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Effect of Nutrient Solution and *Azolla* and Rice Straw Mixed Compost on Nutrition and Growth of *Dieffenbachia amoena* in Potting Medium

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Abstract

This experiment was performed to investigate the effect of *Azolla* and rice straw mixed compost in peat substitution on *Dieffenbachia amoena*. Factorial experiment based on a completely randomized design with two factors of nutrient solution in 2 levels (1- without solution, 2- with 130 mg N L^{-1}, 32 mg P L^{-1} and 117 mg K L^{-1}) and 5 levels of *Azolla* and rice straw mixed compost (0, 15, 30, 45 and 60 %) was done in 3 replications, with 3 plants per treatment in greenhouse conditions. *Azolla* and rice straw mixed compost was replaced with peat in the control. Compost was prepared from a volumetric mixture of 50 % *Azolla* and 50 % rice straw. *Azolla* and rice straw mixed compost replaced peat in the control treatment. The control bed contained 10 % perlite: 30 % vermiculite: 60 % peat (volume percentage). Growth factors including height, diameter, number of leaves, chlorophyll index, fresh leaf weight, fresh stem weight, leaf dry weight, stem dry weight, leaf area, physical and chemical characteristics of growth medium and nutrients were measured. The results showed that the use of 45 % *Azolla* and rice straw mixed compost in replacement with peat (with formula 10 % perlite: 30 % vermiculite: 45 % *Azolla* and rice straw mixed compost: 15 % peat), in addition to improves the growth factors of *Dieffenbachia amoena* plant, reduces the consumption of peat by up to 75 %.

Keywords: Growth factors, Peat, Perlite, Vermiculite.

INTRODUCTION

The spread of *Azolla* in the wetlands and paddy fields has caused environmental problems for aquatic organisms, and the cultivation of rice farmers, and in large areas rice farmers are forced to collect and transport it outside the farm (Hashemloian and Azimi, 2009). It is estimated that about 1 to 1.5 tons of straw is produced per hectare of rice land (Asadi *et al.,* 2009). In some cases, remained straw was burned and addition to environmental pollution, destroys large amounts of organic matter, or in some places, this amount of straw is left in the paddy fields after harvest and it pollutes the surface and groundwater of the region by releasing nitrate (Mousavi Shalmani *et al.,* 2017). The favorable climatic conditions of Guilan province caused Azolla to grow well and cover most of the wetlands, including 50% of the 20,000 hectares of Anzali wetland, and be considered as a serious problem in these ecosystems (Salehzadeh and Naeemi, 2017). Azolla filiculoides have a very high growth rate, and even in non-optimal conditions can block the entry of light into the seal by creating a dense mass, leading to weakening or even disappearance of submerged plants and related communities (Janes *et al.,* 1996), This species symbiosis with nitrogen-fixing cyanobacteria to obtain atmospheric nitrogen and has great potential for vegetative reproduction under adverse conditions (Fernández-Zamudio *et al.,* 2013). These traits have led to *A. filiculoides* being one of the most dangerous invaders in freshwater habitats and their biodiversity (Champion *et al.,* 2010). The mineral profile of *Azolla* indicates 0.34% phosphorus, 2.71% potassium 1.64% calcium and other minerals in trace levels (Anitha *et al.,* 2016). Soilless cultivation is a method of cultivation that uses materials other than soil as a plant rooting medium (Barrett *et al.,* 2016). Today, many house plants are grown in soilless growth media using peat as the rootstock (Savvas and Gruda, 2018). Research by Chen *et al.,* (1988) showed that during the application of agricultural waste compost, peat and compost mixtures had the best results in all measured parameters. Bugbee and Frink (1989) reported was obtained that as a result of replacement of 10, 20, 30, 40, and 50% (by volume) of sewage sludge compost in parsley flower bed, the dry weight of the stem increased significantly and the highest growth was in the growth bed containing 30% compost. Some studies have shown that organic wastes such as municipal wastes, sewage sludge, animal manure, paper, pruning and mushroom litter and any other green wastes after composting can be replaced with peat in the growth medium with very good results (Jayasinghe *et al.,* 2010). The results of application of *Azolla* compost in *Ficus benjamin* growth medium showed that adding 100 g of compost can provide suitable nutritional conditions for the plant in an 11-month growth period (Khomami and Dehkaei, 2010). It is possible to grow dieffenbachia very well in different growth media, but to prevent root damage, you should use a growth medium that is well ventilated and has a little solute. This plant needs a growth media with a pH of 5 to 6 (Mahboub Khomami, 2007). Due to the applicability of *Azolla* compost in the growth medium (Khomami and Dehkaei, 2010), the possibility of using a mixture of rice straw and *Azolla* in the growth medium was considered to make the resulting mixture more economical.

