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RESEARCH ARTICLE

SOIL FERTILITY STATUS OF ORGANIC PADDY EXPERIMENT

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ABSTRACT

The study aims to determine fertility status of the soil after organic paddy experiments using kinds and doses of organic fertilizers. Experiment was conducted at greenhouse laboratory in Faculty of Agriculture Sebelas Maret University Surakarta. Experimental design used completely randomized design with 9 kinds of treatment was replicated 3 times. Experiments were the use of farmyard manure, Azolla fertilizer, Azolla inoculum and its combinations that are based on fulfilling nutrient requirements of 120 kg N ha^{-1}.

Result shows that the use of farmyard manure, Azolla fertilizers and Azolla inoculum had no effect on changes of soil fertility status. Soil fertility status was not significantly correlated with farmyard manure ($0{,}16^{ns}$), Azolla fertilizer ($0{,}26^{ns}$) and Azolla inoculum ($0{,}16^{ns}$). Average of final soil fertility status included fertile category, which was similar as the initial soil fertility status. Average of final soil properties of treatment but nevertheless was relatively higher than in no treatment, indicating the use of farmyard manure, Azolla fertilizer, Azolla inoculum and its combinations had greater impact to soil properties. Farmyard manure despite increased available K_2O and dry grain, but it did not significantly increase the soil fertility status from fertile to very fertile. This was presumably due to the relatively short experiment period, only one planting season had not given significant effect to soil properties. Implication of this study is the use of farmyard manure, Azolla fertilizer, Azolla inoculum and its combinations although did not increase the soil fertility status but could maintain soil fertility status as the initial conditions before planting.

Keywords: Azolla, soil properties, fertility
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INTRODUCTION

High temperature and decomposition rate, as well as the lack of return organic matter to the soil are typical of soil in tropical region, including Indonesia (Sanchez, 1976). Paddy field in Indonesia have low organic matter (Karama, 2001; Syamsiyah and Mujiyo, 2006). For instance in Palur, Sukoharjo, paddy field have only 1.96% soil organic matter (Mujiyo and Syamsiyah 2006).

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One attempt to overcome the degradation of low organic matter on paddy field, Indonesian farmers implement the system of organic paddy field, which is one of its main components is using organic fertilizers. The use of organic fertilizer will increase soil organic matter content (Sutanto, 2002) and has an impact in soil fertility changes.

Several descriptions above are foundations to study regarding soil fertility status in rice cultivation using several doses and organic fertilizers. Stability of soil fertility are needed to support sustainable rice farming in Indonesia (Sukristiyonubowo et al., 2011).

Initial step is to conduct activities of rice cultivation in the laboratory experiment in greenhouse using soil from organic paddy field Sukorejo, Sambirejo, Sragen. The aim of this research is to determine the soil fertility status after planting experiment of organic paddy using farmyard manure, Azolla fertilizers and Azolla inoculum.

MATERIALS AND METHOD

Greenhouse experiment

Research was conducted by experiment method, this was experiment by planting paddy with media into pots in greenhouse. Soil materials were taken from organic paddy field in Sukorejo, Sambirejo, Sragen, with soil classification followed the Soil Survey Staff (2014) including Umbric Epiaqualf. Soil was taken composite in 0-20 cm layer depth, then airdried and sieved with diameter of 5 mm.

Experimental design used completely randomized design (Steel and Torrie, 1981) with 9 (nine) types of treatments (Table 1) replicated three times on each. Each experimental unit used soil 38.4 kg (air dry weight, moisture content 13.23%) in plastic bucket pot diameter 58 cm and 30 cm height. Rice variety used IR-64. Planting was done 22-day after seedling, 4 seeds per clump, 4 clumps per pot and row spacing 20 cm x 20 cm. Water was maintained $\pm$ 5 cm height until harvesting. Farmyard manure and Azolla fertilizer was given three (3) days before planting of paddy plant and mixed properly into the soil. Azolla inoculum was inoculated five (5) days after transplanting paddy (DAT).

