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INFLUENCE OF AZOLLA TYPE AND CLOSURE RATE ON THE GROWTH AND YIELD OF LEBAK RICE (ORYZA SATIVA L.)

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Abstract

Indonesia as an agricultural country where the agricultural sector is a strategic sector and has an important role in meeting the food needs of the community. In times of economic crisis, the agricultural sector proved more profitable because it was resilient and able to recover faster than other sectors. The area of swampland in Indonesia is around 34.12 million ha, consisting of 8.92 million ha of tidal marshland and 25.20 million ha of lowland swampland. The area of swampland in South Sumatra Province is 613,795 hectares, which is divided into tidal swamps covering an area of 455,949 hectares and lowland swamps of 157,864 hectares. Of the area of lebak swampland that has been planted covering an area of 120,685 hectares, namely 48,782 hectares of lebak rice fields and 150,000 hectares of gardens. The increase in food production, especially rice, cannot be separated from the role of fertilization as an important input in agricultural intensification. Of the many fertilizers that exist, Nitrogen fertilizer is most widely used to increase agricultural production. Considering that the price of N fertilizer is getting more expensive, one alternative to N fertilizer is to use organic N fertilizer from Azolla plants. Azolla plants immersed in pond fields can increase rice yields by 91% in Thailand as stated by Kumarasinghe and Eskew (1993). Budianta et.al (1994) stated that there are two types of Azollae found in South Sumatra, namely Azolla pinnata var. pinnata and A. pinnata var. imbricata. Based on the things above, a study was conducted to see the influence of Azolla type and closure rate on the growth and yield of lebak rice (Oryza sativa L.). Research on the type and degree of closure of Azolla to examine the influence of Azolla type and closure rate in increasing the growth and yield of lebak rice has been carried out at the Greenhouse of the Faculty of Agriculture, Sjakhyakirti University Palembang from June 2020 to October 2020, consisting of 2 factors: type and degree of closure of Azolla. The first factor consists of 2 types of Azollae, Azolla pinnata var. imbricata and Azolla microphylla. The second factor consists of 4 levels, P0 = no Azolla closure, P1 = Azolla closing rate 50%, P2 = Azolla closure rate 75% and P3 = Azolla closure rate 100%. This research uses a Complete Randomized Design (RAK) with 4 replays. This researcher has 32 units. Statistical analysis was carried out with fingerprint analysis and further tests were carried out with the Smallest Real Difference Test of 5%. The results showed that the closure rate of Azolla was 100% and the type of Azolla pinnata var. imbricata (A2P3) gave the highest grain yield. However, at closing rate of 50% in the two types of Azollae had a noticeable effect on the upper dry weight and dry weight of the roots, the grain weight per panicle, the grain weight per clump and the production per hectare. The best influence is achieved by Azolla pinnata var. imbricata. At a closing rate of 100%. For Azolla 50% yield rate positively affects the upper dry weight and dry weight of the roots, the grain weight per panicle, the grain weight per clump and the production per hectare.

I. INTRODUCTION

The prospect of lebak swampland resources owned by South Sumatra is the basic capital and a great opportunity as one of the national rice granaries. The area of lebak swampland in Indonesia is 25.20 million ha and the area of lebak land in South Sumatra province is 157,864 hectares. Of the area of the lebak swamp that has been cultivated 120,685 hectares which is intended as lebak rice fields covering an area of 48,782 hectares, allotment as a garden of 1,500

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hectares, 23,339 hectares for other lalins and the remaining 47,064 hectares have not been utilized (Balai Besar Wilayah Sungai Sumatera VIII, 2017).

The increase in food production, especially rice, cannot be separated from the role of fertilization as one of the important inputs in agricultural intensification. Of the many fertilizers that exist, Nitrogen fertilizer is the most widely used to increase agricultural production. Given the increasingly expensive fertilizer prices due to the large production costs, one alternative that can be done is to take advantage of organic N fertilizer from Azolla plants.

