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***RESEARCH ARTICLE***

# CHANGES IN SOIL CHEMICAL PROPERTIES OF ORGANIC PADDY FIELD WITH AZOLLA APPLICATION

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**ABSTRACT**

The use of organic fertilizer is a way to improve soil fertility. Azolla can be used as organic fertilizer. This study aims to determine the effect of Azolla (*Azolla mycrophylla.* L) on some soil chemical properties on organic paddy field. The field experiments used factorial complete randomized block design of three factors, namely Azolla (0 and 2 tons/ha), Manure (0 and 10 tons/ha) and Rice Varieties (Mira1, Mentik Wangi and Merah Putih), with three times replication. Using Azolla on an organic paddy field does not significantly increase the levels of soil N, organic C, Cation Exchange Capacity and soil pH. However Azolla's influence on soil available P is significant.

***Keywords:*** *Azolla, Soil N, Soil P, organic C., organic paddy field*

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## INTRODUCTION

The increasing of public awareness for healthy diet must be balanced with a healthy cultivation. Organic farming systems are the right choice, because it abandons all the non-organic components. Moreover, it can improve soil organic C, which is less than 1% in paddy soil (Syamsiyah and Mujiyo, 2006), deterioration of soil structure, the efficiency of fertilizers and soil compaction, as well as a decrease in the availability of nutrients in the soil that caused by using inorganic input. In 2010, the Indonesian government has developed an organic farming program called Go Organic.

Organic fertilizers can improve physical, chemical and biological properties of soil, so that the sustainability of agriculture can be maintained.. Azolla is *water fern* that grows quickly. It can capture atmospheric nitrogen to form a symbiotic association with Blue-Green Algae, Anabaena azollae because Azolla has the ability to supply nutrients for plants, especially the need of N. So Azolla can be used as fertilizer, either as green manure or biofertilizer

Subedi and Shrestha (2015) explain that Azolla does not only increase the productivity of rice but also improve the long-term soil fertility. However, there is not much information related to the potential of Azolla in improving soil chemical properties, especially in the organic paddy fields. The aim of this study is to measure changes in soil chemical properties such as soil N, available P, cation exchange capacity and organic C in organic paddy field.

## MATERIALS AND METHOD

This research was field experiment which was conducted in Sukorejo, Sambirejo, Sragen, Indonesia. The characteristics of soil, manure and Azolla are presented on Table 1. The region is located on the northwestern part of Mount Lawu. It uses the organic system in rice cultivation. The water is available throughout the year from the mountain.

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**Table 1.** Chemical properties of Inceptisols

| No | Parameter | Value |
|---|---|---|
| 1 | pH $H_2O$ | 5.0 |
| 2 | organic C | 2.42 % |
| 3 | Total N | 0.19% |
| 4 | Available P | 3.87 mg/kg |
| 5 | Available K | 0.14 cmol (+)/kg |
| 6 | C/N ratio | 19.2 |
| | CEC | 24,23 cmol (+)/kg |
| 7 | Teksture | |
| | • Sand | 35,51% |
| | • Silt | 18,34% |
| | • Clay | 46,15% |

This study used Azolla with 0 and 2 tons/ha dose as green manure and manure (cow dung) with 0 and 10 tons/ha dose, as well as three varieties of rice (Mira-1, Mentik Wangi and Merah Putih). Azolla was distributed after planting rice (5 Days after planting). After Azolla fully grown, when rice plants were 25 DAP, 75% of Azolla was incorporated into the soil in conjunction with the activities of second weeding. Meanwhile, the rest of the 25% of Azolla was allowed to continue to grow until the rice crop was harvested and the manure was mixed thoroughly after tillage.

This experiment used Randomized Complete Block Design. The data were analyzed by using the F test at the level of 95% and then followed by DMR test at the 95% confidence level. Various parameters were measured including soil organic carbon (Walkey and Black), CEC (extract ammonium acetate), pH H2O (1: 2.5) of total N (Kjeldahl), available P (Bray I) (ISRI 2005).

## RESULT AND DISCUSSION

### The Chemical Properties of Azolla

Table 2 shows that Azolla, which was used in the experiment, had C-organic and N-total by 37.87 % and 2.14%, respectively. The application of 2.0 tons/ha of Azolla to the organic paddy soil, might contribute

**Table 2.** Chemical Properties of Azolla and Manure.

| No | Parameter | Value | |
|---|---|---|---|
| | | Azolla | Manure |
| 1 | N | 2.14 % | 1.22 % |
| 2 | P | 1.05 % | 0.82% |
| 3 | K | 2.36 % | 1.31% |
| 4 | Organic C | 37.87 % | 20.50% |
| 5 | C/N ratio | 17.7 | 16,8 |

