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Application of Immature Rice Straw Compost, Azolla, and Urea for Increasing Rice Fields Production Based on Local Wisdom

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ABSTRACT

Local wisdom of incorporating immature rice straw compost technology on a rice field at age of 35 days, followed by urea fertilizer had been applied by farmers in order to solve the soil fertility problems. The objectives of this research were: (1) to find the best combination of immature rice straw compost application, and the amount of *Azolla* and urea fertilizer, (2) to analyze the effectiveness of *Azolla* application in improving the supply of nitrogen to fulfill nitrogen requirement, (3) to analyze the changes in soil organic matter content before and after technological innovation of application of immature rice straw compost and incorporation of *Azolla* and urea fertilizer. A Randomized Block Design (RBD) was used in this study with five treatments and four replications: a) immature rice straw compost + urea 100 kg/ha (the treatment of farmers); b) immature rice straw compost + urea 75 kg/ha + Azolla 200 g/m^{2,}; c) immature rice straw compost + urea 50 kg/ha + Azolla 200 g/m^{2,}; d) immature rice straw compost + urea 25 kg/ha + Azolla 200 g/m^{2,}; e) immature rice straw compost + Azolla 200 g/m$^{2.}$. The result showed that treatment of immature rice straw compost application + *Azolla* 200 g/m^2 + 75 kg urea/ha produced dry grain of 6.14 ton/ha. This result was not significantly different to that of immature rice straw compost application + urea 100 kg/ha. Distribution of Azolla 200 g/m^2 was able to reduce the use of urea at 25 kg/ha in order to suppress the occurrence of N immobilization due to immature rice straw compost application among rice rows. C-organic content of the soil increased twice after harvesting.
KEYWORDS: rice straw compost, Azolla, local wisdom, rice production

INTRODUCTION

An increase in agriculture productivity in Indonesia can be achieved when agricultural development strategy is based on sustainability of resources (land, biodiversity, human). In addition, a specific approach to the concept derived from the local ideas that are thoughtful, full of wisdom, and a good value to be easily followed by the farmers are required. Land resources are often an obstacle to farming activities. In Madura, the fields generally have low soil fertility, as indicated by the soil organic matter content of less than 1 (one) % (Sumenep Department of Agriculture, 2005). This condition prompted the emergence of wise farmers' idea and the wisdom to improve soil fertility, including incorporation of immature rice straw compost among the rice row at age ± 35 days after planting, followed by the application of urea fertilizer [1]. This phenomenon is a strategy of farmer's life in solving the condition of soil problems that are less fertile and help them to fulfil the N element requirement of a rice field. N needed. Ekawati [2] stated that incorporation of immature rice straw compost (C/N ratio of 17.5) was able to improve the synchronization between N mineralization and crop N uptake. Nitrogen immobilization in the early straw decomposition phase could be reduced by N application [3].

To reduce the dose of urea fertilizer which was given after immersion of immature rice straw compost, technological innovation, such as *Azolla* application is needed. According to Sisworo [4] *Azolla* was proven to able to provide N at 30 -40 kg N / ha. The statement was supported by Kikuchi, *et al* [5], in which the average rate of N fixation by *Azolla* in fields was in the range of 0.4 to 3.4 kg N/ha/day. Besides as nitrogen source, *Azolla* could also be a source of organic matters because it contained carbon of 37.72% - 41.29% and nitrogen of 2.09% - 3.02% [6].

A touch of *Azolla* technology innovation on local wisdom of incorporating immature rice straw compost was expected to able to contribute to the improvement of soil fertility and rice production. The objectives of this research were: 1) to find the best combination of immature rice straw compost application + *Azolla* + urea and their effects to the rice production; 2) to analyze the effectiveness of *Azolla* application in improving the supply of nitrogen to fulfil the nitrogen requirement of the rice plant; and 3) to analyze the changes in soil organic matters content before and after the application of technological innovation of Azolla, urea and incorporation of immature rice straw compost.

