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Research Paper

Evaluation of Effect of Different Growing Media and Nitrogen Fertilizer on Some Morphological Traits in *Spathiphyllum wallisii* L.

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Abstract

In order to evaluate different growing media and nitrogen fertilizer (urea) on some morphological traits of *Spathiphyllum*, an experiment was carried out in a split-plot arrangement based on a completely randomized block design in three replications in greenhouse conditions in 2018. The main plot was assigned to different growing media including T1: leaf-mold, T2: vermicompost, and T3: a mixed growing medium (peat moss 20% + cocopeat 50% + perlite 30%) and the subplot was assigned to urea fertilizer at different rates of 0, 1, 2, 3 and 4 g/L. Results showed that the mixed growing medium plus 2 g/L urea fertilizer had significant positive effects on all traits. According to the results for the interaction effects, the highest shoot fresh weight (26.5 g/plant), shoot dry weight (3.75 g/plant), root fresh weight (35.5 g/plant), root dry weight (4.87 g/plant), length petiole (55.1 cm), and leaf number (12.1) were obtained from the mixed growing medium plus 2 g/L urea fertilizer, while the traits were the least in all studied growing media plus 0 g/L urea fertilizer. The increase in the urea fertilizer from 0 to 2 g/L increased shoot dry weight and petiole length while the urea fertilizer at the rates of 3 and 4 g/L decreased them. The growing media with an EC of 2 dS/m, high porosity, and high water holding capacity can have significant effects on improving morphologic traits of *Spathiphyllum* plants.

Keywords: Leaf number, Length of petiole, Root dry weight, Shoot dry weight.

INTRODUCTION

Potting growing media are the most important factor for a plant to access its nutritional requirements (Parviz and Ali, 2014; Jabbar *et al*., 2018). In fact, the shoot growth phase depends on the type and characteristics of the growing medium (Khayyat *et al*., 2007). A growing medium is chosen based on plant type, container size and type, irrigation method, and availability of materials. Mamba and Wahome (2010) reported that a growing medium should have excellent aeration, low bulk density, adequate exchange capacity, low soluble salts, reproducibility, and lower shipping and handling costs. In nurseries and greenhouses, the proper selection of commonly used growing media such as soil, perlite, cocopeat, vermiculite, sand, peat moss, vermicompost, and their integration have direct and indirect impacts on growth, plant performance, and optimum yield (Bidarnamani and Zarei, 2014; Parviz and Ali, 2014). The interaction between earthworms (*Eisenia fetida*) and degrading microorganisms during the breakdown of organic matters such as compost produces an organic substance called vermicompost with a high water-holding capacity, a high proportion of digestible nutrients, and microbial metabolites (Paul and Metzger, 2005; Getachew *et al*., 2018). This substance is rich in a lot of microbial flora such as *Azospirillum*, *Actinomycetes*, *Phoxspor,* and *Bacillus*. The microbial community in a growing medium helps produce plant growth regulators like auxins and gibberellins that do not exist naturally in the soil. Nitrogen stabilizing bacteria with a high capability of nitrogen fixation are also seen in vermicompost (Simek and Pizl, 1989; Pathma and Sakthivel, 2012). Cocopeat, another growing medium, is produced by the process of coconut fruit flaking, which is physically a sponge material and is similar to peat moss. Cocopeat is composed of lignin and cellulose in an equal ratio and is rich in potassium and micronutrients, especially iron, manganese, zinc, and copper. Cocopeat has high concentrations of potassium and sodium, so when it is used as a growing medium, the programming of nutrients must be carefully regulated (Treder, 2008). Honfi *et al.* (2010) reported that lilium growth in cocopeat media increased leaf number, flower diameter, and flower size. Kakoei and Salehi (2013) recorded 2.43 g/plant of shoot dry weight for *Spathiphyllum* planted in perlite growing media. Saberi (2005) also reported that the highest yield of broccoli was obtained in an integrated medium (70% peat + 30% compost). It seems that the use of different substrates leads to considerable alterations in photosynthesis and chlorophyll content during the plant growth cycle (Samartzidis *et al*., 2005). Nitrogen fertilizers are exogenous factors that affect plant growth. Nitrogen is one of the most important elements of many biological molecules such as proteins, nucleic acids, and chlorophyll (Hopkins, 2004; Seyed Nasir and Nikfarjam, 2017).

