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RESPONSE OF *Asparagus densiflorus* "MYERS" PLANT TO DIFFERENT MEDIA AND WATER AMOUNTS.

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ABSTRACT

Being restricted by pot sizes and its medium volumes, pot plants require adequate selection of growing medium and water amount to get optimum growth and best performance. Thus, the present investigation was conducted under plastic house conditions at the nursery of Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt, during 2017/2018 and 2018/2019 seasons to reveal the response of Myers asparagus plant (*Asparagus densiflorus* "Myers" (Kunth.) Jessop) to culture in pure sand (S), pure vermiculite (Ver.), S+ Ver. (1:1, v/v), S+ cocopeat (1:1, v/v) and S+Ver.+ cocopeat (1:1:1, v/v/v) pot mixtures, and irrigation with 100, 150 and 200 ml/plant, every other day during summer months and irrigated once every 3 days during winter months and to their interactions between soil and irrigation treatments. The seedlings were transplanted in 20-cm-diameter plastic pots filled with one of the previous media 2 cm past the rim, where the pots were arranged afterwards in a factorial experiment based on a complete randomized block design. The results showed that amending the sand with either cocopeat or vermiculite + cocopeat significantly increased the means of all vegetative and root growth parameters, as these two media [sand+cocopeat (1:1, v/v) and sand+ vermiculite+cocopeat (1:1:1, v/v/v)] gave the highest means with no major differences among them in most cases of both seasons. On the other hand the means of growth characters progressively increased as irrigation water amount was raised, to maximum by either 150 or 200 ml water/plant which recorded the utmost high values that were at par with each other for most determined parameters. The dominance, however, was for 200 ml treatment which acquired taller plants, highest branch number and length and heaviest weights of plant organs in the two seasons. The interactions, also exhibited a clear influence on growth criteria with various significance levels, but the mastership was found due to planting in either sand+cocopeat or sand+vermiculite+cocopeat mixtures plus irrigation with either 150 or 200 ml water/plant. These four combinations recorded the highest averages, with few exceptions compared to other combinations in both seasons. An identical response of growth attributes occurred as well regarding concentrations of pigments, total carbohydrates, N, P and K % D.W in the leaves, except for carotenoids in both seasons, which exhibited attained a different trend. In addition, dry matter production was improved either by amending the sand with cocopeat alone and vermiculite + cocopeat or by rising irrigation water amount from 100 to 150 or 200 ml/plant. Hence, the best water use efficiency (WUE) was recorded in both seasons by planting asparagus plants in sand+cocopeat or sand+vermiculite+cocopeat plus irrigating with either 150 or 200 ml/plant levels, as these four combinations reduced the water quantity necessary for producing 1 g of dry matter to the minimal quantity. Accordingly, it is proposed to plant Myers asparagus plants in combinations with irrigation every other day during summer and once every 3 days in winter to obtain a picturesque and ideal pot plant.

Key words: *Asparagus densiflorus* "Myres" foxtail fern, media, water amounts, growth traits, and WUE.

1. INTRODUCTION

Asparagus densiflorus "Myers" (Kunth.) Jessop, Myers asparagus fern (Cat's tail asparagus, Foxtail fern or Basket asparagus) is a spreading evergreen perennial herb that has a fine texture, and belongs to Fam. Liliaceae. It grows to 50 -60 cm tall and about 60-120 cm wide. The leaves are scale-like, inconspicuous and actually narrow, light green, leaf-like branchlets called cladophylls. The spear-like stems arise directly from white fleshy tubers just below the soil surface and radiate outwards from the center of the plant to give an overall appearance of a fluffy mound. Tiny white flowers appear tight inside the leaves in mid-summer, followed by green berries that ripen decoratively to red by fall (Gilman *et al*., 2018). It is native to southern Africa, from Mozambique to South Africa, but now is widely cultivated (Norup *et al*., 2015). It can be grown in full sun or partial shade, in well-drained soil of any type. It needs moderate or regular irrigation, especially in a container. It can be used as a specimen, for mass planting, for container and ground cover, small, low-growing, unclipped hedge or border. It is a nice accent plant in a small residential landscape or rock garden. Its deuse plumes of foliage are valued in flower arranging (WCSP, 2011).

Foliage pot plants, being restricted by pot sizes and its medium volumes, require a perfect selection of growing medium and water amount for optimum performance. This fact was documented by Shahin *et al*. (2007) on *Agave americana* cv. Marginata, Shahin *et al*. (2009) on tuberose, Said (2016) on *Duranta erecta* "Variegata" and El-Fouly and Bishara (2016) on pothos and croton who mentioned that the gradual increment of water supply from 25% F.C. up to 100% caused a progressive rising in the means of different vegetative and root growth traits of both pothos and croton pot plants cultured in sand+clay+peatmoss mixture (1:1:1, v/v/v). Concentrations of chlorophyll a, b, carotenoids, total soluble sugars, N, P, K and protein in the leaves of the two plants, as well as anthocyanin level in croton leaves gave also a similar trend.

The effects of media and water treatments on growth and quality of ornamentals were previously clarified by Dwi and Treder (2008) on lily "Star Gazer", Awang *et al*. (2009) on *Celosia cristata*, Van Iersel *et al*. (2010) on petunia, Ali (2011) on dahlia , marigold, zinnia and cosmos, Scagel *et al*. (2011) on rhododendron, Sinclair *et al*. (2011) on zoysia grass, St. augustine grass, bermuda grass and bahia grass, Ucar *et al*. (2011) on carnation, O'Meara *et al*. (2014) on *Hydrangea macrophylla* and *Gardenia jasminoides*, Sardoei and Rahbarian (2014) on *Ficus benjamina, Pandanus sanderi* and *Rosmarinus officinalis*, Jie *et al*. (2016) on poinsettia, Fisher and Smith (2017) on geranium, Nambuthiri *et al* (2017) on *Buxus hybrid* and *Deutzia gracilis*, Panupon and Soraya (2017) on petunia, Gohil *et al*. (2018) on aglaonema, dieffenbachia, anthurium, chrysanthemum, gerbera, orchid and zinnia, as well as Rydlova and Puschel (2020) whom reported that strong drought decreased shoot biomass of *Gazania rigens* and *Pelargonium zonale*, but it had no effect on shoot biomass of *Pelargonium peltatum*, that even increased flowering.

