Research article

Evaluation of Lignocellulolytic Fungal Consortium for Composting Sugarcane Bagasse, Filter Cake and Manure

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Abstract.
Three lignocellulolytic fungi isolates, *Amblyosporium* sp, *Aspergillus* sp1, and *Aspergillus* sp2, were tested for their ability to produce cellulase, hemicellulose, and ligninase enzymes as a consortium. They were also used in a mixture with sugarcane bagasse, filter cake and manure to make mixed compost. In the compost house of the State Agricultural Polytechnic of Pangkep, composting took place for 35 days. The composting process of the consortium of lignocellulolytic fungi was carried out at a temperature of 32^{o}C-75^{o}C, with a water content of 12.58-30.32% and a pH of 6.80-8.20. The 35-day lignocellulolytic fungal consortium was able to speed up the composting process with a C-organic yield of 10.41-26.06%, a C/N ratio of 9.00-22.00%, phosphorus of 1.98%, magnesium of 6866 ppm, and sulfur of 0.25%. The fungal consortium was able to effectively speed up the composting process while also increasing nutrient content in various composting media compositions.

Keywords: Fungi, lignocellulolytic, sugarcane, bagasse, manure

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Published 07 June 2022

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the PGPR 2021 Conference Committee.

1. Introduction

Sugarcane bagasse and filter cake are by-products of sugarcane processing into sugar. The amount of sugarcane bagasse is 30 percent and filter cake is 3-4 percent of the total weight of the grinded sugarcane stalks, so they are produced by Sugar Mill industry in a high amount every year. So far, sugarcane bagasse has been reused as fuel for sugar mills, while filter cake, besides being used for sugarcane, is mostly discarded in the field. However, filter cake gives a bad odor and disturbs the surrounding environment.

Naturally, the process of decomposition of sugarcane bagasse and filter cake runs very slow due to the high content of lignocellulose of sugarcane bagasse. Composting is one of the solutions to process the by-products of sugarcane into useful products for

How to cite this article: R Rahmad, and N Nurmiaty*, (2022), "Evaluation of Lignocellulolytic Fungal Consortium for Composting Sugarcane Bagasse, Filter Cake and Manure" in *First Asian PGPR Indonesian Chapter International e-Conference 2021*, KnE Life Sciences, pages 340–351. DOI 10.18502/kls.v7i3.11135

plants. Composting is a method for treating solid organic waste that is environmental-friendly and economical [1]. The purpose of composting is to produce compost that is healthy and stable, as well as contains mineral elements needed for soil and plants [2]

Compost is a product of composting process that is useful for improving physical, chemical, and biological soil properties. The results of research by Boonyuen et al. [3] shows that the sugarcane bagasse content consists of 49.59% of cellulose, 32.01% of hemicellulose, and 18.76% of lignin, 93.36% of C-organic, 158.51% of C/N ratio. Meanwhile, filter cake contains 22.91% of cellulose, 17.51% of hemicellulose, and 9.00% % of lignin, 72.25% of C-organic, and 28.89% of C/N ratio.

The high lignocellulose content of sugarcane bagasse and filter cake causes the decomposition process to run very slowly. The use of lignocellulolytic fungal consortium is expected to accelerate the process of decomposition into compost. This compost is the final product of the composting process that can be used as a growth medium for plants as well as a way to overcome the environmental pollution.

So far, there have not been many researches on the use of the fungus consortium in the process of making compost using mixed media of sugarcane bagasse, filter cake and cow manure. The purpose of this study is to examine the ability of the lignocellulolytic fungus consortium to degrade organic matter into compost.

2. Research Methods

Consortium fungi used in this research were isolates from sugarcane bagasse in which their ability to produce cellulase, hemicellulase and ligninase enzymes have been tested in vitro data is not displayed. The lignocellulolytic fungal consortium consisted of a combination of three isolates, namely *Amblyosporium* sp, *Aspergillus* sp1, and *Aspergillus* sp2. isolates compared to *Trichoderma* sp.

