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STRAW COMPOSTING WITH BIOLOGICAL AGENT INOCULATION AND APPLICATION BIOFERTILIZER TO INCREASE RICE PRODUCTION

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ABSTRACT
Problems using straw directly include the contamination of germs on the straw from the previous crop. Alternatives that can be done are giving inoculant of biological decomposers The purpose of the research to test isolates decomposer in the rate of straw decomposition in soil and to test isolates biofertilizer on rice plants in soil treated straw compost. Greenhouse experiment was conducted for selecting isolates and formulations decomposer consortium and biological agents as well as the selection and formulation of biological fertilizers isolates. This experiment was consisted of treatments, i.e. incubation time composting (1, 2, 3, and 4 weeks) and inoculant (formulation A containing microbes T. harzianum, Bacillus subtililis, Cytophaga sp. and Bacillus licheniformis; i_2 = Formulation B containing microbes B. subtililis, Cytophaga sp., and B. licheniformis, Streptomyces sp.) The field experiment was conducted to determine the effect of straw compost and biofertilizer inoculants (nitrogen fixation bacteria and phosphate solubilizing bacteria) on rice. Research at this stage using split plot experimental design was repeated three times. The main plot was the doses of straw compost + biofertilizer consisting of 8 treatments (0; 2.5; 5.0; 7.5 t ha^{-1} without and with biofertilizer 400 g ha^{-1}). The subplot was doses of inorganic fertilizer N, P and K consisting of 5 levels (100%, 90%, 80%, 70% and 60% of recommendations dosages). The results showed that the A formulation containing T. harzianum, B. subtililis, Cytophaga sp. and B. Licheniformis whereas B formulation contains B. subtililis, Cytophaga sp., and B. Licheniformis, Streptomyces sp. B formulation capable of decomposing straw is better than A formulation. Application of straw compost and biofertilizer (5,0 t ha^{-1} + 400 g ha^{-1}) could increase the yield of rice to 13.3% and substitute 20% of inorganic fertilizer (N, P and K).

Keywords: Composting, Biofertilizer, Biological agents, Straw, Rice.

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Contribution/ Originality
This study is one of very few studies which have investigated to obtain decomposers consortium formulation which can be effective to straw composting and to study the effect of biofertilizer inoculants on rice plants in soil treated with straw compost.

1. INTRODUCTION
Rice straw is a plant residue that is easy to obtain in paddy fields. Problems of using straw directly are the danger of contamination of germs on straw from the previous crop. The recommended solution is composting hay earlier. The main straw composting, these include the necessary labor (preparation of materials, transport and maintenance) and the cost is relatively large. An alternative solution is to do a haystack inoculation with a consortium of decomposers with biological agent before tillage (direct composting). Inoculation consortium

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decomposers are added to the rice straw needs to be tested in decomposition rate primarily influence the incubation time and the type of consortium.

Another thing that can be done to increase rice production and increase the availability of nutrients is to utilize the potential of biofertilizers as nitrogen fixation bacteria (*Azotobacter* sp. and *Azospirillum* sp.), phosphate solubilizing bacteria (*Pseudomonas* sp. and *Bacillus* sp.). Fitriatin *et al.* (2011) phosphate solubilizing microorganisms-producing growth regulator (Fitriatin *et al.*, 2013). Application of consortium biofertilizer can increase the yield of tomatoes and maize production significantly (Simarmata, 2007).

The effort of using straw to increase rice production and efficiencies of inorganic fertilizers, further research is necessary to (1) determine using microbial consortia of decomposer with biological agent, especially cellulolytic and lignolytic, (2) the duration of prior inoculation of a haystack simultaneously incorporated into soil, (3) measuring the decomposition of straw after incorporated into soil, (4) get the best biofertilizer inoculants to improve outcomes rice and reduce inorganic fertilizers needed (Tate, 1984; Sarapatka, 2003).

Straw composting with biological agent can improve the quality of compost. Straw compost is important for sustainable agriculture, as a source of nutrient and energy source for nitrogen fixation bacteria and phosphate solubilizing bacteria (Whitelaw, 2000). Use of these beneficial microbes in cultivated rice fields using the technology of water management systems is very good because the condition is not permanent anaerobe. The combination of composting straw on the field and the use of biofertilizers consortium are expected to increase the availability of nutrients, grain yield and reduce the use of artificial fertilizers significantly (reducing the cost of fertilizer). The main principle of utilizing the potential of environmentally friendly natural and minimizing external inputs in revitalizing soil quality and sustainable agriculture.

