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Effects of AB Mix and *Azolla microphylla*-Based Liquid Organic Fertilizer Proportions on the Growth and Yield of Water Spinach (*Ipomoea reptans* Poir.) in a Wick Hydroponic System

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ABSTRACT

Water spinach (*Ipomoea reptans* Poir.) is a fast-growing leafy vegetable with strong potential for household and urban farming systems. The wick hydroponic system offers a simple, low-cost, and energy-saving cultivation approach; however, its productivity depends strongly on the nutrient source used. This study evaluated the effects of different proportions of inorganic AB Mix and *Azolla microphylla*-based liquid organic fertilizer (LOF) on the growth and yield of water spinach cultivated in a wick hydroponic system. The experiment was conducted from April to July 2025 at the Experimental Garden of the Faculty of Agriculture, Udayana University, Denpasar, Indonesia, using a randomized block design with one factor and four replications. Seven nutrient treatments were tested: water control, 100% AB Mix, 100% *Azolla* LOF, 75% AB Mix + 25% *Azolla* LOF, 50% AB Mix + 50% *Azolla* LOF, 25% AB Mix + 75% *Azolla* LOF, and 100% AB Mix + 100% *Azolla* LOF. The observed variables included plant height, number of leaves, leaf area, stem diameter, leaf chlorophyll, root length, fresh and dry biomass, and shoot-to-root ratio. Analysis of variance showed that nutrient proportion significantly or highly significantly affected most growth and yield variables, except plant height and leaf number at 7 days after planting and shoot-to-root ratio. The combined 100% AB Mix + 100% *Azolla* LOF treatment produced the highest vegetative performance, whereas 100% *Azolla* LOF produced the highest total fresh weight (33.5 g plant−1), representing a 50.2% increase over the control. These findings indicate that *Azolla microphylla*-based LOF can be used as a sustainable nutrient source in wick hydroponics, either alone or combined with AB Mix, particularly for low-input urban vegetable production.

Keywords: AB Mix, *Azolla microphylla*, liquid organic fertilizer, urban farming, water spinach, wick hydroponics

INTRODUCTION

Agriculture remains an essential sector for food security and rural livelihoods in Indonesia. However, rapid urbanization and residential expansion continue to reduce the availability of productive agricultural land, particularly in urban and peri-urban areas (Hidayat et al., 2023). This condition requires cultivation technologies that are efficient, space-saving, and suitable for small-scale production. Hydroponics is one such technology because it enables plant cultivation without soil by supplying water and dissolved nutrients directly to the root zone (Ilhamdi et al., 2020).

Among hydroponic systems, the wick system is particularly suitable for household and urban farming because it is simple, inexpensive, and does not require electricity (Mustikawati et al., 2023). Nutrient solution is transported from the reservoir to the root zone through capillary action using a wick, making the system easier to construct and maintain than active hydroponic systems such as the Nutrient Film Technique or Deep Flow Technique. Despite these advantages, the productivity of wick hydroponics is strongly influenced by the quality, concentration, and composition of the nutrient solution.

Water spinach (*Ipomoea reptans* Poir.) is a widely consumed leafy vegetable with a short production cycle, high market demand, and good adaptability (Dewi and Mardiana, 2023) to intensive cultivation systems. In hydroponic production, AB Mix is commonly used because it provides readily available macro- and micronutrients. Nevertheless, exclusive dependence on commercial inorganic nutrient solutions may increase production costs and reduce the sustainability of household-scale systems. Therefore, alternative or complementary nutrient sources are needed to improve the economic and environmental feasibility of hydroponic vegetable cultivation.

Azolla microphylla is an aquatic fern that forms a symbiotic association with nitrogen-fixing cyanobacteria, making it a promising raw material for liquid organic fertilizer. Previous studies have reported that *Azolla*-based organic fertilizer contains nitrogen, phosphorus, potassium, and several micronutrients that support vegetative growth (Lestari et al., 2019). Its local availability, rapid biomass production, and potential contribution to nutrient recycling make *Azolla microphylla*-based LOF a promising input for low-cost hydroponic systems. However, comparative information on the use of AB Mix and *Azolla* LOF proportions in wick hydroponic systems remains limited.