The ability of the consortium fungus isolates in the composting process was tested using the following experimental treatments:

Treatment A = 50 kg of sugarcane bagasse + 50 kg of manure + consortium of fungi *Amblyosporium* sp*, Aspergillus* sp1*, and Aspergillus* sp2

Treatment B = 50 kg of sugarcane bagasse + 50 kg of manure + fungi *Trichoderma* sp.

Treatment C = 50 kg of sugarcane bagasse + 50 kg of manure + 50 kg of filter cake + consortium of fungi *Amblyosporium* sp*, Aspergillus* sp1*, and Aspergillus* sp2.

DOI 10.18502/kls.v7i3.11135

Treatment D = 50 kg of sugarcane bagasse + 50 kg of manure + 50 kg of filter cake + fungi *Trichoderma* sp.

Treatment E = 50 kg of filter cake + 50 of manure + consortium of fungi *Amblyosporium* sp, *Aspergillus* sp1, and *Aspergillus* sp2

Treatment F = 50 kg of filter cake + 50 of manure + fungi *Trichoderma* sp.

Fungal consortium and *Trichoderma* sp. were given 4 grams to each of 1 kg of compost according to the treatment given. The fungus was mixed with water containing 2% of sugar solution of the total water used then the compost material was watered until the humidity reaches 60% then covered with plastic sheeting. Compost was flipped every 7 days until day 35. The experiment was repeated three times. The parameters observed were temperature (mercury thermometer), pH (electrometry), water level (Oven), C/N (calculation), Nitrogen (Kjeldahl), Phosphorus (spektrofotometri), Pottassium (AAS), C-organic, Magnesium (AAS), Sulfur (spektrofotometri). The experiment was arranged in the form of a completely randomized design (CRD) with three repetitions. If the results of analysis of variance (ANOVA) is significantly different, there will be further testing using Duncan test (<0.05).

3. Results and Discussion

3.1. Temperature Changes During Composting

Temperature changes during composting process are determined by the fungus and compost media. Temperature changes during the observation show that treatment A, B, C, and D, with fungal consortium *Amblyosporium* sp, *Aspergillus* sp1, *Aspergillus* sp2 and *Trichoderma* sp., on different compost media combinations in the first week of the composting have different results. The composting temperature of treatment A is at 47°C, treatment C is at 75°C, treatment B and D are at 52°C and 49°C respectively, and treatment E and F are at 35°C and 30°C respectively.

Temperature changes in treatment A, B, C, and D in the second week to the fifth week continue to decrease. Treatment A, B, C and D in the fourth week are still in the range of 39^0 C-41^0C and in the fifth week are in the range of 32^0C-35^0C. Meanwhile, temperature of treatment E and F in the second week until the third week increases around 35°C-37°C, the temperature decrease to 35°C in the fourth week, and the temperature is around 30°C-32°C in the fifth week (Figure 1).

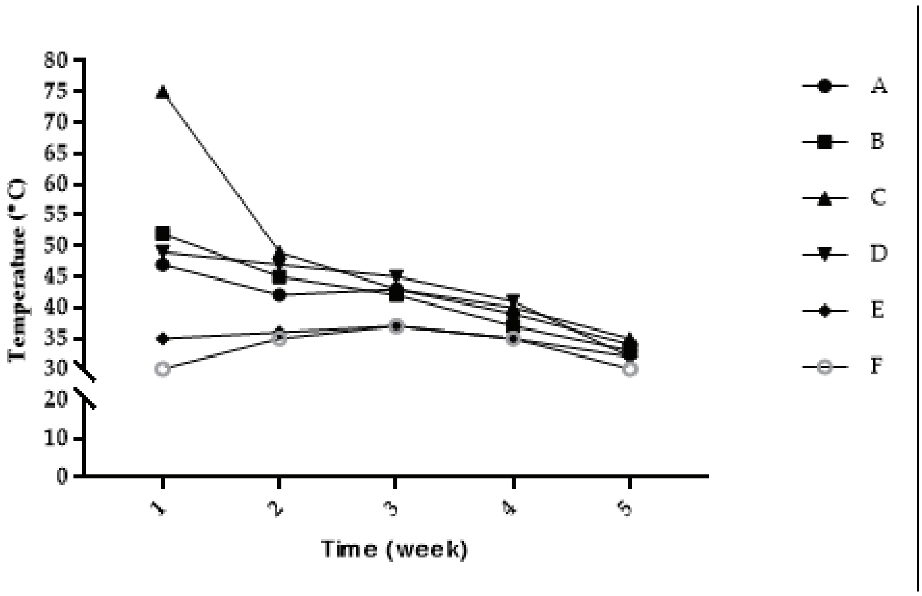

Figure 1: Temperature changes during composting.