Soil Analysis

Soil samples at harvesting time taken from each experimental unit in composite, then airdried and sieved 2 mm. Final soil properties observed: C-organic, cation exchange capacity (CEC), available P_2O_5, available K_2O and pH H_2O. Method of soil analysis followed procedure by Eviati and Sulaeman (2009).

Plant Parameter Measurement

Measured parameter was dry grain (DG), is the weight of harvested grain after being dried in direct sun until the water content up to 14%.

Table 1. Type of Treatments

Code	**Type of Treatments**	**N Supply (kg N ha^{-1})**			**N Total Supply (kg N ha^{-1})**
		PK	**PA**	**IA**	
A	Control (Without N)	0	0	0	0
B	FM 8 ton ha^{-1}	120	0	0	120
C	AF 5 ton ha^{-1}	0	120	0	120
D	AI 4 ton ha^{-1}	0	0	120	120
E	FM 4 ton ha^{-1} + AF 2,5 ton ha^{-1}	60	60	0	120
F	FM 4 ton ha^{-1} + AI 2 ton ha^{-1}	60	0	60	120
G	AF 2,5 ton ha^{-1} + AI 2 ton ha^{-1}	0	60	60	120
H	FM 2,67 ton ha^{-1} + AF 1,67 ton ha^{-1} + AI 1,33 ton ha^{-1}	40	40	40	120
I	FM 8 ton ha^{-1} + AF 5 ton ha^{-1} + AI 4 ton ha^{-1}	120	120	120	360

FM = farmyard manure, AF = Azolla fertilizer, IA = Azolla inoculum (Azolla as a dual cropping with rice plant). Total supply 120 kg N ha^{-1} based on requirement of paddy field (Sanchez, 1976). N Content of farmyard manure 1,2% (Syamsiyah, et. al, 2010, Mujiyo, et. al, 2010 and Hartati, et. al, 2010), and assumption of fertilizing efficiency 80%. N content of Azolla fertilizer (fresh) 2% (Mujiyo, et. al, 2010 and Hartati, et. al, 2010), and assumption of fertilizing efficiency 80%. Azolla inoculum 1 ton ha^{-1} which is applied 5 day after planting, for 30 days (when paddy plant is in peak of vegetative growth) will be able to supply 30 kg N ha^{-1} (Bharati, *et al*., 2000).

Data Analysis

Determination of soil fertility status by comparing parameters of soil fertility with category by Dobermann and Fairhurst (2000) (not fertile, fertile, very fertile). Determining the relationship between treatment with fertility status of the soil parameters using correlation analysis (Steel and Torie, 1981).

RESULT AND DISCUSSION

Properties of initial soil before planting; loam texture (clay 24,56%, silt 34,70%, sand 40,74%) (fertile), C-organic 2,09% (very fertile), CEC 27,75 cmol(+) kg^{-1} (very fertile), available P_2O_5 9,70 mg kg^{-1} (fertile), available K_2O 0,30 cmol(+) kg^{-1} (fertile), and pH 6,26 (not fertile). Dry grain (DG, water content 14%) 6,68 ton ha^{-1} (very fertile). DG is dry grain harvest (water content 14%), data obtained from the results of field experiment in control treatment without fertilizing. Soil fertility status according to Pusat Penelitian Tanah (1983) includes moderate, and according to Dobermann and Fairhurst (2000) includes fertile.

Data of final soil properties are presented in Table 2. Based on the comparison between initial and final soil properties shows that no significant changes. The average of soil properties after treatment was not significantly different from initial soil properties. Soil properties of C-organic, CEC, available P_2O_5 and pH were similar with initial soil properties. Available K_2O increased its fertility status from fertile became very fertile, caused by available K_2O 0.30 cmol (+) kg^{-1}, at initial soil was a critical limit of fertile became very fertile and farmyard manure significantly improved available K_2O (Table 3).

