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Research article

AZOLLA - BASED ORGANIC FARMING: LOW BIOTECHNOLOGY FOR HIGH RICE PRODUCTIVITY

Sudadi and Sumarno

Soil Science Department, Faculty of Agriculture, Sebelas Maret University, Surakarta.
Ir. Sutami Street 36th A Kentingan Surakarta 57126.
Contact person: sudadi_uns@Yahoo.com

ABSTRACT: The experiment was conducted at Field Experiment Laboratory, Faculty of Agriculture, UNS Surakarta at Jumantono, Karanganyar, Central Java, to study the application of azolla-based organic farming systems to increase rice yield on Alfisol. Three treatment factors were evaluated i.e. Dosages of azolla inoculum (0; 250 and 500 gm^{-2}), dosages of phosphate rock (equivalent to 0%, 50%, 100% of recomendated 150 $kgha^{-1}$SP-36) and dosages of plant ash-K (equivalent to 0%, 50%, 100% of recomendated 100 $kgha^{-1}$KCl). As much of 12 kg fine soil (Ø 2 mm) was mixed thoroughly with these fertilizers, put into plastic pot then incubated at 5 cm height of standing water. Three rice tillers were planted each pot and azolla inoculums were spreaded at planting day. The experiment was arranged in completely randomized design with three replications. The variables observed included growth and yield of rice, soil total-N, available-P and exchangeable-K. Data analyzed by F test at 5% of level significant, followed by DMRT if any significant differences. The result showed that the treatment combination of $A_1P_2K_2$ (250 gm^{-2} azolla inoculum, phosphate rock equal to100 $kgha^{-1}$ SP-36 and organic-K equal to 75 $kgha^{-1}$KCl) gave highest yield of paddy which was higher than the yield of both NPK and manure fertilizer treatment. This research shows that azolla can substitute manure as organic fertilizer in high rice yield organic farming system.
Keyword: Alternative organic farming azolla-based high yield rice Alfisol

INTRODUCTION

With various reasons, organic farming systems have been trend since last decade in many countries over the world [5]; [9]; [14]; and [27]. In Indonesia, they have been introduced intensly more than a decade [2]; [3]; [6]; [23]; and [24], and now many farmer are interesting to apply it in their cultivation systems. Generally, their organic farming are based on the applied of manure, which make its demand increased along with the number of farmers applied organic farming systems [15]; [16]; [17] and [18]. The dosage of manure applied per hectare was high enough while its source is limited [26]. This tend to rise its scarcity and price at growing season. Unfortunetely, currently most farmers do not have enough cattle as source of manure so they have to buy it in large quantities to practice organic farming. Production cost of this will be an obstacle for farmers to adopt organic farming systems that affect the expansion of organic agriculture. The farmers will back to conventional farming systems, and the efforts to restore soil fertility and maintaining land productivity is hampered. The risk of land degradation will increase. The increase interest of farmers to adopt organic farming systems should be supported by developing alternative organic farming systems through diversification of organic fertilizer sources to prevent shortages, especially during the growing season. For areas with adequate irrigation, this can be done by the application of azolla-based organic farming systems [19]; [20]; [22]; [23] and [24].

MATERIALS AND METHODS

The experiments were conducted at the Field Experiment Lab. Fac. of Agriculture UNS in Jumantono, Karanganyar District, Surakarta, Central Java, Indonesia, April - November 2012, with Alfisol soil. Experiments using two gallon size pot filled with finely ground soil (2 mm in diameter), mixed thoroughly with treatment fertilizer, and watering to reached as high as 5 cm standing water. Three treatment factors were evaluated i.e. dosages of azolla inoculum ($A_{0,1,2}$) (0; 250 and 500 gm^{-2}), dosages of phosphate rock ($P_{0,1,2}$) (equivalent to 0, 75 and 150 $kgha^{-1}$SP-36) and dosages of plant ash-K ($K_{0,1,2}$) (equivalent to 0, 50 and 100 $kgha^{-1}$KCl). As control treatments were treatment with 5 $tonha^{-1}$ manure and treatment with NPK fertilizer (250 - 150-100 kgha-1 in form of urea, SP-36 and KCl). Each treatment combination was repeated three times.