3.2. pH Changes during Composting

Changes in pH during composting process occur for all treatments. In treatments A, B, C, and D during the first week to the fourth week, pH ranges from 6.8-7.4. Meanwhile, in the fifth week, pH decreased for 7.0-7.1. This is different from treatment E and F during the first week, in which their pH is 8.0, and it decreased to 7.7 at the end of the experiment (Figure 2).

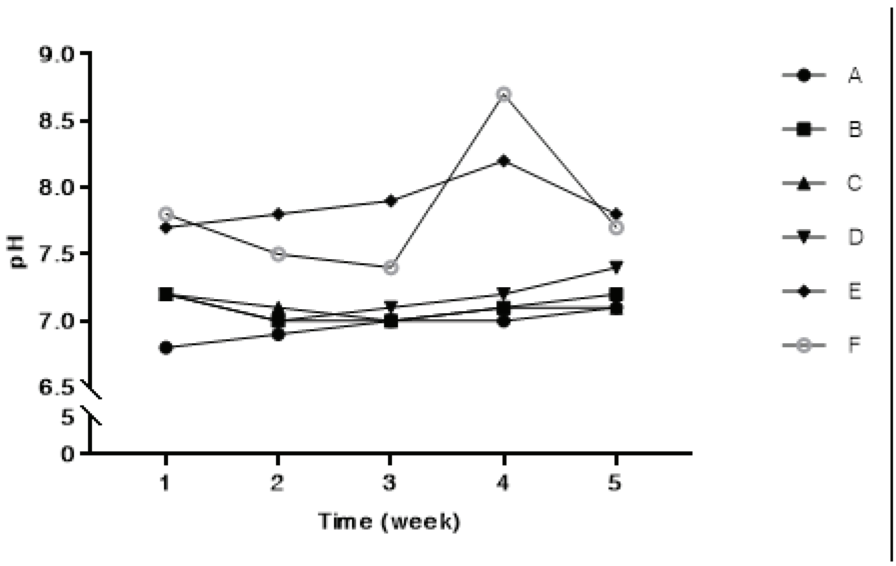

Figure 2: pH changes during composting.

3.3. Water Content of Compost

Water content in 35-day composting process shows different variations in the treatment with fungal consortium *Amblyosporium* sp, *Aspergillus* sp1, *Aspergillus* sp2 and treatment with *Trichoderma* sp. The treatments of fungal consortium A, C, and E have lower water content, namely 12.58%, 14.42%, and 30.32% compared to the treatment B, D and F with *Trichoderma* sp., containing water content of 18.18%, 24.69%, and 37.08% at different types of composting media (Figure 3). Differences in water content are caused by temperature differences when composting process occur (Figure 3). High temperatures in composting process due to the activity of fungus consortium result in low water content at the end of composting process.