This study aimed to evaluate the effects of different proportions of AB Mix and *Azolla microphylla*-based LOF on the growth and yield of water spinach cultivated in a wick hydroponic system. The results are expected to provide practical information for developing sustainable, low-input hydroponic nutrition strategies for urban farming.

MATERIALS AND METHODS

Study site and materials

The study was conducted from April to July 2025 in the greenhouse of the Experimental Garden, Faculty of Agriculture, Udayana University, located at Jl. Pulau Moyo No. 16X, Pedungan, South Denpasar, Denpasar City, Bali, Indonesia. Seed germination testing was performed at the Laboratory of Plant Breeding and Seed Technology, whereas oven-drying of harvested samples was carried out at the Laboratory of Agronomy and Horticulture, Faculty of Agriculture, Udayana University.

The equipment used in the study included flannel fabric, cutters, a soldering tool, scissors, a sprayer, a ruler, writing instruments, a total dissolved solids (TDS) meter, a pH meter, a chlorophyll meter, a manual caliper, a digital balance, a measuring cup, a dropper pipette, Petri dishes, a mobile phone camera, labels, knives, cutting boards, buckets, hoses, recycled bottles, stirrers, and filter cloth. The materials included seeds of the Bangkok LP-1 variety of water spinach, burnt rice husk charcoal, recycled 15 L gallon bottles as wick-system containers, AB Mix nutrient solution (Infarm brand), fresh green *Azolla microphylla*, molasses, effective microorganisms 4 (EM4), young coconut water, cooked white rice, first rice-washing water, tap water, and tissue paper (Figure 1).

Experimental design and treatment structure

The experiment used a randomized block design with one factor, namely the proportion of AB Mix and *Azolla microphylla*-based LOF (Table 1). Seven treatments were tested with four replications, resulting in 28 experimental units. Each unit consisted of one recycled 15 L gallon bottle containing 18 water spinach seeds, so the total number of seeds used in the experiment was 504.

Preparation of nutrient solutions and Azolla LOF

The full-dose AB Mix solution was prepared at 10 mL L−1 of water. Therefore, 75%, 50%, and 25% AB Mix corresponded to 7.5, 5.0, and 2.5 mL L−1, respectively. The *Azolla microphylla*-based LOF was also prepared with a full dose of 10 mL L−1 of water; thus, the 75%, 50%, and 25% doses corresponded to 7.5, 5.0, and 2.5 mL L−1, respectively. Tap water from the research site was used as the solvent and was left standing for 24 h before use to reduce chlorine content and sediment suspended particles. Each planting container was filled with 5 L of water, and nutrient solution was added according to the assigned treatment (Figure 2).

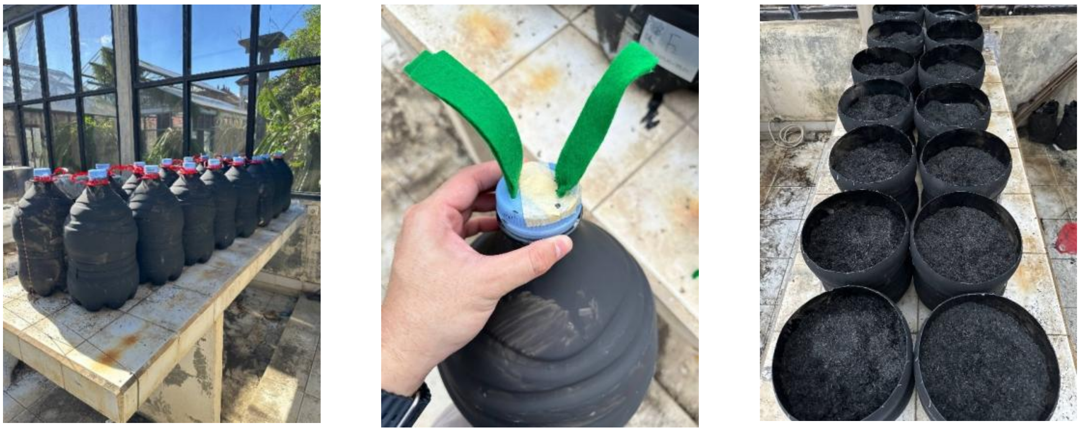

Figure 1. Preparation and arrangement of planting containers for the wick hydroponic system

Table 1. Nutrient treatments applied in the wick hydroponic system.

