

Research Article

Effects of *Azolla microphylla* and Effective Microorganisms on Rice Production in Cement Pots for Small-Scale Farming

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ABSTRACT

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Azolla is a nitrogen-fixing aquatic fern that can potentially reduce the use of synthetic nitrogen fertilizer in rice production, while effective microorganisms (EM) are widely promoted to enhance crop growth. This study evaluated the effects of *Azolla microphylla* and EM on rice production in 1-m- diameter cement pots under chemical fertilizer (CF) and chicken manure (CM) fertilization systems. Two experiments were conducted using glutinous rice cultivar 'Sakhon Nakhon' in Loei Province, Thailand. Treatments included *A. microphylla* grown before transplanting (BA) or after transplanting (A), with or without EM application. Results showed that *A. microphylla* grown in BA significantly increased tiller number, plant height, and panicle number in both CF and CM experiments. Grain weight/hill and yield/pot tended to be highest in treatments with *A. microphylla* grown BA, although differences were not always statistically significant. One crop of *A. microphylla* grown A and two crops grown BA reduced the requirement for chemical nitrogen fertilizer. EM application to the water showed no positive effects on rice growth or yield. These results indicate that integrating *A. microphylla*, particularly when grown prior to transplanting, is a practical and beneficial strategy for small-scale rice production in cement pots, whereas EM application under these conditions is not recommended.

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1. Introduction

Rice is a vital crop for global food security. The conventional production system of rice relies on paddy fields. In addition to conventional paddy fields, small-scale and household rice production systems have gained interest, particularly in limited-space environments, where alternative rice-growing systems such as container or cement pot cultivation are increasingly practiced.

Enormous efforts have been put to find procedures to enhance rice production while reducing production cost. Replacing synthetic fertilizer may be a good procedure to reduce the costs of rice production. *Azolla* is a genus of floating water fern that has the ability to accumulate substantial amounts of fixed nitrogen. *Azolla* contains nitrogen as high as 4-6% of its dry matter (Marzouk *et al.*, 2023). This

makes *Azolla* suitable as a biofertilizer for rice as both crops grow in flooded natural environments (Bhuvaneshwari and Singh, 2015). *Azolla* can also reduce ammonia volatilization, improve nitrogen use efficiency (de Macale and Vlek, 2004; Yao *et al.*, 2018; Yang *et al.*, 2021), accumulate phosphorus, potassium, and minerals from the water so the plants can take them when it decomposes (Arora and Singh, 2003; Bhuvaneshwari and Singh, 2015). In addition, *Azolla* has the ability in weed suppression, improve soil organic matter, improve the efficiency of inorganic fertilizer, and maintain soil pH, contributing to greater grain yield of rice (Thapa and Poudel, 2021). *Azolla* can be incorporated into the soil during the soil preparation process before rice transplantation or grown as an intercrop with rice (Adhikari *et al.*, 2021).

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Numerous species of *Azolla* have been used as biofertilizers for rice, including *A. pinnata*, *A. filiculoides*, and *A. microphylla* (Ventura and Watanabe, 1993; Bhuvaneshwari and Singh, 2015; Adhikary and Shrestha, 2018; Razavipour *et al.*, 2018; Setiawati *et al.*, 2020; Khair *et al.*, 2021). However, most previous studies on *Azolla* application in rice have been conducted under field or paddy conditions, while limited information is available on the performance of *A. microphylla* in container-based or cement pot rice production systems. In Thailand, *A. microphylla* is the species used for agricultural purposes as the Department of Agriculture, Ministry of Agriculture and Cooperatives has promoted the species among Thai farmers for several years (Suraphonphinit *et al.*, 2023). *A. microphylla* is the species having the highest biomass production and ability to fix nitrogen among *A. filiculoides*, *A. mexicana*, *A. microphylla*, *A. pinnata*, *A. rubra* and *A. caroliniana* (Arora and Singh, 2003).

Effective microorganisms (EM) are a mixed culture of microorganisms isolated from fertile soil that are beneficial for crop production (Olle and Williams, 2013). EM consist of photosynthetic bacteria, lactic acid bacteria, yeast, and actinomycetes (Higa and Parr, 1994). Numerous studies have been conducted to find out the efficiency of EM for various purposes such as plant growth, development, and yield (Renseigné, 2006; Megali *et al.*, 2014; Meng *et al.*, 2018; Domenico, 2019; Pszczółkowski *et al.*, 2023), disease control (El-Hadidy and El-Ati, 2014; Alshammari *et al.*, 2022), waste treatment (Namsivayam *et al.*, 2011; Lu *et al.*, 2019), waste decomposition (Kumar *et al.*, 2022; Amaral *et al.*, 2025), and reducing bad smell (Addeo *et al.*, 2023). Moreover, limited information is available on the effectiveness of EM when applied to flooded water in container-based rice systems, particularly in combination with *Azolla*, which may alter nutrient dynamics and microbial activity.

