KnE Life Sciences
ISSN 2413-0877 Volume 2 (2015) 677-681
The 3rd International Conference on Biological Science 2013
(The 3rd ICBS-2013)

The Synergy of Biochar During Composting for Supporting Sustainable Agriculture

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Abstract. To initiate the decomposition process need decomposer inoculants and an easily available nutrient as C sources (sugar, carbohydrate) and N sources (protein, N inorganic fertilizer). Fresh organic materials are suitable sources for all nutrient needed. Cattle manure or Urea is important N sources for the initiation of composting process. Charcoal – Ash is referring the entire remnants of a wood/bamboo burning fire. In reality, what remains after a typical fire in a bamboo or wood burning stove or fireplace is both ash and charcoal. Both ash and charcoal can offer tremendous benefits to the compost and garden soil. In order to enhance the decomposition processes and its quality of compost, addition of other valuable materials are necessary. Therefore preliminary study of synergy of biochar for composting was conducted**.** The field experiments were conducted in Terantang village, Sampit-Central Kalimantan and laboratory analysis were conducted in the laboratory of ecology and physiology of microorganisms, Reserach Center for Biology Cibinong. Composting experiments were done by using compostion of brackens (*Pteridium aquilinum*) and rattan wastes : bamboo charcoal : cattle dung (80:3:17; by volume). Use a shovel to turn the compost after reach maximum temperature and start to cooling. After 3 months incubation, the parameters measured were the number of plant growth promoting rhizobacteria after composting and the C/N ratio of the compost. Those all parameters were compared with natural composting (control). The significant higher number of PGPR and better quality of final compost of treated biochar were observed

Key words: biochar, compost, plant growth promoting rhizobacteria, sorghum

INTRODUCTION

Bracken (*Pteridium aquilinum*) is a fern commonly found in woodland and heath land. It is tolerant of a wide range of soils and climates. Bracken is typically fern-like, producing triangular fronds, divided into three, that can reach over 1.5m (5ft) in height. The old fronds turn reddish-brown and die back to ground level, with new fronds unfurling from the base (Donnelly, 2004). The home industry of rattan found widely in Terantang. Therefore the waste of rattan processing and bracken biomass can be used as raw material for composting.

Bracken is a valuable compost ingredient, with relatively high concentrations of nitrogen and potassium. The carcinogen ptaquiloside is destroyed during the composting process (Pitman

Selection and Peer-review under responsibility of the 3rd ICBS-2013
Doi http://dx.doi.org/10.18502/kls.v2i1.247

and Webber, 1998, Donnelly at al, 2006). Composting might be increased the proportion of 'fines' (particles less than 6 mm in length) so giving better water holding capacity.

In order to enhance the decomposition processes and its quality of compost, addition of other valuable materials are necessary. Charcoal – Ash is referring the entire remnants of a wood/bamboo burning fire. Both ash and charcoal can offer tremendous benefits to the compost and garden soil. To initiate the decomposition process need decomposer incolulant and an easily available nutrient as C sources (sugar, carbohydrate) and N sources (protein, N inorganic fertilizer). Fresh organic materials are suitable sources for all nutrient needed. Cattle manure or Urea is important N sources for the initiation of composting process.

The aim of this research was to evaluate the effect of bambo biochar on bracken composting that combined with rattan waste and cattle manure. Those biomass wastes represents an important organic waste generated in Terantang village, Sampit, Central Kalimantan. The effect of bambo biochar was compared to naturally composting process. The effects of biochar on the composting process were evaluated based on the changes in different containing PGR and C/N ratio of the final compost.

MATERIALS AND METHODS

Composting

Collected dry and fresh Bracken (*Pteridium aquilinum*) and small amount of dry rattan wastes:cattle dung:bambo charcoal (80%:17%:3%) were mixed well. The Charcoal bambo were prepared by burning bambo in the carbonizing steel pan. After addition of 1 % Urea, all materials were poured with water and arranged as a bin composting and covered by plastic "Terpal". Use a shovel to turn the compost after reach maximum temperature (about 3 weeks) and start cooling. After 3 weeks incubation, the composting materials were turned and mixed well every 10 days. After 3 months incubation, the parameters of the number of plant growth promoting rhizobacteria and the C/N ratio of the compost were measured by CN-coder.

