Effect of Azolla Extract Addition in Hydroponic Nutrient Solution on Growth and Yield of Chinese Lettuce (*Lactuca sativa* L.)

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ABSTRACT

Production of N fertilizers is very energy intensive. Reducing the use of synthetic fertilizers is a very crucial task to save energy, protect the environment, and achieve agriculture and economic sustainability. The use of natural materials such as plant extracts as a fertilizer subtitution can reduce the consumption of synthetic fertilizers. This study observed the effect of azolla extract addition in hydroponic nutrient solution on growth and yield of chinese lettuce (Lactuca sativa L.). This study was conducted by cultivating chinese lettuce on NFT (Nutrient Film Technique) hydroponic system. Nutrient solutions used were AB mix (0% ; 100%; 50%) and Azolla microphylla extract (0 mL/L; 17 mL/L; 21 mL/L; 25 mL/L). The results showed plant height, number of leaves, leaf area, and fresh edible weight were affected by addition of 17 mL/L and 21 mL/L azolla extracts. The addition of AB mix was needed to increase chlorophyl content. Furthermore, the water content of the plant tends to be greater in the treatment with azolla extract.

Keywords: *hydroponic, chinese lettuce, azolla, nutrient sollution, AB mix.*

INTRODUCTION

The hydroponic system is widely known as a cultivation system that can increase crop yields, yield quality and shorten the crop cycle due to the optimal nutrition provided by this system. The use of hydroponic technology in lettuce cultivation has advantages compared to conventional cultivation in the soil. Lettuce plants produced in hydroponic system are more hygienic, have uniform growth, and can be grown at close planting distances (1). An excellent hydroponic system can supply water and nutrients, must also be able to supply oxygen to the rooting zone. The results showed that lettuce plants that were given dissolved oxygen 20-30 mg/L could increase plant growth (2).

The nutrient solution used in the hydroponic system is called the AB mix, a combination of solutions A and B. The addition of nutrient solutions from other sources can also be used as a substitute for synthetic fertilizers of AB mix, such as plant extract or liquid organic fertilizer. The primary purpose of substituting AB mix with natural ingredients is to reduce the use of synthetic fertilizers that use a lot of energy in their manufacture. Production of N fertilizers is very energy intensive, and natural gas is the primary energy source. Combining the N and H to form NH3 requires considerable natural gas as the hydrogen feedstock and as energy for heat required during the process. A modern ammonia production plant requires net energy consumption of approximately 29.7 million BTUs per ton of N (3). Therefore, reducing the use of synthetic fertilizers that link to reducing energy consumption is a very crucial task to save energy, protect the environment, and achieve agriculture and economic sustainability. Another purpose is to reduce production costs because

relatively organic compound has lower prices.

Elements that suppose to be substituted are elements needed in significant quantities by plants (macronutrients), such as nitrogen, phosphorus, and potassium. Plants that have yields in the form of leaves, such as lettuce, require more nitrogen elements in the growth process until harvest. One of the plants with a significant nitrogen content is Azolla. Azolla is a mini water fern that is in symbiosis with Cyanobacteria (*Anabaena azollae*) fixing N. azolla contains 3.91% nitrogen and also contains nutrients P and K (4).

Chinese lettuce or sword leaf lettuce, pointed leaf lettuce, Taiwan sword leaf, Orient sword leaf, Yu Mai Tsai, is a kind of lettuce plant with a pandan scent when cooked. In general, chinese lettuce has the same harvest age and characteristics as other lettuce. This study aimed to explore the effectiveness of azolla extract substitution in AB mix solutions on hydroponic chinese lettuce growth and yield.

MATERIAL AND METHODS

This study was conducted from February to April 2015 in experimental field and Animal Husbandry Laboratory of Agriculture and Animal Husbandry Faculty, Muhammadiyah University of Malang. Plant extraction was conducted in Biotechnology Laboratory, Muhammadiyah University of Malang.