Azolla has its own charm for botanists because of the symbiotic relationship in the fixation of N with cyanobacterium namely Anabaena azollae (Lumpkin and Plucknett, 1982). Based on the results of research in Thailand, it shows that Azolla as a water cover can increase rice yields by 32% while as an immersed organic fertilizer it can increase rice yields by 91% (Kumarasinghe and Eskew, 1993).

Lumpkin and Plucknett (1982), suggest that Azolla spp. originated in the northernmost regions such as Denmark, continuing to the Equator and southernmost areas such as Tierra del Fuego (South America) to an altitude of 5,000 m above sea level. Abdulkadir 1982) added that in Indonesia Azolla grows throughout the year. Budianta et.al (1994) stated that two types of Azolla were found in South Sumatra, namely Azolla pinnata var. pinnata and A.pinnata var.imbricata.

Based on the things above, a study was conducted to see the influence of Azolla type and Azolla closure rate on the growth and yield of lebak rice (Oryza sativa L.).

II. THEORETICAL FOUNDATIONS

1. Potential Land Area of Lebak

The area of raw rice fields owned by Indonesia is 7,463,948 hectares and those spread across South Sumatra are 470,602 hectares (Central Bureau of Statistics, 2019). The area is divided into 48,782 hectares of lebak rice fields and the rest of the irrigated rice fields. This is the basic capital for the Indonesian state to become one of the largest rice producing countries in the world in the future. According to the Agricultural Research and Development Agency (2011), South Sumatra has a diversity of agroecosystems so that it requires peculiarities in the technological components provided for rice farming. By paying attention to the condition of water availability in nature, rice planting in pond and tidal land can be done twice a year, while others who irrigate can 4 times a year in certain ways by taking advantage of opportunities and the will of farmers.

2. The Concept of Mutualism Symbiosis Azolla sp. and Anabaena azollae

Historically, Azolla has been used as a green manure for rice lebak in northern Vietnam and central to southern China for centuries. In the 1970s, research and use of this type of association was intensively carried out due to the increase in the price of chemical fertilizers and their negative impact in agriculture, namely in third world countries (Carrapiço et.al, 1991). The biological fixation of N performed by Azolla-Anabaena azollae is a great advantage for rice

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plants. Azolla contains 0.2% - 0.3% N on fresh weight (Patel et.al., 1980) and 3% - 5% N on its dry weight (Singh, 1982) which is a good source of N for rice crops. The N-fixing capability of the Azolla -Anabanea collaboration has the potential to increase rice yields at a fairly low cost. Soubert (1949) in Surahman (1993) reported that Azolla biomass accumulates 310 kg N/hectare/year. Azolla also releases 12% N to 14% N into water during the fixation process. Shen et.al. (1963) in Surahman (1993) reported that the use of N Azolla at 50% Azolla mexicana can release the 20% N it fixes. Decomposing Azolla takes 5 days – 10 days after being immersed in the soil, then new N can be released from Azolla. The rate of this decomposition depends on the quantity, variety and degree of maturity of Azolla (Lumpkin and Plucknett 1982). The quantity of N released from 1 g of Azolla – Anabaena was 0.3 g for 21 days.

The results of the research of Mian and Stewart (1982), showed that after Azolla was decomposed subsequently within a few days there was a release of N in the form of NH_4^+ and NO_3^-. Each is released somewhat differently where NH_4^+--N is released in increasing amounts and accumulating in the soil within 30 days, then gradually disappearing. For releases NO_3^--- N occurs less and less then rises in 30 days and decreases back to the next 60 days.

3. Review the Results of Previous Research

Based on Bangun (1986) reported that the 40% and 60% closure of Azolla pinnata achieved 7 days after planting was effective as a cover crop that reduced weed growth and increased rice yields markedly compared to without Azolla. Rice production at a closing rate of 40% and 60% differs unnoticeably. In addition, Azolla can also reduce the total weed weight by 79% compared to control at 50 days after rice is planted.