Isolation of bacteria from compost

The P- solubilizers were isolated from the compost samples compared to natural compost by serial dilution technique (Johnson and Curl, 1972). Appropriate dilution was spread on Pikovskaya agar plate containing insoluble calcium phosphate. Plates were incubated at 30±0.1 ºC for 24-48 h. Colonies showed halo zone were considered as P-solubilizer. The P-solubilizers were purified by repeated streaking and stocked for further use.

Isolation and detection of IAA producing bacteria

The IAA producing bacteria were isolated by serial dilution technique. Appropriate dilution was spread on trypto soy broth (TSB) agar containing 0.1% DL tryptophan and incubated at

room temperature. After the colony eppeared, the Salkowski reagent were sprayed and incubated 30 min in dark. Colonies showed pink colour were consindered as IAA-producer. To measure the IAA producing activity, the bacteria target were grown in the nutrient broth suplemented with DL tryptophan (Loper and Schroth).

RESULTS AND DISCUSSION

In order to produce a good quality of organic fertilizer we combined biomass of dry and fresh Bracken (*Pteridium aquilinum*), dry rattan wastes, cattle dung and bamboo charcoal for composting. According to Neklyudov et al. (2006), all proper composting processes go through four stages: (1) mesophilic, (2) thermophilic, (3) cooling, finally ending with (4) compost maturation. The duration of each stage depends on the initial composition of the mixture, its water content, aeration and quantity and composition of microbial populations. The final product of this biological process is a humus-like, stable substrate, being free of pathogens and plant seeds which can be beneficially applied to land as an agent for soil amelioration or as an organic fertilizer.

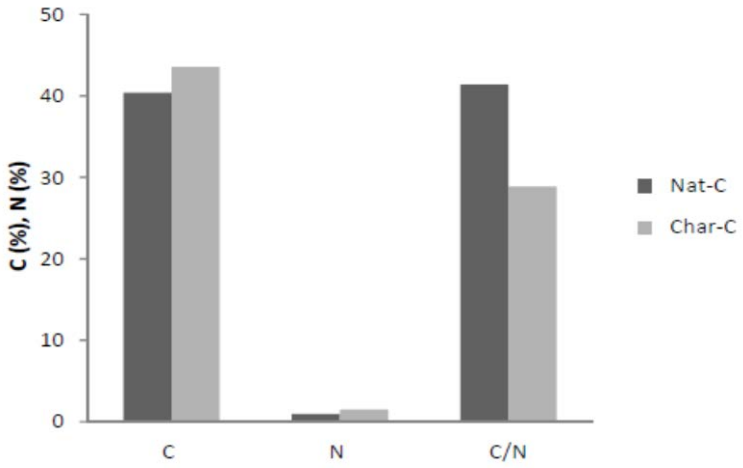

Figure 1. C/N ratio of compost after finish composting

Figure 1. shows that compost made from bracken, dry ratan wastes, cattle dung and biochar (bambo charcoal) contained higher C and N, compared to natural compost. It indicated that addition of 17 % cattle dung, 3 % bamboo charcoal and 1 % Urea could improve chemical properties of compost. Compared to natural compost and biochar mixing, an increased decomposition of biochar can be expected during composting although biochar is much more stable than other organic materials. Kuzyakov et al. (2009) reported that biochar decomposition rates increase if easily degradable C-rich substrate was available. Furthermore surface oxidation will enhance the capacity of biochar to chemisorb nutrients, minerals and dissolved OM. The overall reactivity of biochar surfaces therefore probably increases with composting (Thies & Rillig, 2009).