This was presumably because experiment time was relatively short-term, only one planting season which has not given signficantly effect to soil properties. Although changes in soil properties is not significant, but the average final soil properties to the use of farmyard manure, Azolla fertilizer, Azolla inoculum and its combination were relatively higher than in control (Table 2), which indicates the treatment actually had a greater impact on soil properties. Sutanto (2002) stated that the use of 7.5 ton ha^{-1} Azolla to paddy field increase soil organic matter (C-organic) 0.09 times of control treatment without Azolla.

Dry grain by farmyard manure, Azolla fertilizer, Azolla inoculum and its combination (except 5 ton ha^{-1} Azolla fertilizer treatment) ranged from 5.77 to 7.62 ton ha^{-1} which were higher than in control that only 5.28 ton ha^{-1} (Table 2). Treatment of 5 ton ha^{-1} Azolla fertilizer produced dry grain only 4.62 ton ha^{-1} which was lower than control. Likewise plant height parameter, total number of tillers, number of productive tiller, fresh dry weight, grain weight per panicle and 1.000 grain weight (data not shown) by the treatment was lower than control.

It is suspected in 5 ton ha^{-1} Azolla fertilizer treatment occured restricted growth due to the accumulation of nitrite (NO_2^-) in soil at initial of growth. Observation at 38 DAT content of NO_2^- was the highest (0.41 mg N kg^{-1} soil, data not shown), while the average of other treatment was lower (0.17 mg N kg^{-1} soil, data not shown). Research from Sustiprijatno et al. (2007) stated that the supply of N sources in the form of NO_2^- in paddy plants that are not genetically modified to be resistant to NO_2^- damages root cells, and ultimately lead to death of the plant. NO_2^- accumulation causes oxidation of acid and neutral thus leads to cell damage.

Final soil fertility status for all treatment that is relatively fertile (Table 2). Farmyard manure, Azolla fertilizers, Azolla inoculum and its combination were not significantly effect to the soil.

Table 2. Final soil properties and fertility status

Treatment	Texture	Cate-gory	C-Organic (%)	Cate-gory	CEC (cmol(+) kg^{-1})	Cate-gory	Available P_2O_5 (mg kg^{-1})	Cate-gory	Available K_2O (cmol(+) kg^{-1})	Cate-gory	pH	Cate-gory	Dry Grain	Cate-gory	Average of Category	Fertility status
Control (Unfertilised)	**Loam**	**2**	**1,81**	**3**	**24,23**	**3**	**5,70**	**2**	**0,31**	**3**	**6,25**	**1**	**5,28**	**3**	**2,4**	**Fertile**
FM 8 ton ha^{-1}	Loam	2	2,01	3	28,53	3	12,53	3	0,36	3	6,17	1	6,67	3	2,6	Fertile
AF 5 ton ha^{-1}	Loam	2	1,86	3	25,00	3	8,58	2	0,33	3	6,08	1	4,62	2	2,3	Fertile
AI 4 ton ha^{-1}	Loam	2	1,79	3	29,31	3	8,42	2	0,31	3	6,11	1	5,77	3	2,4	Fertile
FM 4 ton ha^{-1} + AF 2,5 ton ha^{-1}	Loam	2	1,87	3	28,49	3	14,06	3	0,36	3	6,25	1	7,62	3	2,6	Fertile
FM 4 ton ha^{-1} + AI 2 ton ha^{-1}	Loam	2	2,29	3	28,95	3	13,88	3	0,36	3	6,27	1	6,50	3	2,6	Fertile
AF 2,5 ton ha^{-1} + AI 2 ton ha^{-1}	Loam	2	2,36	3	29,17	3	14,42	3	0,34	3	6,40	1	7,11	3	2,6	Fertile
FM 2,67 ton ha^{-1} + AF 1,67 ton ha^{-1} + AI 1,33 ton ha^{-1}	Loam	2	2,03	3	28,73	3	11,63	3	0,36	3	6,32	1	6,49	3	2,6	Fertile
FM 8 ton ha^{-1} + AF 5 ton ha^{-1} + AI 4 ton ha^{-1}	Loam	2	2,26	3	28,84	3	10,19	3	0,38	3	6,24	1	7,39	3	2,6	Fertile
Average	**Loam**	**2,0**	**2,06**	**3,0**	**28,38**	**3,0**	**11,71**	**2,8**	**0,35**	**3,0**	**6,23**	**1,0**	**6,52**	**2,9**	**2,5**	**Fertile**