The results of Kustiono's research et.al. (2012), the provision of Azolla 6 tons / ha produces 8.67 tons / ha of grain in Ciherang rice plants. The results of Huda et.al (2016) showed that giving fresh azolla 5 tons ha-1 to carrots of the Kuroda variety gives the highest yield and better tuber shape, can increase the weight of tubers by 34.09 t ha-1. The application of fresh azolla and azolla compost as organic fertilizers exerts a noticeable influence on the growth of carrot crops on the parameters of plant length, plant height, number of leaves and leaf area index. Khan (1988), stated that Azolla pinnata can fix N fixation by 400 kg – 500 kg N per hectare/year.

The results of the research of Setiawati et al. (2017) states Azolla pinnata can be recommended as an alternative carrier of solid biofertilizers that can replace peat and litter compost materials with a 30% inoculant dose.

The objectives of this study are: (1) to examine the effect of Azolla type and closure rate on growth and yield of lebak rice (Oryza sativa L.) (2) To know the potential that Azolla pinnata has as a specific variety local South Sumatra

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III. RESEARCH METHODS

This study used a Complete Randomized Design (RAL) arranged randomly factorially with 4 tests. The factors studied are:

A = type Azolla, A1 = Azolla microphylla and A2 = Azolla pinnata var. pinnata. Imbricata

P = closing level, P0 = no close, P1 = 50% close, P2 = 75% close and P3 = 100% close. The data obtained were analyzed with Fingerprint Analysis and further tests were carried out for the Smallest Real Difference Test (BNT).

The study was conducted in the greenhouse of the Faculty of Agriculture, Sjakhyakirti University, Palembang from June to October 2020.

The materials used in this study were lebak soil, local rice, Azolla pinnata var. imbricata and Azolla pinnata var. imbricata, inorganic fertilizers, pesticide Curacron 60 EC. As for the tools used are hoes, harrows, plastic pots, scales, scissors, drying ovens, paper bags, crossbars and tools write.

Observed Changers

a) Growth Parameters:

1. Plant height
2. Number of saplings
3. The dry weight of the upper part of the plant
4. Dry weight of the roots

b) Result Parameters:

1. The number of productive saplings
2. Flowering age
3. Grain weight per panicle
4. Amount of grain per panicle
5. Grain weight per clump
6. Amount of grain per clump
7. Weight 1,000 grains
8. Prediction of rice yield per hectare

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IV. RESULTS

The results of the fingerprint analysis showed that there was a treatment interaction between Azolla types and the degree of closure has a very noticeable effect on the dry weight of the top crop, grain weight per panicle, grain weight per clump and yield prediction per Hectares.

Table 1: Results of Fingerprint Analysis of Various Influences of Treatment Type and Level Azolla's Closure of Observed Modifiers

No.	Treatment	F Count			KK (%)
		A	P	A x P	
	Growth components:				
1.	Plant height (cm)	2.59 TN	2.67 TN	0.99 TN	0,79
2.	Number of saplings (saplings)	17,20 **	24,69 **	2.08 TN	6,08
3.	The dry weight of the upper part of the plant (g)	87,89 **	109,29 **	37,39 **	4,85
4.	Dry weight of the root (g)	231,04 **	223,38 **	99,75 **	4,56
	Components of Results:				
5.	The number of productive saplings (saplings)	17,64 **	56,25 **	0.79 TN	5,95
6.	Flowering age (days)	0.34 TN	0.39 TN	2.05 TN	10,29
7.	Grain weight per panicle (g)	0.05 TN	37,85 **	5,75 **	4,67
8.	Amount of grain per panicle (grain)	8,83 **	0.38 TN	0.74 TN	2,20
9.	Grain weight per clump (g)	52,57 **	169,88 **	13,15 **	3,70
10.	Amount of grain per clump (grain)	13,21 **	60,81 **	0.59 TN	5,60
11.	Weight 1,000 grains (g)	0.01 TN	1.19 TN	0.38 TN	2,22
12.	Prediction of rice yield per hectare (ton/ha)	202,27 **	556,83 **	6,55 **	1,76