The species *Spathiphyllum wallisii* L. is a monocotyledonous flowering plant in the Araceae family. Spathiphyllum is native to tropical America and Southeast Asia with shiny and green leaves. The flowers are small and form on a cylindrical white spike that is covered with a white bracelet that forms a spoon. Its cultivation is like anthurium (*Anthurium andraeanum*). The plant has no or a small stem. Its flowering time varies depending on the species from spring to summer (Ghasemi and Kafi, 2010). It lives in shade and needs a little sunlight to thrive (Kakoei and Salehi, 2013). The present study aimed to compare the effects of different growing media with different amounts of nitrogen fertilizer on the growth and development of *Spathiphyllum*.

MATERIALS AND METHODS

In order to investigate the effect of different growing media and nitrogen fertilizer (urea) on morphological traits in greenhouse conditions, an experiment was carried out in a split-plot arrangement based on a completely randomized block design in three replications. The main plot was assigned to T1: leaf-mold, T2: vermicompost (sawdust + cow manure + *E. fetida*) and T3: a mixed growing medium (peat moss 20% + cocopeat 50% + perlite 30%) and the subplot to different rates of urea as N1: 0, N2: 1, N3: 2, N4: 3 and N5: 4 g/L. The physical indices of the growing media were measured according to Razi Kordmahaleh *et al*. (2005). A volumetric method was used to measure pH and electrical conductivity (EC). The sample was sieved, then 100 g was taken from it and poured into a container. Next, it was added with 500 ml of distilled water at 20°C and the lid of the container was closed. The sample was shaken on a shaker for 20 minutes and the pH and EC of the solution was then measured for ten minutes. The sieve size could indicate the particle size distribution. The sieve size of less than 12 mm was used to measure the particle size percentage. To measure water-holding capacity, 50 g of each sample was poured into a container and weighed. The sample was heated to 105 ± 2°C and re-weighed after cooling. The process of heating, cooling, and weighting was repeated until the difference of two consecutive weights was more than 0.1 g. Based on this weight loss, the percentage of water retention in the original sample was calculated. Bulk density was measured using a cylinder, collar, and funnel. The sieved sample was passed through the funnel and collar and filled the cylinder. The piston was then gently placed on the sample for three minutes. In the end, the collar and piston were removed and the cylinder surface was smoothed using a straightener. The bulk density (BD) was calculated using the following formula:

BD = Weight of cylinder with sample – Empty cylinder weight / The volume of the cylinder.

Some properties of the growing media are shown in Fig. 1 and Table 1. Clay soil, silt, decomposed leaves, manure, and rice hull were used to make the leaf-mold. Pot dimensions were 19×19 cm and 15 pots were used for each treatment. Before filling the pots, the growing media were passed through a 2-mm sieve. Before transplanting the *Spathiphyllum* plantlets in the pots filled with the growing media, the morphological traits such as shoot fresh weight, shoot dry weight, root fresh weight, root dry weight, petiole length, and leaf number were measured. The irrigation was done at 8 a.m. every day. After the adaptation of the plants to these conditions and their establishment, the second factor (urea) was applied weekly for four months. Shoot fresh and dry weight, root fresh and dry weight, petiole length, and leaf number, length, and width were measured in 45 plant samples. The shoots and roots of the plant samples were oven-dried at 74°C for 48 hours. The leaf area was also measured with a leaf area meter (LI-3100C Leaf Area Meter). Data analysis was carried out using the MSTATC software and the means were compared with Duncan's multiple range test (DMRT) at the 5% level.

Table 1. Some characteristics of the growing media treatment.

Raw material	Size (mm)	pH	EC (dS m^{-1})
Leaf-mold	1.2-2.5	6.76	1.56
Vermicompost	50%<4	5.8-8	6.5-8.5
Mixed growing medium (perlite 30% + cocopeat 50% + peat moss 20%)	1-2	5.9	2.1

RESULTS AND DISCUSSION

Shoot fresh weight (SFW)

The analysis of variance (ANOVA) showed that the growing media (GM), urea (U) and GM×U interaction had significant effects (P<0.01) on shoot fresh weight (SFW) (Table 2). The maximum SFW was obtained from the mixed growing medium in which it was 56% higher than that of leaf-mold and vermicompost (Table 3). The application of 2 g/L urea had the highest SFW (18.1 g/plant) and the minimum SFW was recorded for the control treatment (Table 4).