Seeding was done by embedding chinese lettuce seeds on wet rockwool media 2 cm x 2 cm. After 2 leaves appear, plants were transplanted to the hydroponic installation. The hydroponic system used in this study was the NFT system (Nutrient film technique) with a 5% slope. Azolla extract was made by grinding cleaned azolla with the addition of 200 ml of distilled water, then filtered. The content of nitrogen, phosphorus, and potassium elements of azolla can be seen in Table 1. AB mix nutrients used are produced by Parung Farm with contents that can be seen in Table 2. based on the comparison of nitrogen content between azolla extract and AB mix, a dose of 20 ml/L azolla extract was obtained, which was equivalent to 200 ppm/L AB mix.

Table 1. Content of *Azolla microphylla* Extract

Content	Total (%)
Nitrogen (N-total)	0.9715
Phosphorus (P_2O_5)	0.0565
Potassium (K_2O)	0.128

Table 2. Content of AB mix Nutrient

Contents		Concentration (ppm)
Macronutrients	N	200
	P	80
	K	320
	Ca	120
	Mg	80
	S	104
Micronutrients	Fe	1,34
	Cu	0,88
	Mn	0,88
	Zn	0,24
	B	0,32
	Mo	0,008

The experimental method used a factorial nested randomized block design. There are two factors: 1) the nutrient concentration of AB mix consisting of 0%; 100%; 50%, 2) *Azolla microphylla* extract of 0 ml/L; 17 ml/L; 21 ml/L; 25 ml/L. Based on these two factors, 12 treatment combinations were obtained. Each treatment consisted of three replications, so 36 experimental units and every experimental unit used five plants. This experiment used 180 plants in total. Observation variables are plant height, number of leaves, leaf area, fresh edible

weight, chlorophyll content, and water content.

The data were analyzed statistically with the ANOVA (Analysis of Varian) method to determine the effect of treatment or a combination of treatments on the measured parameters. The significant difference between treatments. Further tests were carried out using Tukey's HSD (honestly significant difference) test method at a level of 5%.

RESULT

Chinese lettuce plant height, number of leaves, leaf area, and fresh edible weight data showed significant differences under nutrient solution combination treatments (P>0.05). Table 3 shows that all plants under azolla extract treatments generally have higher plant height and number of leaves than treatments without azolla extract and AB mix. However, azolla extract doses of 17 ml/L and 25 ml/L could not perform good data without the addition of AB mix.

Table 3. Effect of different azolla extract and AB mix doses on plant height and number of leaves

Perlakuan	Height (cm)[a]	Number of leave
Azolla 0 ml/L + AB mix 0 %	6,70 a	2,13 a
Azolla 0 ml/L + AB mix 100 %	27,37 ab	9,00 c
Azolla 0 ml/L + AB mix 50 %	12,97 ab	4,93 abc
Azolla 17 ml/L + AB mix 0%	6,67 a	2,67 ab
Azolla 17 ml/L + AB mix 100 %	24,33 ab	7,20 bc
Azolla 17 ml/L + AB mix 50 %	28,50 b	8,33 c
Azolla 21 ml/L + AB mix 0%	21,70 ab	6,60 abc
Azolla 21 ml/L + AB mix 100 %	29,77 b	8,67 c
Azolla 21 ml/L + AB mix 50 %	31,90 b	9,20 c
Azolla 25 ml/L + AB mix 0%	6,65 a	3,20 ab
Azolla 25 ml/L + AB mix 100 %	22,23 ab	6,53 abc
Azolla 25 ml/L + AB mix 50 %	17,23 ab	4,93 abc

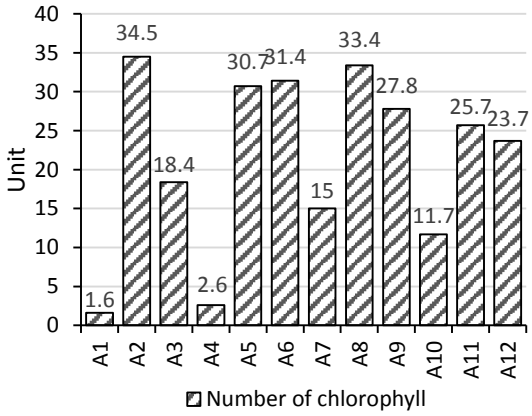
[a]Numbers followed by the same letter in the same column show results that are not significantly different based on the Tukey's HSD test at a 5% significance level

In line with plant height and number of leaves data, data of leaf and edible fresh weight show a similar result (Table 4). However, on the edible fresh weight treatment of azolla 17 ml/L + AB mix 50% had the highest data. While the highest average in other parameters is azolla 21 ml/L + AB mix 50%.