The purpose of the present study was to determine the most suitable water quantity for each medium under study, in which Myers asparagus fern plants can grow well with good performance as a pot plant.

2. MATERIALS AND METHODS

A pot experiment was carried out under plastic house at the Nursery of Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt throughout the two consecutive seasons of 2016/2017 and 2017/2018.

Uniform seedlings about 9-10 cm tall with 4 branches were immediately transplanted on the first of April for each season in 20-cm-diameter plastic pots filled with one of the following media: pure sand (S), pure vermiculite (Ver.), S + Ver. Mixture (v/v), Ver. + cocopeat (coir) mixture (v/v) and a mixture of S+Ver.+Coir (v/v). The physical and chemical properties of the sand used are shown in Table (a), while properties of vermiculite and coir are listed in Table. (b)

Immediately after transplanting, all pots were irrigated with 300 ml of tap water/pot, but afterwards received the following quantities of water commencing from April, 4^{th} till the end of the experiment on the next March, 31^{st} for each season: 100, 150 and 200 ml/pot. The plants were irrigated with the previous water treatments every other day during summer months, and once every 3 days during winter months. The treatments of media and water amounts were combined factorially to formalize fifteen interaction treatments.

Table (a): The physical and chemical properties of the sand used in both seasons.

Season	Particle size distribution (%)				S.P	E.C (ds/m)	pH	Cations (meq/l)				Anions (meq/l)		
	Coarse sand	Fine sand	silt	clay				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{--}
2016/17	86.50	3.55	0.76	9.19	23.88	3.36	7.78	9.33	2.50	31.10	0.90	3.68	21.96	18.19
2017/18	85.00	5.93	1.68	7.39	21.37	3.15	7.69	15.98	6.71	10.33	0.86	3.13	10.50	20.25

Table (b): Properties of vermiculite and coir used in both seasons.

a - vermiculite			
Property	Value	Property	Value
Bulk density (very low)	100- 160 kg/m^3	Total pore space (Porosity)	92-94%
CEC (Cation Exchange Capacity)	35.0 cmol/kg	Available air	50-70%
pH	8.0 – 9.7	WHC (Water Holding Capacity)	300-400%
Particle size	0.75 – 8.0 mm	Available water from WHC	40-53.5%
b - coir			
Property	Value	Property	Value
Bulk density (very low)	70.0 kg/m^3	Total pore space (Porosity)	9-10% very low
CEC (Cation Exchange Capacity)	31.7 cmol/kg	Available air	17.7% very low
pH	6.5 – 6.6	Water retention	85- 90%
EC (Electrical Conductivity)	0.16 (mS/cm)	Available water	54%

A complete randomized block design in a factorial experiment was accomplished in this study, with three replicates, as each replicate contained five plants (Mead *et al*., 1993). All plants under various treatments received the usual agricultural practices required for such plantation whenever needed.

At the end of each season, data were recorded as follows: plant height (cm), number of branches/plant, foliage fresh and dry weights, mean branch length (cm) (average of the tallest 5 branches) and its fresh and dry weights (g), the longest root length (cm), number of tubers/plant, as well as fresh and dry weights of foliage (top growth), roots and tubers (g). In fresh samples of cladophylls (leaf-like structures) taken from the middle part of the plant, photosynthetic pigments concentration (chlorophyll a, b and carotenoids, mg/g f.w.) was measured according to the method of Sumanta *et al* (2014), while in dry ones, total carbohydrates, nitrogen, phosphorus and potassium concentrations as percentages were determined using the methods described by Herbert *et al* (1971), Blake (1956), Luatanab and Olsen (1965) and Jackson (1973), respectively. Besides, water use efficiency (W.U.E.), (plants irrigated 92 times from April to the end of November and 32 times from the 1st of December till the end of March), for each level of water treatments was calculated from this equation: W.U.E. = Total amount of water (Liter)/plant/season ÷ Total amount of dry matter (g)/plant/season to determine the quantity of water necessary for production of 1 g dry matter of Myers asparagus plant under the different media acquired in this investigation.

Data were then tabulated and subjected to analysis of variance using the computer program of SAS Institute (2009) that was followed by Duncan's New Multiple Range Test (Steel and Torrie, 1980) to verify the significance level between the means of various treatments.

3. RESULTS AND DISCUSSION

3.1. Effect of medium, water amount and their interactions on:

3.1.1. Vegetative and root growth traits:

Data in Tables (1, 2, 3, 4, 5 and 6) clear that amending the sand either with coir or coir+vermiculite significantly improved all vegetative and root growth parameters, expressed as: plant height (cm), No. branches/plant, branch length (cm) and its fresh and dry weights (g), root length (cm), No. tubers/plant, and fresh and dry weights of top growth, roots and tubers (g), as these two media (sand+coir and sand+vermiculite.+Coir (v/v/v) gave the highest means over the other media with non-significant differences among them in most cases of the two seasons. This may be ascribed to that coir had acceptable pH (6.5) which makes nutrients more available for uptaking by roots, had better cation exchange capacity (CEC), satisfactory EC and other chemical attributes (Awang *et al*., 2009). Vermiculite has high total pore space (92-94%),

Table (1): Effect of media, water amounts and their interactions on plant height, branch number and length of *Asparagus densiflorus* "Myers" (Kunth.) Jessop plant during 2016/2017 and 2017/2018 seasons.