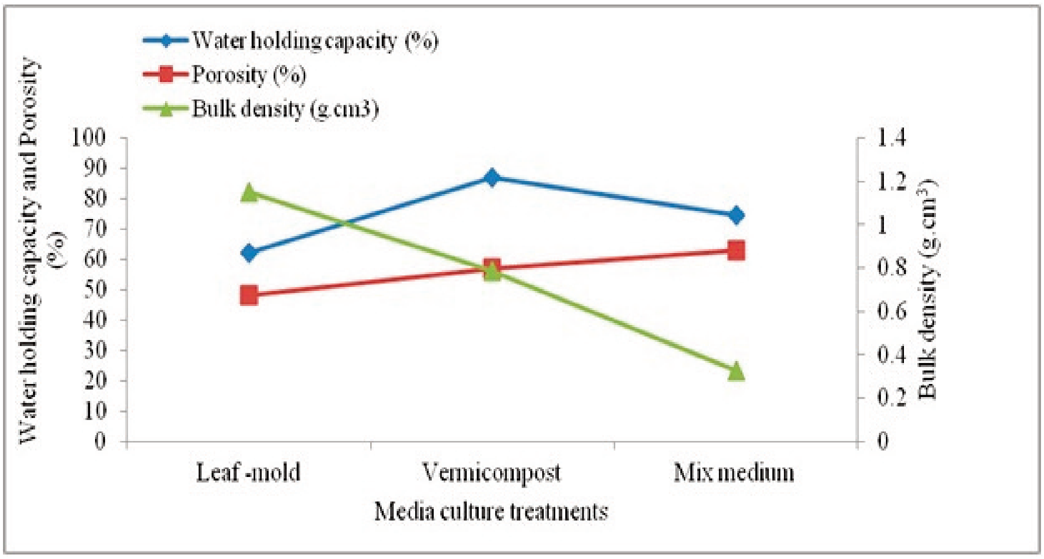

Fig. 1. Some physical indices of bulk density, porosity (%) and water holding capacity (%) of the growing media.

SFW was the highest (26.5 g/plant) when the mixed growing medium plus 2 g/L of urea was applied. However, when the leaf-mold was used without urea, SFW was the least (Table 5). It was considered that SFW was more than 15.8 g/plant in all U treatments in the mixed growing medium. It seems that cocopeat has a very high water-holding capacity, which contributes to the retention of aeration in the rhizosphere and the prevention of oxygen reduction in the root zone (Aslanpour *et al*., 2019). Adding perlite to growing media improves aeration and drainage of the media. The bulk density was lower in the mixed growing medium than in leaf-mold and vermicompost. This property improves aeration and drainage conditions of the mixed growing medium (Fig. 1) and increases oxygen diffusion (Yahya *et al*., 2009). Plant roots need oxygen for respiration and ATP is produced to absorb nutrients (Taiz *et al*., 2014). It seems that more nutrients were transmitted from around the roots to the leaves and as a result, the photosynthesis process increased SFW. Cho *et al*. (2006) and Mobini *et al*. (2009) recommended combining one part perlite with 3 parts cocopeat to obtain an optimum growing medium. In another study, adding 25% perlite to cocopeat improved aeration level and potato growth and yield significantly (Mobini *et al*., 2009). The results of the present study are in agreement with them.

Table 2. Analysis of variance (means of squares) for shoot fresh weight (SFW), shoot dry weight (SDW), root fresh weight (RFW), root dry weight (RDW), petiole length (PL), and leaf number (LN) of *Spathiphyllum* plants.

S.o.V	df	SFW	SDW	RFW	RDW	PL	LN
Block	2	51.5 ns	3.37 ns	483**	3.94 ns	6.35*	45.3 ns
Growing media (GM)	2	667**	10.3**	615**	3.18 *	24.7**	889**
Error	4	98.2	1.46	524	10.6	6.67	60.1
Urea (U)	4	191**	5.66**	84.3 **	2.03 ns	4.17*	96.1*
GM×U	8	6.62 **	0.81 **	111 *	5.67*	89 **	333**
Error	24	12.8	0.21	4.74	1.15	12.1	2.99
CV (%)		15.6	13.2	17.4	10.5	11.1	12.8

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

Table 3. Means comparison for the effect of growing media on shoot fresh weight (SFW), shoot dry weight (SDW), root fresh weight (RFW), root dry weight (RDW), petiole length (PL), and leaf number (LN) of *Spathiphyllum* plants.

