# Azolla Mycrophylla Fertilizer For Sustainable Agriculture: Compost And Liquid Fertilizer Applications

**Sri Utami Lestari, Enny Mutryarny, Neng Susi**

**Abstract:** The purpose of this study is a field test of the use of Azolla mycrophylla as a cheap and high-quality alternative fertilizer in Indonesia that aims to assist the Indonesian government's program in terms of national food security. The field test in this study involved two types of Azolla Mycrophylla namely wet and dry azolla, which were analyzed using analysis of variance (Anova) and Duncan's advanced test at the level of 5%, analyzing the chemical composition of Azolla mycrophylla in various technological innovations either as compost or liquid fertilizer (POC) using wet azolla and dried azolla in its application. The study found that the best treatment of compost Azolla was found in A3 treatment, namely azolla compost 96 g/polybag + 0.75 g urea/polybag, and the best treatment of liquid fertilizer Azolla is in the A4 treatment, namely the administration of Azolla mycrophylla POC 120 ml/l + 0.5 g urea/polybag. The average yield of variance showed the treatment of both the combination of Azolla mycrophylla compost and POC and urea significantly affected all parameters of observation. The results showed the combination treatment of both Azolla mycrophylla compost and Azolla mycrophylla POC can save the use of urea fertilizer which is needed to keep up with food demand but is also environmentally friendly. Both compost and POC Azolla mycrophylla have met the standards of organic fertilizer for vegetables according to the Regulation of Ministry of Agriculture No. 28 of 2009.

**Keywords:** Azolla Mycrophylla Fertilizer, Agriculture, Compost and Liquid.

## 1 INTRODUCTION

For most farmers in Indonesia, chemical fertilizers such as urea are compared to rice for plants, so it is obligatory for plants. Thus when the the price of urea fertilizer is expensive, it is the farmers who are the most troubled. It is even more ironic if one considers fertilizer to be only urea so they only use urea excessively without organic fertilizer balancing it (Tătaru-Fărmuș et al., 2018; Chen, 2006; Heluf, 2002). The use of inorganic fertilizers such as urea continuously does provide significant results but long-term use of urea has also proven to have very significant negative results (Chand et al., 2006; Delschen, 1999). The use of inorganic fertilizers in agriculture with a high level of dependence on chemicals has a negative impact (Indriani, 2002) that continues to bet the value of human health and also the destruction of the surrounding environment because inorganic fertilizer cause chemical residues (Sönmez et al., 2008; Oad et al., 2004) and possess polluting heavy metal elements (Arifin et al., 2018). Several studies have shown agricultural systems that intensively use fertilizers and chemical drugs can cause the process of supplying nutrients by microbes to run abnormally (Savci, S., 2012). Damage to land where the soil becomes hard and dense, soil becomes sour, diseases and pests of plants become resistant to pesticide, chemical compounds in land, water, crop products, and livestock accumulates are also undeniable impacts on the overuse of fertilizers on soil (Allen et. al., 1974; Yadav et al., 1997). Aside from the problem that inorganic fertilizer is environmentally unfriendly, the raw material for fertilizers is dwindling so the price of fertilizer is increasingly expensive (Mano, 2018; Bappenas, 2011; Departemen Pertanian, 2009; Oad et al., 2004), but it is still necessary to increase agricultural production in order to meet the increasing need of food (Sabadas et al., 2019). Therefore, this study sees the need to take tactical steps to minimize the use of chemical fertilizers while increasing the productivity of agricultural products in order to improve food quality, and also maintaining food security and most importantly, improving the welfare of the community. One tactical step is to see and utilize plants around the community that have the potential to become cheap organic fertilizers, but contain the nutrients needed by plants. This study looks at this potential in Azolla mycrophylla, but further research is needed on the effectiveness and content of these plants in supporting the productivity of agricultural products for national food security. Based on the initial information collected by this study, the Azolla pinnata matching varieties turned out to have fairly high nitrogen (N) element. Lab test results showed that the Azolla variety contained N 2.55 – 3.95% (Lestari, 2018). The availability of adequate nutrients such as N is one of the factors that can affect agricultural yields, because the nitrogen content in fertilizers is a much-needed nutrient of various plants including vegetables which are the focus of increased production in this study with the application of Azolla organic fertilizer (Sarief, 1986).

