GSC Advanced Research and Reviews

eISSN: 2582-4597 CODEN (USA): GARRC2

Cross Ref DOI: 10.30574/gscarr

Journal homepage: https://gsconlinepress.com/journals/gscarr/

(Research Article)

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Valorisation by composting of sawdust for agronomic use in the commune of (Marcory), Abidjan, Ivory Coast

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GSC Advanced Research and Reviews, 2022, 12(02), 136–143

Publication history: Received on 07 July 2022; revised on 17 August 2022; accepted on 21 August 2022

Article DOI: https://doi.org/10.30574/gscarr.2022.12.2.0212

Abstract

The environmental challenges in the context of climate change require the design of a sustainable organic agriculture. To achieve such a challenge, the use of organic fertilizers is highly recommended. Among these organic fertilizers, compost is of paramount importance as it is widely recommended and used in the agricultural world. However, the quality of compost depends on the organic matter used. The search for several sources of compost is necessary in order to offer several choices to producers, depending on the source of organic matter available. With this in mind, a study on the use of sawdust from carpentry by composting was conducted in the south of Côte d'Ivoire, in the commune of Marcory, with a view to its use for agronomic purposes. In a 2 x 1.5 x 1 m pit, 50 kg of fresh sawdust and 20 kg of chicken litter were composted over a period of 5 months. The mature compost obtained is in decomposed form (detritus), black in color, oily, free of pathogenic micro-organisms and with appreciable contents expressed in g/kg of assimilable mineral elements such as: N(28.8) K(19.2) Ca(04.5) P(03.1) and Mg(01.5). Its use as a substrate in soilless tomato cultivation has resulted in a yield of 0.75 kg per plant, compared to 0.20 kg per plant in full soil cultivation. This represents a yield of 45 t per hectare, compared to 11 t.

Keywords: Compost; Marcory; Sawdust; Poultry litter; Abidjan

1. Introduction

Rubbish or waste causes several types of pollution, including water, air and soil pollution [12].The problem of household and industrial waste management in large African cities is acute [19]. The waste sector produces 10% of total greenhouse gas emissions in Côte d'Ivoire [3]. According to the organisation [8], waste production in Abidjan is increasing on average by 9.4% per year. The commune of Marcory in the city of Abidjan is hardly spared from this phenomenon. This commune produces a large quantity of household waste and sawdust. Two methods are commonly used for the disposal of wood waste. These methods are either burning as energy in the fireplaces or used as litter by poultry farmers. While the latter use has no apparent environmental impact, the former emits carbon monoxide and dioxin into the atmosphere in addition to the smoke. It is estimated that about 24 mg/year of dioxin is released into the air [24]. Composting offers very interesting solutions to transform organic waste from household, industrial and agricultural operations into a resource [14]. Recycling this waste by composting appears to be an alternative way of recovering waste and reducing its impact on the environment and human beings. Composting is an alternative way of

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transforming household and industrial waste into resources for sustainable farming. Indeed, it is a very interesting proposition as it presents interests such as the improvement of soil fertility and quality, favourable to an increase in agricultural productivity, a better biodiversity of the soil, a reduction of ecological and environmental risks. Composting is a process that consists in transforming and decomposing in a controlled manner the organic matter contained in household waste in the presence of oxygen from the air and under the action of microbial populations to give compost [1]. This alternative is therefore important for agricultural use. The aim is to enrich the soil with organic matter, and the mineral nutrients of the crops associated with it. In addition, compost can also be used as a substrate in organic substrate cultivation, commonly known as soilless cultivation in market gardening. It is with this in mind that this study devoted to aerobic and pit composting of waste, particularly sawdust from sawmills in the commune of Marcory in the city of Abidjan in the southern region of Côte d'Ivoire, was conducted to assess the quality of the compost produced for agricultural use.

2. Material and methods

2.1. Materials

2.1.1. Presentation of the study area

The present study took place in the commune of Marcory, precisely at the Lycée Municipal of the said commune. Built on an area of 10 ha, on a swampy land previously filled. This establishment has about a hundred classrooms, with an enrolment of more than 5000 students. The experimental plot borders the lagoon and its surface area is estimated at nearly half a hectare, the soils of which are made up of Gleysols. This site is regularly exploited by a dozen market gardeners who cultivate various crops including: spinach (Spinacia oleracea), mint (Mentha spicata), tomato (Solanum lycopersicum), lettuce (Lactuca sativa) and potato (Ipomoea batatas) for its leaves (figure 1).