Three rice seedlings of IR-64 varieties were planted each pot. Azolla inoculum spreaded out at planting day. Observed variables included plant growth variables (shoot dry weight and number of tillers), plant yield (number of seeds, 100-seeds dry weight and seed dry weight) and soil chemical properties (total-N, available-P, and exchangeable-K). The data obtained were analyzed by F test at level confidence of 5%, followed by DMRT if any significant influence [8].

RESULTS AND DISCUSSION

Alfisol soil used in this experiment has relatively low soil fertility as indicated by it several chemical properties, especially of it low content of soil organic matter, total-N, available-P and soil pH as shown in table 1.

Table 1. Chemical and physical properties of Alfisol from Jumantono used for experiments

Soil properties	Value	Classification
Organic matter content, %	1,40	low
Total-N content, %	0,12	low
Available-P, ppm	7,38	low
Exchangeable-K, mg100g^{-1}	0,22	low
Cation exchange capacity, cmol (+) kg-1 [1]	20,59	medium
pH (H_2O)	5,6	slightly acid
pH KCl	4,5	acid
sand, %	26,70	
silt, %	35,87	
clay, %	37,43	
soil texture class	clay loam	

*Sulaeman *et al*., 2005.

The use of azolla as organic fertilizer will increase soil organic matter and total-N content. Azolla is a source of organic matter with high N content. Azolla has doubling time 3 - 4 days and produce large biomass in relatively short time [10]; [11] and [21]. While, the use of phosphate rock and plant ash-K as source of P and K will be more profitable than the use of SP-6 and KCl, the more soluble fertilizers, because of rather acidic soil pH. Soluble-P fertilizer will easily change into non-soluble form that is not available to plants any more. Utilization of azolla as organic and nitrogen fertilizer for rice have been carried out mainly in the countries of China, India, Cambodia, and Vietnam. Some farmers in these countries have been applied azolla as organic fertilizer traditionally for long time. There were many research demonstrated the ability of azolla to substitute chemical nitrogen fertilizers in rice cultivation [13]; [1]; [7]; [12]; [6]; [22]; [19]; [23] and [24].

