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Efficiency of Nitrogen and Phosphorus Fertilizer With Vesicular Arbuscular Mycorrhiza (VAM) Applicatio Yield of Situbagendit Rice Variety On Rainfed Lowland Rice

Achmad Fatchul Aziez*[1], Setie Harieni[1], Daryanti[1], dan Dika Saputra[2]

[1]Program study Agrotechnology, Faculty of Agriculture, Tunas Pembangunan University, Surakarta

[2] Student of Program study Agrotechnology, Faculty of Agriculture, Tunas Pembangunan University, Surakarta

[*] Corresponding Author :achmad.aziez@yahoo.com

ABSTRACT

The area of rainfed lowland rice in Indonesia was 3,292,578 ha or 24% of the total area of rice, but the used is still very small, so that opportunities are still open for the development of rice plants. The main constraints on rainfed lowland are drought stress and inefficient use of nitrogen (N) and phosphorus (P) nutrients. The purpose of this study was to determine the effect of mycorrhizal fungi on the efficient use of nitrogen and phosphorus in rice planted in rainfed lowland. This research was conducted in rainfed lowland in April to July 2019 in the village of Demangan, Sambi, Boyolali, Central Java. The research method was a randomized completely block design. Factor 1: Doses of nitrogen fertilizer (N) 0; 45; 90; 135 kg/ha. Factor 2: phosphorus dose (P) 0; 25; 50; 75 kg/ha. Observations included the number of total tillers, number of productive tillers, panicle number, panicle length, 1000 grain weight, and grain weight per plot. Data Analysis was analysis of variance. If there was a difference between treatments then it was tested further by using Duncan's New Multiple Range Test at 5% level. To know the relationship of direct and indirect influence, regression and correlation analysis were done. Data were analyzed by computer using SAS for window 9.0 programs. The results showed that the application of VAM could save the use of nitrogen fertilizer and eliminate the use of phosphorus fertilizer.

Keywords: nitrogen, phosphorus, Situbagendit variety of rice, rainfed lowland rice, Vesicular Arbuscular Mycorrhiza

1. INTRODUCTION

Rice was one of the main food sources consumed by nearly three billion people of the world. Rice was also a food commodity that is able to meet 32% of calorie needs (Sarwar and Kanif, 2005; Bouman et al., 2001).

The total area of rice in the world is estimated to reach 148 million ha, of which 70 million ha is irrigated rice field, while lowland rice and upland rice reach 54 million ha and 14 million ha respectively. Of the total world rice production, 75% of them are produced from the irrigated paddy system, while 19% and 4% are contributed from rainfed and upland rice (Maclean et al, 2002).

Increased productivity of rainfed lowland rice is hampered by various obstacles, one of which is water stress (drought) and inefficiency of fertilizer absorption. One alternative that can be done to improve the efficiency of P fertilizer absorption is through the use of MVA (Permanasari et al., 2016). This fungus can symbiosis with roots and has an important role in plant growth, both ecologically and agronomically (Hidayati & Huda, 2018). These roles include increasing the uptake of P and other nutrients, such as N, K, Zn, Co, S and Mo from the soil, increasing drought resistance, improving soil aggregation, increasing soil microbial growth that is beneficial for host growth and protecting plants from root pathogen infections (Sukarno, 2003; Bolan, 1991). This is also reinforced by Bolduc and Hijri (2010) that mycorrhizae increase the efficiency of nutrient uptake, increase plant resistance to pathogens and abiotic stress. Mycorrhiza can increase nutrient absorption, especially P and other nutrients (N, K, Ca, Mg, Cu, Mn, and Zn), production of hormones and growth regulators, and resistance to drought, root pathogens (Fujihara et al., 2013) and heavy metals (Paul and Clark, 1996).

Some other research results show that inoculation of mycorrhizal can increase N and P nutrient uptake in soybean plants (Mieke et al., 1999), increase P uptake in wheat (Permanasari, 2016), increase the efficiency of P fertilizer used and reduced the applications of P lime on acid soils, as well as increasing crop yields of soybeans, peanuts, green beans, corn and sweet potatoes (Simanungkalit, 1999). Noviani and Majid (2009) stated that the use of mycorrhizae as biological fertilizer greatly helps the process of reducing nutrients that are absorbed in colloidal soils due to low pH or Al and Fe activity.

