅	Compost 5 t/ha + Urée (100 kg/ha)

Data collection

Soil samples were collected from the experimental plot at the site at a depth of 0 to 20 cm at nine points. All of these collected elementary samples were thoroughly mixed. Then, a composite sample of five hundred grams (500 g) was prepared for chemical characterization at the laboratory of the

National Soil Bureau (BUNASOLS) in Ouagadougou, Burkina Faso.

The compost based on effluent used for soil amendments at the site was also characterized. Evaluations were conducted using the plants harvested from each useful elementary plot. The measurements concerned yield parameters, the average weight of cotton seed per plant (AWCP), and the cotton seed yield (CSY).

Data analysis

The data collected from the experimental plots and obtained from the chemical characterization of the composts were entered into the Excel 2016 spreadsheet. The mean values were subjected to an analysis of variance (ANOVA) using the XLSTAT 2007 software. The Student-Newman-Keuls test at a 5% significance level was used for the comparison of means.

RESULTS

Chemical characteristics of compost

The contents of organic matter (OM), major fertilizing elements, and the acidity of effluent-based composts collected and analyzed are recorded in Table 2. The composts showed relatively average levels of organic matter (20.95%) and total phosphorus (0.30 g/kg) compared to FAO standards. However, the total potassium content (0.62 g/kg) is slightly below the recommended threshold. As for nitrogen, its content was slightly above the threshold. Regarding acidity, the composts had pH values close to neutrality (7.02) and the carbon-to-nitrogen ratios (C/N) were balanced.

Table 2. Chemical characteristics of effluent-based composts

Characteristics	Effluent compost	FAO's norms
MO (%)	20.95	10 - 30
N _{tot} (%)	0.66	0.4 - 0.5
C/N	19	20 - 25
P _{tot} (g/kg)	0.30	0.1 - 1.6
K _{tot} (g/kg)	0.62	4 - 23
pH _{eau}	7.02	5.5 - 7

OM: Organic matter; C: Organic carbon; N_{tot}: Total nitrogen; P_{tot}: Total phosphorus; P_{ass}: Assimilable phosphorus; K_{tot}: Total potassium; (FAO, 2005)

Soil chemical analysis

The chemical analysis results of the site's soil are recorded in Table 3. These results show that the contents of organic matter (0.500%), total nitrogen (0.029%), total potassium (214.35 ppm), total phosphorus (169.04 ppm), and available phosphorus (6.6 ppm) were below the recommended thresholds, while the content of available potassium (59.1 ppm) was relatively average. Regarding the pH of the analyzed soil, it was slightly acidic.

Table 3. Chemical parameters of the soil

Chemical parameters	Values	Bunasols norms
MO (%)	0.500	1.0-2.0
N _{tot} (%)	0.029	0.06-0.10
C/N	10	
K _{tot} (ppm)	214.35	1000-2000
K _{avail} (ppm)	59.1	50-100
P _{tot} (ppm)	169.04	200-400
P _{ass} (ppm)	6.6	10-20
pH _{eau}	6.18	5.4-5.5

OM: Organic matter; C: Organic carbon; N_{tot}: Total nitrogen; P_{tot}: Total phosphorus; P_{ass}: Assimilable phosphorus; K_{tot}: Total potassium; K_{avail}: Available potassium. (BUNASOLS, 1990)

Variation of cotton yield parameters according to treatments

The results of the analysis of variance for the average seed cotton weight per plant (ASCWP) and the seed cotton yield (SCY) evaluated are presented in Table 4. From these results, it can be concluded that the analysis conducted on the average seed cotton weight per plant (ASCWP) on one hand and the seed cotton yield (SCY) on the other hand revealed a significant difference according to the treatments.

For the average weight of seed cotton per plant, significantly higher average values (24.85 g) were observed in plots under the compost 5 t/ha + NPK 200 kg/ha treatment (T4), whereas those only amended with compost 5 t/ha (T2) recorded the lowest average values (18.72 g). The analysis also showed that plots under treatment T1 (NPK 200 kg/ha + Urea, 100 kg/ha), T3 (Compost 6 t/ha), and T5 (Compost 5 t/ha + Urea, 100 kg/ha) had statistically equivalent average seed cotton weights, which were 20.75 g, 20.15 g, and 19.38 g, respectively.

