Scientific J. Flowers & Ornamental Plants
www.ssfop.com/journal
ISSN: 2356-7864 **doi: 10.21608/SJFOP.2023.344266**

IMPROVING GROWTH OF *SCHEFFLERA ARBORICOLA* ENDL. CV. GOLD CAPELLA PLANT GROWN IN SANDY SOIL BY SOME NATURAL, ORGANIC AND BIOTIC ADDITIVES UNDER VARIOUS WATER REGIMES TREATMENTS

S.M. Shahin, Magda A. Ahmed and Hanan M.A. Khider
Botanical Gardens Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt

ABSTRACT: A pot experiment was conducted under plastic house conditions at the Nursery of Bot. Gardens Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt during 2021 and 2022 seasons to study the effects of planting in the following media: sand (S) alone as control (M0), S + bentonite (B) at 3:1, v/v ratio (M1), S + organic compost (OC) at 3:1, v/v ratio (M2), M2 + 10 ml/l EM biostimulant (M3), S + B + OC at 2:1:1, v/v/v ratio (M4) and M4 + 10 ml/l EM biostimulant (M5), irrigation frequencies at thrice a week, twice a week and once a week and their interactions on growth and chemical composition of the dwarf umbrella tree (*Schefflera arboricola* Endl.) transplants. The obtained results indicated that in both seasons amending the sand with either bentonite or organic compost or both improved the mean values of various growth traits over control means in most cases both seasons, with the prevalence of M4 and M5 mixtures, which gave the highest values compared to the control. The plants irrigated thrice or twice a week had better growth than those irrigated once a week, with the dominance a week water treatment, which recorded in most growth characteristics. It was also, noticed that the various single and combined treatments raised chlorophyll a, b, carotenoids, total carbohydrates, N, P, K and proline concentrations in the leaves, with some exceptions relative to control, but the superiority was M4 or M5 mixture, with irrigating thrice or twice a week and their interactions, which acquired the utmost high concentrations over the other individual and combined treatments. Accordingly, it can be recommended to culture *Schefflera arboricala* Endl. transplants in a mixture of sand + bentonite + organic compost (2:1:1, by volume), with 10 ml/l EM biostimulant and irrigating them either thrice a week (when water is available) or twice a week (at water shortage) to get the best growth appearance and high quality of potted Schefflera plants.

Keywords: *Schefflera arboricola*, soil amendments, pot plants, bentonite, growth, active constituents, EM biostimulant

Scientific J. Flowers & Ornamental Plants, 10(4):273-287 (2023).

Received:
28/11/2023
Accepted:
20/12/2023

Corresponding author:
Magda A. Ahmed
magabhameed@gmail.com

INTRODUCTION

The information collected from the literature suggests that normal garden/field soils are not suitable alone for container media preparation unless its structure is modified by adding other forms of physical conditioners. Among these conditioners may be the bentonite. Alghamdi *et al*. (2018) reported that bentonite is a clay generated material used on a wide scale to ameliorate the sand properties. It enhances nutrient holding capacity, improves soil structure and its moisture content and provides a better habitat for soil microorganisms. The positive

impacts of bentonite on ameliorating sand properties and plant development were previously reported by Owen *et al*. (2008) on *Cotoneaster dammeri* 'Skogholm', Hazrati *et al*. (2017) on *Aloe vera*, Paradalo *et al*. (2019) on *Lolium multiflorum*, Kayama *et al*. (2021) on teak (*Tectona grandis*), Younas *et al*. (2022) on *Bougainivillea* sp., Satje and Nelson (2009) on sugarcane, AbdEl-Hamid *et al*. (2013) on wheat and peanut, Mi *et al*. (2020) on millet (*Setaria italica*), Karbout *et al*. (2021) on date palm cv. Deglet Nour and Hassan *et al*. (2022) on date palm cv. Siwi.

Another way to improve the physicochemical properties and fertility of the sand is the application of either organic compost or microbial inoculation with an EM stimulant. The organic compost provides the plants with nutrients and keeps high moisture levels in the rooting zone (Mlih *et al*., 2019). The organic compost not only contains various macro- and micronutrients which are essential for plant growth but also improves sand's physical properties, such as bulk density, aeration, moisture, minerals retention and water infiltration (Lehmann and Kleber, 2015). Effective microorganisms (EM) include yeasts, photosynthetic, lactic acid bacteria, and actinomycetes that secrete useful substances such as vitamins, organic acids, and hormone-like substances, and create favorable conditions for plant growth. When mixed with organic substances, it also chelates heavy metals and antioxidants (Elbashier *et al*., 2021).

Previous studies regarding the usage of either organic or EM amendments for preparing growing mixtures and their positive effects on ornamental and woody plants were conducted by Saadaway *et al*. (2005) on peperomia, schefflera and syngonium, Khan *et al*. (2006) on *Albizia procera*, Abdel-Fattah *et al*. (2008) on *Schefflera actinophylla*, Khan *et al*. (2011) on *Dalbergia sissoo*, Mohamed *et al*. (2013) on *Coffea arabica*, Khan *et al*. (2014) on *Acacia auriculiformis*, Tawila *et al*. (2015) on neem, Panupon and Soraya (2017) on 'Coral Pink Wave' petunia hybrid, Meshaal *et al*. (2018) on *Russelia equisetiformis* and El-Haddadi *et al*. (2022) on *Tetraclinis articulata*.

On the other hand, determination of the suitable irrigation interval (frequency/week), which go in line with components of the growing mixture, is critical for optimizing the growth and subsequent aesthetic value of pot plants. This true was documented by Abdel-Moneim *et al*. (2018) on *Euphorbia milii* var. *longifolia*, El-Leithy *et al*. (2018) on rosemary, Akhtar (2019) on *Calendula officinalis* and *Dianthus barbatus*, Do Bomfim *et al*. (2020) on ornamental pineapple and Scagel and Bryla (2022) on *Rhododendron* cvs. Gibraltar, PJM and Catawbiense Album.