Irrigation Amount (ml) / Media(1:1,v/v)	Plant height (cm)				Branch number/plant				Branch length (cm)			
	100	150	200	Mean	100	150	200	Mean	100	150	200	Mean
	First season: 2016/2017											
Sand (S)	12.77f	14.60e	14.30e	**13.89C**	9.33g	10.00g	12.33f	**10.55D**	20.73h	29.47d	29.10d	**26.43B**
Vermiculite(Ver.)	11.97g	11.87g	14.50e	**12.78D**	11.67f	12.67f	14.33f	**12.89C**	18.73i	23.33g	25.33f	**22.43D**
S+ Ver.	15.53d	16.47c	16.37c	**16.12B**	12.67f	15.33de	16.67bc	**14.89B**	23.33g	25.93f	27.17e	**25.48C**
S+ Cocopeat (Coir) (1:1,v/v)	18.23b	19.97a	20.37a	**19.52A**	15.67cd	17.33ab	18.33a	**17.11A**	22.67g	33.67b	35.67a	**30.67A**
S+ Ver. + Coir	16.23cd	20.80a	20.80a	**19.28A**	14.33e	15.00de	15.33de	**14.89B**	25.40f	32.33c	33.13bc	**30.29A**
Mean	14.95C	16.74B	17.27A		12.83C	14.07B	15.40A		22.17C	28.93B	30.08A	
	Second season: 2017/2018											
Sand (S)	12.37i	13.40gh	14.67ef	**13.48C**	9.67i	12.00h	13.00f-h	**11.56D**	20.97h	30.33c	29.27cd	**26.86C**
Vermiculite(Ver.)	12.83hi	12.17i	13.90fg	**12.97C**	12.67gh	14.00ef	15.67d	**14.11C**	20.21h	23.87fg	24.57f	**22.88E**
S+ Ver.	15.43de	16.30cd	16.10cd	**15.94B**	14.33e	16.00cd	17.00bc	**15.78B**	23.00g	26.91e	28.10d	**26.00D**
S+ Cocopeat (Coir) (1:1,v/v)	18.43b	20.67a	20.37a	**19.82A**	17.00bc	17.67ab	18.67a	**17.78A**	24.23f	35.37a	36.17a	**31.92A**
S+ Ver. + Coir	17.03c	20.73a	20.23a	**19.33A**	13.67e-g	16.00cd	16.00cd	**15.22B**	25.92e	32.80b	33.60b	**30.77B**
Mean	**15.22B**	**16.65A**	**17.05A**		**13.47C**	**15.13B**	**16.07A**		**22.87C**	**29.86A**	**30.34A**	

Means followed by the same letter in a column or row are not differ significantly according to Duncan' New Multiple Range t-Test at 5% level.

Table (2): Effect of media,water amounts and their interactions on branch fresh and dry weights of *Asparagus densiflorus* "Myers" (Kunth.) Jessop plant during 2016/2017 and 2017/2018 seasons.

Irrigation amount (ml) / Medium(1:1,v/v)	Branch fresh weight (g)				Branch dry weight (g)			
	100	150	200	Mean	100	150	200	Mean
	First season: 2016/2017							
Sand (S)	1.13gh	1.29cd	1.29cd	**1.24BC**	0.483f	0.503ef	0.587de	**0.524D**
Vermiculite(Ver.)	1.08h	1.32bc	1.20e-g	**1.20C**	0.517ef	0.663cd	0.687c	**0.622C**
S+ Ver.	1.16fg	1.31bc	1.26c-e	**1.24B**	0.550ef	0.760a-	0.750bc	**0.687B**
S+ Cocopeat (Coir)	1.38b	1.52a	1.47a	**1.46A**	0.767a-c	0.850a	0.800ab	**0.806A**
S+ Ver. + Coir	1.22d-f	1.31bc	1.32bc	**1.28B**	0.710bc	0.747bc	0.740bc	**0.732B**
Mean	**1.19C**	**1.35A**	**1.31B**		**0.605B**	**0.705A**	**0.713A**	
	Second season: 2017/2018							
Sand (S)	1.12g	1.19ef	1.27d	**1.19C**	0.410g	0.583f	0.467g	**0.487D**
Vermiculite(Ver.)	1.01h	1.24de	1.25d	**1.17C**	0.577f	0.717cd	0.640ef	**0.645C**
S+ Ver.	1.13g	1.15fg	1.28cd	**1.19C**	0.617ef	0.773bc	0.803ab	**0.731B**
S+ Cocopeat (Coir)	1.33bc	1.51a	1.53a	**1.46A**	0.757bc	0.850a	0.773bc	**0.793A**
S+ Ver. + Coir	1.19ef	1.36b	1.33bc	**1.29B**	0.683de	0.747b-d	743b-d	**0.724B**
Mean	**1.16C**	**1.29B**	**1.33A**		**0.609C**	**0.734A**	**0.685B**	

- Means followed by the same letter in a column or row are not differ significantly according to Duncan' New Multiple Range t-Test at 5% level.

Table (3): Effect of media, water amounts and their interactions on top growth fresh and dry weights of *Asparagus densiflorus* "Myers" (Kunth.) Jessop plant during 2016/2017 and 2017/2018 seasons.

Irrigation amount (ml) / Medium(1:1,v/v)	Top growth fresh weight (g)				Top growth dry weight (g)			
	100	150	200	Mean	100	150	200	Mean
	First season: 2016/2017							
Sand (S)	7.45k	9.15j	9.03j	**8.54E**	2.72h	3.29g	3.34g	**3.12D**
Vermiculite(Ver.)	12.53i	15.90g	15.13h	**14.52D**	3.56fg	4.37e	3.42g	**3.78C**
S+ Ver.	14.41h	19.22e	18.33f	**17.32C**	3.68fg	4.36e	4.12ef	**4.05C**
S+ Cocopeat (Coir)	23.07d	25.23c	25.33c	**24.54B**	6.45d	7.15c	6.95cd	**6.85B**
S+ Ver. + Coir	28.47b	31.63a	31.90a	**30.67A**	8.16b	9.09a	9.16a	**8.80A**
Mean	**17.19B**	**20.23A**	**19.95A**		**4.91C**	**5.65A**	**5.40B**	
	Second season: 2017/2018							
Sand (S)	7.38j	8.88i	8.77i	**8.34E**	2.32h	3.20g	3.29g	**2.94D**
Vermiculite(Ver.)	12.31h	16.60f	15.74g	**14.88D**	3.88ef	4.16e	4.03ef	**4.02C**
S+ Ver.	15.75g	19.72e	19.10e	**18.19C**	3.57fg	4.15e	4.27e	**4.00C**
S+ Cocopeat (Coir)	24.37d	26.77c	16.83c	**25.99B**	7.18d	7.99c	8.04c	**7.74B**
S+ Ver. + Coir	30.57b	34.27a	34.98a	**33.27A**	9.03b	10.57a	10.43a	**10.01A**
Mean	**18.08B**	**21.24A**	**21.08A**		**5.20B**	**6.01A**	**6.01A**	