The study was based on the development of biotechnology science to increase rice production and reduce dependence on external inputs, the purpose of this research as follows:

1) to obtain decomposers consortium formulation which can be effective to straw composting
2) to study the effect of biofertilizer inoculants (nitrogen fixation bacteria and phosphate solubilizing bacteria) on rice plants in soil treated with straw that had been inoculated decomposer consortium.

2. MATERIALS AND METHODS

The preliminary research to screening of isolates and formulations consortium decomposers and biological agents carried out in the Laboratory of Soil Biology and the Laboratory of Phytopathology, Agriculture Faculty, Universitas Padjadjaran. Two formulation decomposer with biological agent (A: *Trichoderma harzianum*, *Bacillus subtililis*, *Cytophaga* sp. and *B. Licheniformis*; B: *B. subtililis*, *Cytophaga* sp., *B. licheniformis*, *Streptomyces* sp.) was carried out to determine the best formulation decomposer in the rate decomposition straw composting. C/N ratio and CEC were observed for every week during composting until four weeks.

The field experiment with water management system was using the split-plot design with three replications. As the main plot was the dose of straw compost + biofertilizer (*Azotobacter* sp., *Azospirillum* sp., *Pseudomonas* sp. and *Bacillus* sp.); consists of eight factors (0 t ha^{-1} to 7.5 t ha^{-1} without and plus biofertilizer 400 g ha^{-1}). As a subplot was doses of an inorganic fertilizer N, P and K consists of five factors (100%, 90%, 80%, 70% and 60% of recommendations dosages).

The plot treatment was 120 plots with an area of each plot was 10.5 m2 (3.0 x 3.5) m. The population of 100 plants per plot clump planting system TS = Twin seedling) with a spacing of 30 cm x 35 cm. The main response variable, is due to the treatment of data include: plant growth, yield of rice, soil chemical : content of soil N, P, and K . Soil nitrogen was measured using the Kjeldahl method. Soil P available was measured using Olsen and soil potassium was measured using HCl 25 %.

Compost Preparation Composting straw was using a consortium decomposers of : *Bacilus subtilis*, *Cythopaga* sp, and *Streptomyces* sp. with an incubation period of 2 weeks (according to the results of the preliminary study).

Biofertilizer Application Biofertilizer applications have been diluted given 2 stages. The first stage was application in the nursery field with a dose of 50 g m^{-2}, given the spread just before sowing. The second stage was application on cropping land.

3. RESULTS AND DISCUSSION

3.1. Screening of Decomposer with Biological Agent on Quality of Straw Compost

The results of chemical analysis of the compost (Table 1) as a whole because there has been a successful composting of organic matter decomposition, as shown by the organic-C, C/N ratio, CEC compost tends to fall and N compost increased. Treatment consortium decomposer formulation to give effect to the results of chemical analysis, along with increasing incubation period of composting. Formulation B is the best because C / N ratio is lower due to period of incubation.

The high value of C/N ratio obtained after incubation is possible because of the high value of the C/N ratio of early rice straw because straw is used for this experiment was 1 week after harvest, where the straw is still relatively fresh , and the size of straw (30 - 50 cm). However, this condition is categorized either as compost straw incorporation still have time before planting. The C / N ratio of organic materials in accordance with the C / N ratio of the soil (Dou *et al.*, 2008; Simarmata *et al.*, 2009).

Composting of straw materials which have C/N high initial composting takes longer , but it can shorten your activator by adding organic material containing high nitrogen , such as proteins, amino acids, urea , etc. Activators can be obtained from decomposer microbes originating from animal waste, compost or other soil containing humus. The size of straw is important of the raw material . The smaller of organic material will increase the surface area of compost materials to facilitate microbial to decompose. Size range 5-10 cm suitable for composting , because it is better for air circulation (Nuraeni, 2003).

Microorganisms require carbon for growth and nitrogen for protein synthesis . Carbon takes as many as 30 parts by weight of a part nitrogen , so that the ratio C/N : 30 is the most efficient value for composting. Composting will success depends on several factors, such as : C/N ratio, particle size, aeration and humidity (Dou *et al.*, 2008).