Category according to Dobermann and Fairhurst (2000); Category $\leq$ 1 = not fertile, > 1 – < 3 = fertile, $\geq$ 3 = very fertile

Table 3. Correlation between treatment with parameter of soil fertility status

	FM	AF	AI	CO	CEC	AP	AK	pH	DG
CO	$0,33^{ns}$	$0,18^{ns}$	$0,36^{ns}$						
CEC	$0,28^{ns}$	$-0,09^{ns}$	$0,38^{ns}$	$0,46^{*}$					
AP	$0,37^{ns}$	$0,01^{ns}$	$-0,02^{ns}$	$0,58^{**}$	$0,48^{*}$				
AK	$0,51^{**}$	$0,25^{ns}$	$0,04^{ns}$	$0,28^{ns}$	$0,10^{ns}$	$0,47^{*}$			
pH	$-0,01^{ns}$	$-0,05^{ns}$	$0,03^{ns}$	$0,30^{ns}$	$0,17^{ns}$	$0,39^{*}$	$0,25^{ns}$		
DG	$0,46^{*}$	$0,06^{ns}$	$0,20^{ns}$	$0,38^{ns}$	$0,34^{ns}$	$0,59^{**}$	$0,33^{ns}$	$0,41^{*}$	
FS	$0,16^{ns}$	$0,26^{ns}$	$0,16^{ns}$	$0,67^{**}$	$0,15^{ns}$	$0,45^{*}$	$0,38^{ns}$	$0,23^{ns}$	$0,15^{ns}$

FM = farmyard manure, AF = Azolla fertilizer, AI = Azolla inoculum, CO = C-organic, CEC = cation exchange capacity, AP = available P_2O_5, AK = available K_2O, pH = pH H_2O, DG = dry grain, FS = fertility status

Unfertilised control treatment caused all parameters were lower than the average, however, by Dobermann and Fairhurst (2000) it is still categorized as fertile soil.

Soil fertility status was not significantly correlated with farmyard manure ($0,16^{ns}$), Azolla fertilizer ($0,26^{ns}$) and Azolla inoculum ($0,16^{ns}$) (Table 3), which indicated that they had no significant effect to soil fertility status. Farmyard manure but nevertheless had very significantly correlated with available K_2O (0.51^{**}) and was significantly correlated with DG (0.46^{*}). Correlation indicated that farmyard manure increased available P_2O_5 and DG, but had not increased the soil fertility status. Myint, et al. (2010) and Dong et al. (2012) stated that the increase of soil fertility by fertilization treatment, especially organic fertilizer, will be known by long-term treatment up to several years.

Results also implied that the use of farmyard manure, Azolla fertilizers and Azolla inoculum were able to maintain soil fertility status as the initial soil before planting. The use of farmyard manure, fertilizer Azolla, Azolla inoculum and its combination did not lower soil fertility status, and rice yield were not significantly different from the result with commonly practiced by farmers which used farmyard manure 8 ton ha^{-1}.

CONCLUSION

Farmyard manure, Azolla fertilizers and Azolla inoculum was not significantly affecting soil fertility status. Average of final soil fertility status included fertile, which was the same as the initial soil fertility status. Average of final soil properties was relatively higher in treatment, which showed that giving farmyard manure, Azolla fertilizer, Azolla inoculum, and its combination had a greater impact on soil properties. Farmyard manure despite increased available K_2O and DG, but not significantly improved soil fertility status to very fertile soil. This was presumably due to the relatively short experiment period, only one planting season which had not given significant effect in soil properties. The implication of this study is the use of farmyard manure, Azolla fertilizers and Azolla inoculum were able to maintain soil fertility status as the initial soil condition before planting.

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