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Effectiveness of rice straw with biodecomposer and biofertilizer application in new land clearing in Merauke, Papua

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Abstract. In order to fulfil rice production, there were new land clearing programs outside Java, including Merauke, Papua. There were several obstacles on rice cultivation in this area such as low soil fertility which has an effect on less optimal production. The objective of the research was to determine the effect of rice straw with biodecomposer and biofertilizer application for improving soil quality in new land clearing in Merauke, Papua. The research design was a split plot with the main factor was fertilizer (with and without rice straw with biodecomposer and biofertilizer application). The sub factor was three kinds rice varieties. The data were collected consist of soil chemical and biological properties, the rice growth and yield components. The results showed the addition of fertilizer did not significantly improved soil quality in new land clearing in Merauke, Papua. On the contrary, biofertilizer affect to seed vigor and viability in the nursery. The fertilizer addition significantly effected on rice growth and yield components, it was suspected by rice varieties having different resistance to pests and diseases and straw as compost will suppress the blast growth through temperature factor during decomposition. The highest yield was reached by Inpari 33 of 8.20 Mg ha^{-1}.

1. Introduction

Foodstuff is a strategic commodity, the availability of food is an absolute priority because it can create food security and national stability [1]. Rice is a strategic commodity and has become the main program of Ministry of Agriculture and since 2017 the government has targeted rice self-sufficiency. The opening new lands especially outside Java is an alternative to increase rice production. New open rice fields are important and the production needs to be increased because the rice position in Indonesia are very strategic in social, economic and political perspective; the need for rice continues to increase in line with the increase in population; the existence of irrigated rice fields in Java and Bali is getting smaller due to land conversion.

Land clearing faces many obstacles, including low soil fertility and soil organic matter. Most of land clearing on dry land is almost always faced with the problem of low land productivity at the beginning of utilization [2]. The low level of soil fertility is caused by intensive nutrient leaching in line with high rainfall and soil parent material is poor in mineral reserves. The development of new open rice fields outside Java generally occupies marginal soils such as Ultisols, Oxisols, Inceptisols and Histosols [3].

Soil fertility plays an important role in determining crop production. Continuous land use caused in reducing soil fertility due to removing during harvest. To compensate for the nutrients released at harvest and provide nutrient for plant uptake, fertilization is carried out both chemically and organically. The continued chemical fertilizers application has a negative effect on the soil and the environment. To reduce these effects and ensure adequate nutrients for plants, the use of organic and biological fertilizer are very important.

Organic fertilizer is beneficial for increasing agricultural production both quality and quantity, reducing environmental pollution and improving soil quality. Organic matter has an important role in improving the soil physical, chemical and biological properties. Organic matter contains organic C and to obtain optimal land productivity, C-organic > 2.5% is needed. Organic matter with high C/N content such as rice straw has a greater effect on improving soil physical properties compared to decomposed organic matter such as compost [4]. The nutrient composition of rice straw is as follows: N (0.66%), P (0.07%), K (0.93%), Ca (0.29%), Mg (0.64%), Fe (427 mg kg^{-1}), Cu (9 mg kg^{-1}), Zn (67 mg kg^{-1}), and Mn (365 mg kg^{-1}) [4].

Rice straw components such as cellulose, hemicellulose, lignin and protein create a high C/N ratio so that it takes a long time for the straw decomposition process. For accelerating the straw decomposition process, it is necessary to add a decomposer in the form of bacteria or fungi which are producing cellulase enzymes [5]. The process of reforming organic matter that occurs naturally will take a relatively long time (2 months), greatly inhibiting the use of organic matter as a nutrient source. When faced with short planting deadlines, immersing organic matter is often considered impractical and inefficient. To overcome this, it is necessary to inoculate selected microbes to accelerate the process of organic matter decomposition. The acceleration of crop residues decomposition can increase the amount of organic matter and nutrient availability and soil preparation period is shorter and accelerates the next planting period. The decomposition of plant residues is the right strategy to protect and improve soil quality and avoid nutrient immobilization and allelopathy [6].

The straw produced from rice cultivation is 7 to 10 Mg ha^{-1} [7]. The rice straw which contains about 40% C and it is easily to decompose biologically and is a substrate for soil microorganism growth. In Papua, especially Merauke, rice straw was not used as animal feed and after harvest the straw was usually burned. To make use of the straw so that it is not wasted, straw composting was carried out as a source of organic matter.

Biofertilizer is a non-pathogenic microbial-based fertilizer which functions to improve soil fertility and health through several activities produced by these microbes, including nitrogen fixation, dissolving insoluble phosphate and producing phytohormones. Biofertilizer can increase fertilization efficiency and support eco-friendly agriculture. Biofertilizer technology is the use of active biological products consisting of soil fertilizing microbes to increase fertilization efficiency, fertility and soil health. The use of soil fertilizing microbes can provide nutrients for plants and plant growth regulating metabolites, as well as protect roots from pests and diseases. The use of organic fertilizer as one of the components of agricultural technology that is environmental friendly and sustainable is complementary to other technology components, so it is appropriate for use in agricultural productivity improvement programs [6].

One of the technological innovations that are relied on increasing rice productivity is the use of new high yielding varieties (VUB). The development of rice using new high yielding varieties has advantages such as resistant to pests and diseases, resistant to environmental stress and has a higher yield potential when compared to local varieties. The Indonesian Agency for Agricultural Research and Development has released several new high yielding varieties of rice that can be cultivated in accordance with the local agro-ecosystem.