Besides, the effects of interactions between growing media and irrigation on the growth and quality of potted ornamental plants were explored by Saadawy *et al*. (2011) on *Ficus nitida* 'Hawaii', Mazher *et al*. (2012) on *Amaranthus tricolor*, Nofal *et al*. (2014) on *Hymenocallis speciosa*, Said (2016) on *Duranta erecta* var. *variegata*, Rydlova and Puschel (2020) on *Gazania rigens*, *Pelargonium peltatum* and *P. zemale*, El-Fouly *et al*. (2020) on *Asparagus densiflorus* 'Myers', Shahin and Sayed (2021) on *Ochna serrulata*, Shahin *et al*. (2021) on *Ranunculus asiaticus* var. Orange, El-Ghazaly *et al*. (2021) on *Gasteria corinata* var. Verrucosa and Shahin *et al*. (2023) on *Arenga englerí*.

Among foliage ornamental pot plants, which requires good preparation of the growing mixture and precise determination of the water treatment may be the dwarf umbrella tree (*Schefflera arboricola* Endl.). It is an evergreen shrub up to 2-3 m height. The leaves are palmately compound, with 7-9 leaflets (9-20 cm long), belongs to Araliaceae family and native to Taiwan. It is commonly used as a houseplant and as a garden landscape specimen in temperate climates where frosts are not severe sometimes pruned to use as a hedge. The cv. Gold Capella is the most popular as an indoor plant. Although it thrives at higher light, it can adapt to a wide range of light levels. It prefers to be moist but not wet to avoid root rot. When the conditions

are proper, aerial roots are formed giving the plant an interesting and unusual appearance (Huxley *et al*., 1992; Brickell, 1997).

The goal of this investigation is to choose the most suitable growing mixture along with water treatment reliable for the production of the proper dwarf umbrella plant.

MATERIALS AND METHODS

A pot experiment was undertaken inside a plastic house at the Nursery of Botanic Gardens Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt during 2021 and 2022 successive seasons to study the response of the dwarf umbrella tree transplants to different growing mixtures and various irrigation times a week and their interactions in a factorial experiment.

Therefore, homogenous transplants of *Schefflera arboricola* Endl. cv. Gold Capella at a length of about 20 cm, with one main stem carrying about 8 leaves were well selected and transplanted on April 15th for every season in plastic pots measuring 20-cm-diameter (one transplant/pot) filled with one of the following growing mixtures till 2 cm before the pot rim:

1. Sand (S) only, referred to as control (M0).
2. S + bentonite (B) at 3:1, v/v ratio (M1).
3. S + organic compost (OC) at 3:1, v/v ratio (M2).
4. M2 + effective microorganisms (EM) at 10 ml/1 (M3).
5. S + B + OC at 2:1:1, v/v/v ratio (M4).
6. M4+ EM at 10 ml/l (M5).

The analysis of the sand, bentonite and organic compost utilized for both seasons are presented in Tables (a, b and c, respectively).

Besides, EM (the Japanese biostimulant), it is a commercial product which includes more than 60 strains of effective microorganisms (EM), viz. lactic acid bacteria, photosynthetic bacteria, yeast, fermenting fungi and actinomycetes.

Immediately after transplanting, the plants were irrigated once every 2 days with 250 ml of fresh water/pot till May 1st, as they were irrigated with the following 3 frequencies: Thrice (3 times) a week, twice (2 times) a week and once (1 time) a week. In addition, each water treatment was combined factorially with each growing mixture to formalize 18 interaction treatments. All the different agricultural practices required for this plantation were carried out in time, as gardeners usually did.

Table a. The physical and chemical properties of the sand used in 2021 and 2022 seasons.

Soil type	Particle size distribution (%)				S.P.	pH	E.C. (dS/m)	Cations (meq/l)				Anions (meq/l)		
	Coarse	Fine	Silt	Clay				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}
Sand	84.71	6.35	1.50	7.44	21.93	7.90	3.65	17.45	10.30	7.25	0.70	2.33	9.51	23.86

Table b. The physical and chemical properties of the bentonite used in 2021 and 2022 seasons (obtained from Al-Ahram Mining Co., Al-Maady).

Component	Value	Component	Value	Component	Value	Component	Value
pH (5 % soln)	8.5	**Silica (SiO_2)**	53.31 %	**Magnesium (MgO)**	3.95 %	**Potassium (K_2O)**	0.08 %
Calcium (CaD)	2.47%	**Iron (Fe_2O_3)**	12.44 %	**Sodium (Na_2O)**	1.89 %	**Manganese (MnO)**	1.85 %

Table c. The physical and chemical properties of the organic compost used in 2021 and 2022 seasons.

Component	Value	Component	Value	Component	Value
Weight of m^3 (kg)	550.5	**EC (dS/m)**	1-15	**MgO (%)**	0.96
Humidity (%)	55.6	**Water retention**	100	**Fe (ppm)**	1240
Organic matter (%)	47.7	**N (%)**	3.0	**Mn (ppm)**	324
Organic carbon (%)	27.3	**P_2O_5 (%)**	0.5	**Zn (ppm)**	33.5
C/N ratio	17.5/1	**K_2O (%)**	2.5	**Cu (ppm)**	31.6
pH (1:10)	6.0	**$CaCO_3$ (%)**	1.6		

The following data were recorded at the end of each season (Oct. 30th); plant height (cm), stem diameter (cm), number of both shoots and leaves/plant, the longest root length (cm), as well as roots and aerial parts fresh and dry weights (g). In fresh leaf samples taken from the middle parts of the plant, photosynthetic pigments (chlorophyll a, b and carotenoids, mg/g f.w.) and free amino proline (mg/100 g f.w.) were determined according to the methods of Sumanta *et al*. (2014) and Bates *et al*. (1973), successively, whereas in dry ones, the percentages of total carbohydrates (Herbert *et al*. 1971), as well nitrogen, phosphorus and potassium (Chapman and Pratt, 1982) were measured.

Data were tabulated and statistically analyzed using the computer program of SAS Institute (2009), which was followed by Duncan's New Multiple Range t-Test (Steel and Torrie, 1980) to verify the significance level among means of various treatments.