## 2. METHODOLOGY

This experimental study aims to test the use of Azolla mycrophylla to improve environmentally friendly agricultural production and simultaneously determining whether the use of Azolla mycrophylla can streamline the use of urea fertilizer in vegetable crops such as pakchoy and lettuce. The study was conducted for one year (12 months) at the Experimental Garden of the Faculty of Agriculture, Universitas Lancang Kuning at Jl. Yos Sudarso Km. 8 Rumbai. Observation techniques and chemical analysis laboratory tests were applied in this study to determine and test the potential of Azolla mycrophylla, both the chemical composition of compost and POC. This study applies a trial and error method to examine the role and effectiveness of Azolla mycrophylla as organic fertilizer in making the use of urea fertilizer more efficient for vegetable crops such as pakchoy and lettuce. To prove that Azolla plants are biased as technological


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innovations in creating environmentally friendly agricultural activities (sustainable agriculture), further analysis is needed. To analyze the Chemical Composition Test of the Azolla mycrophylla POC, this study used the method below.

***Table 1. Compost and POC Azolla mycrophylla Chemical Composition Test and Methods Used.***

| No | Chemical Analysis | Method |
|---|---|---|
| 1. | C-Organik | Wakley and Black |
| 2. | pH $H_2O$ | pH meter |
| 3. | N total | Kjedhal |
| 4. | P available | Bray 1 |
| 5. | K dd | N $NH_4OA_c$ pH 7,0 |
| 6. | Ca-dd | N $NH_4OA_c$ pH 7,0 |
| 7. | Mg-dd | N $NH_4OA_c$ pH 7,0 |
| 8. | K-dd | N $NH_4OA_c$ pH 7,0 |

## 3. Result and Discussion

The findings of this study indicate that Azolla mycrophylla does grow well at a pH of water 6.0-8.5 with air temperature 28-30° C. The use of Azolla can be applied from various forms of Azolla mycrophylla such as compost, POC, extract, wet azolla and dried azolla but this study only focus on compost and POC to be able to streamline or reduce the use of urea fertilizer. The results of the analysis of compost Azolla mycrophylla and Azolla mycrophylla POC in this study illustrate clearly that organic fertilizer standards have been fulfilled according to Regulation of Ministry of Agriculture No. 28 of 2009.

***Table 2. Results of Chemical Analysis of Compost and POC Azolla mycrophylla***

| No | Test Parameters | Unit | Compost | Criteria | POC | 2009 Regulation | | Criteria |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Bokhasi | POC | |
| 1. | pH $H_2O$ | - | 6,5 | Fulfilled | 4,3 | 8-Apr | 8-Apr | Fulfilled |
| 2. | C-organic | % | 42,95 | Fulfilled | 0,10 | ≥ 12 | ≥ 4 | - |
| 3. | N-total | % | 3,94 | Fulfilled | 0,05 | < 6 | < 2 | Fulfilled |
| 4. | C/N Ratio | - | 11 | - | - | 15-25 | - | Fulfilled |
| 5. | $P_2O_5$ - total | % | 1,21 | Fulfilled | 0,02 | < 6 | < 2 | Fulfilled |
| 6. | $K_2O$ - total | % | 4,88 | Fulfilled | 1,54 | < 6 | < 2 | Fulfilled |
| 7. | Mn- total | ppm | 542 | Fulfilled | 55 | - | - | Fulfilled |
| 8. | Cu- total | ppm | 6 | Fulfilled | 0,8 | - | - | Fulfilled |
| 9. | Zn- total | ppm | 46 | Fulfilled | 5,9 | - | - | Fulfilled |
| 10. | B- total | ppm | 55 | Fulfilled | 1,6 | - | - | Fulfilled |