Merauke is one of the districts in Papua Province which has potential land resources for agriculture. Based on data from Statistic of Papua Province [8], the pady fields in Merauke is 40,266 ha, the largest in Papua and as the main producer of rice which enters Papua's paddy needs. The rice harvest area was 31,133 ha with a production of 130,718 Mg and a productivity of 4.12 Mg ha^{-1}. To increase rice production, starting in 2015 the Ministry of Agriculture opened a new rice field in Merauke covering an area of 2,115 ha. This is a special government effort to increase rice production as a support to achieve food self-sufficiency and to support the government program to become a world food barn by 2045.

This research was conducted to determine the effectiveness of rice straw with biodecomposer and biofertilizers application for improving soil properties and quality on new land clearing in Merauke, Papua.

2. Materials and methods

2.1. Research site, experimental design and farming management

This study was conducted at Nggutibob, Tanah Miring Sub-district, Merauke Regency, Papua, on September 2016 to January 2017. The research design was a split plot with the main factor was fertilizer (with and without rice straw with biodecomposer and biofertilizer application). In this experiment, rice straw with biodecomposer as organic fertilizer and together with biofertilizer in one packet treatment. The sub factor was three kinds rice varieties (Inpari 30 Ciherang Sub 1, Inpari 32 HDB, and Inpari 33). The area of the main plot was 30,000 m^2 and the subplot area was 10,000 m^2 with each subplot divide became three area as replication. Total plot area of 60,000 m^2 was collaborated with 5 farmers, each subplot stated ownership of the individual farmer. The soil has been classified as an Inceptisol.

Around 2 to 4 kg ha^{-1} commercial biodecomposer was mixed with 400 L clean water to decompose 2 to 4 Mg fresh rice straw from the previous harvest residue. The biodecomposer solution was watered evenly over the stumps and straw in the paddy fields, then processed by tractor, the soil was left moist and not flooded for at least 7 days [9]. After about two weeks the straw begins to decompose and the soil can be processed for planting preparation. Biodecomposer are microorganisms that break down fiber, lignin, and organic compounds containing nitrogen and carbon from organic matter [10]. According to ISRI [11], biodecomposer are microbes that play a role in accelerating the decomposition organic matter from plant debris into compost so that it can provide nutrients, improve soil structure and increase water holding capacity and soil biological activity. The biodecomposer consist of *Trichoderma reesei, T. harzianum, T. koningii, Phanerochaeta crysosporium, Cellulomonas, Pseudomonas, thermospora*, *Aspergillus niger, A. Terreus, Penicillium* and *Streptomyces*. Utilization of microorganism that decompose organic matter in accordance with the substrate of organic matter and soil condition is an effective alternative to accelerate the decomposition of organic matter and as fertilizer supplementation.

Then, commercial biofertilizer was prepared, which is only applied once when the seeds will be sown, in the following ways [9]: (a) rice seeds that had been soaked and brooded for 24 hours were drained in humid condition and then mixed with biofertilizer (mixing was carried out in a shady place); (b) the seeds that had been mixed with biofertilizer were sown immediately, try not to be delayed more than three hours and not to be exposed to sunlight to prevent microbes from dying which has adhered to the seed surface; (c) the remaining biofertilizer were distributed in the nursery; (d) prevent seed dispersal in rainy condition.

Biofertilizer contains a consortium of non-pathogenic endophytic bacteria for plants and humans, consisting of : (a) phyllosphere bacteria of phytohormones producer, *Methylobacterium* sp; (b) non-symbiotic rhizosphere bacteria for N_2-fixing and soil P solvent, *Azotobacter vinelandii*; (c) rhizosphere bacteria for soil P solvent, *Bacillus* sp.; (d) soybean symbiotic bacteria for N_2-fixing isolated from leaves, roots and rhizosphere, *Rhizobium* sp. and *Bradyrhizobium* sp.

The microbial consortium makes biofertilizer able to be used in several food crops and horticulture by increasing nutrient uptake (as N-fixing and phosphate solvent) and producing growth-promoting hormones that can stimulate growth, flowering, ripening, breaking dormancy, increase vigor and viability of rice seeds.

Then, around 15 to 18 days after seeds had been sowed, the seeds were planted in the paddy field that had been prepared. NPK Fertilization (15-15-15) at a dose rate of 300 kg ha^{-1} and Urea 200 kg ha^{-1}. NPK as basic fertilizer was given all at 1 to 2 weeks after planting, half the dose of urea was given as supplementary fertilizer at 3 to 5 weeks after planting and the rest was given at 6 to 7 weeks after planting. Recommendations for fertilizer requirements were based on test results with the Paddy Soil Test Kit. The level of N adequacy was monitored using the Leaf Color Chart (BWD) after the plants were more than 3 weeks after planting in a period of 7 to 10 days until the primordial phase. The pests and diseases eradication was caried out with pesticides according to the frequency of attack and weed control with herbicides and manual weeding.

2.2. Soil sample collection and analyses

Soil samples were collected before biodecomposer application and the plants were 40 days after planting. Soil sampling with auger at a depth of 0.3 m. Samples were taken by random sampling of 3 sample point each replication, the samples were composite as representatives each subplot. The samples were analyzed at Laboratory of Soil, Plants, Fertilizer, Water, Indonesian Soil Research Institute, Bogor. The analyses consist of soil chemical and biological properties namely C-organic (Walkley & Black), total nitrogen (N) (Kjeldahl), C/N ratio, P_2O_5 (Bray 1) and K_2O (Morgan), pH H_2O, pH KCl, and soil respiration.