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MATERIALS AND METHODS

The experimental materials used were Ciherang rice field variety, immature rice straw compost, *Azolla microphyla*, bio-organic fertilizer, phonska and urea. This research was conducted at farmers' fields during the dry season from March to July 2012 at Paberasan, Sumenep. Randomized Block Design (RBD) with five treatments and four replications was used, as follows:

Treatment I : immature rice straw compost + Urea 100 kg/ha
Treatment II : immature rice straw compost + Urea 75 kg/ha + Azolla 200 g/m^2
Treatment III : immature rice straw compost + Urea 50 kg/ha + Azolla 200 g/m^2
Treatment IV : immature rice straw compost + Urea 25 kg/ha + Azolla 200 g/m^2
Treatment V : immature rice straw compost + Azolla 200 g/m^2

The soil was initially plought twice by a tractor, and then divided into several plots with each of 5 x 4 m^2. Fertilization was carried out in three stages: in the first stage, Bio-organic fertilizer of 400 kg/ha and Phonska of 125 kg/ha were given before planting; then second one, Phonska of 125 kg/ha and urea of 50 kg/ha were given at 15 days after planting; and finally, fertilization was given at age of 35 days after planting in accordance to the existing treatments. After the soil treatment and basic fertilizing, the seed at 10-days-old after seedlings planted using SRI method with row spacing of 25 x 25 $cm^{2.}$

Azolla was spreaded when rice at the age of 7 days after planting by dosage of 200 g/m^2. Rice straw compost of Ciherang variety obtained from naturally composted in the middle of the rice field and immersed among the rows at the age of 35 days after planting by dosage of 2.45 ton/ha. The dosage of immature rice straw compost and its application, as well as plant cultivation were in accordance to farmer's local wisdom.

Variables observed were height of plants, number of tillers, percentage of empty grains and pithy, and yield in dry grain/ha. The height of plants and the number of tillers were observed at ages of 21, 35, 50, and 65 days after planting, In addition, total N, N-NO_3^- and N-NH_4^+ of soil were also determined by semi-micro distillation Kjeldahl method, P content of soil was observed by Olsen method, whereas N and P contents of plants were analysed by extraction with $HClO_4$ + HNO_3.. Before planting, the soil was analysed to determine the physical and chemical properties of the soil.

The data obtained were analysed using variance analysis (F test), followed by *Duncan's Multiple Range Test* (DMRT) with an error rate at 5% when there were differences between the treatments. These statistical test were done by SPSS.

RESULTS AND DISCUSSION

Soil Characteristics

Soil analysis results showed that the content of C-organic was very low at only 0.74%, even though the rice fields had received inputs of organic matters over the last three years [1]. Similarly, the content of N-total was as low as 0.10%. The cation exchange capacity was also low only at 15 me/ 100 g of soil. P, K, and Na contents were low, while Ca and Mg in average category [7]. To improve soil fertility and achieve a sustainable agricultural industry requirement, continuous input of organic matters should be considered. Hairiah *et al.* [8], stated that the sustainable agricultural system could be achieved if the content of soil organic matters were more than 2%, in which inputs of organic matter of around 8-9 tons/ha/year were required [9].

Rice Growth

Application of immature rice straw compost and *Azolla* combined with urea affected the height of plants significantly and also number of tillers at ages of 50 and 65 days after planting. The highest plant growth rate was shown by rice plant in the field with treatment of immature rice straw compost + *Azolla* 200 g/m^2 + urea 75 kg/ha (P2), even though was not significantly different to that of immature rice straw compost + urea 100 kg/ha without *Azolla* (P0). It seemed that *Azolla* was able to replace the role of urea in influencing plant growth (Table 1 and Table 2). According to Sisworo *et al* [4], *Azolla* was able to produce N in the range of 30-45 kg N/ha which was equal to 100 kg urea. Kikuci *et al* [5] also stated that the rate of N fixation by *Azolla* in the fields ranging from 0.4 to 3.4 kg N per hectare per day.

The number of tillers increased and reached a maximum at age of 50 days after planting then decreased in all treatments. The decrease in tillers number was caused by the death of productive tillers. Indriyati *et al* [9] stated that the application of rice straw in flooded paddy soil also showed the same results. The highest number of tillers was demonstrated by P1 treatment, although was not significantly different to that of P2 and P3.

Table 1 Plant Height of Rice as the Results of immature Rice Straw Compost Application, Azolla and Urea Fertilizer

Treatment	Plant height (cm)			
	2 1 DAP	3 5 DAP	50 DAP	65 DAP
P1 = immature rice straw compost+ Urea 100 kg without Azolla	39.04 a	51.70 a	79.20 b	95.38 b
P2 = immature rice straw compost + Azolla 200 g/m^2 + Urea 75 kg	39.73 a	52.62 a	80.02 b	96.15 b
P3 = immature rice straw compost + Azolla 200 g/m^2 + Urea 50 kg	38.83 a	52.57 a	78.17 b	96.11 b
P4 = immature rice straw compost + Azolla 200 g/m^2 + Urea 25 kg	37.06 a	50.32 a	68.99 a	88.07 a
P5 = immature rice straw compost + Azolla 200 g/m^2 without Urea	39.80 a	52.93 a	69.62 a	88.83 a