Table 4. Effect of different azolla extract and AB mix doses on leaf area, and edible fresh weight

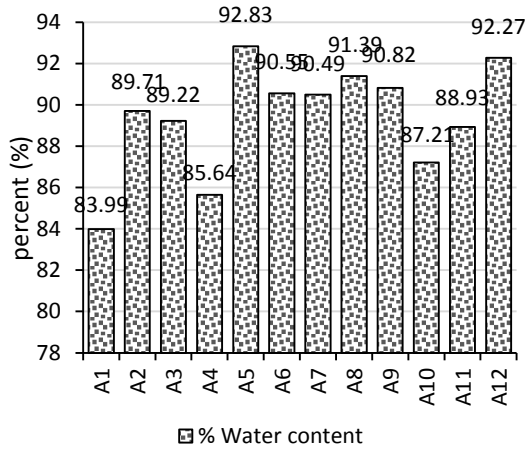
Perlakuan	Leaf Area (cm^2)		edible weight [a] (g)	
Azolla 0 ml/L + AB mix 0 %	7,19	a	0,07	a
Azolla 0 ml/L + AB mix 100 %	662,07	cd	31,67	cd
Azolla 0 ml/L + AB mix 50 %	105,86	ab	2,39	a
Azolla 17 ml/L + AB mix 0%	11,94	a	0,12	a
Azolla 17 ml/L + AB mix 100 %	495,64	abcd	36,67	d
Azolla 17 ml/L + AB mix 50 %	606,28	bcd	40,83	d
Azolla 21 ml/L + AB mix 0%	294,36	abcd	11,67	ab
Azolla 21 ml/L + AB mix 100 %	836,38	d	37,50	d
Azolla 21 ml/L + AB mix 50 %	689,34	cd	31,67	cd
Azolla 25 ml/L + AB mix 0%	15,58	a	0,39	a
Azolla 25 ml/L + AB mix 100 %	487,76	abcd	21,67	bcd
Azolla 25 ml/L + AB mix 50 %	201,73	abc	13,33	abc

[a]Numbers followed by the same letter in the same column show results that are not significantly different based on the Tukey's HSD test at a 5% significance level



Note : A1 (Azolla 0 ml/L + AB mix 0 %); A2 (Azolla 0 ml/L + AB mix 100 %); A3 (Azolla 0 ml/L + AB mix 50 %); A4 (Azolla 17 ml/L + AB mix 0%); A5 (Azolla 17 ml/L + AB mix 100 %); A6 (Azolla 17 ml/L + AB mix 50 %); A7 (Azolla 17 ml/L + AB mix 0 %); A8 (Azolla 21 ml/L + AB mix 100%); A9 (Azolla 21 ml/L + AB mix 50%); A10 (Azolla 25 ml/L + AB mix 0%); A11 (Azolla 25 ml/L + AB mix 100%); A12 (Azolla 25 ml/L + AB mix 50%).

Figure 1. Effect of different azolla extract and AB mix dosis on number of chlorophylls.



Note : A1 (Azolla 0 ml/L + AB mix 0 %); A2 (Azolla 0 ml/L + AB mix 100 %); A3 (Azolla 0 ml/L + AB mix 50 %); A4 (Azolla 17 ml/L + AB mix 0%); A5 (Azolla 17 ml/L + AB mix 100 %); A6 (Azolla 17 ml/L + AB mix 50 %); A7 (Azolla 17 ml/L + AB mix 0 %); A8 (Azolla 21 ml/L + AB mix 100%); A9 (Azolla 21 ml/L + AB mix 50%); A10 (Azolla 25 ml/L + AB mix 0%); A11 (Azolla 25 ml/L + AB mix 100%); A12 (Azolla 25 ml/L + AB mix 50%).

Figure 2. Effect of different azolla extract and AB mix dosis on water content.