The benefits of EM for crop production derive from a substantial release of nutrients from organic matter mixed with EM, and increased photosynthesis and protein synthesis (Jusoh *et al.*, 2013; Olle and Williams, 2013). EM reduce the uses of chemical fertilizer and pesticides since EM helps improve soil structure and fertility, organic matter, and nutrient cycling (Abd El-Mageed *et al.*, 2020). However, both positive and non-positive impacts of EM on crop growth and yield have been reported. Mayer *et al.* (2010) conducted a 4-year field study to evaluate the effects of EM on crop yields under an organic system in Switzerland and found that EM had no positive effect on crop yield. Cui *et al.* (2021) reported positive effects of biochar and EM application on the growth of *Sesbania cannabina*. Talaat (2015) reported that EM reduced the negative effects of salt stress on common bean production by altering plant physiology, resulting in plant growth enhancement under stress condition.

Cement pots have been used in Thailand to grow some plants, including terrestrial plants such as lime and rice, and aquatic plants such as *Azolla*, *Wolffia*, and water lilies. The pot height is fixed at 0.5 m, but the pot diameter varies. The pots diameter 0.8 m and 1 m are popular among growers and researchers (Suriyakup *et al.*, 2007; Yamuangmorn *et al.*, 2020; Sanwong *et al.*, 2023). Some Thai farmers use these cement pots to grow rice for family consumption because it's more convenient and it can be used throughout the year. The transplanting method has been used for growing rice in the cement pots. Although cement pot rice cultivation is practiced by some Thai farmers for household consumption, scientific information on nutrient management and the use of biofertilizers such as *Azolla* and EM in this system is very limited. Therefore, evaluating suitable nutrient management strategies for cement pot rice production is necessary to improve the productivity and sustainability of this small-scale system.

Therefore, this study aimed to evaluate the effects of *A. microphylla* and effective microorganisms on rice growth and yield under chemical fertilizer (CF) and chicken manure (CM) fertilization in a 1-m diameter cement pot system. The results will provide scientific information for developing appropriate nutrient management strategies for small-scale rice production in container-based systems in Thailand.

2. Materials and Methods

2.1 Experimental design

Two experiments using different types of fertilizer: the CF experiment and the CM experiment, but similar treatments with *A. microphylla* and EM application were conducted (Figure 1). The two experiments were run at the same time from April to August 2020 at the Agricultural Training Center, Loei Rajabhat University, Loei Province, Thailand. Glutinous rice cultivar 'Sakon Nakhon' was grown in the two experiments. Completely Randomized Design (CRD) with five treatments and four replications was used in both experiments. Cement pots sized 1-m diameter (the actual diameter was approximately 92 cm) placed outdoor were used for this study. The soil ground in the open space was levelled before setting the cement pots for this study. The cement pots were filled with fertile soil below the top of the pot 15 cm. The soil was from a Para rubber tree plot in the Agricultural Training Center. The soil was clay loam with a pH of 7.26, organic matter 4.81%, total nitrogen 0.45%, total phosphate 0.10%, and total potassium 0.20% according to the soil test for this study. Rice seeds were activated for root emergence, and the pre-germinated seeds were sown in a 1-m diameter cement pot for seedlings. CM was applied in the seedling pot for seedling growth at seven days after sowing (DAS).



Figure 1 CF experiment and CM experiment (A) *A. microphylla* at nine DAG (days after growing); (B) *A. microphylla* at 22 DAG; (C) *A. microphylla* being incorporated into the soil at 28 DAG; (D) the soil after *A. microphylla* incorporated; (E) transplanted rice in the soil incorporated with *A. microphylla* at one DAT; (F) treatment CM of CM experiment at 56 DAS (28 DAT); (G) treatment CF2 + *A. microphylla* BA + EM of CF experiment at 56 DAS; (H) treatment CM + *A. microphylla* A of CM experiment at 56 DAS; (I) the two experiments at 60 DAS; (J) the two experiments at 112 DAS; (K) the two experiments at 123 DAS; and (L) treatment CF of CF experiment at 140 DAS.

