The Growth of Rice (Oryza sativa L.) on Non Tidal Lowland Soil through Enrichment of Azolla and Different Level Fertilization Dosage (N and P)

by Dedik Budianta

Journal of Environmental Science and Engineering A 11 (2022) 95-100
doi:10.17265/2162-5298/2022.03.003

DAVID PUBLISHING

The Growth of Rice (*Oryza sativa* L.) on Non Tidal Lowland Soil through Enrichment of Azolla and Different Level Fertilization Dosage (N and P)

Badriyah, Nuni Gofar and dan Dedik Budianta

Department of Soil Science, Faculty of Agriculture, Sriwijaya University, Jl. Raya Palembang-Prabumulih KM 32 Indralaya, Ogan Ilir 30662, Indonesia

Abstract: Rice can grow in the non tidal lowland despite its limited soil fertility. One of the biofertilizers that can be used to improve fertility is azolla. This research aims to evaluate the growth of rice in non tidal lowlands using azolla to enrich the soil and different dosage of N (Nitrogen) and P (Phosphate) fertilization. A FCRD (Factorial Completely Randomized Design) was adopted consisting of 3 treatment factors, namely concentrations of N with doses of N1: 46 kg/ha; N2: 69 kg/ha; N3: 92 kg/ha; P with P1: 34 kg/ha; P2: 68 kg/ha; and the application of azolla (A0: without azolla and A1: with 100 g/m^2 azolla). The result showed that enriching the soil with azolla, fertilization dosage N and P, has a significant effect on plant height in the 4th WAP (Week After Planting). Furthermore, the interaction between azolla and N significantly influences panicle number, grain weight, and plant height at 2nd, 4th, and 8th WAP. Conclusively, the application of azolla, N, and P fertilization supplied nutrients to rice crops in the non tidal lowland.

Key words: Azolla, fertilization dosage, P, N, non tidal lowland.

1. Introduction

The non tidal lowland is a sub-optimal area used for rice cultivation to provide food security. Low soil fertility, particularly the unavailability of N (Nitrogen) and P (Phosphate) nutrients, as well as a low soil pH, inhibits cultivation in this area [1]. Furthermore, the use of the traditional technology can only generate 1.8-3.1 tons/ha [2], which implies that rice cultivation requires proper management due to the low nutrient content found in this area.

Liming and fertilization are two methods of nutrient management that are essential for rice growth in the non tidal lowland. Chemical fertilizers (inorganic) are most commonly used, particularly N and P [3]. However, their regular use might lead to a decline in land quality. An alternative approach for increasing nutrients in agricultural soil is the use of organic materials, which can act as biofertilizers.

Azolla is a type of water fern that is commonly farmed and utilized in biofertilizer production. It can minimize the use of urea by up to 50%, and its combination treatment (as much as 100 g/m^2) with 100 kg/ha N produces superior plant growth outcomes on plant length, leaf area, and total dry weight parameters than a 100% N [4]. The application of 112 kg/ha N combined with 3.45 tons/ha fresh azolla increases crop output by 29.31% when compared to a treatment of 225 kg/ha N [5]. Furthermore, the use of azolla in the planting area can boost the availability of N for rice plants [6]. Based on the results of this research, intercropping azolla and rice increased the availability of N and P as well as grain dry yield by 16.1% [7]. Its ability to decrease N requirements in rice plants, particularly in lowland marshes, remains unknown. Therefore, this research aims to evaluate the growth of rice in non tidal lowlands using azolla to enrich the soil and different dosage of N and P fertilization.

Corresponding author: Badriyah, Nuni Gofar, research fields: soil chemistry, soil fertility and soil pollution.

2. Materials and Methods

This research was conducted at the plastic house in Ringin Agung Village, Lalan Sub-district, Musi Banyuas in Regency, South Sumatra Province. The soil sample was analyzed in the Integrated Laboratory at PT. Sampoerna Agro (Tbk) from December 2019 to July 2020.