Table 2: Test Results of the Smallest Real Difference Effect of Azolla Type Interaction and Degree of Closure to the Dry Weight of the Upper Part of the Plant and Dry Weight of Roots

Treatment	Top dry weight (g)		Dry weight of the roots (g)	
	A1	A2	A1	A2
P0	32.63 a	33.93 a	6.30 a	6.53 a
P1	40.85 BC	38.05 b	7.20 b	7.55 BC
P2	41.30 c	55.53 s	7.95 BC	9.61 s
P3	41.93 c	56.60 s	8.08 c	14.08 e
BNT 0.05	3,016		0,559	

From the results of the BNT Test, the highest dry weight of the upper part of the plant was obtained at the interaction of A2P3 treatment (Azolla pinnata with a closure rate of 100 %) which was 56.60 g and the highest dry weight of roots on A2P3 14.08 g. At the closing rate Azolla pinnata 100% is able to provide a supply of Nitrogen from the symbiosis between Azolla and Anabaena azollae which fixes N in the air which is well utilized by rice plants. Soubert (1949) in Surahman (1993) reported that Azolla biomass accumulates 310 kg N/hectare/year. Azolla also releases 12% N to 14% N into water during the fixation process. Shen et.al. (1963) in Surahman (1993) reported that the use of N Azolla of 50% Azolla mexicana can release the 20% N that it fixes Lumpkin and Plucknett (1982) add that the speed of Azolla decomposition depends largely on the amount given, the variety and stadia of Azolla maturity, the content of N Azolla as well as the environmental conditions of the soil (microorganisms and temperature).

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As per the opinion of Kannaiyan et al. (1982), that the combination of Azolla immersion with artificial N fertilizer was able to increase hay production by 9.55 kg per hectare, added also by Murod (1994), that Azolla pinata var. imbricala. imbricata has the highest biomass production at various levels of inundation compared to other types of Azollae. Added Qixion (1984) in Bangun (1986), organic matter enhances buffer capacity, adds nutrients, accelerates the growth of rice-rotated palm roots, regulates the supply of nutrients and increases the aggregate diameter of the soil. Ponnamperuma (1984), stated that the addition of organic matter accompanied by the application of (artificial) fertilizers will provide good conditions for plants where the supply of N will increase, increase N release, increase K ions, add other nutrients and improve soil structure. The growth of rice plants in fertile fields shows that nutrients are well available to support vegetative growth so that the photosynthesis process can take place properly as well. This can be seen in Table 3 the total N content of the soil tends to increase after the study by > 0.3% compared to the N-Total content before the study of 0.3%.

Table 3: N-Total Content (after research)

Treatment	N-Total Content (%)
A1P0	0,38
A1P1	0,30
A1P2	0,34
A1P3	0,47
A2P0	0,33
A2P1	0,31
A2P2	0,44
A2P3	0,46

Table 4: Results of C-Organic and N-Total Content Analysis in Azolla

Types of Azolla	C-Organic (%)	N-Total (%)
Azolla microphylla	26,22	4.59
A.pinnata var.imbricata	27,57	4,69

Table 5: Test Results of the Smallest Real Difference Effect of Treatment Interaction on Grain Weight per Panicle, Grain Weight per Clump and Prediction Production per Hectare

Treatment Interactions	Grain weight per panicle	Grain weight per clump	Production prediction /ha
A1P0	3.78 ab	48.19 a	3.16 a
A1P1	3.75 ab	46.86 a	3.23 a
A1P2	4.72 e	64.50 a	3.40 b
A1P3	3.66 ab	64.94 c	4.35 e
A2P0	3.55 a	47.92 a	3.35 b
A2P1	4.07 c	58.92 b	3.67 c
A2P2	4.39 s	66,82 c	3.81 s
A2P3	3.84 BC	73.09 s	4.62 f
BNT 0.05	0,271	3,177	0,095