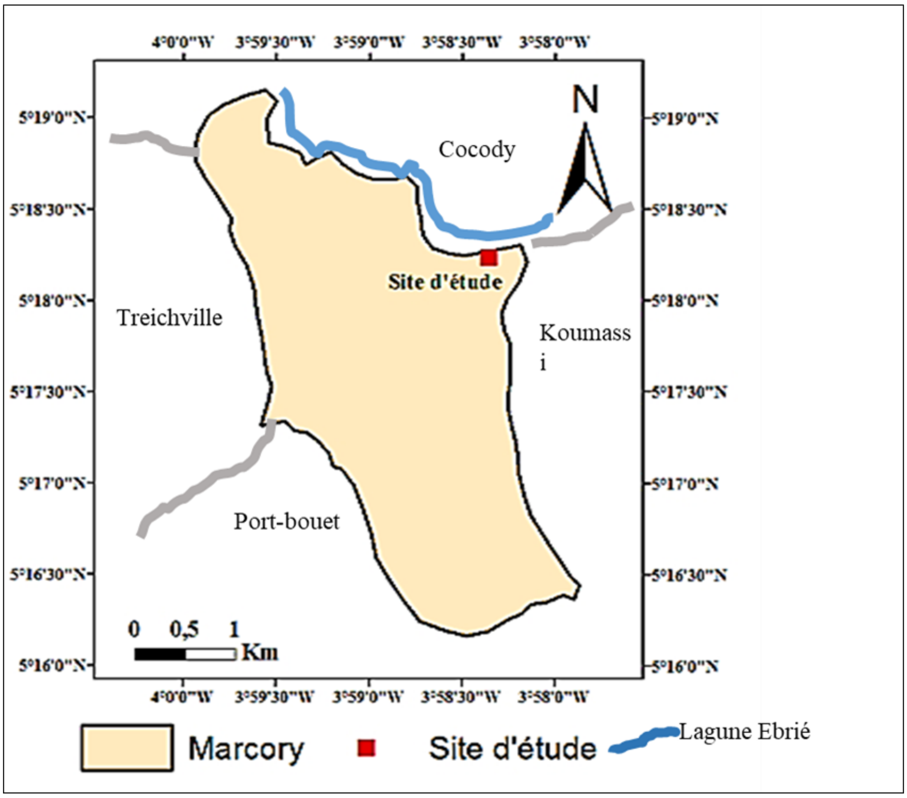

Figure 1 Study site

2.1.2. Tomato variety

The variety used is F1 LINDO, which is an improved variety with determinate growth [5]. It is one of the most widely grown varieties in market gardening because of its high yield and disease resistance.

2.1.3. Growing medium

The substrate used in this study was mainly fresh sawdust (rich in carbon) from mechanised carpentry and poultry litter collected from surrounding farms. The poultry litter was used as a decomposition activator for its high nitrogen content. The resulting compost was used as a substrate for soilless cultivation (cultivation on organic substrate) in the market garden. It is placed in plastic containers filled to ¾ to receive the seedlings to be transplanted. On average, 10 bags of the 30 x 30 cm type were filled with the 20 L of substrate obtained at the end of the composting operation (figure 2). We note a loss of 10 kg due to the mixing, collection and transport operations.

Figure 2 Filling plastic containers in soilless culture

2.1.4. Technical equipment

- A white tarpaulin which was used to line the bottom and sides of the composting pit ;
- A black tarpaulin used to cover the substrate (sawdust) on the surface of the composting pit ;
- A pickaxe and hoe which were used to sink the composting pit ;
- A shovel used for sinking and periodic turning of the mixture;
- Pieces of wood used to reinforce the surface cover;
- A piece of wood used as an aeration stake;
- A decameter, for measuring the dimensions of the pit.

2.2. Methodology

2.2.1. Acquisition of the raw material

The raw material is sawdust combined with poultry litter. The sawdust came from sawmills. A total of 50 kg of sawdust was collected and packed in 25 kg bags. The litter was purchased from a poultry farm and packed in 25 kg bags.

2.2.2. Sinking the pit

Figure 3 Compost pit

Using picks and shovels, two pits, each measuring 2m x 1.5m x 1m, were dug to receive the material to be composted for one (sawdust), the other being turned every fortnight. The bottom and sides of each pit were lined with a white tarpaulin to avoid mixing with excavated soil (Figure 3).