A RALF (Completely Randomized Factorial Design) was adopted with three treatment factors namely: N concentration with doses of N1: 46 kg/ha, N2: 69 kg/ha, and N3: 92 kg/ha, P (P_2O_5) with P1: 34 kg/ha, P2: 68 kg/ha, and azolla administration (A) (A0: no azolla and A1: with azolla). Based on the number of components and the treatment level used, 12 combinations were created, which were then repeated three times resulting in a total of 36 experimental units. The preparation of planting media begins with the collection of lowland soil from a depth of 0-30 cm, which is dried for several days before being crushed and sifted. It was then weighed up to 10 kg and placed in a plastic bucket with a diameter and height of 29 and 37 cm, respectively. Afterward, each therapy was given to the media, stirred, and saturated with ion-free water. The rice seeds that have been planted are in parivariety. In each treatment bucket, two seedlings were planted at a depth of 3-4 cm. Furthermore, the rice plant maintenance includes checking the height of standing water in the treatment bucket, embroidery, weeding, and managing pests and diseases.

The observed variables in the rice vegetative phase include plant height, N uptake, and dry weight. During the generative phase, the number of productive tillers, the number of grains in each panicle, and the weight count were measured. The ANOVA (Analysis of Variance) was employed for data analysis and mean differences were separated using LSD (Least Significance Different) test at the 5% level of significance.

3. Results and Discussion

3.1 ANOVA Variables of Rice Plant Growth

The ANOVA results showed that the addition of azolla and several doses of N and P fertilizer had different effects on the plant's growth (Table 1). The application of azolla to rice plants can be a natural supply since it has a symbiotic association with cyano bacteria called *Anabaena azollae*, which can fix free N [7]. Furthermore, *Anabaena azollae* was shown to be capable of fixing up to 30-60 kg/ha N. The observation results of rice growth and production on lowland soil with the addition of azolla, N, and P fertilizer are shown in Table 1.

3.2 Plant Height

The result showed that the administration of azolla and the application of N and P fertilizer had a significant effect on plant height at 2nd, 4th, and 6th WAP, and no effect on the 8th. Furthermore, the interaction of azolla and N fertilizer had a very significant effect on the 2nd, 4th, 6th and 8th WAP.

Table 1 The ANOVA results of rice plant growth on the treatment of N, P, and azolla fertilizers.

Variable	A	N	P	AN	AP	NP	ANP
Plant height							
2 WAP	4.83*	50.4**	27.32**	11.04**	1.50^{tn}	0.15^{tn}	2.68^{tn}
4 WAP	7.25*	48.07**	22.86**	10.09**	1.89^{tn}	0.62^{tn}	4.63**
6 WAP	19**	77.40**	25.01**	7.08**	2.29^{tn}	0.2^{tn}	1.33^{tn}
8 WAP	0.15^{tn}	0.35^{tn}	0.15^{tn}	3.71*	0.23^{tn}	0.06^{tn}	1.65^{tn}
N uptake	1.18^{tn}	19.44**	9.39**	2.34^{tn}	0.83^{tn}	0.65^{tn}	0.77^{tn}
Plant dry weight	6.82**	53.54**	15.9*	0.23^{tn}	1.01^{tn}	2.0^{tn}	0.34^{tn}
Grain in each panicle	20.46**	49.99**	2.63^{tn}	18.36**	0.007^{tn}	0.35^{tn}	1.53^{tn}
Grain weight	7.97**	37.28**	5.89*	5.64**	2.26^{tn}	0.57^{tn}	1.39^{tn}

**= very significant effect, *= significant effect, tn= no effect, WAP: Week After Planting.

The joint interaction of azolla, N and P fertilizer had a very significant effect on the 4th WAP. Its decomposition also has a significant effect on the variables. The results showed that azolla decomposed for 3-6 weeks after application, by releasing 56%-80% N into the soil can replace inorganic N nutrient requirements [8]. The average height of rice plants at the vegetative stage is shown in Table 2.