Rice seedlings were transplanted at 28 DAS. Seven rice seedlings were transplanted in each cement pot with one seedling/hill where six hills were along the pot edge and one hill was in the middle of the pot. CF, CM, *A. microphylla* and EM were applied depending on the experimental conditions. Weeds were controlled by hand. Rice was harvested in both experiments at 142 DAS (114 days after transplanting, DAT).

2.2 CF experiment

There were five treatments for the CF experiment including: 1) CF1 (53.75 kg N/ha), 2) CF2 (39.375 kg N/ha) + *A. microphylla* BA, 3) CF2 (39.375 kg N/ha) + *A. microphylla* A, 4) CF2 (39.375 kg N/ha) + *A. microphylla* BA + EM, and 5) CF2 (39.375 kg N/ha) + *A. microphylla* A + EM. For treatment 1 CF1 at 53.75 kg N/ha: 16-16-8 fertilizer rated 156.25 kg/ha (25 kg N/ha) (10.39 g/pot) was applied at 5 DAT, and 46-0-0 fertilizer rated 62.5 kg/ha (28.75 kg N/ha) (4.16 g/pot) was applied at 39 DAT. The fertilizer uses in treatment CF 1 followed the recommendation for the rice cultivar 'Sakon Nakhon' which is

16-16-8 fertilizer rated 25 kg/rai and 46-0-0 fertilizer rated 10 kg/rai. For treatment 2-5 CF2 at 39.375 kg N/ha: 16-16-8 fertilizer rated 156.25 kg/ha (25 kg N/ha) (10.39 g/pot) was applied at 5 DAT, and 46-0-0 fertilizer rated 31.25 kg/ha (14.374 kg N/ha) (2.08 g/pot) was applied at 39 DAT. In the treatment CF2, 46-0-0 fertilizer was used in a half rate of the treatment CF1.

2.3 CM experiment

There were five treatments for the CM experiment including: 1) CM, 2) CM + EM, 3) CM + *A. microphylla* BA + EM, 4) CM + *A. microphylla* A, and 5) CM + *A. microphylla* A + EM. For the five treatments, CM rated 1,875 kg/ha (124.69 g/pot) and 1,250 kg/ha (83.13 g/pot) were applied at 5 DAT and 39 DAT, respectively.

2.4 *A. microphylla* application

For the treatment *A. microphylla* before transplanting, *A. microphylla* 200 g/pot was grown in the assigned pots for 28 days before rice transplanting. No fertilizer was applied for the

fern growth. Water was then regularly added to the pot for the fern growth. At transplanting date, *A. microphylla* was integrated into the soil before transplantation. For the treatment *A. microphylla* after transplanting, *A. microphylla* 66.5 g/pot was grown in the assigned pots along the rice plants at 3 DAT.

2.5 EM application

EM® used in this study was a branded product acquired from local market which consisted of photosynthetic bacteria, lactic acid bacteria, and yeast. EM was fermented and diluted before adding to the assigned pot. For EM preparation, 1 ml EM from the product was mixed with 1 g brown sugar and 1 l water and fermented for seven days. The EM solution 0.665 ml/pot (6.25 l/ha) was added to the water in the assigned pots three times at: 5 DAT, 39 DAT, and 64 DAT, respectively.

2.6 Data collection

Data recorded were 1) tiller number at 70 DAT, 2) plant height (cm) of the main plant at 114 DAT measured from the plant base to the collar of flag leaf, 3) panicle number at 114 DAT, 4) grains/panicle of the main plant at 114 DAT, 5) grain moisture (%) from three hills/pot, 6) grain weight/panicle (g) of the main plant at 14% moisture, 7) grain weight/hill (g) at 14% moisture, and 8) yield/pot (g) at 14% moisture. Seven hills/pot were measured for tiller number, plant height, panicle number, grains/panicle, grain weight/panicle, grain weight/hill, and yield/pot.

2.7 Statistical analysis

Data were analyzed using SAS OnDemand for Academics. Analyses of variance, and comparisons between group of treatments (orthogonal contrasts) were performed using PROC GLM. Homogeneity of variance were tested using PROC GLM. Fisher's least significant difference (LSD) was used to perform pairwise comparison of all treatments in the analysis of variance ($p = 0.05$). Coefficient of variation (CV) was obtained using PROC UNIVARIATE.