Chemical analysis that has been carried out on Azolla mycrophylla compost shows the pH produced is high which is 6.5 and is close to neutral based on the criteria of soil chemical properties assessment (Pusat Penelitian Tanah, 1983), with organic C 42.95% and the total N 3.94% included in the very high criteria. The results of this analysis are also in accordance with the analysis result of Zainudin & Winaya (1999), that Azolla pinnata contains N 2.55–3.95%. Whereas the C/N 11 ratio indicates that fertilizers originating from Azolla mycrophylla are in fairly good condition (medium criteria) in supplying nutrients needed by plants. Decomposition of advanced organic matter is characterized by low C/N, while high C/N shows that decomposition has not yet advanced or has just begun (Cotrufo et al., 2013; Hakim et al., 1986). Based on the above results it can be seen that N content in azolla fertilizer is still above its critical value so that it can be mineralized immediately. According to Stevenson (1994) in Isrun (2010), in order for mineralization to occur immediately N levels in compost material must be higher than the critical value of 1.5–2.5%. Furthermore, Janzen and Kucey (1988) in Wahyudi (2009) suggested that the critical value of N is around 1.9–1.1%, if the N level is below the critical value, immobilization will occur. Referring to these findings, it is proven that Azolla mycrophylla meets the standards of good organic fertilizer based on applicable rules. Application of Azolla mycrophylla compost and urea on mustard plant. Compost fertilizer acts as a soil conditioner in the formation of soil aggregates or acts as a granulator (formation of granular soil structure) which causes the soil structure to become loose and has sufficient pores for soil water and air content (Nushanti, 2009). The use of Azolla mycrophylla compost in this study shows that the compost is able to cause greater soil aeration so that the soil becomes more loose, which makes it easier for the roots to grow and develop so it is easy to absorb nutrients (proliferation and interception) based on observations in this study. The mean results of variance in table 3 show that the combination treatment of Azolla mycrophylla and urea compost had a significant effect on all parameters of observation. The best treatment is found in A3 treatment, namely azolla 96 g/polybag compost + 0.75 g urea/polybag. It is suspected that the N nutrients of Azolla compost applied on plants can be well absorbed to form vegetative parts such as plant height, leaf number, leaf length, leaf width which in turn will affect the fresh weight and weight of plant consumption, as illustrated in the table below.

***Table 3. Average Plant Height (cm), Number of Leaves (Leaves), Leaf Length (cm), Leaf Width (cm), Fresh Weight (g) and Consumption Weight (g) of Mustard Plant Due to Composting of Azolla mycrophylla and Urea Fertilizer***

| Treatment | Observational Parameters | | | | | |
|---|---|---|---|---|---|---|
| | Plant Height (cm) | Number of Leaves (blade) | Leaf Length (cm) | Leaf Width (cm) | Fresh Weight (gr) | Consumption Weight (gr) |
| A0 | 23,00a | 4,63a | 11,98a | 9,20a | 20,94a | 16,73a |
| A1 | 30,80b | 8,00bc | 16,70b | 12,46b | 51,61b | 39,35b |
| A2 | 33,91c | 8,38c | 17,66b | 12,96bc | 65,33b | 54,37c |
| A3 | 36,29d | 9,63d | 21,43c | 14,13c | 108,42c | 89,46d |
| A4 | 30,91b | 7,38b | 17,38b | 12,40b | 54,53b | 43,99bc |

nformation :

A0 : Control
A1 : Compost *Azolla mycrophylla* 32 g + Urea 1,5 g
A2 : Compost *Azolla mycrophylla* 64 g + Urea 1,1 g
A3 : Compost *Azolla mycrophylla* 96 g + Urea 0,75 g
A4 : Compost *Azolla mycrophylla* 128 g + Urea 0,37 g

All observational parameters show that the A4 treatment (128 g of Azolla mycrophylla + urea fertilizer 0.37 g) is not significantly different from treatment A1 (32 g of Azolla mycrophylla + urea fertilizer 1.5 g), thus this study suspects Azolla mycrophylla compost is able to streamline the administration of urea fertilizer. Although A4 treatment tends to decrease in yield for all observation parameters compared to A3, in this case, despite A4 ability to streamline the administration of urea fertilizer, plant growth and production is not optimal. The results of the analysis of N uptake in soil and leaves of mustard plants are as follows:

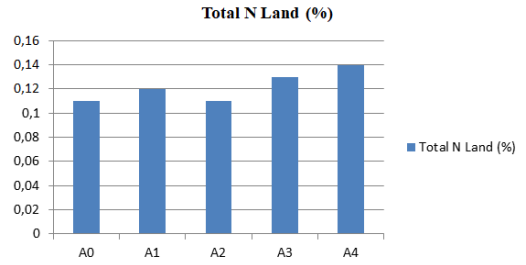


***Figure 1. Comparison Graph of Total N Land (%) as a Result of Giving Combination of Azolla mycrophylla Compost and Urea Fertilizer.***

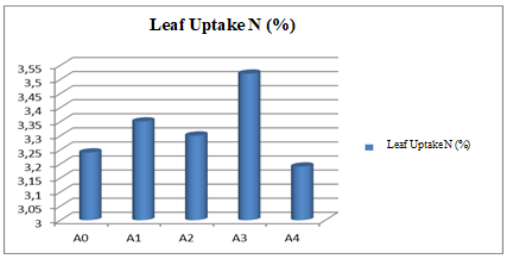


***Figure 2. Comparison Graph of N Leaf Uptake (%) as a Result of Giving Combination of Azolla mycrophylla Compost and Urea Fertilizer.***