For soil respiration, 100 g of soil samples at field capacity put into a jar, and 1 open plastic bottle containing 10 ml 0.2 N KOH (for CO_2 fixation released by microbial respiration in soil samples), then the jar was tightly closed during 7 days incubation. The same method was used for the control, for the jar was not filled with soil samples. After 7 days, take a plastic bottle that contains KOH and CO_2 which was already tied, then add 2 drops of phenoptalin indicator and titrate with 0.2 N HCl until the color of the solution changes from pink to clear. Then, drop KOH with 2 drops of methyl orange and the solution turns yellow. Titrate again with 0.2 N HCl and the solution change became orange. The CO_2 levels in each treatment were obtained after subtracting CO_2 levels in the jar without soil (blank). Nutrients uptake of N, phosphorus (P) and potassium (K) were measured respectively from leave samples of each rice viariety.

2.3. The growth and harvest data

In determining the effect of biofertilizer in spurring plant growth, at the nursery, the shoot heights of seedlings were measured at three days after sowing, and measuring plant height and root length at eleven days after sowing. The samples collection of 15 seedlings for each subplot of each rice variety and treatment. In the paddy field, data were collected for plant height and maximum tillers number at 36 days after planting. Before harvest, the data were collected again for plant height, productive tillers number, panicle length, number of seeds per panicle, and number of filled seeds. The data were taken 10 samples from each replication or 30 samples from each subplot for a total of 180 samples from the entire area. Afterwards, we weighed 1,000 grains and measured rice yield from each treatment. The calculation of rice yield refers to the Statistics Indonesia method.

2.4. Statistical analyses

Data were analyzed by ANOVA to determine the significance of the main factors and their interactions. If the results were significant differences, it was analyzed using Tukey test. The difference in the mean of the two independent sample groups using the t test. To determine the relationship between indicators used Pearson correlation. Data processing software used Excel and SPSS version 23 (SPSS Inc., Chicago, USA).

3. Results and discussion

3.1. The effect of rice straw with biodecomposer and biofertilizer application on soil chemical properties and soil biological activities

The results from soil analyses, the rice straw with biodecomposer and biofertilizer application had no significant effect on soil chemical and biological improvement (table 1).

Application of straw decomposed with biodecomposer on the soil before tillage and the addition of biofertilizer in the nursery did not have a significant effect on improving soil chemical properties. Based on the general criteria for assessing nutrients availability in the soil, the levels of C-organic and P_2O_5 in all treatments were low, as well as the total N content except in the straw with biodecomposer and biofertilizer treatments after soil tillage showed moderate criteria [12].

Tabel 1. The effect of rice straw with biodecomposer and biofertilizer application on soil chemical properties and soil biological activities.

	C-org	Total N	C/N Ratio	P_2O_5	K_2O	pH H_2O	pH KCl	Soil respiration
	%			mg kg^{-1}				(mg C-CO_2 day^{-1} kg^{-1} dry soil)
Treatments								
Before soil tillage	1.96	0.17	11	3	298	5.2	3.9	11,000
After soil tillage[a]	2.05	0.21	9	3.2	306	4.9	3.8	11,000
After soil tillage[b]	1.78	0.17	11	3.3	316	5	3.8	10,871
Significance	ns	ns	ns	ns	ns	ns	ns	ns

[a] After soil tillage (40 days after planting) with rice straw with biodecomposer and biofertilizer.
[b] After soil tillage (40 days after planting) without rice straw with biodecomposer and biofertilizer.
Numbers followed by the same letter within treatments were not significantly different at $P < 0.05$ by a Tukey test.

The experiment location was a new land clearing and showed a low pH that causes the low nutrient content in the soil. Changes in dry soil conditions into new paddy fields have consequences for changes in the soil physical, chemical and biological properties [3]. In the newly opened rice fields of Ultisols, iron poisoning and nutrient deficiency were the main problems that found in the first cultivation [2]. The other factor that causes low soil pH was the application of inorganic fertilizer which will be used by microorganism as an energy source to break down organic matter, resulting in organic acids which have the potential to reduce soil pH. These organic acids also indirectly cause the solubility of phosphate to decrease [13] which causes low P_2O_5 levels in the soil. Nutrients in soil are strongly affected by soil pH, phosphorus availability to plants is influenced by soil pH and its availability is maximized when pH is between 5.5 and 7.5 [14]. Ammonium ($NH4^+$) which is resulted from organic matter mineralization, is absorbed more efficient at a neutral pH, and optimum P availability is at pH 6.5 and K are less available in acid soil [15].

The rice straw with biodecomposer application before soil tillage can increase microbial activity [16]. However, from our results, the microbial activity in the soil did not show any difference before and after treatment, it was stable in 11,000 mg C-CO_2 day^{-1} kg^{-1} dry soil. In the first-year of fertilizer treatment, it has not shown improving soil biological properties and low content of soil organic matter is thought to have an effect on the low soil microbial activity. This reason is in accordance with the research results of previous studies which stated that organic matter affected the existence of microbial communities in the soil [17, 18]. Furthermore, the large amounts of organic matter derived from plant residues stimulate soil microbial activity and help increase P availability for plants [19]. Several further studies showed that the pH factor also affects to the soil microorganism activity. Allegedly, low soil pH which affects the soil microbial activity did not change much after treatment. The growth of phosphate solubilizing microorganisms is strongly influenced by soil acidity, optimum fungi are at pH 5 to 5.5, in contrast to optimum bacteria at neutral pH and increases with increasing soil pH. The rate of mineralization also increases with a pH value suitable for microorganism metabolism and the release of phosphate will increase with increasing pH values from acid to neutral [4]. Other studies suggest that bacteria reproduce at a pH of 5.5 or moderate, nitrogen-fixing bacteria from the air and nitrifying bacteria can only thrive at pH > 5.5 [20].