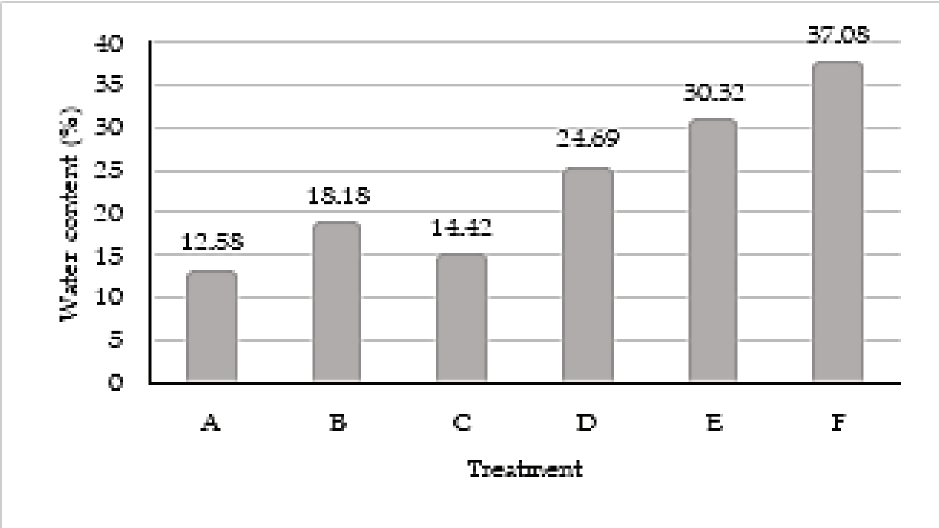

Figure 3: Water content on day 35 of composting process.

3.4. C-Organic Content of Compost

The results of 35-day composting process show significantly different treatment effects on C-organic content. Treatment A gives a significantly different effect on treatment B. Treatment A consortium *Amblyosporium* sp, *Aspergillus* sp1, *Aspergillus* sp2., gives C-organic content of 26.06% lower than treatment B using *Trichoderma* sp., which is 29.13%.

The results of composting in treatment C and D show significantly different effects. Treatment C gives 21.72% of C-organic content, which is higher than treatment D, that is, 14.40%. The results of composting with filter cake and manure in treatment E and F show significantly different effects. Treatment E gives a higher C-organic content, which is 10.41%, compared to F treatment, which is 10.09% (Table 1).

TABLE 1: C-organic content on day 35 of composting process.

Treatment	C-Organik (%)
A	26.06^{c}
B	29.13^{d}
C	21.72^{b}
D	14.40^{ab}
E	10.41^{a}
F	10.09^{a}

3.5. C/N Ratio of Compost

The results of 35-day composting process show that the treatments significantly affect the C/N ratio of compost produced. Treatment A, that mixes sugarcane bagasse and manure with fungal consortium *Amblyosporium* sp, *Aspergillus* sp1, *Aspergillus* sp2., gives lower C/N ratio, which is 22%, compared to treatment B that uses *Trichoderma* sp., with C/N ratio of 25%. The results of composting by mixing sugarcane bagasse, filter cake, and manure in treatment C and D show significant differences. Treatment D gives lower C/N ratio value of 13.00% compared to treatment C that gives C/N ratio of 19.00%. The results of composting by mixing filter cake and manure in treatment E and F show significant differences. Treatment F gives lower C/N ratio, which is 8.00%, compared to treatment E, which is 9%. Composting process using fungal consortium and sp.is in the range of 8% -25% (Table 2).

TABLE 2: C/N ratio on day 35 of composting process.

Perlakuan	C/N (%)
A	22.00^{e}
B	25.00^{f}
C	19.00^{d}
D	13.00^{c}
E	9.00^{b}
F	8.00^{a}

Note: The numbers followed by the same letter are not significantly different based on the test Duncan at the 1% level.

3.6. Nutrient Value of Compost

Composting method using fungal consortium *Amblyosporium* sp, *Aspergillus* sp1, *Aspergillus* sp2., on various composition in the composting media is able to increase nutrient content of nitrogen by 1.13-1.16%, phosphorus by 0.90-1.98%, potassium by 0.79-1.62%, magnesium by 4585-6866 ppm, and sulfur by 0.21-0.25%. Meanwhile, composting method using *Trichoderma* sp is able to increase nutrient content of nitrogen by 1.12-1.17%, phosphorus by 0.97-1.59%, potassium by 0.72-1.84%, magnesium by 4136-6804 ppm, and sulfur by 0.18-0.245%.

TABLE 3: Nutrient content of nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), and sulfur (S) in the 35th day of composting.