RESULTS

Effect of growing mixtures, water treatments and their interactions on:

1. Vegetative and root growth parameters:

It is clear from data outlined in Tables (1, 2, 3 and 4) that all growth traits mean values, viz. plant height (cm), stem diameter (cm), number of both shoots and leaves/plant, root length (cm), as well as roots and aerial parts fresh and dry weights (g) were maximized by planting in either M4 (sand + bentonite + organic compost at 2 :1: 1, v/v) or M5 (M4 + 10 ml/ EM biostimulant) as these two mixtures gave the highest means of growth traits compared to the control and other mixtures in the two seasons, except M1 (sand + bentonite at 3:1, v/v) and M2 (sand + organic compost at 3: 1, v/v), which increased the means of roots dry weight. in the first season to 15.25 and 14.91 g, respectively, which were very close to that of the M5 superior mixture (15.21 g) with non-significant differences among themselves. The second rank, however, was occupied by either M2 (sand + organic compost, 3:1 ratio) or M3 (M2 + 10 ml/l EM biostimulant), which exchanged recording good results of growth in both seasons.

As regards the effect of water treatments, the results indicated that irrigation treatment thrice a week (day by day) attained the highest records of various growth criteria in the two seasons, followed by irrigation twice a week and then irrigation once a week, taking the following descending order thrice a week > twice a week > once a week in most cases of the two seasons. Only two exceptions were observed, where the twice a week treatment raised the formation of shoots/plant to maximum values in both seasons (4.11 and 4.53, consecutively) over the other two water treatments, as well the same treatment (twice a week) gave a mean value of aerial parts dry weight (24.61g) in the 1st season, which was greatly near to that acquired by thrice a week treatment (24.44 g) without significance difference in between. In general, the least records of growth characters were obtained in the two seasons by applying irrigation treatment every week.

Also, the interaction treatments exhibited a great variable in their effects on the different vegetative and root growth parameters mean values, but the superiority was for the interaction between planting in either M4 or M5 mixture and irrigating thrice a weak, as these two interactions resulted in the highest means of various growth traits in all cases of the two seasons. Besides, combining planting in either M2 or M3 mixture and thrice a weak irrigation treatment achieved higher means of stem diameter in the first (1.400 and 1.367 cm) and second (1.467 and 1.500 cm, respectively) seasons. Also, interacting between M5 mixture and twice a week water treatment improved the mean No. shoots/plant in both seasons. Likewise, the combination of M3 mixture + thrice a week irrigation treatment attained the greatest value of roots dry weight in the 1st season. In general, the second class was positioned in the two seasons by the interaction between both M3 mixture + thrice a week water treatment and planting in either M4 or M5 mixture +

Table 1. Effect of growing media, irrigation treatments and their interactions on plant height and stem diameter of *Schefflera arboricola* Endl. plant during 2021 and 2022 seasons.

Growing media	Irrigation frequency							
	Thrice a week	Twice a week	Once a week	Mean	Thrice a week	Twice a week	Once a week	Mean
				Plant height (cm)				
	First season: 2021				Second season: 2022			
M0	27.67 gh	32.60 f	24.33 i	2.20 d	28.80 ij	31.00 h	25.23 k	28.34 d
M1	34.00 d-f	32.53 f	25.60 i	30.71 c	36.50 d-f	33.17 g	27.3 j	32.50 c
M2	33.20 ef	32.93 f	25.93 hi	30.69 c	36.40 d-f	35.07 f	27.67 j	33.04 c
M3	36.27 bc	34.17 d-f	27.50 gh	32.64 b	38.97 c	35.17 ef	28.60 ij	34.24 b
M4	40.47 a	35.30 b-d	29.00 g	34.92 a	44.60 a	36.90 de	29.70 hi	37.07 a
M5	36.90 b	34.87 c-e	28.67 g	33.48 b	41.73 b	37.37 cd	30.87 h	36.66 a
Mean	34.75 a	33.73 b	26.84 c		37.83 a	34.78 b	28.32 c	
				Stem diameter (cm)				
M0	1.000 hi	1.133 fg	0.867 j	1.000 d	1.100 f	1.233 de	0.933 g	1.089 d
M1	1.133 fg	1.133 fg	0.933 ij	1.067 c	1.233 de	1.200 e	1.000 g	1.144 c
M2	1.400 ab	1.233 de	1.067 gh	1.233 b	1.467 b	1.300 cd	1.233 de	1.333 b
M3	1.367 bc	1.200 ef	1.200 ef	1.256 b	1.500 b	1.300 cd	1.300 cd	1.1367 b
M4	1.467 a	1.300 cd	1.233 de	1.333 a	1.600 a	1.433 b	1.333 c	1.456 a
M5	1.367 bc	1.333 bc	1.100 fg	1.267 b	1.600 a	1.433 b	1.267 c-e	1.433 a
Mean	1.289 a	1.222 b	1.067 c		1.417 a	1.317 b	1.178 c	

M0: sand only (S) as control, M1: S.+ bentonite (B) at 3:1, v/v, M2: S + organic compost (OC) at (3:1, v/v), M3: M2 + EM (10 ml/l), M4: S + B + OC (2:1:1, v/v/v) and M5: M4 + EM 10 ml/l).
Means followed by the same letter in a column or raw don`t fifer significantly according to Duncan`s New Multiple Range t-Test at 5 % level.

Table 2. Effect of growing media, irrigation treatments and their interactions on number of shoots and leaves of *Schefflera arboricola* Endl. plant during 2021 and 2022 seasons.