- Means followed by the same letter in a column or row are not differ significantly according to Duncan' New Multiple Range t-Test at 5% level .

Table (4): Effect of media, water amounts and their interactions on mean root length and No. tubers of *Asparagus densiflorus* "Myers" (Kunth.) Jessop plant during 2016/2017 and 2017/2018 seasons.

Irrigation amount (ml) / Medium(1:1,v/v)	Root length (cm)				Number of tubers/plant			
	100	150	200	Mean	100	150	200	Mean
	First season: 2016/2017							
Sand (S)	50.30ij	42.67k	55.37g	49.44D	39.67l	57.33i	54.00ij	**50.33D**
Vermiculite(Ver.)	39.92k	47.43j	51.67hi	46.34E	39.00l	49.00jk	43.67kl	**43.89E**
S+ Ver.	53.63gh	65.97e	63.13ef	60.91C	45.00kl	76.33h	86.33g	**69.22C**
S+ Cocopeat (Coir)	69.07d	81.87b	97.30a	81.74A	128.67c	159.33a	148.33b	**145.44A**
S+ Ver. + Coir	62.33f	72.37c	74.27c	69.66B	96.00f	111.67e	118.33d	**108.67B**
Mean	55.05C	62.06B	67.75A		**69.67B**	**90.73A**	**90.13A**	
	Second season: 2017/2018							
Sand (S)	53.14g	52.00g	53.20g	52.78D	43.33g	46.33g	46.00g	**45.22E**
Vermiculite(Ver.)	42.87i	46.03h	59.73f	49.54E	57.00f	63.33f	49.33g	**56.56D**
S+ Ver.	51.13g	61.73f	67.37d	60.08C	60.67f	73.33e	80.00d	**71.33C**
S+ Cocopeat (Coir)	61.63f	76.40b	88.77a	75.60A	120.33b	145.00a	143.00a	**136.11A**
S+ Ver. + Coir	64.33e	67.30d	72.53c	68.06B	107.67c	120.00b	115.33b	**114.33B**
Mean	54.62C	60.69B	68.32A		**77.80B**	**89.60A**	**86.73A**	

- Means followed by the same letter in a column or row are not differ significantly according to Duncan' New Multiple Range t-Test at 5% level.

Table(5): Effect of media, water amounts and their interactions on tuber fresh and dry weights of *Asparagus densiflorus* "Myers" (Kunth.) Jessop plant during 2016/2017 and 2017/2018 seasons.

Irrigation amount (ml) / Medium(1:1,v/v)	Tubers fresh weight/ plant (g)				Tubers dry weight/ plant (g)			
	100	150	200	Mean	100	150	200	Mean
	First season: 2016/2017							
Sand (S)	170.6d	158.3e	144.3g	**157.7C**	6.70de	5.97fg	7.27d	**6.65C**
Vermiculite(Ver.)	156.0ef	147.0g	150.0fg	**151.0D**	6.11fg	6.97de	5.85g	**6.31D**
S+ Ver.	127.0h	150.2fg	172.1d	**149.8D**	5.83g	5.95fg	6.08fg	**5.95E**
S+ Cocopeat (Coir)	157.9e	492.3a	483.5b	**377.9A**	6.57ef	16.83b	18.98a	**14.13A**
S+ Ver. + Coir	129.2h	275.3c	270.1c	**224.8B**	5.96fg	12.27c	12.17c	**10.13B**
Mean	**148.1B**	**244.6A**	**244.0A**		6.23C	9.60B	10.07A	
	Second season: 2017/2018							
Sand (S)	175.2e	143.2g-i	147.5gh	**155.3C**	6.06ef	5.26g	7.75d	**6.36C**
Vermiculite(Ver.)	164.7f	150.2g	163.2f	**159.3C**	5.44g	6.60e	6.31e	**6.12C**
S+ Ver.	134.7j	138.3ij	158.0f	**143.7D**	6.33e	6.35e	5.37g	**6.02C**
S+ Cocopeat (Coir)	141.8h-j	453.1b	473.0a	**356.0A**	7.50d	17.11a	17.26a	**13.96A**
S+ Ver. + Coir	122.6k	259.4c	244.1d	**208.7B**	5.70fg	12.14b	11.55c	**9.80B**
Mean	**147.8C**	**228.8B**	**237.2A**		**6.21B**	**9.49A**	**9.65A**	

- Means followed by the same letter in a column or row are not differ significantly according to Duncan' New Multiple Range t-Test at 5% level .

Table (6): Effect of media, water amounts and their interactions on roots fresh and dry weights of *Asparagus densiflorus* "Myers" (Kunth.) Jessop plant during 2016/2017 and 2017/2018 seasons.