Media culture	SFW (g/plant)	SDW (g/plant)	RFW (g/plant)	RDW (g/plant)	PL (cm)	LN per plant
Leaf-mold	6.36 b	1.01 b	18.3 b	3.62 b	41.9 c	7.4 b
Vermicompost	8.21 b	1.06 b	20.9 b	3.72 b	55.3 b	8.7 b
Mixed growing medium	18.5 a	2.34 a	29.3 a	4.42 a	61.5 a	12.6 a

In each column, means with a similar letter are not significantly different (P < 0.05) using the Duncan's test.

Table 4. Means comparison for the effect of urea on shoot fresh weight (SFW), shoot dry weight (SDW), root fresh weight (RFW), root dry weight (RDW), petiole length (PL), and leaf number (LN) of *Spathiphyllum* plants.

Urea	SFW (g/plant)	SDW (g/plant)	RFW (g/plant)	RDW (g/plant)	PL (cm)	LN per plant
Control	8.66 b	1.18 b	20.4c	3.21 a	30.1 b	5.1 c
1 g L^{-1}	9.78 b	1.20 b	21.1bc	3.63 a	33.1 b	7.6 ab
2 g L^{-1}	18.1 a	2.72 a	26.6 a	4.03 a	47.4 a	8.4 a
3 g L^{-1}	10.1 b	1.33 b	22.4 bc	4.30 a	48.4 a	6.3 bc
4 g L^{-1}	8.51 b	1.01 b	23.0 b	4.41 a	15.8 c	4.7 c

In each column, means with a similar letter are not significantly different (P < 0.05) using the Duncan's test.

Table 5. Means comparison for the interaction effect of growing media and urea on shoot fresh weight (SFW), shoot dry weight (SDW), root fresh weight (RFW), root dry weight (RDW), petiole length (PL), and leaf number (LN) of *Spathiphyllum* plants.

Growing media	Urea	SFW (g/plant)	SDW (g/plant)	RFW (g/plant)	RDW (g/plant)	PL(cm)	LN per plant
Leaf-mold	Control	1.72 d	0.510 h	14.0 g	1.98 c	12.9 g	3.67 e
	1 g L^{-1}	5.68 cd	0.752 gh	18.9 def	2.5 bc	17.5 fg	3.95 e
	2 g L^{-1}	16.3 b	2.97 c	23.5 c	2.78 bc	37.3 c	5.01 de
	3 g L^{-1}	4.25 d	0.701 gh	19.1 def	2.11 c	25.2 de	4.61 de
	4 g L^{-1}	3.82 d	0.138 h	16.1 fg	2.59 bc	29.1 d	5.64 cde
Vermicompost	Control	6.35 cd	1.39 d-g	16.8 efg	2.64 bc	20.3 ef	4.36 de
	1 g L^{-1}	7.82 cd	2.01 d	14.2 g	2.34 bc	18.2 fg	5.92 cde
	2 g L^{-1}	11.5 bc	1.43 d-g	20.8 cde	3. 01 abc	47.1 b	7.60 bcd
	3 g L^{-1}	7.85 cd	0.821 fgh	29.4 b	3.56 abc	30.3 d	6.31 cde
	4 g L^{-1}	7.52 cd	0.948 e-h	21.4 cd	3.21 abc	25.7 de	8.71 bc
Vixed growing medium	Control	15.8 b	1.64 def	30.5 b	3.81 abc	25.1de	6.35 cde
	1 g L^{-1}	15.8 b	2.14 d	30.3 b	4.44 ab	45.7 b	10.2 ab
	2 g L^{-1-1}	26.5 a	3.75 a	35.5 a	4.87 a	55.1 a	12.1 a
	3 g L^{-1}	18.2 b	2.14 d	18.7 def	3.9b abc	48.7 b	9.65 ab
	4 g L^{-1}	16.2 b	1.74 de	31.5 b	2.49 bc	26.2 de	8.67 bc

In each column, means with a similar letter are not significantly different (P < 0.05) using the Duncan's test.