Increased N uptake of plants can be caused by increased N availability in soil sourced from compost organic material. According To Warman & Termeer (2005), compost is highly influential in increasing the concentration of N, P, and K in plants. Wahyudi (2009) further reported that an increase in plant N uptake was related to an increase in dry weight of canopy, improvement in plant root development, and increase in soil N availability. It's clear that increased plant development has a direct relationship with improving soil conditions. This will cause an increase in the ability of plant roots to absorb water and N nutrients in the soil, which in turn will support the development of plant parts above the soil surface (Wagner, 1997). The data above confirms that Azolla mycrophylla compost causes greater soil aeration (water and air system) so the soil is looser, thus soil conditions become easier for roots to grow so it is easy to absorb nutrients. This is in line with the findings of Wiskandar (2002) stating that the influence of organic matter will increase the total pore of the soil and will reduce the weight of the soil volume. Soil aeration is associated with respiratory microorganisms in the soil and roots of plants, because aeration is related to O2 in the soil and therefore soil aeration will affect the soil microbial population. Application of Azolla mycrophylla and urea POC fertilizers in mustard greens. The mean results of variance in table 4 also show that treatment of the combination of Azolla mycrophylla POC and urea significantly affected all observational parameters. Liquid Organic Fertilizer (POC) is a solution resulting from the decay of organic materials derived from plant residues, animal feces and humans, which contain more than one element. POC generally does not damage the soil and plants even though it is used as often as possible and can be used as an activator to make compost. POC concentrations that are used can affect the permeability of plant leaf cells and determine the amount of nutrients that can be absorbed by plants so that it affects the optimal or not plant growth. The best treatment is in the A4 treatment, which is 120 ml/l POC + 0.5 g urea/polybag. This is suspected to be due to the nutrient element N of Azolla mycrophylla POC applied is absorbed well by plants to form vegetative parts such as plant height, stem diameter (cm), number of leaves (blade), which in turn will affect the fresh weight (g) and plant consumption weight (g) and plant dry weight (g). All parameters observed show that treatment A0 (control) produced the lowest growth and production of plants compared to other treatments. It is suspected that the low nutrient content in the research area is the main limiting factor of plants in reaching optimal plant growth and production so the administration of Azolla mycrophylla POC and urea fertilizer affects the plant growth and production. Indicators of the adequacy of nutrients that land can provide are reflected in the growth and production of plants that grow on them. Plant growth will increase according to nutrient supply to the optimal extent (Hanafiah, 2005). Plants need macro nutrients (N, P, K, Ca, Mg, and S) in large quantitites to grow optimally (Hanudin et al., 2010; Bokhtiar & Sakurai, 2005). Of the six macro nutrients, nitrogen (N), phosphorus (P), and potassium (K) are three nutrients that compose complete fertilizers and are the most important nutrients for plants, and Azolla mycrophylla POC contains all of them. N plays a role in stimulating vegetative growth of plants, P encourages the growth of roots, and K strengthens the plant's body.

***Table 4. Average Plant Height (cm), Stem Diameter (cm), Number of Leaves (Blade), Fresh Weight (g) and Weight of Consumption (g) Due to Giving Azolla mycrophylla POC and Urea Fertilizer.***

| Treatment | Observational Parameters | | | | | |
|---|---|---|---|---|---|---|
| | Plant Height (cm) | Stem Diameter (cm) | Number of Leaves (blade) | Fresh Weight (g) | Consumption Weight (g) | Dry Weight (g) |
| A0 | 22,70a | 0,65 a | 8,13 a | 28,97 a | 29,94 a | 0,5 6a |
| A1 | 24,04a | 0,81 ab | 10,88 b | 52,31 ab | 51,02 ab | 1,38 ab |
| A2 | 25,69a | 0,91 b | 11,25 b | 66,25 b | 62,48 b | 1,63 b |
| A3 | 25,18a | 0,76 ab | 9,25 ab | 49,97 ab | 47,62 ab | 0,6 ab |
| A4 | 25,50a | 0,95 b | 11,75 b | 68,48 b | 65,50 b | 1,46 b |

Information :

A0 : Control
A1 : POC *Azolla mycrophylla* 30 ml/l + Urea 2g
A2 : POC *Azolla mycrophylla* 60 ml/l + Urea 1,5 g
A3 : POC *Azolla mycrophylla* 90g ml/l + Urea 1 g
A4 : POC *Azolla mycrophylla* 120 ml/l + Urea 0,5 g