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The BNT Test results obtained the interaction of A1P2 treatment having the highest grain weight per panicle of 4.72 g at a closing rate of 50% of Azolla microphylla. This is closely related to the grain filling phase where at that time the need for N nutrients has been met properly because the amount of Azolla biomass is less rapidly decomposed at a closing rate of 50% than the closing rate above it with a larger quantity. This makes the difference in the time of availability of N for rice plants during the grain filling phase. However, the highest grain weight per clump was found in the A2P3 treatment interaction, which was 73.09 g from the 100% closure rate of Azolla pinnata var. imbricata.

There is a relationship between the dry weight of the upper part of the plant and the weight of grain per clump. The amount of nutrients absorbed during growth is reflected in the quantity of upper dry weight produced by the rice plant. It is very supportive of the physiological process of rice plants especially for photo synthesis and grain filling. Thus the photosynthate produced increases so that the energy stored in the form of ATP also increases which affects the growth of rice saplings and subsequently the yield of rice plants can increase. A larger number of saplings provides an opportunity for rice plants to form more panicles. Which will be directly related to the amount of grain that contains will be more. The reality is that in the field the amount of hollow grain that exists is very small.

As per Mengel's opinion in Mukminah (1994), that plants that meet their N needs well will have good vegetative and generative growth as well. For the prediction of production per hectare obtained from the interaction of A2P3 treatment which gives the highest prediction of production per hectare which is 4.62 tons / ha at a 100% closing rate of Azolla pinnata var. imbricata. This is inseparable from the influence of the high number of productive saplings and the high dry weight of the upper part of A2P3.

The high and low yield of a grain crop is largely determined by the magnitude of the photosynthate flowed into the seed plant. Gardner et al. (1985), suggest that photosynthetes stored in seed limbung come from the source of the uatama i.e. photosynthetic flow from leaves, photosynthetic flow from non-leaves and assimilate mobilization from other parts. One more thing that affects these three main sources is the environmental factors of the soil. The soil contains a lot of organic matter and nutrients available to plants.

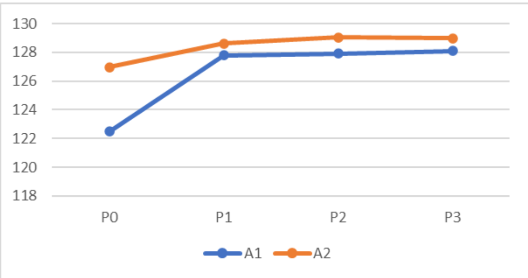

Figure 1: Rice plant height

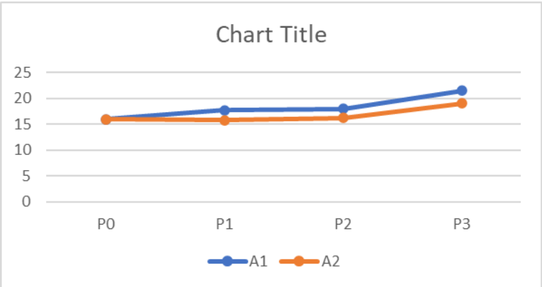

Figure 2: Number of rice saplings

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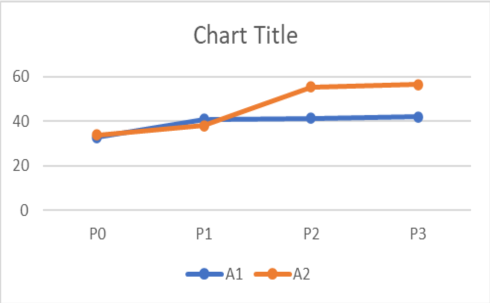