Shoot dry weight (SDW)

Growing media (GM), urea (U), and GM×U interaction brought about significant differences (P<0.01) in SDW (Table 2). The leaf-mold, vermicompost and mixed growing medium had 1.01, 1.06 and 2.34 g of SDW per plant, respectively (Table 3). Khalaj *et al.* (2011) showed that the highest levels of flower characteristics in gerbera plants were obtained from perlite + peat + expanded clay (25% + 70% + 5%). In the mixed growing medium plus 2 g/L of U, SDW was the highest (3.75 g/plant) whilst it was the lowest in the three GM (leaf-mold, vermicompost and mixed growing medium) without any urea. Increased growth is the result of the proliferation and development of cells, followed by the construction of non-structural carbohydrates and higher biomass (Taiz and Zeiger, 2002). Growing media with lower bulk density, higher cation exchange capacity (CEC), and higher porosity increase the uptake and storage of nutrients and water, which facilitate plant growth by the mobilization of nutrients through two mechanisms of mass flow and diffusion to the roots (Khalaj *et al*., 2011). The high rate of absorption by the roots reduces nutrient elements in the root zone. This depletion is mitigated by was filled with diffusion and mass flow mechanisms. It seems that the presence of potassium and phosphorus in the mixed growing medium plus nitrogen treatment increased the absorption of these materials and consequently increased plant growth and biomass. Jabbar *et al*. (2018) showed that the highest rate of phosphorus (0.39%) and potassium (0.27%) uptake in two gladiolus cultivars was in the cocopeat: perlite (1:3, V/V) treatment.

Root fresh and dry weight

Significant differences (P<0.01) were observed in root fresh and dry weight per plant between the treatments (Table 2). The mixed growing medium had the maximum root fresh weight (RFW) of 29.3 g/plant and the lowest was found in the leaf-mold medium (Table 3). As shown in Table 4, the application of 2 g/L urea increased RFW by about 23% versus the control. The results for the GM×U interaction revealed that RFW was increased when U was increased from 0 to 2 g/L. The lowest RFW was found in the control treatments (Table 5). The analysis of variance showed that the GM and GM×U interaction treatments had significant effects on root dry weight (RDW) but U had no significant effect. The highest RDW was recorded in the mixed growing medium so that it was 16% and 18% higher than that of the leaf-mold and vermicompost, respectively. RDW was more than 4 g/plant in the application of 1 and 2 g/L of U to the mixed growing medium and the minimum RDW (1.98 g/plant) was recorded in leaf-mold plus 0 g/L of urea (Table 5). Rajkumar *et al*. (2017) showed that when perlite and cocopeat were added to the mixed media, the maximum RFW of pomegranate was obtained (2.08 and 2.03 g, respectively). In another study, Isfendiyaroglu *et al*. (2009) suggested that the highest fresh and dry weights were recorded by olive cuttings in sand-perlite (1:2) media culture. Kakoei and Salehi (2013) suggested that the existence of perlite in media culture increased the root fresh and dry weight and root length in *Spathiphyllum*. In pothos plants, cocopeat improved the fresh and root dry weights. Our results are in agreement with the findings of these researchers. Water-holding capacity and porosity are two characters that determine root permeability in media culture. Although root growth and morphology have a genetic basis, it can be affected by external factors, in particular the supply of oxygen and nutrients that are important for root growth and development. Root growth and development is dependent on the supply of oxygen and nitrogen. High porosity in seedbeds decreases mechanical strength at the root tip, and thus the longitudinal growth, branching, and the formation of mandibular roots expand. The existence of high water storage capacity in the rhizosphere increases the density of roots, which improves water and nutrient uptake. As shown in Fig. 1, the amount of porosity and water-holding capacity was higher in the mixed growing medium than in the other two treatments, and it seems that this might be one of the reasons for its higher root fresh and dry weight.