The highest data average on number of chlorophylls was showed by AB mix 100% treatment. However, the addition of extract azolla all doses without addition of AB mix could not produce good data on this parameter, such as A4, A7, and A10 (Figure 1). All parameters showed that doses of 25 mL/L could not give good results, but not on the water content data. Water content data (Figure 2) showed all treatment with the addition of azolla extract could maintain water content better than AB mix 100% treatment.

DISCUSSION

Plant height, number of leaves, leaf area, and fresh edible weight

Chinese lettuce plant height, number of leaves, leaf area, and fresh edible weight data presented in Table 3 showed significant differences under different nutrient concentrations. These data are important in determining the quality of chinese lettuce results. A good harvest of chinese lettuce must have a high fresh edible weight. This was influenced by the number of leaves, good leaf width, and height.

In general, the addition of azolla extract 21 ml/L + 50% AB mix had higher data than others, especially AB mix 100%. Furthermore, the addition of azolla extract 21 ml/L + 50% AB mix was not significantly different from the addition of only azolla 21 ml/L without the addition of AB mix, except for edible weight data. The highest edible weight data was showed by azolla extract 21 ml/L + 100% AB mix treatment which had not significant difference from AB mix 100% treatment and azolla extract 21 ml/L + 50% AB mix. These results ascertain that the addition of azolla extract can function as a substitute nutrient to reduce the use of AB mix. Meanwhile, adding only azolla 21 ml/L without adding AB mix will not make the hydroponic chinese lettuce grow maximally. However, a research reported that hydroponic lettuce plant height, number of leaves, and fresh weight with the addition of azolla extract were better than that given POC rabbit urine, POC goat urine, POC cow urine, and POC leftover vegetables (5).

Based on the observation of the leaf chlorophyll number (Figure 1), the treatment AB mix 0% with or without azolla extract showed a low average value. The highest average was showed by the 100% AB mix treatment. Graph on figure 1 showed significantly contrasting that the value of the number of chlorophylls in the AB mix 50% treatment decreased by half from the AB mix 100%. Furthermore, with the addition of azolla extract doses of 17 ml/L and 21 ml/L, it can support doses of 50% AB mix to increase the amount of chlorophyll that equally as good as 100% AB mix treatment (positive control). However, a dose of 25 ml/L of azolla extract inhibited the formation of

chlorophyll, in line with the results of the vegetative plant growth above (Table 3).

The result above could be suspected that the nutrient content in azolla is not fully ready to be absorbed by plants, but some of the compounds need to be reformed or decomposed first or taken by microorganisms. The study reported that the nitrogen solutions content showed a significant positive relationship with chlorophyll content for both cultivars, which implies that more nitrogen will produce more chlorophyll content (6). The form of azolla extract, which is liquid and full of organic compounds, is very favored by microorganisms. This possibility was indicated by the number of mosses in the nutrient channel hose in the azolla extract treatment, especially in 25 ml/L doses. Solution consistency that is too high is considered ineffective for plant absorption and attracts more microorganisms. Research also reported that POC *Azolla microphylla* 120 ml l^{-1} + 0.5 g urea $plant^{-1}$ was not significantly different from POC *Azolla microphylla* 60 ml l^{-1} + Urea 1.5 g $plant^{-1}$ on support lettuce growth and yield (7). Instead of increasing the dose extract, it may be more effective to increase the giving intensity.

Compared to AB mix-only treatment, treatment with the addition of azolla extract tended to have higher result on water content. Comparing fresh edible weight and plant water content data, seen that AB mix-only treatment had good edible weight data but not in water content. Indicated that chinese lettuce on AB mix-only treatment had a good amount of plant tissue/fiber than water. However, the doses of azolla extract that had no significant differences from AB mix but also had high data on water content indicated plant yield had good texture (watery/crunchy)

CONCLUSION

The addition of azolla extract could support chinese lettuce plant height, number of leaves, leaf area, and fresh edible weight as good as AB mix 100%. However, to get a good number of chlorophyll, the addition of AB mix was still very much needed. Furthermore, the water content of the plant tends to be greater in the treatment with azolla extract. In order to maximize the function of azolla extract, it is necessary to increase the frequency of application, instead of increasing the dose extract.

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