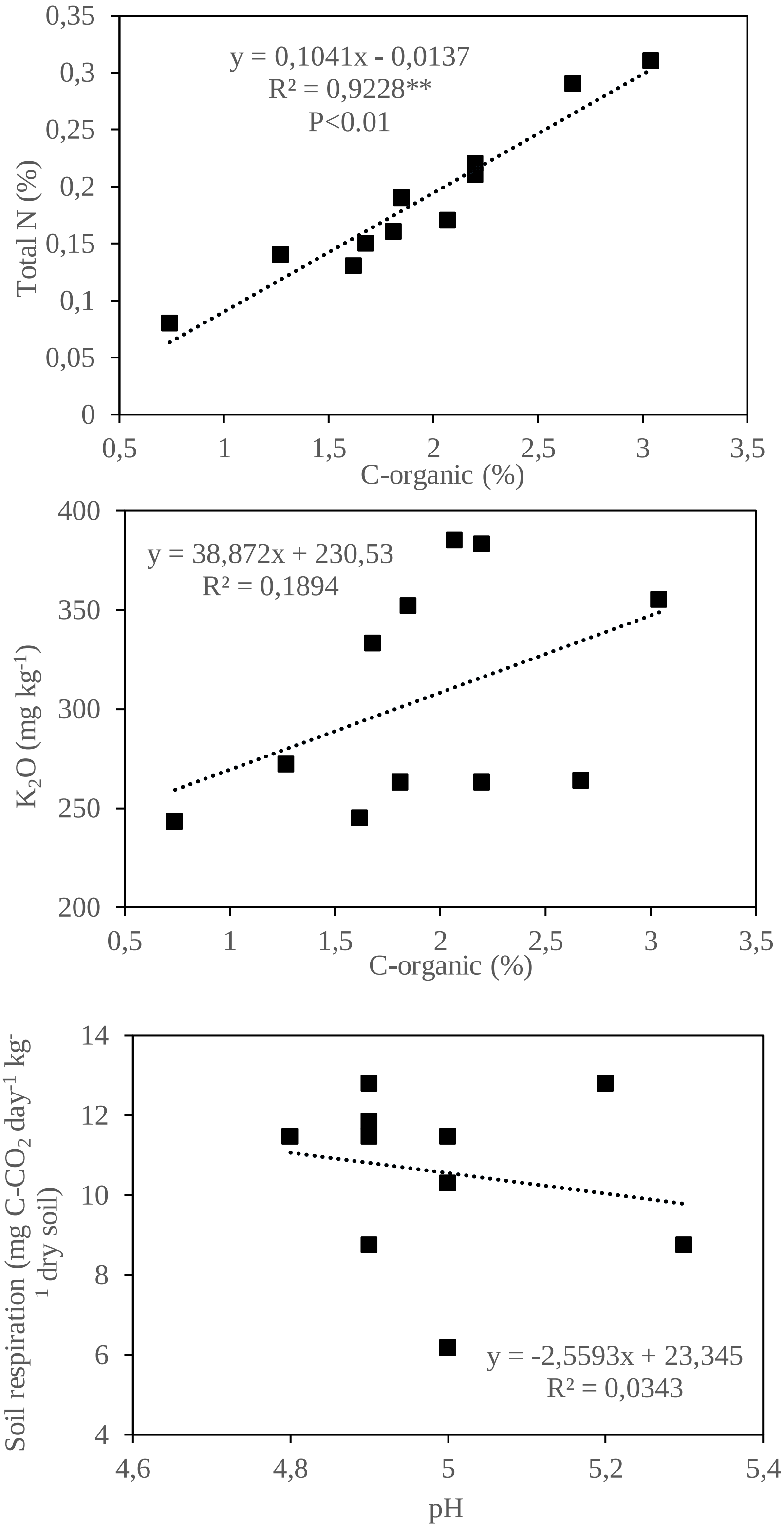


Figure 1. Correlation between C-organic and total N (a), C-organic with K_2O (b) and soil pH with soil respiration (c).

In the experimental data, only C-organic showed a strong relationship with total N in the soil (Figure 1a), on the other hand, the other soil elements did not show any correlation, either with P_2O_5, K_2O (Figure 1b) and microbial activity in the soil as described in soil respiration. Likewise, the soil microbial activity did not show a correlation with P_2O_5 and pH (Figure 1c).

Several previous studies showed different results that there was a strong relationship between C-organic and soil chemical-biological properties. Organic matter can increase P availability for plants uptake through DOM (Dissolved Organic Matter) which is released by organic matter and inhibits P adsorption onto the soil [21]. The addition of plant residues every year to the soil as a source of organic matter will increase the K content in the soil [22] and high levels of C-organic would stimulate soil microbial activity and mediate the mineralization of organic P to become available to plants [19].

3.2. Seed condition and seedling growth in the nursery
Rice seeds with biofertilizer showed that the shoots and roots grow faster when compared to those of untreated seeds. After being brooded for 24 hours and given biofertilizer, within 12 hours the seeds will have grown shoots and roots. On the other hand, it takes 2 days to grow for seeds that were without biofertilizer. There was no difference in growth among varieties with the same treatment (Table 2).

Tabel 2. Rice seed growth in the nursery.