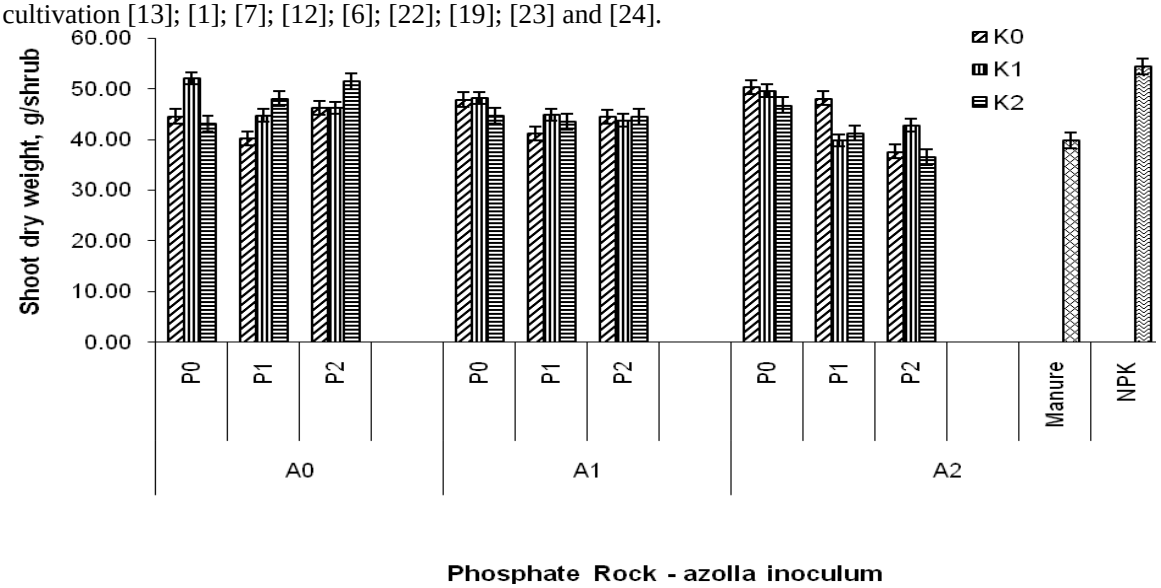

Fig. 1. Effect of azolla inculum, phosphate rock and plant ash-K dosages on rice shoot dry weight in Alfisol at Jumantono, Karanganyar, Central Java. Explanation: A_0, A_1, A_2 were azolla inoculums at 0, 250 and 500 gm^{-2}; P_0, P_1, P_2 were phosphate rock dosages equivalent to 0, 75 and 150 kgha^{-1} of SP-36; K_0, K_1, K_2 were plant ash-K dosages equivalent to 0, 50 and 100 kgha^{-1} of KCl. Manure = 5 tonha^{-1}; NPK fertilizer (250-150 -100) kgha^{-1} in the form of urea, SP-36 and KCl.

The results of this research showed that the effect of doses of azolla, phosphate rock fertilizer, plant ash-K-fertilizer and interaction among these three factors are very significant on soil organic matter (SOM) content, total-N, available-P, exchangeable-K and cation exchange capacity (CEC). Soil organic matter content increased with increasing doses of azolla inoculum used up to 500 gm^{-2}, as well as total-N. As for the available P, exchangeable-K and CEC, the use of azolla inoculum 250 gm^{-2} had the highest yield. Increasing doses of phosphate rock to equal 150 $kgha^{-1}$SP-36 also increases SOM, available-P and exchangeable-K, while the highest total-N and CEC were resulted from the treatment of phosphate rock equivalent to 75 $kgha^{-1}$ of SP-36.

Of the use of plant ash-K (mixed of variety plant ash) show that SOM, total-N content, available-P and exchangeable-K and CEC increased with increasing doses of plant aash-K used to equivalent of 100 $kgha^{-1}$ KCl. Generally speaking, the use of azolla, phosphate rock and plant ash-K are able to provide plant nutrients, and increase CEC and SOM higher than the use of manure and NPK fertilizer. This means that the used of azolla, phosphate rock and plant ash-K are able to substitute manure, SP-36 and KCl fertilizer and azolla-based organic farming can be an alternative organic farming systems with high rice yield and better soil chemical properties. The analysis of varian on growth and yield of rice plants variables showed that the influence of azolla inoculum dose was highly significant for shoot dry weight (P = 0.0002) and seed dry weight (P = 0.0019) but not significantly to 100-seed weight. The effect of phosphate rock dose on shoot dry weight, number of tillers and seed dry weight of rice were highly significant (P = 0.0000), but was not significant on 100-seed weight. Plant ash-K dose affect significantly on shoot dry weight (P = 0.0454) and tiller number (P = 0.0405) and highly significant (P = 0.0001) on seed dry weight. It influence on 100-seeds weight are not significant. The interaction of these three treatment factors showed a highly significant influence on shoot dry weight (P = 0.0000) and seed dry weight (P = 0.0000), significant (P = 0.05) on the number of tillers, but has no significant effect on 100-seed weight. It can be concluded that these three treatment factors as well as their interaction were able to influence significantly on rice yield (seed dry weight). This maybe caused by their ability to influence or increase nutrients availability, especially of N, P and K, and improve soil chemical properties (SOM and CEC). Of the shoot dry weight, show that the growth of rice cultivated in azolla-based organic farming is still less than one treated with NPK fertilizer. But some of treatment combination of azolla-based organic farming show higher shoot dry weight than plant grown in manure-based organic farming (Fig.1), maybe caused by their capability to increase nutrient availability especially N, P and K. Cow manure is an excellent organic fertilizer to improve soil physical-chemical properties and stimulate plant growth.