MATERIALS AND METHODS

Azolla was collected from the wetlands of this province. After mixing the *Azolla* and rice straw with an equal volume ratio (50 %: 50%), they were dumped in 1-cubic-meter (1 × 1 × 1) wooden boxes with pores for providing aerobic conditions and microbial activity (Fig. 1). The temperature was measured in the center of the compost mass by a thermometer every 3–5 days, and the material was removed from the boxes and adjusted to create good ventilation, and the moisture content of the mass was adjusted; this operation continued for 4 months until the temperature stability and maturity of the compost mass was sustained. After producing rooted cuttings of *Dieffenbachia amoena* (Fig. 2) and preparing *Azolla* and rice straw mixed compost, Factorial experiment was conducted based on completely randomized design with two factors, nutrient solution in 2 levels (1- without solution, 2- with 130 mg N L^{-1}, 32 mg P L^{-1} and 117 mg K L^{-1}) and *Azolla* and rice straw mixed compost in 5 levels (zero, 15, 30, 45 and 60 %) and 3 replications, with 3 plants per treatment in greenhouse conditions. Azolla and rice straw mixed compost was replaced with peat in the control. The control bed consisted of 10 % perlite: 30 % vermiculite: 60 % peat (volume percentage). Nutritional solution was given at a ratio of 130 mg L^{-1} nitrogen, 32 mg L^{-1} phosphorus 117 mg L^{-1} potassium, with compounds of H_2PO_4, KNO_3 and Ca $(NO_3)_2$ at a rate of 200 cm^3 per pot once every 10 days. Irrigation was done during the week, depending on the type of bed and the needs of the plant, so that the water coming out of the pot drainage was not high. After a growth period of 7 months, plant growth factors such as height, diameter, number of leaves, leaf chlorophyll content index, fresh and dry weight of leaves, dry and fresh weight of stem, leaf area, physical and chemical properties of substrate and leaf nutrients were measured (Table 1). Leaf chlorophyll content index was measured with CCM-200 chlorophyll meter.

Fig. 1. Boxes for producing *Azolla* and rice straw mixed compost.

Fig. 2. Image of pots containing dieffenbachia.

The total nitrogen was determined by the procedure proposed by Bremner and Mulvaney (1982) after digesting the samples with concentrated H_2SO_4 and $HClO_4$ (9:1 v/v). Each ground sample was ashed in a muffle furnace at 550 °C to determine the other nutrients (Horwitz, 1980). Total P was analyzed according to Murphy and Riley (1962) by a spectrophotometer (CECIL 2041). According to Houba *et al.,* (1989), the total K was analyzed by a flame photometer (JENWAY PFP7). The total organic carbon was measured according to the method proposed by Nelson and Sommers (1982). According to the method proposed by Munter and Grande (1981), Ca, Mg, Fe, Cu, and Zn were determined in the plants and substrate samples by inductively coupled plasma atomic emission spectroscopy.

Measurement of physical properties

Physical properties such as total porosity, bulk density, air-filled porosity, and container capacity were measured using Fonteno's (1996) method. The pH and EC of the extract (1:5) were measured by EC meter and pH meter of Metrohm 644 and Metrohm 691, respectively (Verdonck and Gabriels, 1992).