No.	Varieties	With biofertilizer			Without biofertilizer		
		Shoot height at 3 DAS[a] (m)	Plant height at 11 DAS (m)	Root length at 11 DAS (m)	Shoot height at 3 DAS (m)	Plant height at 11 DAS (m)	Root length at 11 DAS (m)
1	Inpari 30 Ciherang Sub 1	0.04	0.15	0.10	0.02	0.12	0.07
2	Inpari 32 HDB	0.04	0.15	0.10	0.02	0.12	0.07
3	Inpari 33	0.04	0.15	0.10	0.02	0.12	0.07

[a] DAS: Day After Sowing

As the previous statement, biofertilizer has some advantages such as an increase of seed vigor and viability [9]. In observing the growth of seedlings up to 11 days after sowing in the nursery, microbes in biofertilizer showed its role in supporting seedling growth. However, from our observation, at 40 days after planting the soil microbial activity showed no difference compared to that before treatment, the cause was that the acid soil conditions (Table 1) and this environment did not support the soil microbe's life. Inundation of paddy field slowly decreases the oxygen concentration followed by the reduction process of various mineral components of the redox system and reduced oxygen decreases the obligate aerobic microbial population and increases the anaerobic microbial population [23]. *Azotobacter* as one of the consortia of bacteria in biofertilizer is an aerobic bacterium that receives energy from redox reactions using organic compounds as electron donors [24]. Hereafter, the level of soil acidity also plays an important role, as previously explained, *Azotobacter* sp. found in soil with soil pH of 6.0 or more, although at a soil pH of less than 6.0 it can also be alive but inactive [25], on the contrary, data in the field shows a lower soil pH (Table 1).

3.3. Plant growth conditions and yield
The application of straw with biodecomposer and biofertilizer gave significant results on plant growth. The maximum tillers number, plant height before harvest and the productive tillers number were higher in the treated rice compared to the untreated rice (table 3).

Tabel 3. The effect of straw with biodecomposer and biofertilizer application as well as different varieties on plant growth.

Treatments	Plant height at 36 DAP[a] (m)	Maximum tillers number (stem clump^{-1})	Plant height before harvest (m)	Productive tillers number (stem clump^{-1})
Fertilizer				
WR	0.50	24 a	1.23 a	20 a
NR	0.53	19 b	1.15 b	16 b
R	Ns	*	*	*
Varieties				
I30	0.53 a	19 b	1.18 b	16 b
I32	0.51 b	22 a	1.23 a	18 a
I33	0.49 b	22 a	1.14 b	20 a
V	*	*	*	*
Interaction				
R x V	*	*	*	Ns

[a] DAP: Day After Planting
WR, with rice straw with biodecomposer and biofertilizer; NR, without rice straw with biodecomposer and biofertilizer; R, fertilizer; I30, Inpari 30 Ciherang Sub 1; I32, Inpari 32 HDB; I33, Inpari 33; V, varieties.
Numbers followed by the same letter within treatments were not significantly different at $P < 0.05$ by t and Tukey test.
* Significant at $P < 0.05$.

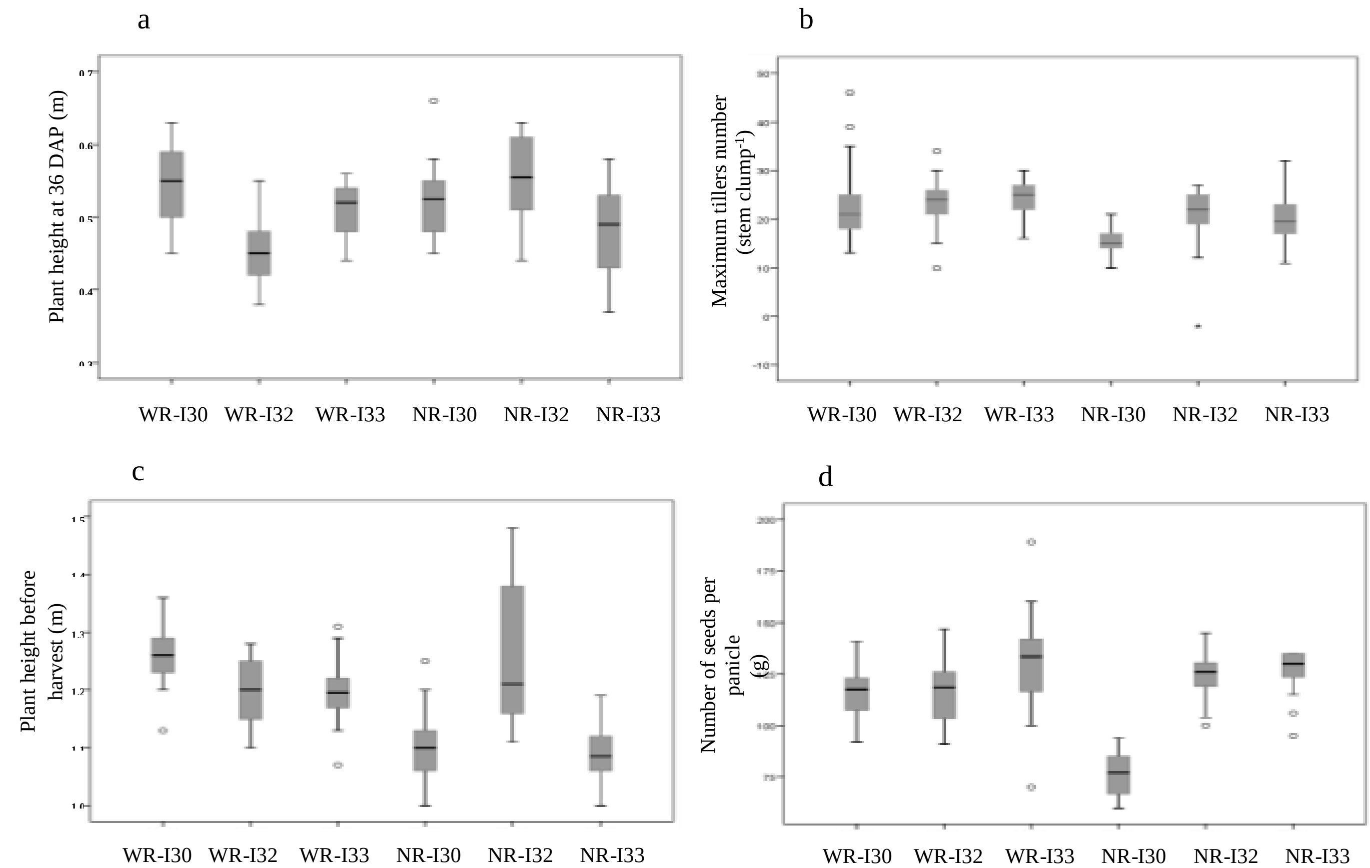
Rice varieties variables also showed different results, at the 36 days after planting, Inpari 30 Ciherang Sub 1 had the maximum plant height and was significantly different from other varieties, on the contrary, before harvesting Inpari 32 HDB showed the maximum plant height. Afterward, Inpari 32 HDB and Inpari 33 together showed better maximum tillers number and productive tillers number which were significantly different from Inpari 30 Ciherang Sub 1 (table 3).