Growing media	Irrigation frequency							
	Thrice a week	Twice a week	Once a week	Mean	Thrice a week	Twice a week	Once a week	Mean
				Number of shoots/plant				
	First season: 2021				Second season: 2022			
M0	3.50 hi	4.00 c-e	3.17 j	3.56 c	3.83 h	4.30 ef	3.37 i	3.30 c
M1	3.67 f-h	4.17 b-d	3.33 ij	3.72 b	4.10 fg	4.60 cd	3.70 h	4.13 b
M2	3.3 e-g	3.90 d-f	3.53 hi	3.76 b	4.20 ef	4.30 ef	3.93 gh	4.14 b
M3	3.83 e-g	4.00 c-e	3.57 g-i	3.80 b	4.30 ef	4.43 de	3.93 gh	4.22 b
M4	4.60 a	4.23 bc	3.83 e-g	4.22 a	5.07 a	4.77 bc	4.27 ef	4.70 a
M5	4.37 ab	4.33 ab	3.93 d-f	4.21 a	4.87 ab	4.77 bc	4.37 d-f	7.67 a
Mean	3.97 b	4.11 a	3.56 c		4.39 b	4.53 a	3.93 c	
				Number of leaves/plant				
M0	22.00 f	25.27 e	14.00 h	20.42 d	24.23 fg	27.60 e	15.47 k	22.43 c
M1	23.20 f	25.67 de	14.43 h	21.10 d	25.57 f	27.97 e	15.93 k	23.16 c
M2	27.77 cd	26.30 c-e	17.80 g	23.96 c	30.63 b-d	28.93 de	19.60 j	26.39 b
M3	28.43 c	26.0 c-e	18.23 g	24.49 c	31.30 bc	29.23 c-e	20.43 ij	26.99 b
M4	43.23 a	28.17 c	19.53 g	30.31 b	48.17 a	31.03 bc	21.83 hi	33.68 a
M5	44.20 a	30.83 b	21.67 f	32.23 a	47.37 a	32.37 b	23.03 gh	34.26 a
Mean	31.47 a	27.17 b	17.61 c		34.54 a	29.52 b	19.38 c	

M0: sand only (S) as control, M1: S.+ bentonite (B) at 3:1, v/v, M2: S + organic compost (OC) at (3:1, v/v), M3: M2 + EM (10 ml/l), M4: S + B + OC (2:1:1, v/v/v) and M5: M4 + EM 10 ml/l).
Means followed by the same letter in a column or raw don`t fifer significantly according to Duncan`s New Multiple Range t-Test at 5 % level.

Table 3. Effect of growing media, irrigation treatments and their interactions on root length and roots fresh and dry weights of *Schefflera arboricola* Endl. plant during 2021 and 2022 seasons.

Growing media	Irrigation frequency							
	Thrice a week	Twice a week	Once a week	Mean	Thrice a week	Twice a week	Once a week	Mean
				Root length (cm)				
	First season: 2021				Second season: 2022			
M0	29.57 i	29.63 i	26.30 j	28.50 d	32.03 g	32.47 g	29.20 h	31.23 d
M1	33.87 gh	34.00 gh	30.43 i	32.77 c	37.13 ef	35.77 f	31.63 g	34.84 c
M2	35.03 g	34.27 g	31.63 hi	33.64 c	38.53 e	36.67 ef	33.10 g	36.10 c
M3	43.03 cd	40.00 ef	38.57 f	40.53 b	46.13 c	43.60 d	38.63 e	42.79 b
M4	54.00 a	47.07 b	42.20 de	47.76 a	53.03 a	48.93 b	43.47 d	48.48 a
M5	53.00 a	45.40 bc	41.87 de	46.76 a	52.73 a	46.83 bc	42.23 d	47.27 a
Mean	41.42 a	38.39 b	35.17 c		43.27 a	40.71 b	36.38 c	
				Roots f.w. (g)				
M0	50.67 d-f	51.64 c-e	36.76 j	46.36 d	51.56 ef	52.70 d-f	38.03 i	47.43 d
M1	52.30 cd	51.94 cd	45.97 g	50.07 b	53.63 d	53.67 d	43.76 h	50.36 c
M2	53.58 c	52.35 cd	42.22 i	49.38 b	55.74 c	53.76 d	45.72 g	51.74 b
M3	49.92 ef	49.07 f	44.21 gh	47.73 c	56.95 c	51.35 ef	46.98 g	51.76 b
M4	56.35 b	55.4 bc	44.31 gh	52.16 a	61.83 a	59.62 b	50.98 f	57.47 a
M5	59.54 a	52.48 cd	44.01 h	52.01 a	61.20 ab	57.34 c	53.10 de	57.21 a
Mean	53.73 a	52.22 b	42.91 c		56.82 a	54.74 b	46.43 c	
				Roots d.w. (g)				
M0	12.68 g	11.30hi	9.29 j	11.09 d	13.14 f	11.41 i	9.77 k	11.44 c
M1	15.58 e	16.08e	14.09 f	15.25 a	16.20 c	14.39 e	13.35 f	14.65 b
M2	16.80 d	16.95cd	10.98 i	14.91 a	16.49 c	15.15 d	11.79 hi	14.48 b
M3	17.72 ab	13.20g	7.96 k	12.96 c	17.34 b	14.86 de	10.68 j	14.29 b
M4	17.54 bc	12.52g	11.77 h	13.94 b	19.28 a	14.36 e	12.21 gh	15.28 a
M5	18.34 a	14.67f	12.63 g	15.21 a	19.03 a	15.09 d	12.72 fg	15.61 a
Mean	16.44 a	14.12b	11.12 c		16.91 a	14.21 b	11.76 c	

- M0: sand only (S) as control, M1: S.+ bentonite (B) at 3:1, v/v, M2: S + organic compost (OC) at (3:1, v/v), M3: M2 + EM (10 ml/l), M4: S + B + OC (2:1:1, v/v/v) and M5: M4 + EM 10 ml/l).

- Means followed by the same letter in a column or raw don`t fifer significantly according to Duncan`s New Multiple Range t-Test at 5 % level.

Table 4. Effect of growing media, irrigation treatments and their interactions on aerial parts fresh and dry weights of *Schefflera arboricola* Endl. plant during 2021 and 2022 seasons.