Code	Treatment description
A	Control (water only)
B	100% AB Mix + 0% Azolla LOF
C	0% AB Mix + 100% Azolla LOF
D	75% AB Mix + 25% Azolla LOF
E	50% AB Mix + 50% Azolla LOF
F	25% AB Mix + 75% Azolla LOF
G	100% AB Mix + 100% Azolla LOF

Figure 2. Preparation process of Azolla microphylla-based liquid organic fertilizer

Observed variables and statistical analysis

The observed variables included plant height, number of leaves, leaf area, stem diameter, root length, leaf chlorophyll content, total plant fresh weight, shoot fresh weight, root fresh weight, shoot oven-dry weight, root oven-dry weight, and shoot-to-root ratio. Plant height, number of leaves, and leaf area were measured at 7, 14, 21, and 28 days after planting (DAP). Stem diameter, chlorophyll content, root traits, and biomass variables were measured at harvest. Leaf chlorophyll content was determined using a chlorophyll meter and expressed as SPAD units.

The data were analyzed using analysis of variance (ANOVA). When the treatment effect was significant, mean separation was performed using Duncan's Multiple Range Test (DMRT) at the 5% significance level. Significance levels were interpreted as not significant ($P \geq 0.05$), significant ($P < 0.05$), and highly significant ($P < 0.01$).

RESULTS AND DISCUSSION

Analysis of variance

The proportions of AB Mix and *Azolla microphylla*-based LOF significantly affected most growth and yield variables of water spinach in the wick hydroponic system (Table 2). The treatment effect was not significant for plant height and number of leaves at 7 DAP and for the shoot-to-root ratio. These early-stage responses indicate that nutrient treatments had not yet produced a measurable effect during the initial establishment phase. As plant growth progressed, treatment differences became more pronounced, especially in plant height, leaf number, leaf area, stem diameter, chlorophyll content, root length, and biomass accumulation.

Vegetative growth response

Plant height, number of leaves, and leaf area increased with plant age and were generally higher in treatments receiving AB Mix, *Azolla* LOF, or their combinations than in the water control. At 28 DAP, the highest plant height was recorded in treatment G (41.4 cm), followed by treatment F (39.8 cm) and treatment C (39.4 cm). The same trend was observed for the number of leaves, where treatment G produced the highest value (19.2 leaves plant−1), while treatments C, E, and F also showed strong leaf production. Leaf area at 28 DAP was also highest in treatment G (165.5 cm^2), followed closely by treatments C (161.2 cm^2), F (161.1 cm^2), and E (160.0 cm^2) (Table 3).

Table 2. Significance of the effects of AB Mix and Azolla microphylla LOF proportions on the growth and yield of water spinach.

Variable	F value	F table 5%	F table 1%	Significance
Plant height at 7 DAP (cm)	2.46	2.66	4.01	ns
Plant height at 14 DAP (cm)	3.44	2.66	4.01	*
Plant height at 21 DAP (cm)	6.37	2.66	4.01	**
Plant height at 28 DAP (cm)	13.81	2.66	4.01	**
Number of leaves at 7 DAP	2.49	2.66	4.01	ns
Number of leaves at 14 DAP	7.76	2.66	4.01	**
Number of leaves at 21 DAP	7.06	2.66	4.01	**
Number of leaves at 28 DAP	7.20	2.66	4.01	**
Leaf area at 7 DAP (cm^2)	3.87	2.66	4.01	*
Leaf area at 14 DAP (cm^2)	4.58	2.66	4.01	**
Leaf area at 21 DAP (cm^2)	3.57	2.66	4.01	*
Leaf area at 28 DAP (cm^2)	4.57	2.66	4.01	**
Stem diameter (cm)	20.09	2.66	4.01	**
Root length (cm)	5.03	2.66	4.01	**
Leaf chlorophyll (SPAD unit)	5.70	2.66	4.01	**
Total plant fresh weight (g)	6.27	2.66	4.01	**
Shoot fresh weight (g)	16.86	2.66	4.01	**
Root fresh weight (g)	3.72	2.66	4.01	*
Shoot oven-dry weight (g)	12.40	2.66	4.01	**
Root oven-dry weight (g)	8.12	2.66	4.01	**
Shoot-to-root ratio	0.94	2.66	4.01	ns

Note: ns = not significant ($P \geq 0.05$); * = significant ($P < 0.05$); ** = highly significant ($P < 0.01$).