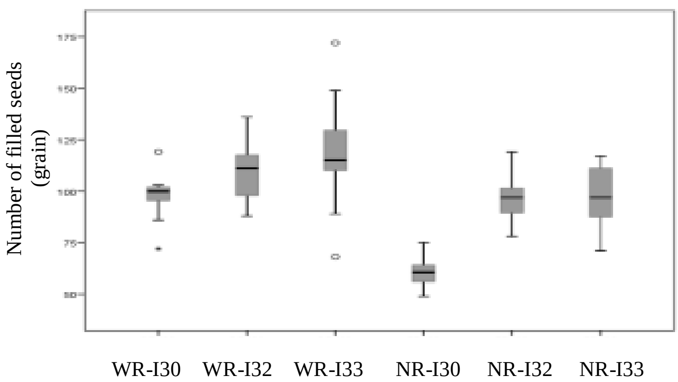
Table 4. The effect of straw with biodecomposer and biofertilizer application as well as different varieties on yield components.

Treatments	Panicle length (m)	Number of seeds per panicle (grain)	Number of filled seeds (grain)
Fertilizer			
WR	0.25 a	121 a	109 a
NR	0.23 b	115 b	90 b
R	*	*	*
Varieties			
I30	0.22 b	103 b	86 b
I32	0.23 b	121 a	103 a
I33	0.26 a	128 a	108 a
V	*	*	*
Interaction			
R x V	*	*	*

WR, with rice straw with biodecomposer and biofertilizer; NR, without rice straw with biodecomposer and biofertilizer; R, fertilizer; I30, Inpari 30 Ciherang Sub 1; I32, Inpari 32 HDB; I33, Inpari 33; V, varieties.
Numbers followed by the same letter within treatments were not significantly different at $P < 0.05$ by t and Tukey test.
* Significant at $P < 0.05$.

The rice straw with biodecomposer and biofertilizer application also affect the yield components. These treatments gave better results on panicle length, number of seeds per panicle and number of filled seeds compared to those without fertilizer application (table 4).





- WR-I30: with rice straw with biodecomposer and biofertilizer for Inpari 30 Ciherang Sub 1
- WR-I32: with rice straw with biodecomposer and biofertilizer for Inpari 32 HDB
- WR-I33: with rice straw with biodecomposer and biofertilizer for Inpari 33
- NR-I30: without rice straw with biodecomposer and biofertilizer for Inpari 30 Ciherang Sub 1
- NR-I32: without rice straw with biodecomposer and biofertilizer for Inpari 32 HDB
- NR-I33: without rice straw with biodecomposer and biofertilizer for Inpari 33

Figure 2. Plant heigh at 36 days after planting (a), maximum tillers number (b), plant heigh before harvest (c), number seeds per panicle (d), number of filled seeds (e), with and without rice straw with biodecomposer-biofertilizer for three rice varieties in Merauke Papua in 2016-2017. The box-whisker which is the top of the vertical line shows the maximum value, the center line of the box shows the median and the underscore of the vertical line shows the minimum value (n = 30).

Different varieties also show different results. From our measurement in the field, Inpari 33 has the maximum panicle length and it is significantly different from other varieties, and together with Inpari 32 HDB has a greater number of seeds per panicle and number of filled seeds and it is significantly different from Inpari 30 Ciherang Sub 1 (table 4).