Growing media	Irrigation frequency							
	Thrice a week	Twice a week	Once a week	Mean	Thrice a week	Twice a week	Once a week	Mean
				Aerial parts f.w. (g)				
	First season: 2021				Second season: 2022			
M0	94.70 h	99.66 g	41.52 l	78.62 e	92.92 h	97.67 g	43.04 m	77.87 f
M1	94.31 h	94.95 h	51.76 k	80.34 d	93.57 h	99.28 g	53.94 l	82.26 e
M2	114.55 e	111.97 ef	58.65 j	95.05 c	116.50 e	111.69 f	59.05 k	95.75 d
M3	113.37 ef	110.55 f	58.29 j	94.07 c	120.18 d	117.41 de	62.48 j	100.03 c
M4	133.62 b	120.39 d	60.20 j	104.74 b	142.44 b	127.82 c	64.95 ij	111.73 b
M5	177.85 a	129.64 c	64.37 i	123.95 a	154.72 a	130.66 c	66.75 i	117.38 a
Mean	121.40 a	111.19 b	55.0 c		120.06 a	114.09 b	58.37 c	
				Aerial parts d.w. (g)				
M0	20.57 hi	25.03 cd	11.32 m	18.97 d	20.47 h	22.42 ef	12.06 m	18.32 e
M1	21.33 gh	20.39 i	12.55 l	18.09 e	21.84 fg	21.45 g	12.55 m	18.61 e
M2	22.04 fg	24.69 d	13.06 l	19.93 c	23.16 de	23.59 d	13.43 l	20.06 d
M3	22.71 ef	23.51 e	12.22 l	19.48 c	24.54 c	24.79 c	13.53 l	20.95 c
M4	25.05 cd	25.81 c	15.79 j	22.22 b	27.26 b	26.76 b	16.34 j	23.46 a
M5	34.96 a	28.22 b	14.04 k	25.74 a	32.16 a	18.36 i	15.08 k	21.87 b
Mean	24.44 a	24.61 a	13.16 b		24.91 a	22.90 b	13.83 c	

- M0: sand only (S) as control, M1: S.+ bentonite (B) at 3:1, v/v, M2: S + organic compost (OC) at (3:1, v/v), M3: M2 + EM (10 ml/l), M4: S + B + OC (2:1:1, v/v/v) and M5: M4 + EM 10 ml/l).

- Means followed by the same letter in a column or raw don`t fifer significantly according to Duncan`s New Multiple Range t-Test at 5 % level.

twice a week water treatment, as such 3 interactions gave, to some extent, means of growth traits near to these of the superior interactions, with non-significant differences in sometimes.

On the other hand, the lowest means of vegetative and root growth parameters occurred in the two seasons by the combination between planting in either control or M1 mixture and once a week water treatment, while in some traits, such as No. leaves/plant, roots dry weight and aerial parts fresh and dry weights, that were achieved by binding between planting in either growing mixture used in the study and irrigating with once a week water treatment, as growing plants under those 6 interactions significantly decreased the mean values of the aforenamed characters to a minimum compared to the mean of control interactions in the two seasons.

2. Chemical composition of the leaves:

Data presented in Table (5) confirmed that the highest concentrations of chlorophyll a, b and carotenoids (mg/g f.w.) were obtained by planting in M4 (sand + bentonite + organic compost, 2:1:1, by volumetric ratio), which maximized the concentrations of these pigments to 1.886, 0.662 and 0.313 mg/g f.w., respectively, followed by cultivating in M2, M3 and M5 mixtures. The lowest concentrations, however, were recorded in plants growing in the M1 medium. As for the effect of water treatments, applying twice a week irrigation treatment gave the utmost high concentration of these

Table 5. Effect of growing media, irrigation treatments and their interactions on pigments and total carbohydrates in the leaves of *Schefflera arboricola* Endl. plant during 2022 season.

Growing media	Irrigation frequency							
	Thrice a week	Twice a week	Once a week	Mean	Thrice a week	Twice a week	Once a week	Mean
	Chlorophyll a (mg/g f.w.)				Chlorophyll b (mg/g f.w.)			
M0	1.490	1.690	0.944	1.375	0.534	0.573	0.470	0.526
M1	1.553	1.572	1.343	1.489	0.498	0.569	0.467	0.511
M2	1.690	1.808	1.713	1.737	0.596	0.613	0.578	0.596
M3	1.685	1.967	1.510	1.721	0.583	0.671	0.481	0.578
M4	1.935	1.938	1.785	1.886	0.676	0.725	0.586	0.662
M5	1.664	1.848	1.664	1.725	0.554	0.623	0.515	0.564
Mean	1.670	1.804	1.493		0.574	0.629	0.516	
	Carotenoids (mg/g f.w.)				Total carbohydrates (% d.w.)			
M0	0.198	0.230	0.168	0.199	35.181	38.862	32.982	35.675
M1	0.197	0.188	0.154	0.180	42.680	51.261	35.807	43.249
M2	0.246	0.280	0.241	0.256	44.849	53.823	36.643	45.105
M3	0.245	0.333	0.197	0.258	40.653	39.495	35.355	38.501
M4	0.315	0.342	0.281	0.313	38.861	48.114	32.123	39.699
M5	0.237	0.292	0.195	0.241	46.574	57.896	33.530	46.000
Mean	0.240	0.278	0.206		41.466	48.242	34.407	

M0: sand only (S) as control, M1: S.+ bentonite (B) at 3:1, v/v, M2: S + organic compost (OC) at (3:1, v/v), M3: M2 + EM (10 ml/l), M4: S + B + OC (2:1:1, v/v/v) and M5: M4 + EM 10 ml/l).

pigments, followed by thrice a week and then one a week irrigation treatment, taking the following scale-down: once a week < twice a week < thrice a week. Furthermore, interactions of M4 mixture + thrice/week water treatment and either M3 or M4 mixture + twice/week water treatment raised the concentration of pigments to the maximal values. Also, the interaction between either M2 or M5 mixture and twice a week water treatment acquired better pigment concentration, occupying the second rank. However, the lowest pigment concentrations were attained when schefflera plants were grown in M0 (control) or M1 mixture and irrigated once a week.