2.2.3. Composting

Fifty (50) kg of sawdust was mixed with 20 kg of poultry litter in an alternating manner in the pit (a layer of sawdust, 5 to 10 cm thick, followed by a layer of litter). The whole area was watered and then carefully covered with a black tarpaulin held in place by pieces of wood. A piece of wood was pricked onto the closed heap to serve as aeration. The whole was uncovered every fortnight for a homogenisation mixing or turning for 5 months (figure 4)

Figure 4 Periodic processing of compost (stripping, turning)

2.2.4. Test of tomato production in soil-less and soil-full conditions

Two growing cycles were carried out with three treatments, consisting of morning (M), morning-evening (MS) and evening (S) water applications. Transplanting of the plants onto the culture supports took place after a three-week nursery period. The bags were filled with 3/4 of the substrate. The treatments and the collection of agronomic data took place two weeks after the transplanted plants were taken over. Maintenance such as leaf removal and cutting of shoots was also carried out in order to reduce the microclimate around a tomato vine. The plants are given water in the morning and evening. At the same time, a full soil culture was carried out to compare the agronomic performance of each crop support subjected to the same treatments. Four replicates were applied for a given treatment (figure 5).

Soiless open ground

Figure 5 Tomatoes grown above ground and on the ground

2.2.5. Statistical processing of data

The raw data from the field were statistically processed with a 2-factor ANOVA, after checking the normality of the significant difference at the 5% threshold between the yields per tomato plant in soil-less and soil-planted cultivation

3. Results

3.1. Maturation of the compost

In this study, after 5 months of treatment (watering and turning), the compost reached maturity. On maturation, the compost is in decomposed form, i.e. the plant particles break down under finger pressure, black in colour, oily, free of pathogenic micro-organisms and weed seeds (figure 6).

Figure 6 Aspect of matured compost

At the end of the experiment, the substrate is in an earthy form that can be incorporated into the soil. This facilitates its disposal and solves the environmental pollution risks (figure 7).

Figure 7 Compost appearance at the end of a crop cycle

3.2. Uses

3.2.1. Chemical characteristics of the resulting compost and its components

Table I shows the chemical composition of the raw material of the substrate at different stages of the experiment. These are fresh sawdust, manure, mature sawdust and post-harvest sawdust (Table 1).

Table 1 Chemical characteristics of different forms of sawdust and chicken droppings

Chimical composition (time period)	**N**	**P**	**K**	**Ca**	**Mg**
	Content (g/kg of D.M)				
Fresh sawdust (T0 collected at sawmill)	25.8	0.1	01.16	02.62	0.36
Chicken manure (T0 from farm)	32.7	04.4	24.86	04.80	01.54
Mature substrate (4 month after composting)	28.8	03.5	19.21	04.16	01.49
Post-harvest substrate (5 month after use)	26.6	03.6	0.33	0.31	00.14

D.M: Dry matter

From the percentages given in Table 1, it can be seen that on average chicken litter contains 32.7 g/kg of nitrogen, while the mature substrate contains 28.8 g/kg, compared to 26.6 g/kg for the post-harvest substrate and 25.6 g/kg for the fresh sawdust. The high nitrogen content of the chicken litter makes it an activator of compost fermentation. This result constitutes an important parameter for the choice of activator in the maturation process, for example the possibilities of composting which have not been exploited to date in the city of Abidjan. The potassium content of the litter is 24.86 g/kg, clearly above the respective values of this element in the mature substrate (19.21 g/kg), the fresh sawdust (1.16 g/kg) and the post-culture substrate (0.33 g/kg). A gradual decrease in nitrogen content was observed in the different forms of substrates (fresh sawdust - mature substrate and post-culture substrate).

3.2.2. Yields of tomato grown above ground

The average yields per substrate are recorded in Table 2. The statistical treatment by ANOVA, shows a significant difference between the yields per tomato plant in soilless culture and in culture with soil. This is shown by the letters a and b assigned to the different yields.

Table 2 Yields in Kg per tomato plant on two growing media

	Treatments	Soiless (Kg/ft)	Open ground (Kg/ft)	Pr>F
Cycle 1	F3M	630,50a	373.50a	0.2894
	F3M-S	834,75a	10.75b	< 0.0001
	F3S	764,75a	28.25b	< 0.0001
Cycle 2	F3M	472,50a	184.50a	0.0014
	F3M-S	627,50a	19.75b	< 0.0001
	F3S	452,50a	39,25b	0,0002

a = highly significant value; b = not insignificant value

The F3M-S treatment gave the best yields, although the other treatments gave good yields of the soilless plants. Considering the best treatment (F3M-S), we can estimate the average yield obtained per tomato plant in soilless culture to be 0.75 kg, compared to 0.20 kg per plant in soil culture. This is equivalent to about 45 t.ha-1 compared to 11 t.ha-1 on soil.