Irrigation amount (ml) / Medium(1:1,v/v)	Roots fresh weight (g/plant)				Roots dry weight (g/plant)			
	100	150	200	Mean	100	150	200	Mean
	First season: 2016/2017							
Sand (S)	76.33i	69.72j	90.95g	**79.00E**	11.86h	11.18h	12.24h	**11.76E**
Vermiculite(Ver.)	80.37h	97.27f	106.50e	**94.81D**	11.43h	12.53h	17.04g	**13.67D**
S+ Ver.	81.25h	108.57f	99.57f	**96.46C**	16.24g	19.65f	16.23g	**17.37C**
S+ Cocopeat (Coir)	89.77g	241.60b	262.50a	**197.96A**	20.47ef	48.02a	44.42b	**37.64A**
S+ Ver. + Coir (	91.10g	161.61d	171.73c	**141.48B**	21.24e	34.55c	31.57d	**29.12B**
Mean	**83.76C**	**135.76B**	**146.25A**		**16.25C**	**25.19A**	**24.30B**	
	Second season: 2017/2018							
Sand (S)	70.70i	72.43i	87.06g	76.73E	11.40j	13.22hi	12.44ij	**12.35E**
Vermiculite(Ver.)	82.47h	103.53de	94.59f	93.53D	12.90i	14.06h	15.28g	**14.08D**
S+ Ver.	84.37gh	102.45e	105.75d	97.52C	15.19g	18.35f	18.59f	**17.38C**
S+ Cocopeat (Coir)	96.20f	254.38a	255.87a	202.15A	22.93e	44.42b	45.78a	**37.71A**
S+ Ver. + Coir	94.95f	162.53c	170.35b	142.61B	22.81e	36.30c	31.60d	**30.23B**
Mean	**85.74C**	**139.07B**	**142.72A**		**17.05C**	**25.27A**	**24.74B**	

- Means followed by the same letter in a column or row are not differ significantly according to Duncan' New Multiple Range t-Test at 5% level.

good water holding capacity with good buffering properties, has a relative high CEC and contains enough Mg and K (Kang *et al*., 2004). In this regard, Dwi and Treder (2008) noticed that lily "Star Gazer" plants grown in cocopeat had higher fresh and dry weights of leaves, better root system and lower bulb depletion than those grown in the control medium. Likewise, Awang *et al*. (2009) claimed that growth and flowering of *Celosia cristata* plants were the best when grown in 70% cocopeat+ 30% burnt rice hull mixture, perhaps due to the good balance in the aeration and moisture relationship of the mixture. On the contrary, Panupon and Soraya (2017) suggested that higher coconut coir dust portion in the medium was not quite reliable for growth of Coral Pink Wave Petunia hybrids.

Also, means of the previous growth measurements progressively increased with increasing irrigation water amount to reach the maximum by either 150 or 200 ml rates, where these two levels scored the utmost high values which were at par with each other for most parameters studied in the first and second seasons. However, the upper hand was for 200 ml level, which recorded the tallest plants and highest branch number and length in the two seasons. This may indicate the role of enough water in expanding cell enlargement (Abe and Nakai, 1999), in preventing the formation of ABA which causes defoliation and growth inhibition (Hoffman *et al*., 1999) and in releasing minerals to be more available and more uptaking by roots (O'Meara *et al*., 2014). In this regard, Scagel *et al*. (2011) stated that watering rhododendron plants more frequently decreased water stress of plants fertilized with higher N rates, decreased N uptake efficiency (N uptake / g. N applied), increased N use efficiency (growth/g. N uptake) and altered biomass allocation with little influence on total plant biomass. Increasing irrigation frequency improved either the availability of N in the growing medium or the ability of roots to absorb N. Furthermore, Ucar *et al*. (2011) observed that yield of carnation maximized to 89.82 flowering stems/m^2 when irrigation water was added with 1-day interval at amount of 786 mm versus 10 flowering stems/m^2 for 3-day interval and 218 mm water amount treatment. Sinclair *et al.* (2011) recorded a great difference in response of some warm-season grasses to the amount of irrigation water, as zoysia grass root development was maximal at full amount of irrigation (35 mm/week), whereas St. Augustine, bermuda and bahia grasses required deficit irrigation of only 13 mm water/ week to achieve full root development. Jie *et al*. (2016) declared that using total irrigation amount of 12 litre with laying vermiculite in the bottom of the pot was the optimal combination for keeping plant quality and for increasing water use efficiency of potted poinsettia plants.

On the other hand, plants greatly differ in their resistance to water deficit. Rydlova and Puschel (2020) pointed out that *Pelargonium peltatum* being the most resistant to drought, but *Gazania rigens* was the most sensitive. So, sever drought decreased shoot biomass and flowering of *G. rigens* and *P. zonal*e more than *P. peltatum*. This may be attributed to reducing the substrate volumetric water content (VWC) and failure of plants to absorb water. In this respect, O'Meara *et al*. (2014) found that substrate VWC of potted *Hydrangea macrophylla* and *Gardenia jasminoides* plants under strong drought decreased from 0.38 to 0.17 $m^3.m^{-3}$. They also noticed that water use by *H. macrophylla* started to decreased at a higher VWC (0.28 $m^3.m^{-3}$) than *G. jasminoides* (0.20 $m^3.m^{-3}$). Plant water uptake stopped at a VWC of 0.16 $m^3.m^{-3}$ in *H. macrophylla* and 0.12 $m^3.m^{-3}$ in *G. jasminoides*. Water deficit in plant tissues usually declines most metabolic processes, consequently reduces formation of many metabolites necessary for good growth, such as amino acids, carbohydrates, hormones and energy-reserve materials.

The interactions also exerted a pronounced effect on vegetative and root growth traits with various significant differences as compared to the control in the two seasons. Because means of vegetative and root growth characters were gradually increased with rising water amount from 100 ml to either 150 or 200 ml and due to planting in either sand+coir or sand+Ver.+coir mixtures. Thus, the best combined treatments were planting in either mixture mentioned before and irrigation with either 150 or 200 ml water amount, as such four combinations gave the utmost high averages, with few exceptions relative to other combinations in both seasons. This may be referred to lumping the benefit effects of high quality of medium ingredients and the enough supply with water which providing the plants with their requirements of water, air and nutrients necessary for the best and healthy growth.