The purpose of this study was to determine the effect of VAM in the efficiency of nitrogen and phosphorus fertilizer in the yield of Situbagendit Rice Variety on Rainfed Lowland Rice.

2. MATERIALS AND METHODS

This research was carried out from April to July 2019 in rainfed lowland rice with regosol in Demangan, Sambi, Boyolali with an altitude of 130 m above sea level. This study used a factorial Complete Randomized Block Design with nitrogen fertilizer doses of 0; 45; 90; 135 kg/ha and phosphorus doses of 0; 25; 50; 75 kg/ha and repeated three times.

Soil processing is done by plowing, then given manure at a dose of 10 tons / ha, plot size 4.0 m x 1.2 m, the distance between plots is 15 cm. Urea and SP36 fertilizers were given according to the treatment and KCl fertilizer at a dose of 75 kg / ha. Observations included total number of tillers, number of productive tillers, panicles number, panicle length, 1000 grain weights, and plot grain weights.

Data Analysis was analysis of variance. If there was a difference between treatments then it was tested further by using Duncan's New Multiple Range Test (DMRT) at 5% level. To know the relationship of direct and indirect influence, regression and correlation analysis were done. Data were analyzed by computer using SAS for window 9.0 programs.

3. RESULTS AND DISCUSSION

Based on analysis variance (Table 1.) the total number of tillers and the number of productive tillers was influenced by the interaction between the nitrogen dose and the amount of phosphorus dose, while the number of panicles, panicle length, 1000 grain weight and grain / plot weight were not affected by the interaction between the nitrogen dose and the phosphorus dose.

The highest total number of tillers in the treatment without P fertilizer, reached a dose of N 90 kg / ha but did not differ from the dose 135 kg/ha and the dose 45 kg/ha (Table 2.). The least number of total tillers in the treatment without P fertilizer was achieved without N fertilizer treatment (Purwanti, Hidayati, & Nurlina, 2017). The total number of tillers was affected by photosynthesis which occurred during the vegetative phase, and photosynthesis was influenced by the element nitrogen. Nutrient N in plants functions as forming of leaf green matter (chlorophyll) and protein forming element

Table 1. The analysis variance of yield component of rice variety after the application of VAM in rainfed lowland rice (g)

Treatment	Total number of tillers	Number of productive tillers	Panicle number	Panicle length	Weight of 1000 grains	Grain weight / plot
Nitrogen (N)	13.30**	12.95 **	4.09 *	2.37 ns	0.28 ns	3.94 *
Phosphor (P)	1.26 ns	3.00 *	2.10 ns	0.21 ns	0.96 ns	0.22 ns
N x P	7.28**	7.97 **	1.26 ns	1.29ns	0.62 ns	2.08 ns

Note : ** = very significant, * = significant, ns = non significant

Table 2. Effect interaction dosage of nitrogen and phosphor to the total number of tillers of rice variety after the application of VAM in rainfed lowland rice (g)

Dosage of Nitrogen (kg/ha)	Dosage of Phosphor (kg/ha)				Mean
	0	25	50	75	
0	10.067 f	10.500 d-f	10.500 d-f	9.667 f	10.184
45	13.333 b-f	14.000 a-e	16.067 ab	15.333 a-c	14.683
90	14.967 a-c	11.733 c-f	13.867 a-f	17.867 a	14.608

135	14.400 a-d	16.533 ab	16.200 ab	15.867 a-c	15.750
Mean	13.192	13.192	14.159	14.684	(+)

Note : The numbers followed by the same letter are not significantly different according to DMRT 5%

The highest total number of tillers in the treatment dose P 75 kg / ha, achieved at a nitrogen dose of 90 kg / ha and was not different from the dose of 45 kg / ha and a dose of 135 kg / ha, but significantly different from the treatment without nitrogen fertilizer. This is thought to be the role of mycorrhizal fungi. Mycorrhizal fungi have the ability to convert nutrients into plants, including nitrogen nutrients. Thus any dose does not affect the total number of tillers.