Table 3. Effects of AB Mix and Azolla microphylla LOF proportions on plant height, number of leaves, and leaf area of water spinach.

Treatment	Height 7 DAP	Height 14 DAP	Height 21 DAP	Height 28 DAP	Leaves 7 DAP	Leaves 14 DAP	Leaves 21 DAP	Leaves 28 DAP	Leaf area 7 DAP	Leaf area 14 DAP	Leaf area 21 DAP	Leaf area 28 DAP
A	5.5	15.5	21.6	24.0	4.1	7.4	10.8	13.1	32.7	61.4	93.4	113.0
B	6.5	17.4	28.3	34.0	4.5	8.6	14.4	17.6	42.5	78.7	121.0	151.8
C	6.2	19.1	30.7	39.4	5.0	9.6	15.6	18.0	42.3	84.8	124.9	161.2
D	7.5	17.6	29.2	34.5	5.0	9.4	14.3	17.7	40.5	77.3	115.7	151.2
E	6.9	17.7	27.8	35.3	5.0	9.2	14.3	17.8	42.3	79.4	123.1	160.0
F	6.9	20.1	30.2	39.8	4.9	9.7	14.6	18.2	42.2	81.2	126.5	161.1
G	7.9	20.4	32.8	41.4	5.2	10.4	14.9	19.2	46.9	86.2	126.0	165.5

Means followed by the same letter in the original DMRT output were not significantly different at the 5% level. Numeric values are presented using a decimal point for international journal style.

The superior vegetative response under treatment G suggests that a complete supply of inorganic nutrients combined with organic compounds from *Azolla* LOF can support cell elongation, leaf initiation, and leaf expansion. The relatively high performance of treatment C indicates that *Azolla* LOF alone can supply nutrients and bioactive compounds sufficient to sustain competitive vegetative growth under a passive hydroponic system. In contrast, the control treatment consistently produced the lowest values, confirming that nutrient availability was a limiting factor in the wick system (Figure 3).

Stem diameter and leaf chlorophyll

Stem diameter and leaf chlorophyll content responded positively to nutrient application. The highest stem diameter was recorded in treatments C and G (0.7 cm), while the highest chlorophyll value was observed in treatment F (36.6 SPAD units), followed by treatment C (36.2 SPAD units) and treatment G (35.7 SPAD units) (Table 4). These results indicate that *Azolla* LOF contributed substantially to chlorophyll formation and photosynthetic capacity, probably through its nitrogen content and associated organic compounds (Lestari et al., 2019). Adequate nitrogen supply is essential for chlorophyll biosynthesis and leaf tissue development, while balanced nutrient availability supports stronger stem formation.

Root growth and biomass accumulation

Nutrient proportion significantly affected root length and root biomass, but did not significantly affect the shoot-to-root ratio. Treatment G produced the longest roots (9.2 cm), followed by treatment C (9.0 cm). The highest root fresh weight was recorded in treatment F (5.7 g), while the highest root oven-dry weight was recorded in treatments C, E, and G (1.4 g) (Table 5). The lack of a significant difference in shoot-to-root ratio suggests that nutrient treatments increased both shoot and root development in a relatively balanced manner.

The continuous movement of nutrient solution through the wick likely maintained water and nutrient availability around the root zone. Under this condition, roots did not need to elongate excessively to obtain nutrients, which may explain the relatively balanced shoot-to-root ratio across treatments. The high root performance in treatments containing *Azolla* LOF also indicates that organic nutrient sources can support root development in passive hydroponic systems when appropriately prepared and applied.