Growth factors

These traits were measured at the end of the experiment to evaluate the effects of the treatments, which including: Plant height (the height from the surface of the pot at the end of the terminal leaf pod measured by a ruler), stem diameter (approximately the crown diameter of the plant was selected as the measurement criterion) by a caliper; fresh and dry weight of shoots: (the plants were placed in an oven at 75 °C for 48 hours to dry, then their dry weight was calculated); leaf area (determined by video level meter (Model MK2 area meter made in England)).

RESULTS

Growth factors

The results of analysis of variance showed that the effect of compost content on height, diameter, number of leaves, chlorophyll index, fresh and dry weight of leaves, fresh and dry weight of stem, defenbachia leaf area was significant (Table 2), therefore, in the following, we will compare the means.

Height

Considering the significant effect of compost content on plant height, Fig. 3 showed that the application of 30 to 60 % composts in compared to the control, significantly increased the plant height. The highest increase obtained in 60% compost. But significant difference not observed between 30 to 60 % compost levels.

Diameter

Considering the significant effect of compost content on plant diameter, Fig. 4 showed that the application of 30 to 60 % composts in compared to the control, significantly increased the plant diameter. The highest increase obtained in 60 % compost. But significant difference not observed between 30 to 60 % compost levels.

Number of leaves

Mean comparison effect of compost levels (Fig. 5) indicates a significant increase in the number of leaves about 30 % to 60 % of compost application compared to the control and the highest amount is at 30 % compost, but between 30 % to 60 % compost significant difference was not observed.

Fresh leaves weight

Mean comparison effect of compost levels on fresh weight of dieffenbachia leaf (Fig. 6) showed that in terms of fresh weight of the stem, the highest weight of more than 45% of compost was obtained, but no significant difference was observed between this level and control and 15 and 30 % levels.

Dry leaves weight

Mean comparison effect of compost levels on dry levels weight (Fig. 7) showed that 30 to 60 % of compost levels in the growth medium produced the highest leaf dry weight in dieffenbachia and had a significant difference with the control, but there was a significant difference between these levels. was not observed.

Leaf area

Comparison of Mean effect of compost content on leaf area (Fig. 8) shows that 30 to 60 % levels of compost compared to the control significantly (5 % probability level) increased the studied factor and the highest amount was related to 45 %. It is compost. But no significant difference was observed between 30 to 60 % level.

Table 1. Some physicochemical properties of materials used in growth media.

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})	OC (%)	C:N	EC (dS m^{-1})	pH (1:5)
Peat	0.48	0.03	0.31	0.17	0.05	638	28	12.0	1.90	44.4	91.6	0. 26	3.83
Compost of Azolla	2.41	0.43	0.87	0.62	0.28	15150	3247	55.6	41.1	22.0	9.12	3.10	5.46
Azolla and rice straw mixed compost (1:1 v/v)	2.20	1.63	0.40	1.10	1.2	15000	2500	117	41.1	30.0	13.60	5.71	6.20

Table 2. Analysis of variance of dieffenbachia growth factors.

S.o.V	df	MS						
		Height	Diameter	Number of leaves	Chlorophyll index	Fresh weight of leaves	Dry weight of leaves	Leaf area
Nutritional solution (NS)	1	25.234^{ns}	13.051^{ns}	0.814^{ns}	42.8376^{ns}	2333.577^{ns}	10.0028^{ns}	24165.005^{ns}
Compost level (CL)	4	110.097^{**}	35.505^{**}	2.194^{**}	798.484^{**}	11047.572^{**}	30.104^{**}	1588944.833^{**}
NS × CL	4	11.484^{ns}	5.281^{ns}	0.424^{ns}	142.450^{ns}	1665.425^{ns}	4.179^{ns}	19836.718^{ns}
Error	20	31.361	10.659	0.729	144.145	2428.040	12.215	84049.957
Total	29	-	-	-	-	-	-	-
CV (%)	-	46.50	48.79	27.70	21.89	23.03	20.33	22.87

*, ** and ^{ns}: Significant at $P < 0.05$, $P < 0.01$ and insignificant, respectively.