Table 4. Cotton yield according to treatments

Treatment	ASCWP (in g)	SCY (in t/ha)
T1 : NPK 200 kg/ha + Urée, 100 kg/ha	20.75 b	1.10 b
T2 : Compost 5 t/ha	18.72 a	0.86 a
T3 : Compost 6 t/ha	20.15 b	1.16 c
T4 : Compost 5 t/ha + NPK, 200 kg/ha	24.85 c	1.47 d
T5 : Compost 5 t/ha + Urée, 100 kg/ha	19.38 b	0.84 a
Probability (5%)	0.001	0.001
Significance	S	S

NB: The values in the same column assigned the same letters are not statistically different at the 5% level (ANOVA, Student-Newman-Keuls test).

Similar to the variation in the average weight of seed cotton per plant, the highest seed cotton yields (1.47 t/ha) were obtained in the plots under treatment T4, where organo-mineral fertilizer (Compost 5 t/ha + NPK, 200 kg/ha) was applied, while the plots under treatment compost 5 t/ha + Urea, 100 kg/ha (T5) had the lowest seed cotton yields (0.84 t/ha).

DISCUSSION

The results of the chemical analyses of the composts improved with effluent are comparable to the standards established by the FAO for quality organic substrates (FAO, 2005). Although the results revealed a low potassium content, effluent-based composts proved to be an interesting source of nitrogen, organic matter, and phosphorus, usable for soil fertility management and crop nutrition. Furthermore, chemical characterization indicated that these composts were close to neutral (Compaore *et al.*, 2010). Indeed, this characteristic of the compost demonstrated that it can be used to amend the soil, as these organic substrates can provide a favorable environment for many soil microorganisms, which are key players in soil fertility. The neutrality of compost not only promotes the mineralization and bioavailability of nutrients for crops, but also facilitates the absorption of these elements. And such a ratio value revealed by analyses indicates a mature and stable compost conducive to fertility management (Zro *et al.*, 2018; Ouattara *et al.*, 2025). Compared to the soil quality interpretation standards of the National Soil Office (BUNASOLS, 1990), the evaluation of the chemical characteristics of the site's soil shows low levels of nitrogen, organic matter, phosphorus, and potassium. Although the pH of this soil is close to neutrality, favorable for nutrient availability, these characteristics

indicate a nutrient-poor soil. Faced with this situation of degraded soil, it is necessary to find solutions to restore and maintain soil fertility, hence the use of organic substrates such as compost made from effluent (Bamogo *et al.*, 2022). Moreover, the results of agronomic tests show that soil fertility management treatments had different effects, on the one hand on the average weight of cotton seed per plant, and on the other hand on cotton seed yield. It is true that this improvement in cotton yields could be due to several factors, among which is the improvement of soil properties (Ouattara *et al.*, 2025).

Moreover, the results of the chemical characterization of the soil indicate that the soil at the test site was nutrient-poor. This supports the hypothesis that the application of compost made from effluent had beneficial effects on the soil properties. Although all practices contributed to improving cottonseed yields, the organo-mineral combination (compost 5 t/ha + 200 kg/ha NPK) stood out with significantly higher cottonseed yields due to its additive effects. The results obtained are similar to those of Mokolo *et al.* (2024) and Bamogo *et al.* (2025), who demonstrated the influence of enriched compost on crop agronomic parameters. Zro *et al.* (2018) showed that the addition of organic substrates allows for better soil productivity. This result confirms that effluent-based compost is a good source of nutrients for cotton plants.

CONCLUSION

The study aimed to explore the effectiveness of compost produced from biodigester effluent on the agronomic parameters of cotton in the Cascades region of Burkina Faso. The results of this investigation showed that effluent-based composts improved the contents of organic matter, total nitrogen, and total phosphorus.

The investigations indicate that effluent-enriched compost had positive effects on the physical, chemical, and biological properties of the soil as well as on cotton seed yield. The production of compost from biodigester effluent is a promising approach to valorize household waste, plant debris, and animal manure to improve cotton yields while restoring soil fertility.

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