The measurement results in Table 2 showed that the plant height always increases. Measurements were carried out in the vegetative phase, namely the 2nd, 4th, 6th, and 8th weeks. The results showed that rice plant height is influenced by the activity of N, which is a macronutrient that plays an important role in

Table 2 The LSD test result for high rice plants in azolla treatment and the application of various N and P fertilizer doses.

	Fertilizer N (kg/ha)	Plant high 2 WAP	Plant high 4 WAP	Plant high 6 WAP	Plant high 8 WAP
		34 kg/ha P_2O_5			
Without azolla	46	32.00^{h}	39.33^{h}	48.83^{g}	60.50^{g}
	69	39.33^{efg}	43.17^{efg}	54.33^{ef}	64.00^{ef}
	92	42.33^{bd}	45.83^{cd}	59.83^{bc}	68.83^{c}
		68 kg/ha P_2O_5			
	46	37.00^{g}	41.50^{fg}	52.50^{f}	62.33^{fg}
	69	40.83^{cde}	44.67^{def}	57.50^{cd}	67.83^{cd}
	92	46.83^{a}	51.50^{a}	65.00^{a}	74.17^{a}
		34 kg/ha P_2O_5			
Azolla (100 g/m^2)	46	37.67^{fg}	42.50^{fg}	54.33^{f}	63.50^{ef}
	69	40.17^{cdef}	45.33^{cde}	58.17^{cd}	68.50^{c}
	92	41.67^{bcde}	46.67^{bc}	61.33^{b}	69.83^{bc}
		68 kg/ha P_2O_5			
	46	$39.50d^{efg}$	43.67^{defg}	55.83^{de}	65.83^{de}
	69	44.00^{ab}	49.00^{ab}	62.00^{ab}	72.83^{a}
	92	42.83^{bc}	47.00^{bc}	62.33^{ab}	72.00^{ab}

The numbers followed by the same letter in the same row and column are not significantly different at the 5% LSD test level.

Table 3 The average N uptake and dry weight of the dry plant in the vegetative phase of rice plants.

	N fertilizer (kg/ha)	N uptake	Dry weight
	34 kg/ha P_2O_5		
Without azolla	46	0.63^{e}	1.39^{d}
	69	1.33^{cde}	2.08^{d}
	92	3.00^{ab}	4.23^{b}
	68 kg/ha P_2O_5		
	46	0.92^{de}	2.18^{d}
	69	2.17^{bcd}	3.81^{bc}
	92	4.04^{a}	5.58^{a}
	34 kg/ha P_2O_5		
Azolla (100 g/m^2)	46	0.93^{cde}	2.38^{d}
	69	1.49^{cde}	2.51^{cd}
	92	3.01^{ab}	5.61^{a}
	68 kg/ha P_2O_5		
	46	2.41^{bc}	2.61^{cd}
	69	3.21^{bc}	4.26^{b}
	92	3.26^{ab}	5.87^{a}

The numbers followed by the same letter in the same row and column are not significantly different at the 5% LSD test level.

growth and production. It can be sourced from the application of inorganic N from urea and the decomposition of the applied azolla. Furthermore, the application of azolla to rice plants can increase the height, the number of productive tillers, leaf area, and dry weight [3, 5].

The highest mean plant value at week 8 was 74.17 cm at the A0N3P2 surface. This was because the needs were sufficient, and neither excess nor deficiency existed. The lowest was 60.5 cm in the A0N1P1 treatment (without azolla, 46 kg/ha N, and 34 kg/ha P). Furthermore, in A0N1P1, the lowest dose of N and P was given with no azolla application, such that the available N was unable to meet the needs of rice plants, resulting in a lower height value compared to other treatments. The results by Safriyani et al. [9] showed that the N-deficient rice plant is stunted, with a few tillers and the leaves turned yellow. In addition, excess N can cause plants to fall easily resulting in lower crop yield quality.