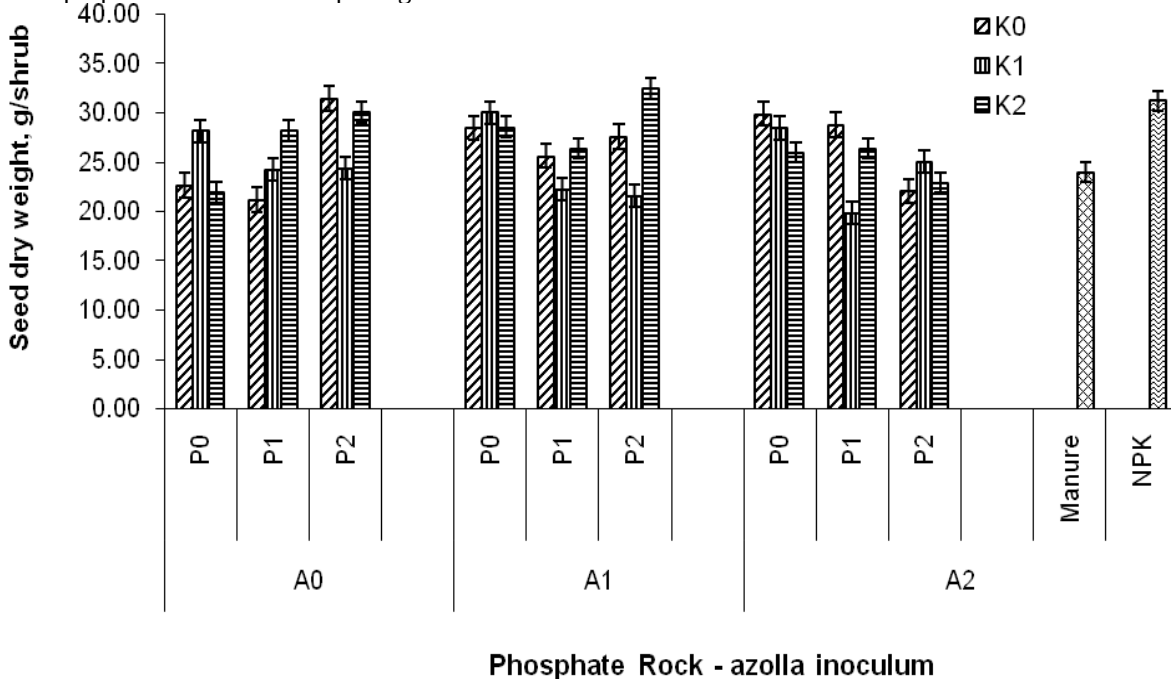

Fig. 2. Effect of azolla inculum, phosphate rock and plant ash-K dosages on rice seed dry weight in Alfisol at Jumantono, Karanganyar, Central Java. Explanation: (see Fig. 1).

As shown at Fig. 2, the treatment combination of $A_1P_2K_2$ (250 gm-2 azolla inoculums, phosphate rock equivalent to 150 $kgha^{-1}$ of SP-36 and plant ash-K equivalent to 100 $kgha^{-1}$ of KCl) give the highest rice seed dry weight (32, 47 $gpot^{-1}$), which is higher than the results of the treatment with NPK fertilizer (31.21 $gpot^{-1}$) and manure (24.00 $gpot^{-1}$) (Fig. 7).

These results indicate that the use of azolla, phosphate rock and plant ash-K can provide more nutrients availability and so higher rice yield than of manure-based organic farming systems. The treatment combination with the most tillers number does not give highest seed dry weight. This is presumably because not all tillers bear panicles. Tiller number is influenced markedly by azolla and plant ash-K dosages and highly influenced by phosphate rock dosage, while seed dry weight is influenced by the interaction of all three treatment factor. In contrast to rice growth and yield parameters, the effect of azolla inoculums, phosphate rock, plant ash-K and their interaction effect on 100-seed weight did not influence significantly. This suggests that no treatment combinations provide nutrients sufficiently to improve grain quality. Nevertheless, in terms of plant yield (seed dry weight) there were some of treatment combinations of azolla-based oganic farming giving higher yield than both manure and NPK fertilizer treatments.

CONCLUSION

The dosages of azolla inoculum, phosphate rock and plant ash-K as well as their interaction influence significantly on SOM, total-N, available-P, exchangeable-K, CEC, rice shoot dry weight, tillers number and seed dry weight of rice on Alfisol of Jumantono, Karanganyar district, Central Java, Indonesia. Combination treatment of $A_1P_2K_2$ (azolla inoculum dose 250 gm^{-2} + phosphate rock equivalent to 150 $kgha^{-1}$ SP-36 + plant ash-K equivalent to 100 $kgha^{-1}$ KCl) give the highest seed yield (32, 47 $gpot^{-1}$), which was higher than both yield of NPK (31.21 $gpot^{-1}$) and manure (24.00 $gpot^{-1}$) fertilizer treatments. This research shows that azolla can substitute manure as organic fertilizer in high rice yield organic farming system.

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