3. Results and Discussion

3.1 CF experiment

Significant differences for tiller number, plant height, and panicle number were observed among the five CF treatments (Table 1). There was no significant difference for grain number/panicle among the five treatments (Table 1). The two treatments having *A. microphylla* grown BA without and with EM application gave rice the highest tiller number, plant height, and panicle number among the five treatments.

Significant differences for grain moisture and grain weight/hill were observed among the five CF treatments (Table 2). There was no significant difference for grain weight/panicle and yield/pot among the five treatments (Table 2). The two treatments having *A. microphylla* grown BA without and with

EM application and the treatment having *A. microphylla* grown A with EM application gave the rice the highest grain moisture and grain weight/hill among the five treatments.

3.2 CM experiment

Significant differences for tiller number, plant height, and panicle number were observed among the five CM treatments (Table 3). There was no significant difference for grain number/panicle among the five treatments (Table 3). The treatment having *A. microphylla* grown BA with EM application gave rice the highest tiller number and panicle number among the five treatments. The treatment having *A. microphylla* grown BA with EM application and the treatment having *A. microphylla* grown A without EM application gave rice the highest plant height among the five treatments. The treatment having *A. microphylla* grown A without EM application was significantly greater than the treatment CM without EM application for plant height.

Significant differences for grain moisture, grain weight/hill, and yield/pot were observed among the five CM treatments (Table 4). There was no significant difference for grain weight/panicle among the five treatments (Table 4). The treatment having *A. microphylla* grown BA with EM application gave rice the highest grain moisture and grain weight/hill. The treatment having *A. microphylla* grown BA with EM application and the treatment having *A. microphylla* grown A without EM application gave rice the highest yield/pot.

3.3 Effects of *A. microphylla*

The treatment CF2 and *A. microphylla* grown A without or with EM applications was not significantly different from the treatment CF1 for all traits (Table 1 and 2). The treatment CM and *A. microphylla* grown A without or with EM applications tended to be greater than the treatment CM without or with EM applications for most traits although differences were not statistically significant (Table 3 and 4). The treatment CF2 and *A. microphylla* grown BA without or with EM application was greater than the treatment CF1 for tiller number, plant height, panicle number, grain moisture, and grain weight/hill (Table 1 and 2). The treatment CM with *A. microphylla* grown BA with EM application was greater than the treatment CM without or with EM applications for tiller number, plant height, panicle number, grain moisture, grain weight/hill, and yield/pot (Table 3 and 4). These suggested that two crops of *Azolla* accumulated nitrogen fertilizer in greater amounts than one crop of *Azolla*. The results also suggested that *A. microphylla* grown A might supply nitrogen fertilizer equal to or above 14.375 kg N/ha. Considering the treatment CF1 had 53.75 kg N/ha while the treatment CF2 and *A. microphylla* grown A had 39.375 kg N/ha, and yield/pot of the treatment CF2 with *A. microphylla* grown A without or with EM tended to be higher than the treatment CF1.

Table 1 CF experiment showing rice data for tiller number, plant height (cm), panicle number, and grain number/panicle of the five treatments.

Treatments	Tiller number	Plant height (cm)	Panicle number	Grain number/panicle
CF1	22.29 ^b	131.35 ^{bc}	19.86 ^b	215.52
CF2 + <i>A. microphylla</i> BA	27.93 ^a	137.11 ^a	24.32 ^a	198.93
CF2 + <i>A. microphylla</i> A	20.43 ^b	129.11 ^c	18.89 ^b	207.29
CF2 + <i>A. microphylla</i> BA + EM	26.07 ^a	134.19 ^{ab}	23.89 ^a	186.96
CF2 + <i>A. microphylla</i> A + EM	21.93 ^b	130.27 ^c	18.96 ^b	218.46
Mean	23.73	132.41	21.19	205.43
F-test	**	**	**	ns
CV. (%)	20.55	5.47	21.04	21.52
Contrast: Group of treatments				
CF1 vs CF2 + <i>A. microphylla</i> BA -/+ EM	**	*	**	-
CF1 vs CF2 + <i>A. microphylla</i> A -/+ EM	ns	ns	ns	-
CF2 + <i>A. microphylla</i> BA -/+ EM vs CF2 + <i>A. microphylla</i> A -/+ EM	**	**	**	-
CF2 + <i>A. microphylla</i> BA & A vs CF2 + <i>A. microphylla</i> BA & A + EM	ns	ns	ns	-

*, ** significant at the 0.05, and 0.01 probability level, respectively; ns not significant.