Petiole length

Petiole length (PL) was affected by growing media (GM), urea (U) and GM×U (Table 2). The maximum and minimum PL were obtained from the mixed growing medium and leaf-mold, respectively (Table 3). The lowest PL was recorded by adding 4 g of urea to the growing media so that it was even smaller than the control. However, the highest amount of this trait was obtained from the application of 3 g/L of urea, showing no significant difference with the U treatment of 2 g/L (Table 4). The amount of PL was not less than 25 cm in the mixed growing medium plus all urea treatments, but the same trend was not observed in the other two treatments. The highest PL was recorded in the mixed growing medium plus 2 g/L urea and the minimum in leaf-mold plus 0 g/L U or the control (12.9 cm) (Table 5). Habib (2012) showed that the response of the studied traits to various amounts of NPK in fishtail palm (*Caryota mitis* Lour) was different so that the maximum plant height and stem diameter were obtained from 2 g of NPK in the mixed media, but the highest leaf area resulted from 4 g of NPK application in the mixed media. In another study, Khalaj *et al*. (2011) recorded the highest flower height (54.5 cm) in a growing medium containing perlite 25% + peat 70% + expanded clay 5%. Aslanpour *et al*. (2019) reported that the cultivar 'optimara' produced the highest number of flowers in cocopeat:perlite medium and the results had a significant difference with the other growing media (peat:cocopeat:peat moss). Papadopoulos *et al*. (1996) recorded the highest flower height (69 cm) when using a mixture of perlite and peat at an equal ratio. As shown in Table 1, the electrical conductivity (EC) of leaf-mold, vermicompost, and mixed growing medium were 1.56, 6.5-8.5, and 2.1 dS/m, respectively. The amount of total soluble solid in the culture media affects ion exchange and as a result, the pH of soluble media exchanges. The presence of ions in the culture medium along with root secretions (cellular slimming liquid, small organic compounds, H^+, HCO_3^-, CO_2, and ethylene) provides a structure in which ions can be exchanged between the cations absorbed to the surfaces of culture media particles. On the other hand, cocopeat can cause the mineralization of N and P to mineral forms. Also, perlite has very high available K content that, with other chemical characteristics in the mixed media, increases plant growth parameters such as petiole length (Jabbar *et al*., 2018).

Leaf number (LN)

The results of the analysis of variance (ANOVA) revealed that growing media (GM), urea (U), and their interaction brought about significant differences (P<0.01) in leaf number (LN) (Table 2). LN was higher in the mixed growing medium by about 42% and 31% than in the leaf-mold and vermicompost, respectively (Table 3). Means comparison in Table 4 shows that with an increase in urea from 0 to 2 g/L, LN was increased from 5.1 to 8.4 but it was decreased when urea was increased to 4 g/L. The maximum and minimum LN were recorded in the interactions of the mixed growing medium plus 2 g/L of U (12.1) and leaf-mold plus 0 g/L of U, respectively (3.67). In the mixed growing medium, there was no significant difference between 1, 2 and 3 g/L of U treatments. The application of the leaf-mold medium plus all U treatments was in the lowest statistical class (Table 5). Campos and Reed (1993) reported that the application of 100-200 ppm N fertilizer produced the highest leaf area and number in *Spathiphyllum* and when the amount of N fertilizer exceeded this range, it could cause noticeable burn symptoms on the leaves. Chen *et al*. (2018) declared that *Spathiphyllum* needed a culture medium with an EC of 2 dS/m above or below which the medium would have adverse effects on plant growth. Mashinchian *et al*. (2017) revealed that LN in *Spathiphyllum* was 71.3 per plant in the control, while it was decreased in the other media. Sardoei and Rahbarian (2014) showed that the application of 50% peat moss + 25% sand + 25% perlite in media significantly increased chlorophyll (Chl. a, Chl. b, total Chl. a+b) and carotenoid in *Rosmarinus officinalis*. It seems that the existence of proper nutrient elements in the mixed growing medium, as well as physical properties such as suitable EC, low bulk density, high water-holding capacity, and porosity, provides optimum conditions for accelerated absorption and photosynthesis processes in plants, thereby enhancing their morphological indices.

CONCLUSION

In the recent study, a proper selection of medium growth ingredients played an important role in the improvement and growth of *Spathiphyllum* plants, so high porosity and water-holding capacity, well drainage, and proper EC (2 dS/m) are the main properties of a growth medium for this plant. On the other hand, the response of *Spathiphyllum* to urea was considerable and 2 g/L of urea had the greatest effect on all morphological traits. In addition, maximum shoot fresh and dry weight, root fresh and dry weight, petiole length, and leaf number were obtained from the mixed growing medium (peat moss 20% + cocopeat 50% + perlite 30%) plus 2 g/L of urea.

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