Remarks: in a colum , means followed by same letter are not significantly different at the p=0.05 by Duncan test

Table 2 Effect of immature Rice Straw Compost Application, Azolla and Urea Fertilizer on Number of Tillers

Treatment	Tillers Number			
	2 1 DAP	3 5 DAP	50 DAP	65 DAP
P1 = immature rice straw compost+ Urea 100 kg without Azolla	5.83 a	12:10 a	16.95 b	14.88 b
P2 = immature rice straw compost + Azolla 200 g/m^2 + Urea 75 kg	6:28 a	12:28 a	17:53 b	14.73 b
P3 = immature rice straw compost + Azolla 200 g/m^2 + Urea 50 kg	6:05 a	12:53 a	16:03 ab	14:00 ab
P4 = immature rice straw compost + Azolla 200 g/m^2 + Urea 25 kg	5:30 a	10:55 a	13.73 a	11.85 a
P5 = immature rice straw compost + Azolla 200 g/m^2 without Urea	5:50 a	12:03 a	14:23 a	12:38 a

Remarks: in a colum , means followed by same letter are not significantly different at the p=0.05 by Duncan test

Rice Production

Rice production was significantly affected by treatment of immature rice straw compost application + urea + *Azolla*. The highest rice production was shown by P1 treatment, but was not significantly different to that of P2 treatment. The results revealed that the distribution of *Azolla* 200 g/m^2 in the early growth of rice plants could reduce the dosage of urea to 25 kg/ha which was given after incorporation of immature rice straw compost at age of 35 days after planting. Urea application was required to balance the occurrence of the N immobilization. According to Javier and Tabien [11], at the beginning of the *Azolla* and uncompensated rice straw restoration, N immobilization occurred up to 14 days after restoration of organic matter. Subsequently, the release of N took place, and among the green manures, *Azolla* gave the lowest N-NH_4. In the case, the use of the green manures still required additional inorganic N supply to fulfill the N requirement of rice plants.

The results also showed that the smaller the dose of urea given after immature rice straw compost immersed among rice rows, the lower the production the rice was (Table 3). The decrease in the rice production up to 23.17% was observed when the incorporation of rice straw compost was not followed by urea, although *Azolla* had been distributed starting one week after planting. The results suggested that the nitrogen supplied by *Azolla* was unable to balance nitrogen plant requirement to produce high grain. The observations arose as a result of competition in N demand due to plant growth and the need of N for the growth of microorganisms [12]. Bird *et al* [12] stated that the incorporation of rice straw to the soil resulted in the increase in microbial biomass N and N immobilization in the first year of incorporated straw. While Takahashi *et al* [13] stated that the short-term application of rice straw was unable to supply sufficient N for plant growth and additional N fertilizer was still required. Decreasing in rice production due to the application of rice straw could be overcome by adding inorganic N [14].

Although rice production was significantly affected by the treatments, the percentage of empty and full grains, however, was not significantly affected by the treatments.

Table 3 Rice yield, Percentage of Empty and Full Grains as Affected by Immature Rice Straw Compost, Azolla and Urea Application

Treatment	Parameter		
	% Empty Grain	% Full Grain	Yield (ton/ha)
P1 = immature rice straw compost+ Urea 100 kg without Azolla	19:07 a	80.93 a	6:17 c
P2 = immature rice straw compost + Azolla 200 g/m^2 + Urea 75 kg	20:22 a	79.87 a	6:14 c
P3 = immature rice straw compost + Azolla 200 g/m^2 + Urea 50 kg	18:34 a	81.67 a	5.79 bc
P4 = immature rice straw compost + Azolla 200 g/m^2 + Urea 25 kg	23:54 a	76.47 a	5:12 ab
P5 = immature rice straw compost + Azolla 200 g/m^2, without Urea	24.73 a	74.76 a	4.74 a

Remarks: in a colum , means followed by same letter are not significantly different at the p=0.05 by Duncan test

Plant uptake of N and P

At the initial stage of the growth, before application of immature rice straw compost (35 DAP), N uptake in the treatment without *Azolla* (P1) was lower than that of with Azolla (P2, P3, P4, P5). This result was caused by the lower availibility of N-minerals in the soil compared to that of P1 treatment. Furthermore, at the age of 50 DAT and 65 DAT, N uptake of P4 and P5 treatments were much lower than that of the P1, P2, and P3 treatments. The highest N uptake was demonstrated by P3 treatment, followed by P1 and P2 treatments (Fig. 1). With the addition of low dose of urea, N uptake decreased except in P3 treatment, although *Azolla* was grown in the soil. The observations showed that the addition of urea was still required to balance the N demanded by soil microorganisms (immobilization) and plant uptake. Bird *et al* [12] stated that the application of rice straw resulted in N immobilization so that N fertilizer was required leading to positive effects, namely the increase in N mineralization and N-biomass of microorganisms after one year rice straw application. Indriyati [10] reported similar observation and stated that rice straw compost application combined with urea could reduce the potency of N immobilization from these organic materials.