The total number of tillers without nitrogen fertilization was no difference in the various P doses tested compared with controls (Ali, Hosir, & Nurlina, 2017). This is because of the role of mycorrhizae. Mycorrhiza is able to absorb P nutrients and other nutrients from the soil into the root system of rice plants. P nutrient that functions as energy storage and transfer, is an important component in nucleic acids, coenzymes, nucleotides, phosphoproteins, phospholipids and phosphate sugars. (Dierolf et al. 2000). The total number of tillers was positively correlated (r = 0.73 **) with the number of productive tillers (Table 6). The more total number of tillers results in the number of productive tillers.

The number of productive tillers without the application of phosphorus fertilization (Table 3) was achieved at a nitrogen dose of 90 kg / ha which was not different from the 45 kg / ha dose and 135 kg / ha dose, but different from without nitrogen / control fertilization. This is in tune with 75 kg / ha of phosphorus. This is because of the role of nitrogen as a constituent of chlorophyll, chlorophyll as an important element in photosynthesis. With maximum photosynthesis, the number of productive tillers is also maximal. Nitrogen is involved in many plant compounds such as proteins, chlorophyll, enzymes, hormones, alkaloids and vitamins (Irfan et al., 2016).

The number of productive tillers has a positive correlation (r = 049 **) with the number of panicles, meaning that the number of panicle productive shoots will increase.

Table 3. Effect interaction dosage of nitrogen and phosphor to the number of productive tillers of rice variety after the application of VAM in rainfed lowland rice (g)

Dosage of N (kg/ha)	Dosage of P (kg/ha)				Mean
	0	25	50	75	
0	6.300 f	6.500 f	6.867 ef	7.833 c-f	6.875
45	8.833 b-f	10.167 a-d	9.833 a-e	10.400 a-d	9.808
90	12.067 ab	9.167 b	10.833 a-c	12.000 ab	8.767
135	11.533 ab	7.400 d-f	12.600 a	11.300 ab	10.708
Mean	9.683	8.309	10.033	10.383	(+)

Note : The numbers followed by the same letter are not significantly different according to DMRT 5%

In the number of panicles per clump (Table 4) there was no interaction between the dose of nitrogen and the dose of phosphorus (Table 4). The number of panicles in the N fertilizer treatment, the highest number of panicles at a dose of 135 kg / ha but did not differ from the 45 dose or 90 kg dose The number of panicles was achieved at least without fertilizing N. The number of panicles did not correlate with panicle length (r = 0.07ns), 1000 grain weight (r = 0.04ns) and grain / plot weight (r = 0.17ns)

The panicle length treatment (Table 4.) was in tune with the number of panicles. The longest panicle length was at a dose of 135 kg / ha but it was no different from the dosage of N 45 or 90 kg / ha. The shortest panicle length was achieved without fertilizing N. The panicle length of the rice plant was wrong. one indicator that determines the number of seeds found in panicles. The longer panicles usually the number of seeds in panicles more and more. Photosynthate translocation during panicle initiation as directed for panicle extension (Yoshida, 1981; Matsuo and Hoshikawa, 1993) Panicle length was negatively correlated with the weight of 1000 grains (r = - 0.65 **), the longer the panicle the weight of 1000 grains decreased.

Table 4. Effect of nitrogen fertilizer to the number of panicle, length of panicle (cm), 1000 grain weight (g), and grain weight per plot (200 cm x 120 cm) (cm)(g) of rice variety after the application of VAM in rainfed lowland rice (g)

Parameters	Dosageof Nitrogen (kg/ha)			
	0	45	90	145
Panicle number	11.72 b	14.44 a	14.25 a	15.20 a
Panicle length(cm)	22.92 b	25.33 ab	26.83 a	26.92 a
Weight of 1000 grains(g)	22.67 a	21.33 a	20.42 a	22.08 a
Grain weight / plot(g)	594.17 b	751.33 ab	866.08 a	865.67 a

Note : The numbers in the same raw followed by the same letter are not significantly different according to DMRT 5%

In the treatment of phosphorus dosage (Table 5), panicle length, 1000 grain weight and grain / plot weight there was no difference between fertilized and not fertilized phosphorus, also phosphorus doses of 25 and 50 kg / ha were not different from without fertilized phosphorus.