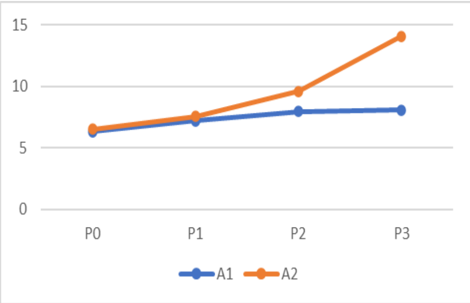


Figure 3: The dry weight of the top of **Figure 4: Dry weight of the roots**

From Figures 1 and 2 it is interpreted that for plant height and number of saplings that are more influential are internal factors than external factors of treatment. For Figures 3 and 4 it can be interpreted that there are different responses to the degree of closure of the two types of Azolla. At a closing rate of 50% each Azolla exerts the same effect on the dry weight of the upper part of the plant as well as the dry weight of the rice roots. Nevertheless, at higher closing rates of 75 % and 100 % A. pinnata var. imbricata showed a better influence than A. microphylla. Based on these pictures, it can be concluded that the A1P1 and A2P1 treatments have been able to increase the dry weight of the upper part and the dry weight of the roots of rice plants. However, to match the influence of Azolla pinnata var. imbricata at a closing rate of 75% and 100% then Azolla microphylla must be increased again the administration of biomass.

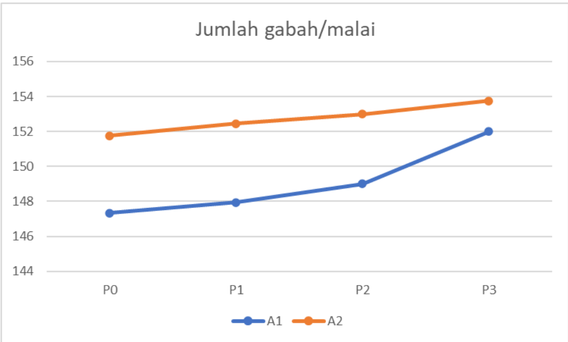
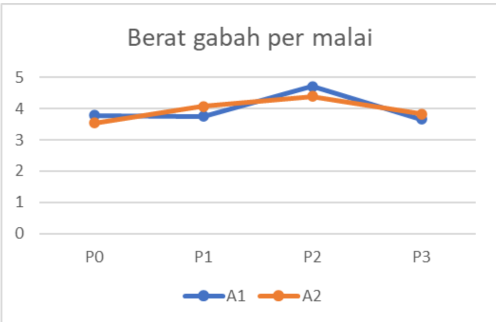


Figure 5: Amount of grain per panicle



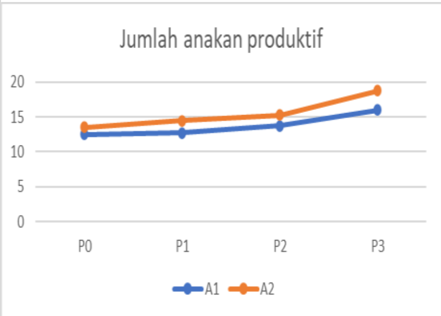


Figure 6: Grain weight per panicle **Figure 7: The number of productive saplings**

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Based on Figure 5 it can be interpreted that A. pinnata var. imbricata exerts a better influence on the amount of grain per panicle than A. microphylla at various closing rates. Based on Figure 6, it can be interpreted that a closing rate of 50% indicates an increase in grain weight per panicle and reaches its peak at a closing rate of 75%. For Figure 7, it is interpreted that both types of Azolla provide almost the same response to the level of closure rate in influencing the number of productive saplings of rice crops.