There was an interaction between fertilizer and varieties variables which influence the growth and yield components (figure 2). The effect of fertilizer application on growth and yield components determined by the rice varieties or rice varieties determines the effect of fertilizer application on growth and yield components. The boxplot above reflected that fertilization treatments showed varied results. In the rice straw with biodecomposer and biofertilizer treatments, all varieties observed showed better results on the component number of filled seeds compared to those without fertilization treatment. With the application of these fertilizers, the Inpari 30 Ciherang Sub 1 and Inpari 33 varieties showed better results on the variable plant height at 36 days after planting, plant height before harvest and the number of seeds per panicle than those without fertilizers. Conversely, without the addition of straw with biodecomposer and biofertilizer, Inpari 32 HDB showed better results than the other two varieties. This variety also showed the highest data compared to other varieties on the components of plant height either with or without fertilization treatment. Moreover, Inpari 32 HDB and Inpari 33 showed better results on the components of the number of seeds per panicle and the number of filled seeds, both with treatment or without treatment. Referring to Table 1, it seems that the farmer's handling factor in the field and resistance of varieties to pests/diseases were the causes of differences in growth and yield components. However, previous studies reported that organic fertilization had an effect on yield differences. All treatments using organic fertilizer combined with inorganic fertilizer and biofertilizer were better than treatment using only biofertilizer or inorganic fertilizer [26] and bokashi had a significant effect on pithy seeds per panicle [27].

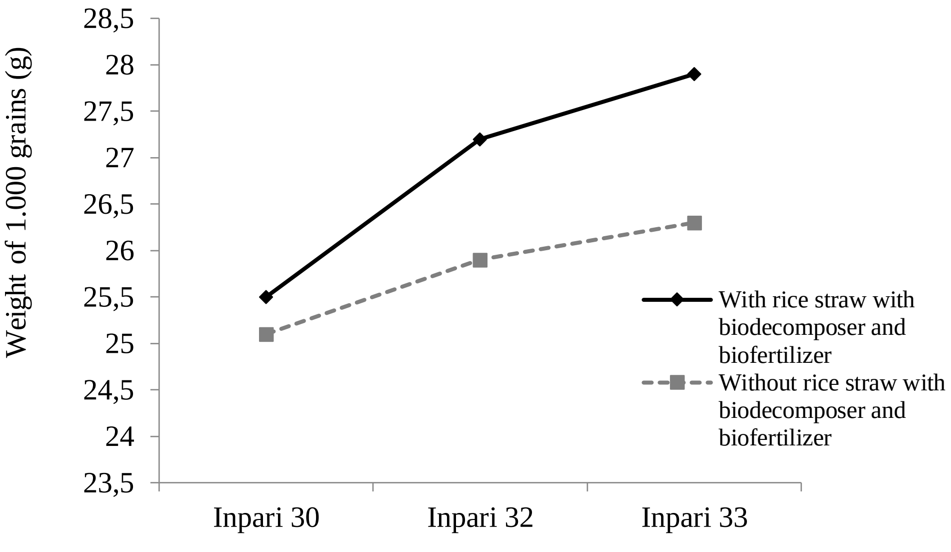


Figure 3. Weight of 1,000 grains with and without straw with biodecomposer and biofertilizer application to three different varieties.

Our observation on the weight of 1,000 grains pointed the same results as the data in Tables 3 and 4, that the application of decomposed straw and biofertilizer showed higher results in all varieties than those without fertilizer application and Inpari 32 HDB and Inpari 33 showed better results than Inpari 30 Ciherang Sub 1 (figure 3).

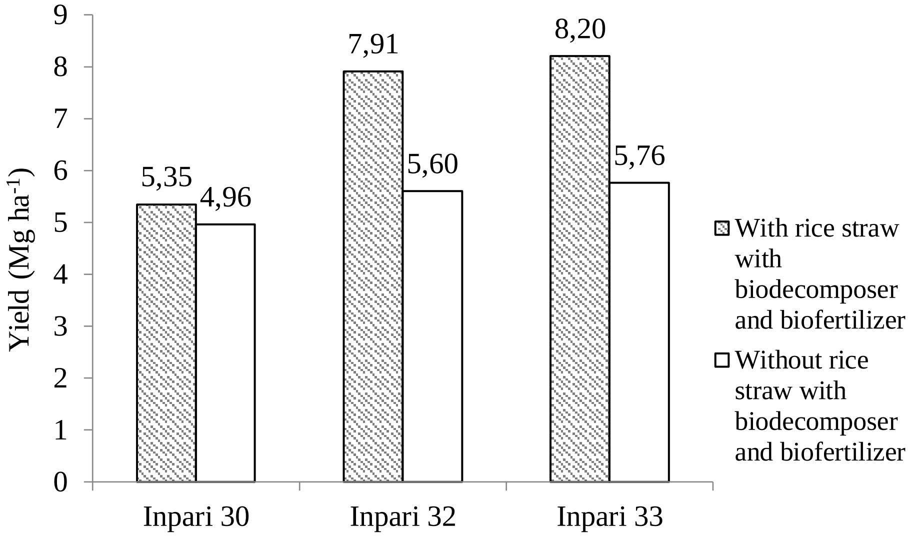


Figure 4. Rice yield with and without straw with biodecomposer and biofertilizer application to three different varieties.

Based on the data above, it was not surprising that the addition of straw as organic matter and biofertilizer resulted the higher yield, Inpari 32 HDB and Inpari 33 showed better results than Inpari 30 (figure 4). The highest yield was achieved by Inpari 33 of 8.20 Mg ha^{-1}.