Means within the same column followed by the same letter are not significantly different at the 0.05 probability level.

Table 2 CF experiment showing rice data for grain moisture (%), grain weight/panicle (g), grain weight/hill (g), and yield/pot (g) of the five treatments.

Treatments	Grain moisture (%)	Grain weight/panicle (g)	Grain weight/hill (g)	Yield/pot (g)
CF1	14.71 ^c	6.16	102.68 ^b	718.76
CF2 + <i>A. microphylla</i> BA	19.18 ^a	5.69	122.41 ^a	856.89
CF2 + <i>A. microphylla</i> A	15.46 ^{bc}	6.07	107.49 ^b	752.40
CF2 + <i>A. microphylla</i> BA + EM	17.70 ^{ab}	5.46	121.68 ^a	851.78
CF2 + <i>A. microphylla</i> A + EM	17.06 ^{abc}	6.16	113.38 ^{ab}	793.64
Mean	16.82	5.91	113.53	794.69
F-test	**	ns	*	ns
CV. (%)	19.27	24.61	22.76	10.16
Contrast: Group of treatments				
CF1 vs CF2 + <i>A. microphylla</i> BA -/+ EM	**	-	**	-
CF1 vs CF2 + <i>A. microphylla</i> A -/+ EM	ns	-	ns	-
CF2 + <i>A. microphylla</i> BA -/+ EM vs CF2 + <i>A. microphylla</i> A -/+ EM	*	-	*	-
CF2 + <i>A. microphylla</i> BA & A vs CF2 + <i>A. microphylla</i> BA & A + EM	ns	-	ns	-

*, ** significant at the 0.05, and 0.01 probability level, respectively; ns not significant.

Means within the same column followed by the same letter are not significantly different at the 0.05 probability level.

However, the results that the fern grown A accumulated nitrogen at 14.375 kg N/ha disagreed with earlier studies that reported one crop of *Azolla* accumulated nitrogen fertilizer at 30 kg/ha (Kanareugsa *et al.*, 1984; Singh and Singh, 1986;

Bhuvaneshwari and Singh, 2015) or higher than 40 kg/ha (Yao *et al.*, 2018). The results also disagreed with previous studies that reported two crops of *Azolla* accumulated nitrogen fertilizer at 60 kg/ha (Kanareugsa *et al.*, 1984; Singh and Singh,

1986). Since this study was not designed to evaluate nitrogen accumulation by *Azolla*, thus, making comparison with other studies may be inappropriate at some points. However, it's apparent that *A. microphylla* growing with rice in cement pot cultivation system is beneficial to rice by providing nitrogen

fertilizer to the system. Rice production in cement pots can completely rely on organic fertilizer such as CM and biofertilizer such as *A. microphylla* to fertilize the system considering equivalent yield/pot in CM experiment and CF experiment.

Table 3 CM experiment showing rice data for tiller number, plant height (cm), panicle number, and grain number/panicle of the five treatments.

Treatments	Tiller number	Plant height (cm)	Panicle number	Grain number/panicle
CM	22.89 ^b	128.93 ^c	19.60 ^b	206.68
CM + EM	22.96 ^b	131.05 ^{bc}	19.21 ^b	206.43
CM + <i>A. microphylla</i> BA + EM	28.18 ^a	137.77 ^a	25.11 ^a	194.46
CM + <i>A. microphylla</i> A	21.57 ^{bc}	134.44 ^{ab}	19.36 ^b	216.89
CM + <i>A. microphylla</i> A + EM	20.64 ^c	129.59 ^c	18.46 ^b	210.39
Mean	23.25	132.36	20.35	206.97
F-test	**	**	**	ns
CV. (%)	20.48	5.80	22.24	18.63
Contrast: Group of treatments				
CM -/+ EM vs CM + <i>A. microphylla</i> BA + EM	**	**	**	-
CM -/+ EM vs CM + <i>A. microphylla</i> A -/+ EM	*	ns	ns	-
CM + <i>A. microphylla</i> BA + EM vs CM + <i>A. microphylla</i> A -/+ EM	**	**	**	-

*, ** significant at the 0.05, and 0.01 probability level, respectively; ns not significant.

Means within the same column followed by the same letter are not significantly different at the 0.05 probability level.

Table 4 CM experiment showing rice data for grain moisture (%), grain weight/panicle (g), grain weight/hill (g), and yield/pot (g) of the five treatments.