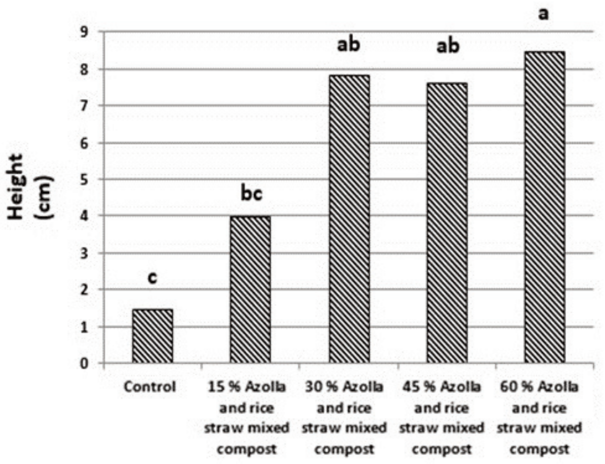

Fig. 3. Height of dieffenbachia.

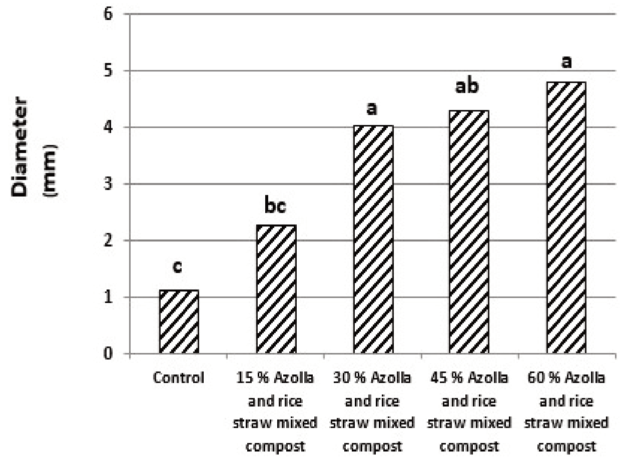

Fig. 4. Diameter of dieffenbachia stem.

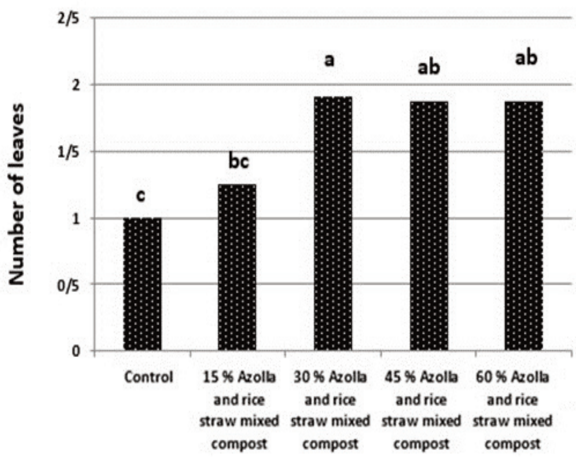

Fig. 5. Number of dieffenbachia leaves.

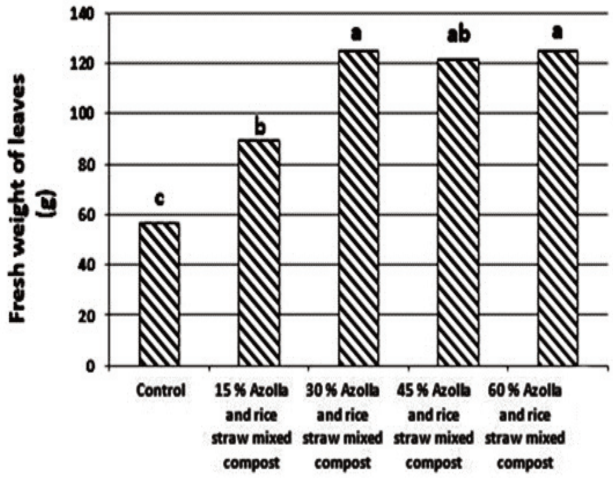

Fig. 6 . Fresh weight of dieffenbachia leaves.