The previous gains are in harmony with those revealed by Van Iersel *et al*. (2010) on

Petunia×hybrida, Ali (2011) on dahlia, marigold, zinnia and cosmos, Sardoei and Rohbarian (2014) on *Ficus benjamina, Pandanus sanderi* and *Rosmarinus officinalis*, Said (2016) on *Duranta erecta* "Variegata", Fisher and Smith (2017) on geranium, Gohil *et al* (2018) on aglaonema, dieffenbachia, anthurium, chrysanthemum, gerbera, orchid and zinnia, as well as Rydlova and Puschel (2020) on *Gazania rigens* and *Pelargonium zonale*.

3.1.2. Chemical composition of the leaves

A similar response to that of vegetative and root growth attributes occurred as well concerning concentrations of active constituents in the leaves (pigments, total carbohydrates, N, P and K % D.W) as shown in Tables (7, 8 and 9), with the exception of carotenoids (mg/g f.w.) in both seasons which gave a differ trend. Hence, carotenoids reached to the maximum concentration (0.131 and 0.128 mg/g f.w. in both seasons) when plants grown in sand and irrigation with 100 ml of water. Merewitz *et al.* (2012) suggested that increasing and accumulation of some metabolites, particularly amino acids, carbohydrates and organic acids that are mainly involed in the citric acid cycle could contribute to improved drought tolerance under water deficit conditions due to their roles in the stress response pathways such as stress signalling, osmotic adjustment and respiration for energy production.

Several studies reported the position effects of enough water and good medium components on active constituents in plants such as those of Shahin *et al.* (2007) on *Agave americana* cv. Marginata, Shahin *et al.* (2009) on *Polianthus tuberosa* and Said (2016) who found that planting in sand+ poultry manure compost (2:1, v/v) medium and irrigating with 300 ml of water/pot raised chlorophyll a, b, carotenoids, total carbohydrates, N, P and K concentrations to the maximal values in *Duranta erecta* cv. Variegate leaves. Fisher and Smith (2017) established that combining 70% peat with 15 – 30% of perlite, vermiculite and or calcined clay increased chlorophyll index and reduced leaf necrosis in *Pelargonium× hortorum* relative to 70% peat+ 30% perlite substrate. Likewise, Gohil *et al.* (2018) found that medium consisted of cocopeat+rice hush+ vermiculite (1:2:1, by volume) improved colour and minerals content in gerbera leaves.

Table (7): Effect of media, water amounts and their interactions on chlorophyll a and b concentrations in leaves of *Asparagus densiflorus* "Myers" (Kunth.) Jessop plant during 2016/2017 and 2017/2018 seasons.

Irrigation amount (ml) / Medium	Chlorophyll a (mg/g f.w.)				Chlorophyll b (mg/g f.w.)			
	100	150	200	Mean	100	150	200	Mean
	First season: 2016/2017							
Sand (S)	0.206hi	0.200i	0.197i	**0.201D**	0.098g	0.102g	0.095g	**0.098E**
Vermiculite(Ver.)	0.221h	0.246g	0.268f	**0.245C**	0.111fg	0.117fg	0.129f	**0.119D**
S+ Ver. (1:1,v/v)	0.308e	0.321de	0.315de	**0.315B**	0.178e	0.186de	0.193c-e	**0.186C**
S+ Cocopeat (Coir) (1:1,v/v)	0.323de	0.314de	0.331cd	**0.323B**	0.206cd	0.215bc	0.236ab	**0.219B**
S+ Ver. + Coir (1:1:1 v/v/v)	0.345bc	0.362a	0.351ab	**0.353A**	0.216bc	0.245a	0.245a	**0.235A**
Mean	**0.281B**	**0.289A**	**0.292A**		**0.162B**	**0.173A**	**0.180A**	
	Second season: 2017/2018							
Sand (S)	0.196h	0.201h	0.211gh	0.203E	0.085g	0.098g	0.093g	**0.092D**
Vermiculite(Ver.)	0.221gh	0.253f	0.241f	0.238D	0.131f	0.142f	0.137f	**0.137C**
S+ Ver. (1:1,v/v)	0.322e	0.340cd	0.325de	0.329C	0.177e	0.197d	0.202cd	**0.192B**
S+ Cocopeat (Coir) (1:1,v/v)	0.326de	0.346c	0.355bc	0.342B	0.207cd	0.218b-d	0.224bc	**0.216A**
S+ Ver. + Coir (1:1:1 v/v/v)	0.369b	0.401a	0.402a	0.391A	0.203cd	0.234ab	0.247a	**0.228A**
Mean	0.287B	0.308A	0.307A		**0.161B**	**0.178A**	**0.181A**	

Means followed by the same letter in a column or row are not differ significantly according to Duncan' New Multiple Range t-Test at 5% level.

Table (8): Effect of media, water amounts and their interactions on carotenoids and total carbohydrates concentration in leaves of *Asparagus densiflorus* "Myers" (Kunth.) Jessop plant during 2016/2017 and 2017/2018 seasons.