Treatments	Grain moisture (%)	Grain weight/panicle (g)	Grain weight/hill (g)	Yield/pot (g)
CM	15.43 ^b	5.98	105.77 ^b	740.40 ^b
CM + EM	15.35 ^b	6.05	106.56 ^b	745.95 ^b
CM + <i>A. microphylla</i> BA + EM	17.53 ^a	5.62	132.88 ^a	930.16 ^a
CM + <i>A. microphylla</i> A	15.48 ^b	6.49	117.54 ^b	822.76 ^{ab}
CM + <i>A. microphylla</i> A + EM	13.15 ^c	6.34	112.17 ^b	785.21 ^b
Mean	15.39	6.10	114.98	804.90
F-test	**	ns	**	*
CV. (%)	17.53	20.83	23.95	12.13
Contrast: Group of treatments				
CM -/+ EM vs CM + <i>A. microphylla</i> BA + EM	*	-	**	**
CM -/+ EM vs CM + <i>A. microphylla</i> A -/+ EM	ns	-	ns	ns
CM + <i>A. microphylla</i> BA + EM vs CM + <i>A. microphylla</i> A -/+ EM	**	-	**	*

*, ** significant at the 0.05, and 0.01 probability level, respectively; ns not significant.

Means within the same column followed by the same letter are not significantly different at the 0.05 probability level.

3.4 Effects of EM application

The treatment CF2 and *A. microphylla* grown A without EM application was not statistically different from the treatment CF2 and *A. microphylla* grown A with EM application for all

traits (Table 1 and 2). Similarly, the treatment CF2 and *A. microphylla* grown BA without EM application was not statistically different from the treatment CF2 and *A. microphylla* grown BA with EM application for all traits (Table 1 and 2).

The treatment CM without EM application was not statistically different from the treatment CM with EM application for all traits (Table 3 and 4). Similarly, the treatment CM and *A. microphylla* grown A without EM application was not statistically different from the treatment CM and *A. microphylla* grown A with EM application for most traits (Table 3 and 4). These suggested that EM applications had no positive effects on the rice plants for all traits in both experiments. These supports Komboonruang *et al.* (1995) which reported that rice yield did not increase in low organic matter soil (organic matter < 2.69%) mixed with EM, but the yield slightly increased in high organic matter soil (organic matter > 6.2) mixed with EM. However, the results contrasted to Myint (1996) which reported the increases in rice yield from the treatment of EM added to the soil having rice straw because EM accelerated rice straw decomposition and decreased soil nitrogen immobilization. The results also disagreed with Yanrong *et al.* (2006) that reported increases in rice grain yield when applied by EM and the increases were greater with increased year of growing. Again, the results from this study didn't support Saida and Mrema (2017) which reported the rice yield increased with application of farmyard manure treated with EM. There were differences in EM application methods used in this study and the other studies. EM solution was added to the water in the pots in this study while different methods of EM application were used in the other studies: EM solution was added directly to the soil (Komboonruang *et al.*, 1995), EM solution was added directly to the soil, and sprayed on the soil and rice plants (Myint, 1996), EM solution was inoculated into Bokashi as fertilizer and added to irrigation water (Yanrong *et al.*, 2006), and EM solution was inoculated into cattle manure as fertilizer (Saida and Mrema, 2017). Results from this study revealed that EM had no impact on the rice growth when added to the water in cement pots where the rice grown. But EM had positive effects on the rice plants when mixed with the soil or organic fertilizer or sprayed on the plants in paddy fields as reported in the other studies. Pests of *A. microphylla* found in this study were caterpillar while pests of rice were not found in this study.

4. Conclusion

One crop of *A. microphylla* grown A, and two crops of *A. microphylla* grown BA reduced the use of chemical nitrogen fertilizer for rice cultivation in 1-m- diameter cement pot in this study. Applying EM to the rice plants by adding it to the water in cement pots had no positive effect on the rice plants. The results suggest that growing *A. microphylla* along rice plants, particularly before rice transplanting, is a practical and useful procedure for small-scale rice farming in cement pots, while EM application to water is not recommended. Growing *A. microphylla* before transplanting in this study didn't require fertilizers because the soil was fertile. In addition, rice production in cement pots could rely on CM and *A. microphylla*

for fertilization. This suggests that organic agriculture may be applied to rice production in cement pots for small-scale farming. However, more knowledge of rice production in cement pots for small-scale farming is necessary, such as fertilization, establishment methods, and watering.

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