Treatment	Nutrient Content				
	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Magnesium (ppm)	Sulfur (%)
A	1.16^{ab}	0.90^{a}	0.79^{b}	4585^{b}	0.20^{b}
B	1.17^{b}	0.97^{a}	0.72^{a}	5050^{c}	0.24^{bc}
C	1.14^{ab}	1.32^{b}	0.91^{c}	6227^{d}	0.21^{bc}
D	1.12^{a}	1.59^{d}	1.27^{d}	6604^{e}	0.13^{a}
E	1.13^{ab}	1.98^{e}	1.62^{e}	6866^{f}	0.25^{c}
F	1.14^{ab}	1.44^{c}	1.84^{f}	4136^{a}	0.18^{b}

Note: The numbers followed by the same letter are not significantly different based on the test Duncan at the 5% level. Control: Cake filter is not composted; C-organik 14.14%, C/N 11%, Nitrogen 1.27%, Phosphorus 2.03%, Pottassium 0.73%, Magnesium 3878 ppm and Sulfur 0.21%.

3.7. Temperature

Temperature is an important parameter in composting organic matter. During the composting process, microorganisms release heat and energy by breaking down organic matter [4]. Temperature fluctuations illustrate the metabolic activity of microbes involved in the composting process [5]. In this experiment, the temperatures in the first week of all treatments increase and continue to decrease in the second week to the fifth week. This decreasing temperature shows that the decomposition process has been going well. In the initial stage of the composting process until the first week, the composting temperature in treatment A, B, and D increase at above 45°C (Fig. 1), temperature of treatment C reaches 75°C. The increasing temperature above 45°C indicates that the composting process is in the thermophilic phase, while mesophilic microbes work at the beginning and the end of composting process. Plat et al. [6] states that during the thermophilic phase, the temperature should be in a range of 52-60 ° C. However, if the temperature exceeds the tolerance limit of thermophilic microbes, the effect is detrimental to the composting process.

The increase in temperature of the fungal consortium *Amblyosporium* sp, *Aspergillus* sp1, and *Aspergillus* sp2 compared to *Trichoderma* sp. fungus. The activity of fungus consortium in degrading the organic material is higher compared to the use of a single isolate *Trichoderma* sp. The use of filter cake and manure on sugarcane bagasse treatment C causes the composition of compost to be denser than treatment A and B. These conditions cause lower porosity, so that the aeration process is lower compared to treatment A and B. Thus, the heat generated due to the activity of fungus metabolism in the composting process is not much lost, so that the temperature in treatment C and D is higher than treatment A and B.

3.8. pH

The pH value indicates the acidity or alkalinity of organic matter and affects the growth of microorganisms. Optimal pH for composting is from 7.0 to 8.0 [7]. Meanwhile, F. Schuchardt et al. [8] say the composting rate is determined at pH 6.0 to 7.5 and the quality of the substrate. The research shows that treatment A, B, C, and D that show the pH range from the first week to day 35 are at pH of 6.5-7.5. It indicates that the composting process is going well. This is different from treatment E and F. The level of pH in the first is at 8.0 and decreases to 7.0 in the following week at the end of the experiment. The change of pH from 6.0 to 7.0 indicates that organic acids have been successfully decomposed [7] and from bases to neutral with pH of 8.0-7.0. This is in line with the results of a research carried out by Dotaniya et al. [9] stating that adding filter cake can increase pH.

3.9. Water Content

Humidity plays a role in controlling the temperature during composting process. The ideal composting humidity is 45-60% [10]. Low humidity slows down the composting process. In treatment C, the composting process seems to be slower than treatment D, in which the C/N ratio of treatment D is lower than treatment C. It is because the water content of treatment C was lower due to the very high temperature in the first week during the composting process. This is in line with Schucdart's statement [8], which is the decreasing water content due to an increase in temperature cause the rate of degradation in the media. Besides the water content factor, the high increase in temperature will cause the enzyme to work improperly, so that it will slow down the process of decomposition of sugarcane bagasse, filter cake, and manure. These two factors are the reason of the fungal consortium in C treatment having higher C/N ration than treatment B using *Trichoderma* sp.

3.10. C/N Ratio

The composting process depends on the composition of ratio of carbon and nitrogen in the compost material. This ratio affects the speed of composting process and volume of compost produced. During composting process, microorganisms utilize carbon as a source of energy and nitrogen as a constituent of cell structures. If the C-organic content is excessive, the decomposition process will decrease. Meanwhile, if the C-organic content to convert nitrogen into protein is less, microorganisms will use most of the available C, resulting in the loss of N through volatilization [11]. When nitrogen content in compost material is less, this condition can be overcome by adding urea or other nitrogen sources [12].