42.8 kg N/ha or equivalent to 94.8 kg urea/ha. Singh & Singh (990) stated that *Azolla* is a great source of N in rice ecosystems, due to the symbiosis between Azolla and *Anabaena azollae* that can fix N from the air. According to Khan (1983), the contribution of N from the plant into the soils is about 60-80 kg N/ha/season

### The Effect Azolla on Soil Total N

Soil total N was not significantly affected by Azolla or manure (Figure 1). Soil total N increased by 16% with Azolla and 18% with manure compare to control, although it was not significantly different. Azolla is a biological fertilizer commonly used on rice crops which supplies an additional 30-40 kg N/ha to the soil (Singh, 1978). The chemical analysis indicates that the Azolla, which was used, has a high N content (Table 2). The element would be released into the ground after Azola decomposed. These results are in line with Singh and Singh (1987) and Yadav et al. (2014), that incorporating Azolla into soil increased the total soil N. Figure 1 shows that Manure (10 tons/ha) were able to improve total N, higher than Azolla (2 tons/ha), though it is not significantly different. It is likely that the increase of total N is related to the fact that N content supplied by 10 tons of manure was higher than N supplied by 2 tons of Azolla.

N is an essential nutrient for rice growth (Spiertz, 2010). Deficiency N in rice will show symptoms such as yellowish leaves, stunted growth, a low tiller number and rice yield

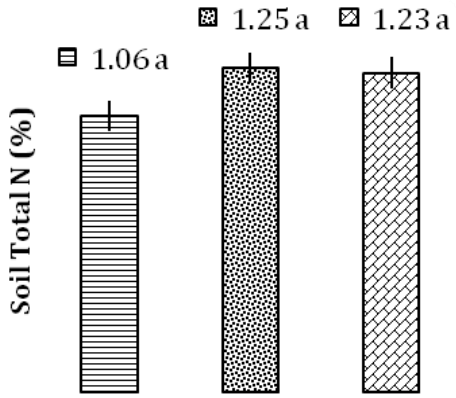


**Figure 1.** Soil Total N on Organic Paddy Field after Azolla and Manure Application

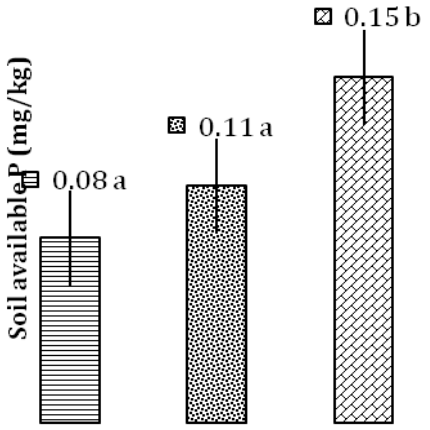


**Figure 2.** Soil available P on Organic Paddy Field after Azolla and Manure Application

(De Datta, 1980). Results from the study showed that the use of Azolla indicated total soil N was only 1.23% (Figure 1). According Sanzez 1976, those N content were insufficient for rice crops. It is in line with (Syamsiyah, et al., (2016) stated that adding Azolla did not significantly effect on plant height, number of tillers and rice yields.

**Soil available P on Organic Paddy Field**

There is significant effect of Azolla on soil available P. The improvement of soil available P with Azolla is about 87% higher than the improvement of control group (Figure 2). It is probably caused by the increasing activity of enzyme phosphatase from Azolla incorporation (Thanikachalam et al. 1984) that would release P to the soil. These results are in line with Sing (1981) and Choudhary & Kennedy (2004). They found that by using Azolla would increase available P after flooding. In general, the application of Azolla enhances the soil nutrients availability through biological activity that also builds up the micro flora for mineralization. Mineralization is a process of breaking down the organic substances and releasing nutrient to the soil. Thus, it indicates that Azolla needs higher P to grow optimally (Rivaie, 2013). However, as Azolla decomposed, it would release soil available P into the soil (Watanebe et al. 1980). Therefore, the soil available P needs to be improved for plant's growth (Singh & Singh 1990; Choudhary & Kennedy 2004).