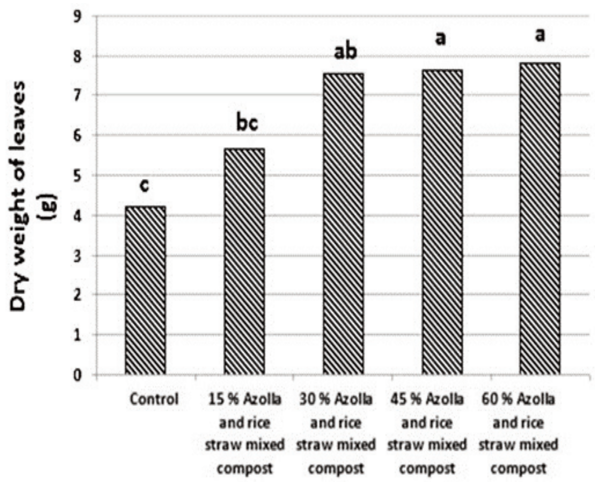

Fig. 7. Dry weight of dieffenbachia leaves.

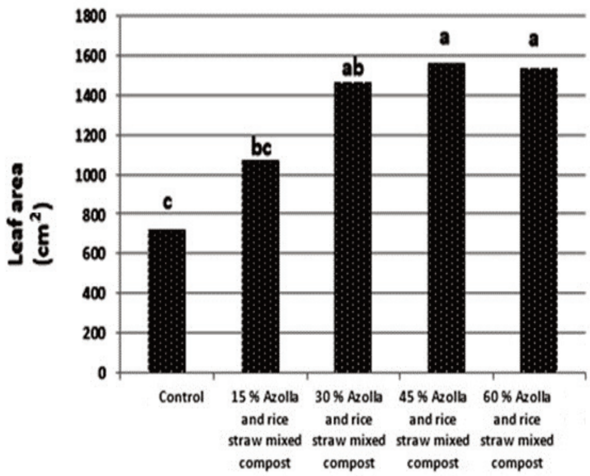

Fig. 8. Area of dieffenbachia leaves.

Chlorophyll content index

Comparison of mean effect of compost levels on the leaf chlorophyll index (Fig. 9) showed that levels of 30 to 60 % of leaf chlorophyll content index were significantly higher than the control and no significant difference was observed between 15 % compost and control.

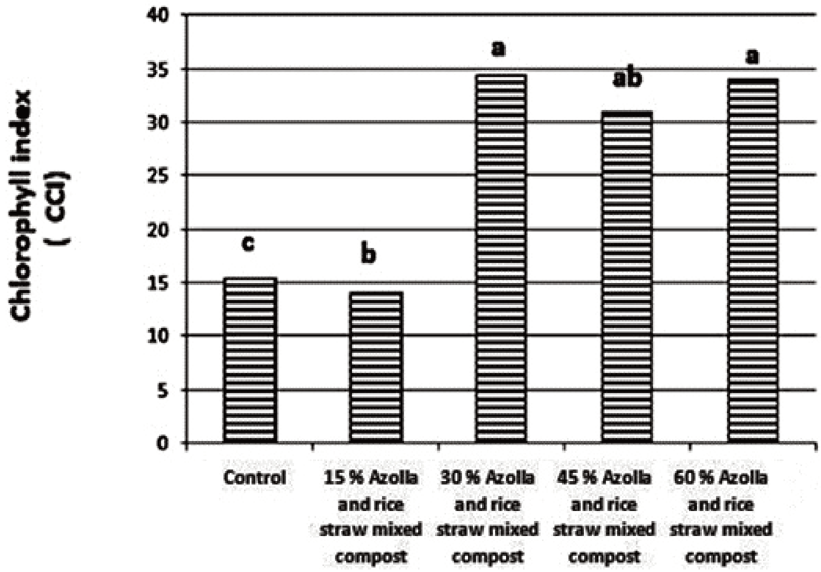

Fig. 9. Chlorophyll content index in dieffenbachia leaves.