In the observation, C/N ratio of treatment A is 22%, which is lower than treatment B, which is 25% (Table 3). This shows that fungal consortium *Amblyosporium* sp, *Aspergillus* sp1, *Aspergillus* sp2., is more effective in accelerating the composting process compared to *Trichoderma* sp. single isolate that is used as a comparison single isolate. This is due to the existence of fungal consortium in degradation process of sugarcane bagasse organic material, filter cake, and manure that will accelerating the composting process faster than using a single isolate. This is in line with the results of research by [5] resulting in an optimal C/N ratio of 20-25% in composting using bagasse, sawdust, alder leaves, and cotton waste.The results of this experiment are better than the results of a study conducted by [13] that uses filter cake, resulting in C / N ratio of 18.54%. Meanwhile, the results of a study carried out by [14] using filter cake composting applying windrow method using a microbial consortium for 45 days show C/N ratio ranging from 10.19% to 22.34%.

The results of experimental show different things in treatment C when the composting media consist of sugarcane bagasse, filter cake, and manure, in which the fungal consortium *Amblyosporium* sp, *Aspergillus* sp1, and *Aspergillus* sp2., has C/N ratio of 19%, which is higher than treatment D using *Trichoderma* sp., with C/N ratio of 13%. This difference can be caused by decomposition inhibition process in treatment C that occurs due to the very high temperature in the first week, that is $70^{0}C$ (Figure 1), generating enzyme that does not work well in decomposition process of organic matter. Furthermore, the low level of water content 14.42% compared to the water content of treatment D 24.69% causes the inhibition of decomposion that induces the increase of temperature, affecting the rate of media degradation. This is line with Schucdart [8]who states that the decrease of water caused by the increase of temperature will decrease the rate of media degradation. Besides water content, the increase of temperature (Figure 1 and 2) makes enzym to not work and affect the decomposition process of organic materials.

The treatments of adding filter cake and manure treatments E and F to the fungal consortium *Amblyosporium* sp, *Aspergillus* sp1, *Aspergillus* sp2 and *Trichoderma* sp.

result in a lower C/N ratio of 9% and 8% compared to treatment A, B, C, and D. The low C/N ratio in treatment E and F are caused by not using sugarcane bagasse as a carbon source, and only using filter cake and manure that have low carbon content and high nitrogen content.

The results of C/N ratio produced in this study indicate that the stability of composting process is achieved on day 35. The composting duration is faster than what has been stated by López-González's research [15] that carries out the composting process using sugarcane bagasse, with a ratio of 2:1 and produced stable compost on day 90. Meanwhile, Zayed & Abdel-Motaal's [16] that use *Trichoderma* fungus with bagasse, filter cake, manure, and fresh alfalfa media, and produces C/N ratio of less than 16% with pH of 5.5 on day 90. The results of the study show that lignocellulolytic fungal consortium is able to accelerate the composting process effectively, which produces compost with C/N ratio of around 9-22%.

3.11. Nutrient Content of Compost

Composting process increases nutrient content of compost in all treatment. The highest nutrient contents increased in consortium *Amblyosporium* sp, *Aspergillus* sp1, and *Aspergillus* sp2 treatment E are phosphorus 1.98%, magnesium 6866 ppm, and sulfur 0.25%. Meanwhile, the highest nutrient content increased in fungi *Trichoderma* sp. treatment F is potassium, which is 1.84%. *Aspergillus* is said to be the most powerful phosphate solvent [17]. The increasing percentage of phosphorus and potassium in the soil that is given treatment is due to *Trichoderma* fungus, which plays an important role in increasing P and K content during the composting process[18].

4. Conclusions

Lignocellulolytic fungus *Amblyosporium* sp, *Aspergillus* sp1, and *Aspergillus* sp2 is able to accelerate the composting process effectively and can increase nutrient content in various composition in the composting media.

5. Acknowledgement

We would like to thank the Ministry of Research and Technology of Directorate of Higher Education, Hasanuddin University, State Agriculture Polytechnic of Pangkep for their financial support and facilities to carry out this research.

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