4. Discussion

In the present study, the compost matured after five months. [20], argues in these studies that the duration of composting involves a range of physical and chemical conditions and parameters during composting. It depends on the nature of the materials to be composted, the process conditions, the degree of aeration, the C/N ratio, the humidity, and the duration of all the microbial reactions of mineralisation and humification of organic substances. The ripening cycle is marked by a period of increasing heat reaching 60°C [9], and gradually decreasing thereafter to about 26°C. In addition, the physical and chemical properties determined by laboratory analysis allow the quality and especially the contents of mineral elements such as nitrogen-N, potassium-K, calcium-Ca, assimilable phosphorus-P and magnesium-Mg to be assessed [15]. In contrast to our study, the curing time of sawdust-based compost was estimated at four months in the studies of [22].

The results of the chemical analyses showed that the mature compost contained 28.8 k/kg confirming that the compost has high contents of fertility elements and comply with the criteria of the standard prescribed by AFNOR. According to this standard, the average contents of the chemical components of the compost should be between 10-30 g/kg for organic matter, between 0.4-05 g/kg for total nitrogen, 0.1-1.6 for total phosphorus and between 0.4-2.3 for total potassium [16].

The results confirm that compost is an organic fertiliser that improves soil fertility. The effects of compost on the chemical and physical properties of soils are: a supply of nutrients (macro and trace elements), a supply of stable organic matter, an improvement in soil structure, better water penetration and retention, a reduction in erosion, an increase in pH. It also has an effect on soil biology. Indirectly, the improvement of all these factors also influences plant health [21]. The dosage of compost to be applied depends on the amount of compost produced, but for millet and sorghum, it is desirable to apply a minimum of about 5 tons of compost per hectare according to [11]. According to [6], compost is used in field crops as an organic manure, but it must be sufficiently elaborated so as not to risk blocking soil or fertilizer nitrogen ("nitrogen starvation").

The yield obtained in soilless culture on the substrate is 45 tha-1 against 11 tha-1 on soil in our study. This high average yield of fruits in soilless culture could be due to a sufficient supply of major elements such as nitrogen contained in compost and manure confirming the results obtained by [23] quoted by [17]. Indeed, according to this author, nitrogen nutrition leads to increased photosynthesis, producing more assimilate for fruit formation. , [13], obtained yields of 90 tha-1 in soilless tomato cultivation with an organic substrate, against 30 tha-1 on soil.

This yield is significantly higher than the results obtained in the present study. This difference could be linked to the dose of litter applied and also to the maturation time of the compost used. Indeed, the results of the work of [18], showed that a compost application at a rate of 40 t/ha produced a better yield than a compost application at a rate of 20 t/ha. The main limitation of this paper is that it does not address the effect of compost on the environment, even though several studies suggest that it has several advantages in this area. Indeed, one of the first environmental benefits is the elimination and sanitation of the living environment. According to [4-2] and [10], composting produces a compost (organic substrate), which has a long-term effect in the soil comparable to chemical fertilisers. In addition, compost has other properties such as reducing soil erosion, increasing water retention capacity or improving gas exchange. It enriches and maintains the biodiversity of soil microbial populations. Composting allows for ecological intensification of cropping systems and an increase in biological activity and the capacity of the soil to produce. The disadvantages of composting, according to the same authors, in the case of household waste, is that the trace metals (heavy metals) present in the starting materials are not eliminated by composting. On the contrary, they concentrate because of the reduction in volume. Composting is in itself a constraining activity, in the sense that the operation requires space, time for monitoring (checking that the composting is going well) and interventions (turning, covering, watering). These constraints can sometimes be significant [7].

5. Conclusion

The present study has shown that composting is a means of recycling waste for agronomic use. A yield of 45t.ha-1, compared to 11t.ha-1 was obtained in a comparative study (soilless and full soil) as a tomato growing medium. In addition, compost can improve the physico-chemical properties of soils in terms of its content of chemical fertilising elements and the active humus produced. Its use as such is a means of eliminating waste and therefore of improving the living environment. Thus, the recycling of household waste, in addition to meeting an environmental goal of eliminating waste, provides a useful product for agricultural production**.**

Compliance with ethical standards

Acknowledgments

I would like to thank all the people who contributed to the improvement of the scientific quality of the article by their inputs

Disclosure of conflict of interest

I certify on my honor that all the authors associated with the drafting of this article have contributed to its drafting and have given their agreement in principle to the publication of the article. Therefore, No conflict of competence arises to hinder the publication of the article.

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