On the contrary, the highest percentage of total carbohydrates was found due to culturing in either M5 mixture (46.00% d.w.) or M2 one (45.105%), followed by planting in M1 mixture (43.249%). As well, combining between M5 mixture and twice a week water treatment was the only combination which maximized the percent of this constituent to 57.896% value, followed by connecting between either M2 or M1 and the same water treatment (twice a week), recording 53.823 and 51.261%, respectively. However, a similar trend to that of pigments concentration was also obtained regarding the effect of water treatment, where twice a week was the dominant.

Likewise, the highest concentrations of both nitrogen and phosphorus (Table, 6) were fulfilled by using M4 mixture (2.545 and 0.874%, successively), followed by M2 one (2.363 and 0.819%, respectively), while the highest concentrations of potassium (2.430 and 2.415%) were acquired by using M3 and M2 mixtures, in consequence order, followed by M4 mixture, that gave 2.256%. However, the lowest percentages of both N and P were registered by control mixture, while that of K was recorded by M5 mixture. Also, using twice a week water treatment attained the maximum percentages of N and K, followed

Table 6. Effect of growing media, irrigation treatments and their interactions on nitrogen, phosphorus, potassium, and proline concentrations in the leaves of *Schefflera arboricola* Endl. plant during 2022 season.

Growing media	Irrigation frequency							
	Thrice a week	Twice a week	Once a week	Mean	Thrice a week	Twice a week	Once a week	Mean
	Nitrogen (%)				Phosphorus (%)			
M0	1.835	2.263	1.165	1.754	0.153	0.747	0.200	0.367
M1	2.485	1.863	1.803	2.050	0.157	0.438	0.697	0.431
M2	2.548	2.255	2.285	2.363	0.698	0.789	0.969	0.819
M3	1.593	2.796	2.359	2.249	0.804	0.467	0.710	0.660
M4	2.155	2.757	2.723	2.545	0.863	0.775	0.985	0.874
M5	2.325	2.533	2.312	2.390	0.695	0.819	0.883	0.799
Mean	2.157	2.411	2.108		0.562	0.673	0.741	
	Potassium (%)				Proline (mg/100 g f.w.)			
M0	2.073	2.091	2.155	2.106	26.753	29.687	19.451	25.297
M1	2.144	2.425	2.115	2.228	28.647	30.495	38.025	32.389
M2	2.468	2.711	2.065	2.415	28.131	30.665	32.000	30.265
M3	2.289	2.393	2.607	2.430	33.105	34.576	36.811	34.831
M4	2.573	2.557	1.637	2.256	34.679	35.694	42.669	37.681
M5	1.986	2.175	1.805	1.989	31.407	33.694	38.913	34.671
Mean	2.256	2.392	2.064		30.454	32.469	34.645	

M0: sand only (S) as control, M1: S.+ bentonite (B) at 3:1, v/v, M2: S + organic compost (OC) at (3:1, v/v), M3: M2 + EM (10 ml/l), M4: S + B + OC (2:1:1, v/v/v) and M5: M4 + EM 10 ml/l).

by thrice a week and then once a week, while that was true for P % by once a week water treatment, followed by twice a week and then thrice a week treatment. As for the interactions' effect, data in Table (6) show that it was variable among the 3 elements, as the greatest % of N was gained by combining between either M3 or M4 and twice a twice water treatment (2.796 and 2.757%, consecutively), followed by combinations of M2 + thrice a week (2.548 %) and M5 + twice a week (2.533%), but that of P % was attained by either M4 or M2 mixture + once a week combined treatments (0.985 and 0.969%, consequently), followed by both M5 + once a week (0.883%) and M4 + thrice a week (0.863%) combinations, whereas the greatest K % was achieved by the interacting between either M3 mixture and once a week (2.607%) or M2 mixture and twice a week (2.711%), followed by connecting between M4 mixture and either thrice a week (2.573%) or twice a week (2.557%).

Concerning the highest content of proline in leaves, it was obtained in plants grown under once a week watering interval (34.645 mg/100 g f.w.), which was followed by twice/week (32.469 mg/100 g f.w.) and then thrice/week treatment (30.454 mg/100 g f.w.). As well planting in M4 mixture raised the proline concentration to the maximum value, giving 37.681 mg/100 g f.w. Thus, a combination between planting in M4 mixes and irrigating at a week interval gave the utmost high proline concentration (42.669 mg/100 g f.w.) overall means of the other combinations and control. However, the second position was occupied by combining the longest interval period of irrigation (once/week) and planting in either M5 (38.913 mg/100 g f.w.), M1 (38.025 mg/100 g f.w.) or M3 mixture (36.811 mg/100 g f.w.). On the other side, the lowest proline content was acquired by the interaction of M0 (control, sand) combined with the irrigation regime of once a week (19.451 mg/100 g f.w.).

DISCUSSION

Results of this study showed that amending the sand with any conditioner used (bentonite, organic compost or EM biostimulant) either individually or combined with others significantly improved vegetative and root growth attributes of schefflera plants, particularly when the sand was fortified with both bentonite and organic compost, in the presence or absence of EM biostimulant. This may be due to the benefits of these additives to the physical and chemical properties of the sand, which originated together ideal circumstances for good and healthy growth, where bentonite enhances sand structure, leading to not only improved nutrient retention and water holding capacity but also create a better habitat for soil microorganisms and provide them with energy need for their activation (Alghamdi *et al*., 2018).

Besides, organic compost acts as slow-release fertilizer which provides the plants with their requirements of macro and micronutrients necessary for the best growth, with keeping high moisture levels in the rooting zone (Mlih *et al*., 2019). Also, it improves the sand bulk density, aeration, water holding capacity, fertility and water infiltration (Lehmann and Kleber, 2015). Applying the commercial, cheap EM biostimulant, which contains various types of microorganisms can secrete some growth-promoting substances (vitamins, organic acids, hormone-like substances, ... etc.) which enhance plant growth. They also chelate HAs and antioxidants when mixed with organic matter (Elbashier *et al*., 2021).