Table-1. Effect formulation decomposer and period of composting on C - organic , N, C/ N and CEC Compost

Formulation* and period of composting	C-org (%) C/N Walkley & Black	N (%) Kjeldahl	CEC (c mol/kg) NH4 acetate pH 7	
1 week				
Control	24.08	0.46	52	36.74
A Formulation	32.63	0.59	55	37.18
B Formulation	27.63	0.55	50	36.06
2 weeks				
Control	23.47	0.48	49	34.09
A Formulation	31.00	0.61	51	36.76
B Formulation	26.78	0.59	45	35.89
3 weeks				
Control	21.45	0.49	44	32.14
A Formulation	30.25	0.64	47	33.89
B Formulation	25.41	0.63	40	32.14
4 weeks				
Control	20.37	0.50	41	30.22
A Formulation	27.26	0.67	41	32.46
A Formulation	23.57	0.65	36	29.30

*formulation A: Trichoderma harzianum, Bacillus subtililis, Cytophaga sp. and B. Licheniformis formulation B: B. subtililis, Cytophaga sp., B. licheniformis, Streptomyces sp.

The C/N ratio of the soil is < 20, and the formula B, incubation period 1 and 2 weeks value of C/N ratio 18 and 17, meaning that the C/N ratio of compost according to the C /N soil. With continued incubation period and the incorporation of the total carbon content decreases while the nitrogen content increases, then the temperature will be stable. At the end of the process will be found that is biologically stable with a C/N ratio is relatively low.

Organic materials can increase the CEC (cation exchange capacity) of soil twice to 30 times greater than colloidal minerals. The increase in CEC is due to weathering of organic 139 material that will produce humin (organic colloids) that has a surface can hold nutrients and 140 water, thereby increasing the soil 's ability to hold nutrients and water.

3.2. Application Straw Compost and Biofertilizer on Rice Cultivation with Water Management System

The results showed that organic fertilizer and inorganic fertilizers (N, P and K) influence on the yield of rice (Table 2). There was an interaction effect between organic fertilizer and inorganic fertilizer. Providing organic fertilizer (compost 2.5 t ha^{-1}; 7.5 t ha^{-1} + 400 biofertilizer) and inorganic fertilizer (100% N, P, K recommendations doses) can increase the yield. The application of compost 5 t ha^{-1} + 400 g ha^{-1} biofertilizer along with 80% dose of NPK increased the yield of rice to 7.20 kg plot^{-1}.

Table-2. Effect of straw compost + biofertilizers and inorganic fertilizers on yield of rice

Straw compost + biofertilizers (J)		**Yield of rice (kg ha^{-1})**			
			Inorganic fertilizer		
	100%	**90%**	**80%**	**70%**	**60%**
0 t ha^{-1} + 0 g ha^{-1}	6.59 b* E	6.48 d D	6.35 c C	6.07 b B	5.99 b A
0 t ha^{-1} + 400 g ha^{-1}	6.77 d E	6.44 c D	5.87 a B	6.21 c C	5.59 a A
2,5 t ha^{-1} + 0 g ha^{-1}	6.82 e E	6.18 a C	6.40 d D	5.91 a B	5.57 a A
2,5 t ha^{-1} + 400 g ha^{-1}	6.66 c D	6.24 b B	6.17 b A	6.49 g C	6.17 d A
5,0 t ha^{-1} + 0 g ha^{-1}	6.29 a C	6.63 e E	6,48 e D	6.24 d B	6.12 c A
5,0 t ha^{-1} + 400 g ha^{-1}	6.83 e C	6.62 e B	7.20 g D	6.36 e A	6.63 f B
7,5 t ha^{-1} + 0 g ha^{-1}	6.88 f E	6.61 e D	6.32 c A	6.45 f C	6.41 e B
7,5 t ha^{-1} + 400 g ha^{-1}	6.88 f C	6.90 f C	6.99 f D	6.56 h B	5.99 b A

*The average values in the same column and row marked with the same letter are not significantly different according to Duncan test at level 95%

Increasing of inorganic fertilizer tend to improve outcomes, when accompanied by high organic fertilizer and biofertilizers, the same trend seen in the provision of 80% of fertilizer N, P, K and show the highest results 7.20 kg plot^{-1} is equivalent to 6.35 tons ha^{-1} (13.3% increased compared to control). This suggests that the provision of straw compost 5 t ha^{-1} +400 g ha^{-1} biofertilizer can substitute 20% of NPK fertilizer and can increase yield of rice.

4. CONCLUSION

Decomposer is important for straw composting to improve quality and shorten period composting. The inoculation of decomposer as biological agents can be formulated by a single package of A formulation (*T. harzianum*, *B. subtililis*, *Cytophaga* sp., B. *Licheniformis*) or B formulation (*B. subtililis*, *Cytophaga* sp., *and B. Licheniformis*, *Streptomyces* sp). Among them, the B formulation had a better capacity for decomposing straw than the A one. Application of straw compost and biofertilizer (5,0 t ha^{-1} + 400 g ha^{-1}) could increase rice yield by 13.3% that is equivalent to 6.35 tons ha^{-1}.

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