The weight of 1000 grain does not affect the interaction between the dose of nitrogen with the dose of phosphorus. The effect of a single dose of nitrogen and the effect of a single dose of phosphorus show the same pattern ie there is no difference between fertilized and not fertilized. The weight of 1000 grain is influenced by genetic factors compared to external factors including fertilization. This is supported by Horie et al. (2006) that the weight of 1000 grains tends to be influenced by genetic factors of a variety compared to environmental factors. Weight of 1000 grains is reflected in the size of quality, i.e. high grain yields are usually small sized but available in large quantities. The weight of 1000 grain is negatively correlated with the weight of grain / plot (r = -0.61 **), meaning that more grain is produced, the quality or size of the grain will be smaller.

Grain weight / plot there is no interaction between the dose of nitrogen with the dose of phosphorus. On the sole influence of nitrogen, grain weight / plot between fertilized nitrogen differs from that of fertilized nitrogen. Weight of grain / plot with doses of nitrogen 45; 90 and 135 kg / ha there is no difference (Table 4.). Nitrogen (N) occupies a conspicuous place in the plant metabolism system. All vital processes in plants are associated with proteins, of which nitrogen is an essential constituent. Consequently to get more crop production, nitrogen application is indispensable and unavoidable. Nitrogen plays a key role in agriculture by increasing of crop yield (Massignam et al., 2009). Nitrogen not only enhances the yield but also improves the food quality (Ullah et al., 2010). The optimum rate of N increases photosynthetic processes, leaf area of production, leaf area duration as well as net assimilation rate (Ahmad et al., 2009).

On the single effect of phosphorus, doses of 25; 50 and 75 kg / ha did not differ from controls (without P fertilization) (Table 5.), this is because mycorrhiza are able to absorb nutrients especially P into the roots so that there is no difference between fertilized P with no fertilization. This is in tune with the research of Yudha et al (2015).

According to Indriani et al. (2011), besides transporting phosphorus, Mycorrhiza also transports other nutrients to host plants such as ammonium, calcium, sulfur, potassium, zinc, copper and water. Mycorrhizae according to Simanungkalit (2006) is also a biological fertilizer that can increase nutrient uptake especially phosphorus (P). Mycorrhiza is able to absorb P from P mineral sources that are difficult to dissolve because it produces organic acids and phosphatase enzymes (Sufardi, 1999).

Table 5. Effect of phosphorus fertilizer to the number of panicle, length of panicle (cm), 1000 grain weight (g), and grain weight per plot (200 cm x 120 cm) (cm)(g)of rice variety after the application of VAM in rainfed lowland rice (g)

Parameters	Dosage of phosphor (kg/ha)			
	0	25	50	75
Panicle number	13.00 b	13.50 ab	13.64 ab	15.47 a
Panicle length(cm)	25.33 a	26.25 a	25.50 a	24.92 a
Weight of 1000 grains (g)	19.75 a	21.92 a	24.00 a	20.83 a
Grain weight / plot (g)	769.42 a	761.75 a	736.00 a	810.08 a

Note : The numbers in the same raw followed by the same letter are not significantly different according to DMRT 5%

Furthermore Lakitan (2012), arbuscular mycorrhizal fungi infect plant roots by forming hyphae internally in cortical tissue, then hyphae extending out the roots (external hyphae) and assisting the roots in absorbing water and nutrients. From the results of research by Rini et al (2017) the application of mycorrhiza in dryland the results are better than without the application of mycorrhiza. In the study area the author is a rainfed area so aerobic conditions often occur because there is rarely rain.

Table 6. The analysis of correlation yield component of rice variety after the application of VAM in rainfed lowland rice (g)

Parameter	Total number of tillers	Number of productive tillers	Panicle number	Panicle length	Weight of 1000 grains	Grain weight / plot
Total number of tillers	-	0.73**	0.68**	0.06 ns	0.12 ns	0.24 ns
Number of productive tillers		-	0.49**	0.07 ns	0.19 ns	0.17 ns
Panicle number			-	0.07 ns	0.04ns	0.17 ns
Panicle length				-	- 0.65 **	0.72 **
Weight of 1000 grains					-	- 0.61 **
Grain weight / plot						-

4. CONCLUSION

The results showed that the application of VAM could save the use of nitrogen fertilizer and eliminate the use of phosphorus fertilizer.

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