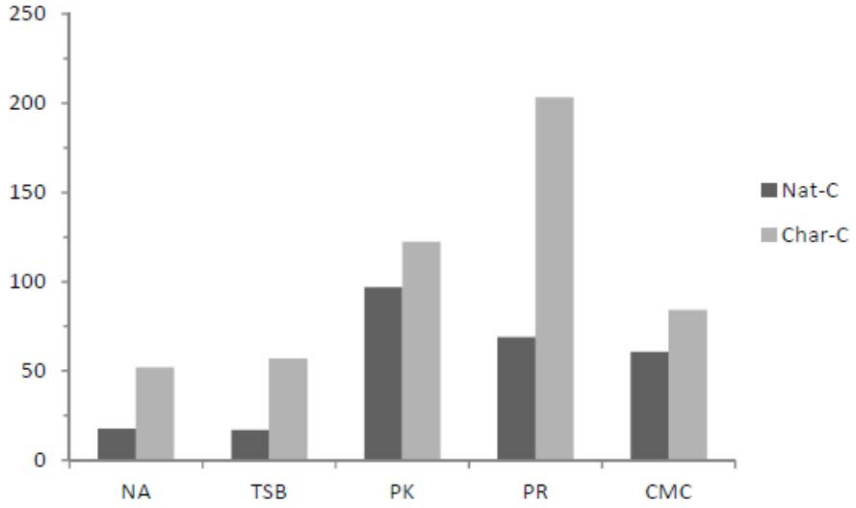

Figure 2. Population of Plant Growth Promoting Rhzobacteria after 3 months incubation
Nat-C: Natural composting; Char-C: composting mix with bamboo charcoal; NA : General Bacteria (10^7), TSB: IAA producing bacteria (10^6), PK: P-solubilising bacteria (10^5), PR: Proteolitic bacteria (10^6), CMC: Cellulitic bacteria (10^6)

Addition of cattle dung and bamboo charcoal in the biomass composting material could also improve the biological properties of the compost, as shown in the figure 2. Compared to natural compost and biochar mixing, an increased number of beneficial bacteria can be expected during composting. The number of general microorganisms, Phosphate solubilizing bacteria, IAA producing bacteria and proteolitic bateria were sginificantly higher in the compost treated with bamboo charcoal and cattle dung compare to natural compost (Figure 2.). Addition of cattle dung and bamboo charcoal in the biomass composting material could also improve the biological properties of the compost, as shown in the figure 2. Compared to natural compost and biochar mixing, an increased number of beneficial bacteria can be expected during composting. The number of general microorganisms, Phosphate solubilizing bacteria, IAA producing bacteria and proteolitic bateria were significantly higher in the compost treated with bamboo charcoal and cattle dung compare to natural compost (Figure 2.). It indicated that biochar in compost provides habitats for microbes, thereby enhancing microbial population and their activity. Steiner et al. (2011) reported increased moisture absorption of biochar-amended composts with beneficial effects on the composting process. Further more, Steiner et al. (2011) and Smith et al. (2010) also stated that from the compost point of view, there is evidence that biochar as a bulking agent improves oxygen availability and hence stimulates microbial growth and respiration rates. Pyrolysis condensates adsorbed to biochar initially provoked increased respiration rates in soils which most likely occur also during composting. Nevertheless, fermentation theoretically provides

microorganisms to soil which could be beneficial for soil health and ecosystem services (Fischer and Galser, 2012). Bacterial strains capable of producing beneficial substances for plant were significantly higher in the composting mixed with charcoal than the natural composting (control), as shown in the figure 2.

Charcoal could improve the composting processes as well as the biochemical properties of compost by increasing the number of PGPR (P-solubiliser, IAA producer, protein and Cellulose degrader) and has a big potential to synergize the use of biofertilizer for supporting sustainable agriculture

Acknowledgment

The research was supported by Center for Sustainability Science (CENSUS)-Hokkaido University and Organic Biiofertilizer National Priority project (PN Pupuk Organik Hayati), The Indonesian Institute of Sciences (LIPI)

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