Soil available P in organic paddy field with Azolla application was only 1.25% (Figure 2) which is relatively low and does not meet the need of rice growth (Sanchez, 1976). As a result, using Azolla did not effect on plant height, tiller number and rice yield significantly (Syamsiyah, et al., (2016)

**Soil organic C**

The effect of Azolla on soil organic matter is presented in figure 1. There is no significant effect of Azolla on organic C. Azolla with 2 tons/ha dose could increase the organic matter up to 3.69% compare to the field without Azolla. However it was 8% lower than the field with manure 10 tons/ha although it was not significantly different. It means that giving 2 tons/ha Azolla has a potential which is almost equal to 10 tons manure. The similar results were also reported by Hasibuhan (1996) in which the use of Azolla was able to increase organic matter. The increasing of organic C is caused by the high content of organic C in Azolla. The incorporated Azolla into soil would soon be mineralized. Watanabe et al, 1991 stated that 90% of Azolla was decomposed in 4 weeks. From the

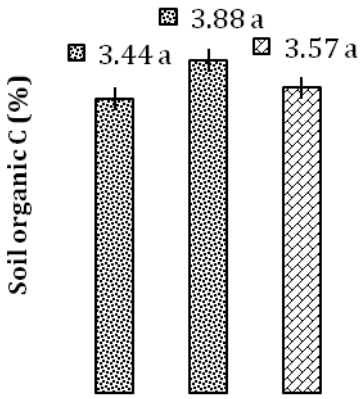


**Figure 3.** Soil Organic C on Organic paddy Field after Azolla and Manure application.

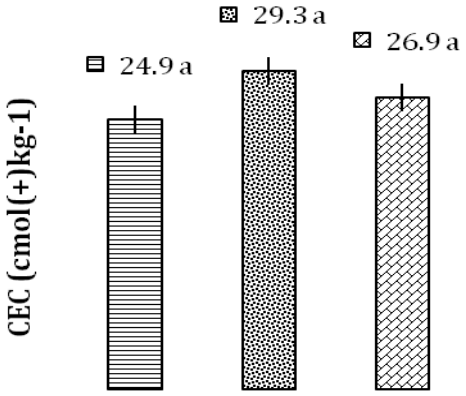


**Figure 4.** Effect of Azolla and Manure on Cation Exchange Capacity.

mineralization process, it would form humic substances (Bhardwaj and Gaur, 1970) which would also produce the soil organic C.

The result shows that 10 tons/ha of manure were also able to increase soil organic C by 24.4% compared to control. It is caused by the high content of organic matter in manure which could add humus to the soil. According to Wang et al. (2015), the carbon content from cow manure (40.45 - 37.87%) was significantly higher than the chicken and pig manure. Zulkarnain et al. (2013) also found that the application of manure soil organic C is higher compared to compost.

**Soil Cation Exchange Capasity (CEC).**

Using Azolla to the organic paddy field does not significantly affect Soil Cation Exchange Capacity (Figure 4). These most presumably caused by only 75% from 2 tons of Azolla that were incorporated into soil while the rest still floated on the water. Thus, the humic substances produced by decomposition were unable to give a significant effect on CEC. 2 tons/ha of Azolla could increase the soil CEC by 8% compared to CEC produced by the control though it was lower by 8% compared to those of manure. Azolla and manure are the source of the organic substances. Decomposition of Soil Organic matter would form functional group that have negative charge. The amount of functional group indicates potential of soil to hold cation (Brady and Weill, 2002).

**Soil pH.**

There was no significant effect of Azolla 2 tons/ha to soil pH. Azolla could improve the soil pH by 1, 02% compared to the field without Azolla, though it is not significant. Meanwhile, the application of 10 tons/ha of manure could only give 0, 64% improvement of soil pH compared to Azolla application (Figure 5).

Soil in the field has pH which is slightly acid to neutral. This condition is a good condition for plant growth because almost all nutrients are available. Organic matter such

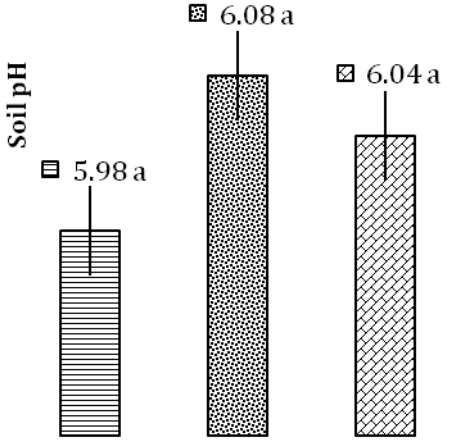


**Figure 5.** The Effect of Azolla and Manure on Soil pH

as Azolla and manure can increase soil pH because it would release OH- ions in the reduction process. Besides, the increasing of soil pH is also caused by releasing basic cation from organic matter decomposition. The increase of pH reached 24% than initial soil. The existence of ion Fe + 3 in reduced soil would turn into Fe + 2 providing the chance to release OH- (Muhammad, 2008).

## CONCLUSION

The use of Azolla as green manure on organic paddy field in Samburejo, Sragen does not significantly affect the total soil N, organic C, soil CEC and soil pH. Whereas, soil available P increased significantly with Azolla application. There is no significant difference on some soil chemical properties on organic paddy field with the application of Azolla 2 tons/ha and manure 10 tons/ha.

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