The treatment of rice straw with biodecomposer and application of biofertilizer in one package showed that the effect of each treatment could not be distinguished and evaluated which one is more dominant effect on rice growth and yield components. The rice straw with biodecomposer did not affect changes in soil chemical properties (Table 1), but several studies stated that the addition of organic matter was good for improving soil properties and providing benefits during plant growth. This experiment that was first time application and fertilizer treatments did not affect significantly to soil chemical and biological properties as shown in the data. To reach a significant nutrients increase, the addition of organic matter needs to be done regularly [26]. The application of straw compost for 4-6 seasons can significantly increase soil C-organic, nutrient availability, soil and plant health [28]. In the long term, compost can improve soil pH and increase crop yield on acid soil [4]. The longterm application of straw compost is potential for K source. Based on the average plant productivity, rice with a yield of 4.7 Mg ha^{-1} absorbs 122.4 kg K ha^{-1}, as much as 89% K is taken by rice plants is in straw. Therefore, the amount of K in rice straw is 108.9 kg and indicates that rice straw is a potential source of K nutrients [29]. The microbes in the biodecomposer will accelerate the straw decomposition into organic matter which provides additional nutrients for plants. Some fungi such as *Aspergillus niger* and *Trichoderma viride* are able to breakdown the lignin content in rice straw [30]. The biofertilizer application can also increase the consortia of non-pathogenic endophytic bacteria in the soil, although from the data above there was no significant difference in the number of microbes both before and after treatment as indicated by the level of soil respiration. Several previous studies have shown that giving straw compost can improve soil quality in the vegetative phase in the form of increasing soil pH and soil organic matter, decreasing soil exchangeable Al and increasing the solubility of Fe^{2+} and SO_4^{2-}. The provision of straw compost also increases the number of tillers, the number of filled grains per panicle, the weight of grain and straw [31]. Inorganic fertilizer combined with organic fertilizer can improve soil chemical properties; specifically total N and available P; plant height, number of tillers; and yield [32]. Likewise, the addition of a mushroom biofertilizer containing *Aspergillus niger* PS1.4, *Penicillium* sp. R7.5 and *Trichoderma viride* can increase the growth of Ciherang planted on land with 0.5% salinity, with increased growth occurring in plant height, number of tillers, total dry weight of biomass/ straw [33]. The rice straw application with gelebeg system increases soil fertility and yield by 11.9 % [28], straw compost increases plant height and dry grain weight per 1,000 grains [34]. Furthermore, the effect of organic and inorganic fertilizer on plant production was not solely due to chemical properties improvements or C-organic content, but also influenced by the development of soil biological populations [35].

The attack of pests and diseases, especially blast is suspected of causing the yield of Inpari 30 Ciherang Sub 1 much lower than other varieties. From field observation, Inpari 32 HDB and Inpari 33 were more susceptible to blast. The blast diseases both leaf and neck blast contribute in yield reduction.

The nutrient content analysis of plant tissue taken from paddy field with fertilizer treatments showed low N content, low-sufficient P and high K. On the other hand, the analysis of samples on plant tissue taken from paddy field without fertilizer treatments showed a low N-P-K content.

Table 5. Nutrient content (%) in plant tissue against plant dry weight.

Varieties	N	Criteria[a]	P	Criteria[a]	K	Criteria[a]
Inpari 30 Ciherang Sub 1[b]	1	low	0.12	sufficient	2.62	high
Inpari 32 HDB[b]	0.7	low	0.09	low	3.07	high
Inpari 33[b]	0.87	low	0.13	sufficient	2.76	high
Inpari 30 Ciherang Sub 1[c]	0.77	low	0.02	low	0.15	low

[a] Nutrient content criteria in plant tissue [36]
[b] Paddy leaves from paddy field with straw with biodecomposer and biofertilizer application
[c] Paddy leaves from paddy field without straw with biodecomposer and biofertilizer application

The fertilizer treatments showed higher K levels in plant tissue than those without treatment (Table 5). This condition causes plants to be more resistant to blast [37] which was indicated by higher K levels than those without fertilizer application. Elemental K in plant tissue stimulates the formation of phenol compounds which are toxic to pathogens and play a role in preventing blast infection. In addition, K is an important element in the formation of cellulose and lignin, which are cell wall components that determine the thickness of the cell walls, thereby inhibiting pathogens' penetration into plant tissue [38]. Furthermore, the straw that was decomposed as organic fertilizer has high silica (Si) content and Si makes the cell wall stronger which contributes to reducing the intensity of blast attack because the epidermal cells with strong and thick walls will make direct penetration of pathogenic fungi difficult [39], although this study did not measure Si in soil and plant tissue. In the short term, the use of straw as compost will suppress the blast growth because the immersion of straw in the soil as compost will increase the temperature during the decomposition and kill the mycelia and spores of P. *grisea* that cause blast [40]. The straw remains from diseased plants in the paddy field can be a source of inoculum for the next season's cultivation [41].

Finally, the addition of straw with biodecomposer and application of biofertilizer did not significantly improved soil quality in new land clearing in Merauke, Papua but it can increase the rice growth and yield component through its role in increasing plant resilience and preventing disease in the paddy field. Selection of varieties which resistant to pest/disease is also important to suppress the pest/disease attack that potentially reduce rice yield.

4. Conclusions

The addition of rice straw with biodecomposer and application of biofertilizer did not significantly improved soil quality in new land clearing in Merauke, Papua. This experiment was first time application and this practice needs to be done periodically for increasing nutrient content in the soil. On the contrary, from field observations it was found that biofertilizer affect seed vigor and viability in the nursery. The addition of these fertilizer significantly effected on plant height, maximum tillers number, productive tillers number, panicle length, number of seeds per panicle, number of filled seeds, weight of 1,000 grains and yield. The highest yield was reached by Inpari 33 of 8.20 Mg ha^{-1} in rice straw with biodecomposer and biofertilizer treatments. The addition of straw with biodecomposer and application of biofertilizer were able to increase growth and yield component, it was suspected that rice varieties variable have different resistance to pests and diseases. Moreover, the use of straw as compost will suppress the blast growth through temperature factor during the decomposition.

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