In this regard, Owen *et al*. (2008) found that amending pine bark medium of *Cotoneaster dammeri* plant with 11% by volume calcined bentonite improved growth and total plant dry weight, with reducing water use by 25% and P effluent losses by 42% as compared to the industry substrate (8 pine bark: 1 sand). Likewise, Hazrati *et al*. (2017) on *Aloe vera* plant, reported that zeolite application at 8 g/kg soil gave the greatest No. new leaves and pup/plant irrigated with either 20 of 40% FC, and also gave the highest leaf fresh weight and gel fresh weight. In general, water use efficiency of *A. vera* increased with less water and more zeolite availability. On teak (*Tectona grandis*), Kayama *et al*. (2021) observed that growth and plant dry mass were markedly increased by the application of bentonite and P-fertilizer to growth substrate. Moreover, the application of bentonite could mitigate drought stress in dry season. On bougainvillaea, Younas *et al.* (2022) noticed that application of 10% bentonite and 15% chicken manure to the sand maximized plant height, length of primary branch, No. secondary branches and leaves/plant, root length, shoot and root weights and root/shoot ratio.

Supporting results to our findings were also gained by Saadawy *et al*. (2005) who declared that the bagasse compost medium resulted in the tallest schefflera plants, the highest No. leaves and the heaviest fresh and dry weights of shoots and roots. Likewise, Abdel-Fattah *et al*. (2008) indicated that planting *Schefflera actinophylla* in sand + FYM (1:1, v/v) mixture maximized the mean values of plant height, stem diameter, No. leaves/plant and dry weight of the leaves, stems and roots, On *Acacia auriculiformis*, Khan *et al*. (2014) mentioned that the treatment of 2%. EM solution significantly increased germination % of the seeds, shoot and root lengths of the resulting seedlings and shoots fresh and dry weights, while roots fresh and dry weights were maximized by 5% EM solution. Tawila *et al*. (2015) found that application of 3 ml/l of EM to sanitary water at 25, 50, 75 and 100% levels caused an extra increment in the means of various vegetative and root growth parameters of neem (*Azadirachta indica*), even with 100% sanitary water treatment owing to its role in creating the proper plant living environment and plant disease resistance. Meshaal *et al*. (2018) on *Russelia equisetiformis*, stated that a mixture of sand + 15% compost was superior in improving survival % and all vegetative and root growth parameters.

Results of such work also, indicated that increasing water supply by irrigating thrice a week mostly gave the best growth followed by irrigating twice a week, which gave mean values, of vegetative growth traits not only closely near to those of thrice a week water treatment but also better than them in some characters, particularly when used for irrigation of plants cultivated in either M4 or M5 mixture. This may indicate the role of proper water treatment in increasing the availability of nutrients and its uptake by roots (Owen *et al*., 2008), in expanding cell volume (Do Bomfin *et al*. 2020) and in preventing the ABA formation, which causes inhibition and defoliation of the growth (Scagel and Bryla, 2022).

On the other side, irrigating plants once a week caused a significant reduction in most growth parameters under various growing mixtures used in the study. This could be interpreted by reducing the volumetric water content of the substrate, and consequently difficult absorption of water by plants. Moreover, most metabolic processes could be declined by insufficient water content in plant tissues, hence the formation of many metabolites required for good and healthy growth (amino acids, hormones, carbohydrates and energy-reserve materials) were reduced (Akhtar, 2019).

In this connection, Abdel-Momeim *et al*. (2018) found that irrigating every 2 weeks was more efficient in raising the studied growth traits of *Euphorbia milii* var. *longifolia* than 3 and 4 weeks ones. Likewise, Akhtar (2019) observed that both *Calendula officinalis* and *Dianthus barbatus* winter annuals gave maximum plant height, stem diameter, shoot fresh weight, shoot dry weight, root length, root dry weight, No. flower buds, No. opened flowers and flower diameter at 4 days of irrigation interval than 2 and 4 days ones. As well Do Bomfin *et al*. (2020) chained that the shortest irrigation treatment (2 days intervals) was better for potting ornamental pineapple (*Ananas comosus*) than 4, 6, 8 and 10 days irrigation intervals, as it maximized the plant height, No. leaves, leaf length and width, rosette diameter, flowering rate, peduncle length and diameter, crown to syncarp ratio and the percent of commercial plants. On *Rhododendron* cvs. Gibraltar, P.J.M. and Catawbiense Album, Guihong *et al*. (2022) concluded that irrigation frequency and volume (once or twice daily with up to 100% container capacity) can be applied to improve nursery stock qualities and growth performance.

In addition, the interaction treatments employed in our trial exerted, great variable effects on the different growth attributes, but the upper hand was for combining planting in either M4 or M5 mixture and irrigating with either thrice a week or twice a week, as these combinations produced the best growth performance with various significance levels in between. In this respect, Said (2016) reported that planting in a mixture of sand + poultry manure compost (2:1, v/v) and watering with 300 ml of water/plant, day by day was more effective for getting the best decorative foliage-pot-plant. El-Fouly *et al*. (2020) recommended to plant asparagus cv. Myers in either sand + coconut coir compost (1:1, v/v) or sand + vermiculite + coconut coir + compost (1:1:1:1, v/v/v) mixture and irrigating with 150 ml water/plant every other day during summer months and once every 3 days in winter ones to obtain an ideal pot-plant. Shahin and Sayed (2021) advised to cultivate *Ochna serrulata* seedlings under shade in sand + FYM (3:1, by volume) mixture and watering once every 2 days to speed their growth during the rearing period in the nursery. Recently Shahin *et al*. (2023) reported that planting arenga (sugar palm) seedlings in a mixture of sand + clay (1:1, v/v) and watering with various water amounts (50, 75 or 100% of F.C) produced plants of various sizes suitable for decorating the limited-area places as pot-plants.

The results attained in such work exhibited also, that planting in either M4 (sand + bentonite + organic compost, 2.1.1, by volume) or M5 (M4 + 10 ml/l EM) mixture and irrigating twice, followed by thrice a

week and their interactions acquired the highest concentrations of pigments, total carbohydrates, N, P, K and proline, with different significant levels among them and relative to the control. Such results could be discussed and explained as mentioned before for the same sole and combined treatments on growth parameters.