Irrigation amount (ml) / Medium(1:1,v/v)	Carotenoids (mg/g f.w.)				Total carbohydrates (% D.W)			
	100	150	200	Mean	100	150	200	Mean
	First season: 2016/2017							
Sand (S)	0.148a	0.122b	0.123b	**0.131A**	11.11h	13.67g	12.91g	**12.56E**
Vermiculite(Ver.)	0.104c	0.101c	0.094cd	**0.0100B**	14.35fg	15.94f	14.51fg	**14.93D**
S+ Ver.	0.083d	0.088cd	0.098cd	**0.090C**	18.57e	20.89d	20.57d	**20.01C**
S+ Cocopeat (Coir)	0.063e	0.048e	0.053e	**0.055D**	25.21c	27.29b	25.87bc	**26.12B**
S+ Ver. + Coir	0.053e	0.045e	0.051e	**0.050D**	31.23a	31.87a	30.25a	**31.12A**
Mean	**0.090A**	**0.081B**	**0.084AB**		**20.09B**	**21.93A**	**20.82B**	
	Second season: 2017/2018							
Sand (S)	0.139a	0.121b	0.124ab	**0.128A**	12.13i	13.20hi	12.90hi	**12.74E**
Vermiculite(Ver.)	0.109bc	0.114bc	0.101cd	**0.108B**	13.87h	15.85g	15.66f	**15.13D**
S+ Ver. (1:1,v/v)	0.091d	0.092d	0.072e	**0.085C**	19.56f	22.33e	21.47e	**21.12C**
S+ Cocopeat (Coir) (1:1,v/v)	0.061ef	0.049fg	0.043g	**0.051D**	26.29d	29.05c	26.26d	**27.20B**
S+ Ver. + Coir (1:1:1 v/v/v)	0.050fg	0.049fg	0.047fg	**0.049D**	30.90b	32.59a	31.46ab	**31.65A**
Mean	**0.090A**	**0.085A**	**0.077B**		**20.55C**	**22.60A**	**21.55B**	

Means followed by the same letter in a column or row are not differ significantly according to Duncan' New Multiple Range t-Test at 5% level.

Table (9): Effect of media, water amounts and their interactions on N, P and K concentration in leaves of *Asparagus densiflorus* "Myers" (Kunth.) Jessop plant during 2016/2017 and 2017/2018 seasons

Irrigation Amount (ml) / Medium (1:1,v/v)	N (% D.W)				P (% D.W)				K (% D.W)			
	100	150	200	Mean	100	150	200	Mean	100	150	200	Mean
	First season: 2016/2017											
Sand (S)	1.097g	1.553ef	1.450f	**1.367E**	0.150cd	0.125d	0.148cd	**0.141C**	1.435h	1.640ef	1.733c	**1.603C**
Vermiculite(Ver.)	1.190g	1.687d	2.027b	**1.634D**	0.121d	0.140cd	0.673a	**0.311A**	1.333i	1.613fg	1.689c-e	**1.545D**
S+ Ver.	1.553ef	1.893c	2.020b	**1.822C**	0.123d	0.140cd	0.189bc	**0.151BC**	1.227j	1.430h	1.567g	**1.408E**
S+ Cocopeat(Coir)	1.650de	2.350a	2.290a	**2.097A**	0.144cd	0.158b-d	0.198bc	**0.167BC**	1.575g	1.704cd	1.907a	**1.728B**
S+ Ver. +Coir	1.703d	2.110b	2.080b	**1.964B**	0.153cd	0.179b-d	0.215b	**0.182B**	1.648d-f	1.845b	1.908a	**1.800A**
Mean	**1.439C**	**1.919B**	**1.973A**		**0.138B**	**0.148B**	**0.284A**		**1.444C**	**1.646B**	**1.761A**	
	Second season: 2017/2018											
Sand (S)	1.173i	1.380g	1.327gh	**1.293E**	0.122g	0.141ef	0.142cd	**0.135D**	1.322i	1.495g	1.658d	**1.492D**
Vermiculite(Ver.)	1.203hi	1.737f	1.943e	**1.628D**	0.133g	0.151e	0.689a	**0.324A**	1.303i	1.686cd	1.578f	**1.523CD**
S+ Ver.	1.407g	1.817ef	1.957e	**1.727C**	0.141ef	0.156e	0.201d	**0.166CD**	1.383h	1.587ef	1.641de	**1.537C**
S+ Cocopeat (Coir)	1.913e	2.400c	2.250d	**2.188B**	0.151e	0.191d	0.217c	**0.186C**	1.642de	1.822b	2.017a	**1.827A**
S+ Ver. + Coir	1.817ef	2.570b	2.737a	**2.374A**	0.154e	0.196d	0.254b	**0.201B**	1.446g	1.680cd	1.733c	**1.620B**
Mean	**1.503C**	**1.981B**	**2.043A**		**0.140B**	**0.167B**	**0.300A**		**1.419C**	**1.654B**	**1.726A**	

- Means followed by the same letter in a column or row are not differ significantly according to Duncan' New Multiple Range t-Test at 5% level

3.1.3. Water use efficiency by *Asparagus densiflorus* "Myers" plants

It is evident from data listed in Table (10) that dry matter production by Myers asparagus plants was improved as a result of either amending the sand with physical and organic materials used in the current work, or elevating irrigation water amount from 100 to either 150 or 200 ml/plant. However, the excellence was for planting in sand+cocopeat (1:1, v/v) media, followed by sand+vermiculite+cocopeat (1:1:1, v/v/v) one, where these two media raised the total DM (g)/plant/season to 72.00 and 69.52 g, followed by 55.91 and 59.01 g under irrigation level of 150 ml water/plant, and to 70.35 and 71.08 g, followed by 52.90 and 53.58 g under irrigation level of 200 ml water/plant in the first and second seasons, respectively. Thus, the best water use efficiency (WUE, ml/g DM) was scored in the two seasons by planting in the two media mentioned before and watering with either 150 or 200 ml/plant level, as these four combined treatments decreased the amount of water necessary to produce 1 g DM to the minimest quantity. However, the upper hand was found due to the combination of planting in sand+cocopeat medium plus irrigating with 150 ml water/plant that resulted the utmost high DM at all and reduced WUE to the least values in both seasons.

These results may indicate the role of increasing water supply coupled with correcting structure and texture of the sand by the natural and organic additives in rising the uptake of nutrients by roots plus absorbing enough water, which usually activates photo-and biosynthesis that finally results in high production of dry matter. In this connection, Bryla *et al.* (2011)

Table (10): Water use efficiency by *Asparagus densiflorus* "Myers" (Kunth.) Jessop plant under various media, water amounts and their interactions during 2016/2017 and 2017/2018 seasons.