Physical properties of growth media

Examination of the average physical properties of growth media used for dieffenbachia growth showed that the mass specificity of treatments added to *Azolla* and rice straw mixed compost was significantly lower than peat (Table 4). The bulk density increased with the addition of *Azolla* and rice straw mixed compost, as observed in studies by Mahboub Khomami *et al.* (2019 a). This led to a gradual decrease in total porosity and a change in the distribution of porosity in the substrates, and as a result, its Air-fill porosity decreased and Container capacity increased (Table 4). In this experiment, the percentage of air-fill porosity of the peat is higher than the optimal level, while the percentage of air-fill porosity is ideal in compost replacement treatments. Cavins *et al.* (2000) stated that the optimum EC for a growing environment is between 0.76 and 1.25 dS m^{-1}, so 30 and 45 % compost levels are in this range (Table 3).

Effect of compost on leaf nutrients

Analysis of variance of nutrients in dieffenbachia leaves (Table 4) showed that the effect of compost on nitrogen, phosphorus, potassium, magnesium, iron and manganese was significant. Accordingly, the results of table 6 show that increase the levels of *Azolla* and rice straw mixed compost significantly increased the levels of nitrogen, phosphorus, potassium, magnesium, iron and manganese in leaves compared to the control and 60 % of compost had the highest level of these elements in leaves. Our results are consistent with Setiawati *et al.* (2017) who showed that the combination of *Azolla* compost with soil increases soil phosphorus, the amount of plant phosphorus in rice. Their study suggested the benefits of *Azolla pinata* compost to increase the nutrient content of soil and rice plants.

Table 3. Some physical properties of the growth media treatments.

Treatment	Bulk density(g cm^{-3})	Air-fill porosity(%)	Containercapacity (%)	Total porosity(%)	pH(1:5)	EC(dS m^{-1})
Control	0.12	38.1	57.4	95.5	4.9	0.3
15 % *Azolla* and rice straw mixed compost	0.17	26.8	64.3	91.7	5.1	0.5
30 % *Azolla* and rice straw mixed compost	0.19	21.4	68.6	90.0	5.1	0.8
45 % *Azolla* and rice straw mixed compost	0.26	14.8	71.4	86.2	5.2	1.1
60 % *Azolla* and rice straw mixed compost	0.27	11.8	73.6	85.4	5.3	1.4
	0.19–0.70a	10–30a	45–65a	50–85a	5.2–7.7b	0.76 –1.25c

a Rang values are recommended physical characteristics (Yeager et al., 2007), b Schaetzl and Thompson (2015), c.Cavins et al., (2000)

Table 4. Analysis of variance of some nutrients in dieffenbachia leaves.

S.o.V	df	MS						
		N	P	K	Ca	Mg	Fe	Mn
Nutritional solution (NS)	1	0.014^{ns}	0.0165^{ns}	0.004^{ns}	0.005^{ns}	0.0025^{ns}	249.35^{ns}	105.267^{ns}
Compost level (CL)	4	0.857**	0.211**	0.741**	0.0984**	0.264**	3581.442*	8144.058**
NS × CL	4	0.0018^{ns}	0.017^{ns}	0.038^{ns}	0.025^{ns}	0.002^{ns}	219.235^{ns}	203.725^{ns}
Error	20	0.01	0.017	0.057	0.013	0.0175	138.25	83.5
Total	29	-	-	-	-	-	-	-
CV (%)	-	4.75	9.12	12.21	13.4	4.91	9.21	5.77

*, ** and ns: Significant at $P < 0.05$, $P < 0.01$ and insignificant, respectively.

Table 6. Comparison of the average effect of compost levels on some nutrients in dieffenbachia leaves.