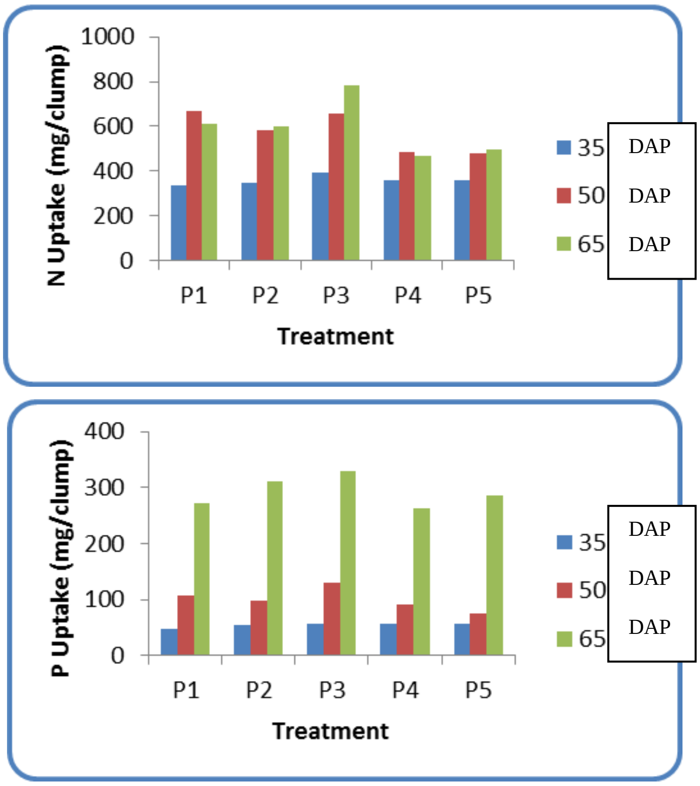

Figure 1. Nitrogen and Phosphor Uptake by Rice Plant in All Treatments

Changes in C-organic Content

Before treatments of incorporating immature rice straw compost and spreading Azolla, the soil had only 0.74% C-organic content. However, when the soil was treated by incorporating immature rice straw compost, spreading Azolla at the early growth and urea application, the C-organic content in each portion increased twice after harvesting. Further, when the treatment of immature rice straw compost application was followed by spreading Azolla, the C-organic content was higher than that of without *Azolla* (Table 4). Therefore, treatments of incorporating immature rice straw compost and spreading *Azolla* should be carried out regularly in order to improve soil fertility.

Table 4 Changes in Soil C-organic Content due to Immature Rice Straw Compost, *Azolla* and Urea Application

No	Treatment	C-Organic content (%)
1.	Before planting	0,74
2.	After harvested	1,53
	P1 = immature rice straw compost + Urea 100 kg without Azolla	1,62
	P2 = immature rice straw compost + Azolla 200 g/m^2 + Urea 75 kg	1,54
	P3 = immature rice straw compost + Azolla 200 g/m^2 + Urea 50 kg	1.58
	P4 = immature rice straw compost + Azolla 200 g/m^2 + Urea 25 kg	
	P5 = immature rice straw compost + Azolla 200 g/m^2 without urea	1,58

CONCLUSION

Local wisdom technologies of immature rice straw compost application to a rice field at the age of 35 DAP, followed by urea application can be combined with Azolla spreading in one week after planting to reduce the potential of N immobilization. Treatment of incorporating immature rice straw compost + Azolla 200 gram/m^2 + Urea 75 kg/ha produced dry rice grain of 6.14 ton/ha which was not significantly different to that of incorporating immature rice straw compost + urea 100 kg/ha (P1). *Azolla* application of 200 gram/m^2 in the early growth was able to reduce urea of 25 kg/ha in order to suppress the occurrence of immobilization due to immature rice straw compost application among rice rows. The C-organic content in each portion increased twice after harvesting, when the soil was treated by incorporating immature rice straw compost, spreading Azolla at the early growth and urea application.

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