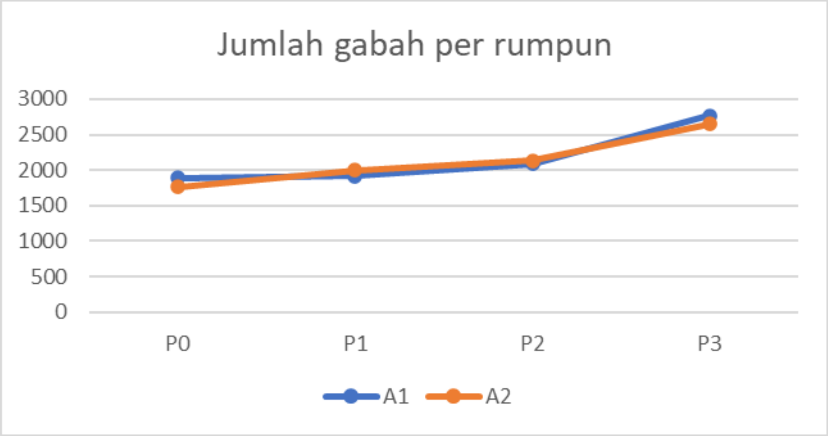
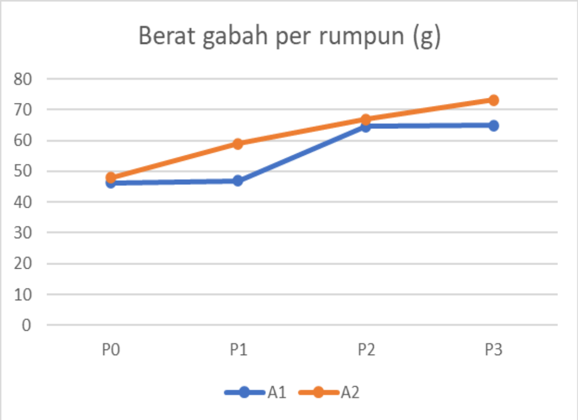


Figure 8: Amount of grain per clump (grain)

Based on Figure 8 it is interpreted that the amount of grain per clump is getting higher with the higher the degree of closure and the type of A. microphylla with A. pinnata var. imbricata its influence is very good.



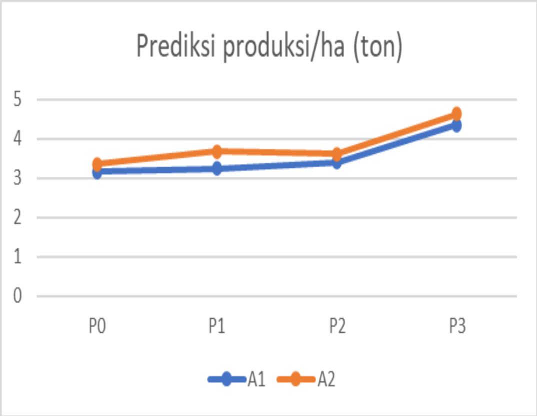


Figure 9: Grain weight per clump Figure 10. Production prediction/hectare

For Figure 9 it is interpreted that at a closing rate of 50 % the increase in grain weight per clump has begun and continues to the closing rate of 75% and 100%. Of the two types of Azolla there is A. pinnata var. imbricata which has a better influence than A. microphylla. Figure 10, interpreted bhwa at a closing rate of 50 % there is already an increase in production and higher at a higher closing rate of the two types of Azolla. However, for the type of A.

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pinnata var. imbricata showed a better influence than A.microphylla in providing production per hectare.

V. CONCLUSIONS AND SUGGESTIONS

A. Conclusion

Based on the results of the study, it can be concluded:

1. Treatment of Azolla microphylla with a closure rate of 50 % and Azolla pinnata var. Imbricata with a closure rate of 50% is able to have a positive influence on increasing the dry weight of the upper part of the plant, dry weight of roots, grain weight per panicle, grain weight per clump and prediction of production per hectare.
2. The treatment of Azolla pinnata var. imbricata with a closing rate of 50% gives the highest production per pot of 976.69 g while the predicted production per hectare is 4.62 tons.
3. The potential of the type of Azolla pinnata var. imbricata as a specific local variety is better than Azolla microphylla.

B. Suggestion

Administration of Azolla pinnata var. imbricata and Azolla microphylla at a closing rate of 50% if given by soaking should be done 3 times, namely before planting, during the first weeding and during the second weeding to obtain maximum results.

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