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)
Control	0.18d	0.05d	0.20e	0.09f	0.11d	38.5e	14.3d
15 % *Azolla* and rice straw mixed compost	0.61c	0.15c	0.40d	0.34e	0.22c	59.6d	35.8c
30 % *Azolla* and rice straw mixed compost	0.58c	0.26b	0.46cd	0.62cd	0.32b	67.8c	60.1b
45 % *Azolla* and rice straw mixed compost	0.70b	0.34a	0.62b	0.72ac	0.43a	129.0b	85.1a
60 % *Azolla* and rice straw mixed compost	0.88a	0.26b	0.74a	0.82a	0.45a	180.7a	82.6a

*In each column, means with the similar letter(s) are not significantly different ($P < 0.05$) using the LSD test.

DISCUSSION

Despite the increase in nutrients with increasing compost levels, the highest amount was observed in 60% of compost, but this increase did not correspond to the increase in growth factors. It seems that the factor affecting plant growth is not only the levels of nutrients and other factors such as the physical properties of the growth medium can be more effective. According to Fonteno *et al.* (1981), an ideal growth medium should have a porosity of more than 85 %. In this experiment, these conditions are not provided for *Dieffenbachia amoena* with increasing compost replacement instead of peat, the bulk density of the substrates increased. As the bulk density increases, the number of coarse porosity decreases and the root capacity for deformation, substitution in the growth medium limited and longitudinal growth increases (Taylor and Ratliff, 1969). Air-fill porosity decreased less than peat when *Azolla* and rice straw mixed compost increased, which is according to Beeson's observations (Beeson, 1996). Water content is very important in the physical parameters of growth media (Marfa *et al.,* 1998). Water should be available in substrates with minimal energy levels, but air in the root zone should also be sufficient (Inbar *et al.,* 1993). Yeager *et al.* (2007) has provided the optimal physical properties for plant growth in an ideal growth medium by describing Container capacity between 45% to 65 % and air-fill porosit between 10 % and 30 %. Through the combination of peat with *Azolla* and rice straw mixed compost, the percentage of bed Air-fill porosity was improved and *Azolla* and rice straw mixed compost as a bed component that has a high water holding capacity, brought the results to an acceptable level. Schaetzl and Thompson (2015) stated that the optimum pH range is between 5.0 and 7.7, and compost-containing substrates are in the desired range. Water should be available in substrates with minimal energy levels, but air in the root zone should also be sufficient (Inbar *et al.,* 1993). Verdonck (1992) presents the optimal physical properties for plant growth in an ideal growth medium as follows: Container capacity between 55 to 75 % and air-fill porosity between 20 and 30%. In this experiment, the percentage of air-fill porosity of the peat is higher than the optimal level, while the percentage of air-fill porosity is ideal in compost replacement treatments. Substrate porosity decreased with increasing *Azolla* and rice straw mixed compost. Decreased porosity due to the addition of *Azolla* compost and various biofertilizers has been reported by Forghan and Mahboub Khomami (2018). Peat-based substrates generally have a total porosity of 85 to 95%, depending on their actual particle size and mass (Michiels *et al.,* 1993). Through the combination of peat with *Azolla* and rice straw mixed compost, the percentage of bed air-fill porosity was improved and *Azolla* and rice straw mixed compost as a bed component that has a high container capacity, brought the results to acceptable level. The results are consistent with the results of other researchers in relation to the replacement of organic matter compost with peat (Jayasinghe *et al.,* 2010; Mahboub Khomami *et al.,* 2019a; Mahboub Khomami *et al.,* 2019b; Massaa *et al.,* 2018).

CONCLUSION

The results showed that in addition to the favorable effect of *Azolla* and rice straw mixed compost on plants, 50 % of rice straw is also consumed in combination with *Azolla* in the form of compost, which can solve some of the problems caused by their accumulation or burning. On the other hand, the absence of differences between nutrient solution and non-solution treatment indicates that compost alone can meet diphenbachia's nutritional needs for at least 7 months. The results showed that the use of 45% *Azolla* and rice straw mixed compost in replacement with peat (with formula 10 % perlite: 30 % vermiculite: 45 % *Azolla* and rice straw mixed compost: 15 % peat), in addition to improves the growth factors of *Dieffenbachia amoena* plant, reduces the consumption of peat by up to 75 %.

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