3.3 N Uptake

The ANOVA result in Table 1 showed that the application of N and P had a very significant effect. However, the interaction between azolla administration and N, P had no significance on N uptake. The lowest N uptake in the combination with A0N1P1 treatment was only 0.63% and the highest of 4.04% was in A0N1P2. The results showed that there is no significant difference between rice plants that were given azolla and those that were not in the vegetative phase. The absorption of N in rice plant tissue in the vegetative phase was relatively the same, and N uptake adjusted to plant needs at each growth phase. The average N content in plant tissue is 2% to 4% dry weight [10]. According to Setiawati [11], N content in plant tissue was influenced by the plant's uptake of NO_3^- and NH_4^+ ions. Table 3 shows N uptake in the vegetative phase of rice plants.

The LSD test results showed that the dry weight of rice plants treated with A0N3P2 is not significantly different from the A1N3P1 and A1N3P2. This showed that the administration of azolla equalizes the dry weight yield of plants with P of about 34 kg/ha P_2O_5 and 68 kg/ha P_2O_5. According to Pawan and Singh [6], its combination with inorganic fertilizers increased the availability of N and P for the rice plant's absorption.

3.4 Panicles and Grain Weight

N is needed by plants because it plays a role in increasing protein levels and amino acid synthesis, while P acts as the main energy source. Furthermore, sufficient N and P nutrients can increase plant vegetative and generative growth. Based on Kollah et al. [7], azolla is a source of biological N that is easily decomposed and can increase the efficiency of N availability for rice plants. The interaction of its administration with different dose of N fertilizer significantly influences the number of panicles and grain weight.

Table 4 shows that A0N3P2 (without azolla, 92 kg/ha N, and 68 kg/ha P fertilizer) outperformed the other treatments in terms of the average number of grains per panicle and total grain weight. The number of grains per panicle is 129.67, with a total grain weight of 69.93 g and a yield of 8.75 tons/ha indicating that the dose of fertilization is in accordance with nutritional needs.

In A1N2P2, the average number of grains per panicle was 129, with a weight of 61.9 g and a production yield of 7.74 tons/ha. The production yield of A1N2P2 is higher than A1N3P2 of 7.62 tons/ha indicating that the azolla treatment of 100 g can replace the need for inorganic N fertilizer by 25%. In addition, 100 g of azolla containing 20.12% organic C, 3.07% N-total, 1.20% P-total, and 3.44% K-total, the application of azolla 6,300 g/plot can substitute 25% inorganic N fertilizer [9]. Meanwhile, the A0N1P1 treatment (no azolla, 46 kg/ha N fertilizer, and 34 kg/ha P fertilizer) yielded the smallest amount of crop, 3.88 tons.

Table 4 The LSD test results mean the number of panicles and the total grain weight of rice plants.

	N fertilizer (kg/ha)	Number of panicles	Total grain weight (g)
		34 kg/ha P_2O_5	
Without azolla	46	102.33^{e}	30.97^{f}
	69	122.33^{cd}	47.69^{de}
	92	127^{ab}	60.97^{abc}
		68 kg/ha P_2O_5	
	46	105.33^{e}	39.9^{ef}
	69	122.67^{bcd}	53.94^{bcd}
	92	129.67^{a}	69.93^{a}
		34 kg/ha P_2O_5	
Azolla (100 g/m^2)	46	120.67^{cd}	49.34^{de}
	69	122^{cd}	52.4^{dc}
	92	126.33^{abcd}	64.46^{ab}
		68 kg/ha P_2O_5	
	46	120.33^{d}	49.33^{de}
	69	129^{ab}	61.9^{abc}
	92	126.33^{abcd}	60.63^{abc}

The numbers followed by the same letter in the same row and column are not significantly different at the 5% LSD test level.

4. Conclusion

Conclusively, the application of azolla with doses of 92 kg/ha N and 34 kg/ha P produced the greatest results in terms of N uptake and plant dry weight. Similarly, the number of panicles, grain weight, and azolla application with an additional dose of 69 kg/ha N and 68 kg/ha P produced the best results in terms of plant height. These results were not significantly different from the treatment without azolla application with an additional dose of 92 kg/ha N and 68 kg/ha P.

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