Yield components

All nutrient treatments increased total fresh weight, shoot fresh weight, and shoot oven-dry weight compared with the control. The highest total fresh weight was obtained in treatment C (33.5 g plant-1), followed by treatment G (33.0 g plant-1). Treatment C increased total fresh weight by approximately 50.2% compared with the control, whereas treatment G increased total fresh weight by approximately 48.0%. For shoot fresh weight, treatment C also showed the highest value (27.9 g plant-1), followed closely by treatment G (27.7 g plant-1). The highest shoot oven-dry weight was recorded in treatments C and G (4.3 g plant-1) (Table 6).

The high yield produced by treatment G demonstrates the agronomic advantage of combining inorganic and organic nutrient sources. AB Mix supplies readily available macro- and micronutrients, while *Azolla* LOF may contribute organic nutrients, micronutrients, humic substances, and beneficial microbial activity. However, treatment C is particularly important from a practical perspective because it produced the highest total fresh weight without the addition of AB Mix. This suggests that *Azolla microphylla*-based LOF has strong potential as a low-cost and environmentally friendly nutrient source for household-scale wick hydroponics.

The visual appearance of plants at 28 DAP supported the quantitative results (Figure 4). Plants grown under treatments C and G showed denser canopy development, broader leaves, and darker green coloration than the control. These characteristics indicate improved nutrient uptake, enhanced photosynthetic capacity, and stronger biomass accumulation. Overall, the results show that *Azolla microphylla*-based LOF can function not only as a supplementary nutrient source but also as a potentially effective standalone nutrient input in wick hydroponic cultivation.

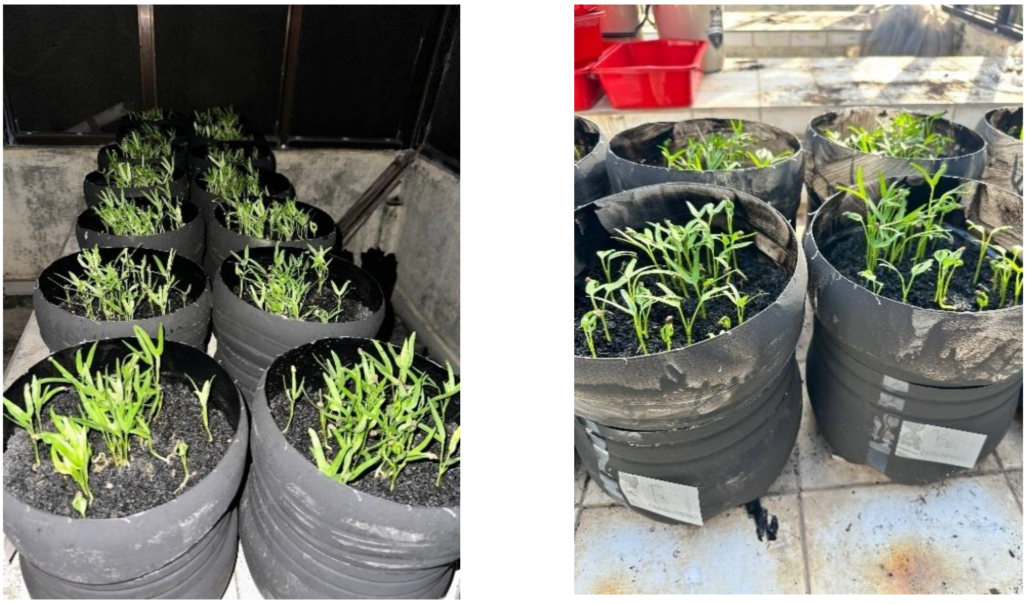

Figure 3. Water spinach plants at 7 days after planting in the wick hydroponic system

Table 4. Effects of AB Mix and Azolla microphylla LOF proportions on stem diameter and leaf chlorophyll content of water spinach at harvest.

Treatment	Stem diameter (cm)	Leaf chlorophyll (SPAD unit)
A	0.3	26.9
B	0.6	32.5
C	0.7	36.2
D	0.6	34.6
E	0.6	33.5
F	0.6	36.6
G	0.7	35.7

Table 5. Effects of AB Mix and Azolla microphylla LOF proportions on root growth and shoot-to-root ratio of water spinach at harvest.