Besides, supporting results to our ones were obtained, as well by Saadawy *et al*. (2005) who found that planting schefflera in the broad bean straw medium gave the highest K %, whereas the highest contents of total chlorophyll, total carbohydrates, N and P were obtained by planting in the bagasse compost one Likewise, Abdel-Fattah *et al*. (2008) on *Schefflera actinophylla*, revealed that using a mixture of sand + FYM+ chicken manure (1:1:1, v/v/v) maximized pigments content, N, P and K percentages, as well as Fe, Mn and Zn contents (ppm) in the leaves. Khan *et al*. (2014) indicated that the contents of chlorophyll a, b and carotenoids were the highest in plants treated with 2% EM solution. Tawila *et al*. (2015) noticed that concentrations of Pb and Cd greatly decreased in the different parts of neem seedlings irrigated with sanitary water by applying 3 ml of EM to each liter of sanitary water.

Furthermore, the aforementioned findings gained by the current work are in accordance with those detected by Kayama *et al*. (2021) who clarified that adding bentonite to the sand increased the contents of Ca, P and K in the leaves of teak (*Tectona grandis*) and photosynthetic rate, showed high value by high concentration of chlorophyll. El-Ghazaly *et al*. (2021) affirmed that planting *Gasteria carinata* var. *verrucasa* in either sand alone or amended with Nile compost (3:1, v/v) medium and irrigating with 100 ml of water/plant, twice a week was the best for improving the contents of chlorophyll a, b, carotenoids, N, P and K in the leaves. On Bougainvillea, Younas *et al*. (2022) declared that the addition of bentonite at 10% and chicken manure at 15% to sandy soil was enough to increase the leaves content of chlorophylls.

From our previous results, it can be advised to plant *Schefflera arboricola* Endl., transplants in sand + bentonite + organic compost (2:1:1, v/v/v) mixture standalone or combined with 10 ml/l EM biostimulant and irrigating them with either thrice a week (at water availability) on twice a week (at water deficit) to get the optimal growth performance with the best quality.

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تحسين نمو نباتات الشيفليرا النامي بالتربة الرملية ببعض الإضافات الطبيعية والعضوية والحيوية عند ريه بمعاملات مياه مختلفة

سيد محمد شاهين، ماجدة عبد الحميد أحمد، حنان محمد عبد الغني خضر
قسم بحوث الحدائق النباتية؛ معهد بحوث البساتين، مركز البحوث الزراعية، الجيزة، مصر

أجريت تجربة أصص بإحدى الصوب البلاستيكية بمشتل قسم بحوث الحدائق النباتية، معهد بحوث البساتين، مركز البحوث الزراعية، الجيزة، مصر خلال موسمي ٢٠٢١ و ٢٠٢٢ لدراسة تأثير الزراعة في البيئات التالية: الرمل كمقارنة (M0)، الرمل + البنتونيت بنسبة ٣ : ١ حجماً (M1)، الرمل + كومبوست عضوي بنسبة (٣: ١ حجماً (M2)، M2 + ١٠ مل/لتر منشط حيوي EM (M3) رمل + بنتونيت + كومبوست عضوي بنسبة (٢: ١ : ١ حجماً (M4) و M4 + ١٠ مل منشط حيوي EM (M5)، معاملات الري التالية: الري ثلاث مرت/أسبوع، مرتان/أسبوع ومرة واحدة/أسبوع والتفاعلات المشتركة بينهما على النمو والتركيب الكيميائي لشتلات الشيفليرا (*Schefflera arboricola* Endl.)، في تجربة عاملية. أوضحت النتائج المتحصل عليها أن إضافة البنتونيت أو الكومبوست العضوي أو كلاهما معاً إلى الرمل أدت إلي تحسين القيم المتوسطة لمختلف صفات النمو الخضري: إرتفاع النبات، قطر الساق، عدد كل من الأفرع والاوراق/نبات، طول الجذر وأوزانه الطازجة والجافة والنمو الخضري مقارنة بمتوسطات الكنترول في معظم الحالات بكلا الموسمين، مع تفوق الزراعة في مخلوطي M4، M5 واللذين تبادلا في إعطاء أعلى القيم مقارنة بالكنترول، أيضا أحرزت معاملتي الري ثلاث مرات أو مرتان أسبوعياً أفضل متوسطات نمو عن معاملة الري مرة واحدة أسبوعياً، مع تفوق معاملة الري ثلاث مرات أسبوعياً والتي سجلت قيماً أفضل لمعظم صفات النمو في الموسمين. لوحظ أيضاً أن مختلف المعاملات الفردية والمشتركة بالدراسة أدت إلى زيادة تركيزات كلوروفيللي أ، ب، الكاروتينويدات، الكربوهيدرات الكلية، النيتروجين، الفوسفور، البوتاسيوم والبرولين مع بعض الاستثناءات مقارنة بالكنترول، لكن السيادة والتفوق كانت لمعاملتي الزراعة في مخلوط البيئة الرابعة (M4) أو مخلوط البيئة الخامسة (M5)، ومعاملتي الري ثلاث مرات أو مرتان كل أسبوع والتفاعلات المشتركة بينهما، والتي أعطت أعلى التركيزات مقارنة بالمعاملات الفردية والمشتركة الآخرى. وطبقاً لهذه النتائج، يمكن التوصية بزراعة شتلات نبات الشيفليرا (*Schefflera arboricola Endl.*) في مخلوط الرمل + البنتونيت + الكومبوست العضوي (بنسبة ٢: ١ : ١ حجماً)، بمفرده أو الجمع المشترك مع ١٠ مل/لتر من المنشط حيوي EM مع الري ثلاث مرات أسبوعيا (عند توفر المياه) أو مرتان أسبوعيا (عند نقص المياه) للحصول على أفضل مظهر للنمو، وأعلى جودة لنبات الشيفليرا النامي في أصص.