Table 4 shows that the higher Azolla mycrophylla POC applied is able to increase plant growth and production, although A4 treatment statistics are not significantly different from A2 treatment but A4 treatment is chosen as the best treatment which could be used as a the recommended fertilizer dose by considering several aspects, and adjusted to the purpose of the research where the considered aspects in selecting fertilizer recommendations are crop yields and the reduction of the use of inorganic fertilizers (urea fertilizer). There was no significant difference from the Azolla mycrophylla POC treatment to plant height because the Azolla mycrophylla POC contained lower nutrients, only 3.94% N-total (Table 1) or 1.8% lower than urea fertilizer (45% N), so the effect does not look real. However, results of visual observations show that mustard plants treated with Azolla mycrophylla POC had higher plant height and significantly different number of leaves compared with without administration. Furthermore, it was

stated by Yusnaweti (2016) and Gardner et al.(1991) in Manullang et al. (2014) that plant growth patterns vary, and the time period may be from a few days to years depending on plants or plant organs. Also, addition of growth progressively decreases with time until it reaches a steady state (climax). Increasing dry weight of plant proves that plant growth is getting better with the provision of fertilizer. Dry weight is the result of three processes, namely fertilization assimilation through photosynthesis, decreased assimilation due to respiration, and accumulation of food reserves with a balance of CO2 extraction (photosynthesis) and CO2 discharge (respiration). If respiration is greater than photosynthesis, dry weight of plants will decrease due to evaporation in the drying process (Parman, 2007). N uptake results on leaves showed that the administration of Azolla mycrophylla POC did not increase N uptake in leaves. This finding is in accordance to result of Poerwowidodo (1993), that soil contributes greater N to plants when compared to POC due to the contribution of N atmosphere entering more land through intermediate N-fixing, rain and lightning microorganisms. Furthermore, Hadisuwito (2007) in Arditia (2016) stated that one of the best types of plants for liquid fertilizer is plants which roots are symbiotic with N-binding microorganisms, and that type of plants are leguminocae so fertilizer liquid plays a larger role in it.

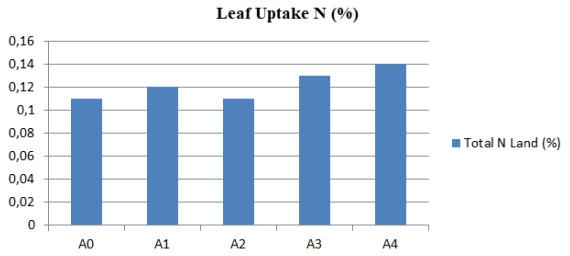


***Figure 3. Comparison Graph of Leaf Uptake N (%) of Lettuce Plants Due to Giving Azolla mycrophylla POC and Urea Fertilizers***

The use of Azolla mycrophylla as a solid organic fertilizer (compost) or POC requires time to first experience the decomposition process before it is used by plants, therefore to accelerate the use of nutrients contained in Azolla solids, Azolla extract can be made which has a lower C/N ratio thus plants can use the extract directly without having to wait for the decomposition process, either by directly putting the extract into the planting media or as a leaf fertilizer which would be given by spraying all parts of the plant. Similar to the combination of Azolla mycrophylla compost and urea fertilizer, all parameters observed show that treatment A0 (control) of Azolla mycrophylla POC and urea fertilizer is the treatment that produced the lowest growth and production of plants compared to other treatments. The A4 treatment for all different parameters is not significant with treatment A3, which means that Azolla extract is able to streamline the use of urea fertilizer by 25%. Nutrient solutions in the media affect the character of cultivated plant physiology. The absorption of these nutrients by plants is influenced by the surrounding environmental conditions to grow, including by the concentration of nutrient solutions given. Each plant has an optimum concentration limit in absorbing nutrients for its growth, and different concentrations will produce different physiological characters.

## 4. CONCLUSION

The results of the study can be summarized as follows:

1) The results of analysis of Azolla mycrophylla compost and Azolla mycrophylla POC have met the standards of organic fertilizer according to Regulation of Ministry of Agriculture No. 28 of 2009.
2) The mean results of variance showed that the combination treatment of Azolla mycrophylla and urea compost had a significant effect on all parameters of observation. The best treatment is found in A3 treatment, namely azolla 96 g/polybag compost + 0.75 g urea/poly bag.
3) The mean results of variance showed that the treatment of the combination of Azolla mycrophylla POC and urea had a significant effect on all parameters of observation. The best treatment is found in the A4 treatment, namely the administration of 120 ml/l of Azolla mycrophylla POC + 0.5 g of urea/polybag.

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