Treatment	Root length (cm)	Root fresh weight (g)	Root oven-dry weight (g)	Shoot-to-root ratio
A	6.3	3.5	0.9	2.7
B	8.1	5.6	1.2	3.4
C	9.0	5.5	1.4	3.0
D	8.5	5.1	1.3	3.0
E	8.5	5.4	1.4	2.8
F	8.2	5.7	1.3	3.1
G	9.2	5.6	1.4	3.2

Table 6. Effects of AB Mix and Azolla microphylla LOF proportions on yield components of water spinach at harvest.

Treatment	Total fresh weight (g plant−1)	Shoot fresh weight (g plant−1)	Shoot oven-dry weight (g plant−1)
A	22.3	14.6	2.4
B	30.4	26.1	4.0
C	33.5	27.9	4.3
D	31.4	25.3	4.0
E	31.9	25.7	4.1
F	32.0	26.2	4.2
G	33.0	27.7	4.3

Figure 4. Visual performance of water spinach plants at 28 DAP from treatments A, B, C, and D (top row, left to right) and E, F, and G (bottom row, left to right).

CONCLUSION

The proportions of AB Mix and *Azolla microphylla*-based liquid organic fertilizer significantly affected the growth and yield of water spinach cultivated in a wick hydroponic system. The combined treatment of 100% AB Mix + 100% *Azolla* LOF produced the strongest vegetative growth, as reflected by the highest plant height, number of leaves, leaf area, and root length. However, 100% *Azolla* LOF produced the highest total fresh weight and shoot fresh weight, with a 50.2% increase in total fresh weight compared with the water control. These findings indicate that *Azolla microphylla*-based LOF is a promising, low-cost, and environmentally sustainable nutrient source for wick hydroponic production of water spinach. It can be used either as a standalone nutrient source or in combination with AB Mix, depending on the production objective. Further studies should evaluate nutrient solution stability, electrical conductivity, pH dynamics, nutrient composition, microbial safety, and economic feasibility across broader hydroponic systems and other horticultural crops.

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REFERENCES

Berliana, Y., Putra, I. A., Juniarsih, T., Sihombing, J. M., Berutu, K. M., Ramadhan, A., and Lase, K. S. 2023. Wick system hydroponic cultivation training at the Purnama Sari Farmers Group, Jati Utomo Village, North Binjai District. Tjut Nyak Dhien Community Service Journal 2(2):115–119.

Dewi, N. A., and Mardiana, M. 2023. Utilization of land water spinach (*Ipomoea reptans* Poir.) into abon kangkung as functional food in Cipareuan Village, Garut Regency. Jurnal Kreativitas Pengabdian Kepada Masyarakat 6(5):1710–1716.

Hidayat, I., Haris, R. A., and Siswanto, I. J. 2023. Mechanism of conversion of agricultural land into housing in Sumenep Regency. E-Journal Wiraraja 20(1):64–82.

Ilhamdi, M. L., Khairuddin, K., and Zubair, M. 2020. Training on the use of liquid organic fertilizer as an alternative to AB Mix nutrient solution in hydroponic farming systems at BON Farm Narmada. Indonesian Science Community Service Journal 2(1):11–15.

Lestari, S. U., Mutryarny, E., and Susi, N. 2019. Chemical composition test of *Azolla mycrophylla* compost and *Azolla mycrophylla* liquid organic fertilizer. Agricultural Scientific Journal 15(2):121–127.

Mustikawati, A. N., Novitasari, D., Cahyaningrum, F. N., Agustina, P. D., Maghfiroh, S. A., and Febryanto, I. D. 2023. Introduction to simple hydroponic plant cultivation using the wick system for elementary school children in grades IV and V. Scientific Journal and Student Work 1(5):119–126.

Putri, F. I., and Asngad, A. 2022. Utilization of *Azolla microphylla* and chicken eggshells as liquid organic fertilizer with bamboo shoot bioactivator.

Proceedings of the 8th National Seminar on Biology and Science Education, 255–261.

Vega, M., Ningrum, F. A., Afriansyah, M., Isra, M., Maharani, N. A., Syahbana, R., and Zain, M. I. 2022. Efforts to utilize household waste as an alternative organic fertilizer to reduce environmental pollution in North Surabaya Village, East Lombok Regency, West Nusa Tenggara. Journal of Community Service for Master of Science Education 5(2):18–21.