Total amount of water (Liter)/plant/ season	Medium type	Total D.M.(g)/plant/season		W.U.E. (ml/g D.M.)	
		2016/2017	2017/2018	2016/2017	2017/2018
12.400 (Liter) (For 100 ml treatment)	Sand (S)	21.28	19.78	582.71	626.90
	Vermiculite(Ver.)	21.10	22.22	587.68	558.06
	S+ Ver. (1:1,v/v)	25.75	25.09	481.55	494.22
	S+ Cocopeat(Coir)(1:1,v/v)	33.49	37.61	370.26	329.70
	S+ Ver. +Coir (1:1:1 v/v/v)	35.36	37.54	350.68	330.31
18.600 (Liter) (For 150 ml treatment)	Sand (S)	20.44	21.68	909.98	857.93
	Vermiculite(Ver.)	23.87	24.82	779.22	749.40
	S+ Ver. (1:1,v/v)	29.96	28.85	620.83	644.71
	S+ Cocopeat(Coir)(1:1,v/v)	72.00	69.52	258.33	267.55
	S+ Ver. +Coir (1:1:1 v/v/v)	55.91	59.01	332.68	315.20
24.800 (Liter) (For 200 ml treatment)	Sand (S)	22.85	23.48	1085.34	1056.22
	Vermiculite(Ver.)	26.31	25.62	942.61	967.99
	S+ Ver. (1:1,v/v)	26.43	28.23	938.33	878.50
	S+ Cocopeat(Coir)(1:1,v/v)	70.35	71.08	352.52	348.90
	S+ Ver. +Coir (1:1:1 v/v/v)	52.90	53.58	468.81	462.86
Medium mean	Sand (S)	21.52	21.65	859.34	847.02
	Vermiculite(Ver.)	23.76	24.22	769.34	758.48
	S+ Ver. (1:1,v/v)	27.38	27.39	680.24	672.48
	S+ Cocopeat(Coir)(1:1,v/v)	58.61	59.40	327.04	315.38
	S+ Ver. +Coir (1:1:1 v/v/v)	48.06	50.04	384.06	369.46

- No. irrigation times during the season = 124 times. Hence total amount of water for the three water treatments = 12.400, 18.600 and 24.800 liter, respectively.

reported that only 570 mm of irrigation water, or the equivalent of 1320 l/plant of *Vaccinium corymbosum*, was required over two seasons to reach maximum total plant dry weight with drip, while 980 mm or more water was needed with sprinklers and microsprays. Consequently, WUE was greater with drip than with the other irrigation methods. Jie *et al*. (2016) affirmed that dry matter of potted poinsettia stems and roots was slightly fall when irrigation water amount decreased from 12 to 6 l/plant/season, but WUE was significantly increased by 72.36%. On container-grown *Buxus sempervirens* × *B. microphylla* and *Deutzia gracilis* woody plants, Nambuthiri *et al*. (2017) inferred that a physiological-based on-demand irrigation system (OD) reduced water consumption by 35.5% and enhanced WUE by 54.5% compared with a daily water use method (DWU) in *Buxus*, while total water use of Deutzia by OD system was reduced by 26.5% compared with DWU methods. This is because OD system offers the advantage of watering as required and reducing water stress as the season progress and as the plant size and atmospheric demand increase.

In view of the previous results, it is advised to plant Myers asparagus either in a mixture of sand+cocopeat or sand+vermiculite+cocopeat (at equal parts by volume) and irrigating with 150 ml of water/plant, when required to obtain a picturesque and ideal pot plant.

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إستجابة نبات الأسبرجس ذيل القط (صنف مايرز) *Asparagus densiflorus* "Myres" (Kunth.) Jessop للبيئات وكميات مياه الري المختلفة

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ملخص

تنمو نباتات الأصص في وسط أو حيز محدود هو حجم الأصيص المنزرعة فيه. يتطلب ذلك الإختيار الأمثل والدقيق لبيئة النمو وكمية المياه اللازمة للري للحصول على أفضل نمو ومظهر للنبات الناتج. لذلك، أجري هذا البحث بإحدى الصوبات البلاستيكية بمشتل قسم بحوث الزينة وتنسيق الحدائق، معهد بحوث البساتين، مركز البحوث الزراعية، الجيزة، مصر خلال موسمي 2017/2016 ، 2018/2017 للتعرف على إستجابة نبات الأسبرجس ذيل القط (صنف مايرز) *Asparagus densiflorus* "Myers" (Kunth.) Jessop للنمو في البيئات التالية: الرمل فقط، الفيرمكيوليت فقط، الرمل+الفيرمكيوليت (1:1 حجما)، الرمل+كمبوست ألياف جوز الهند (1:1 حجما)، مخلوط الرمل+ الفيرمكيوليت + كمبوست ألياف جوز الهند (1:1:1 حجما)، و للري بمعدلات: 100، 150، 200 مل/ نبات يوم بعد يوم في شهور الشتاء ومره كل ثلاثة ايام في شهور الصيف في اصيص 20 سم. و كذلك للتفاعلات بينهما (بين البيئات و كميات مياه الري). و لقد تم زراعة الشتلات في أصص بلاستيك قطرها 20 سم ملأت حتى 2 سم قبل الحافة بإحدى البيئات سالفة الذكر، ثم رتبت الأصص بعد الزراعة في تجربة عاملية تامة العشوائية. أوضحت النتائج أن دعم بيئة الرمل بكومبوست ألياف جوز الهند، أو بمخلوط الفيرمكيوليت+ألياف جوز الهند أدى إلى زيادة متوسطات جميع قياسات النمو الخضري و الجذري المسجلة معنوياً، حيث أعطت أعلى المتوسطات مقارنة بالبيئات الآخرى دون وجود فروق معنوية فيما بينهما في معظم الحالات بكلا الموسمين. أيضاً، فإن متوسطات النمو الخضري و الجذري قد زادت تدريجياً بزيادة كمية مياه الري حتي 150، 200 مل للنبات، و التي كانت متقاربة فيما بينها لمعظم الصفات التي تم قياسها. وكانت معاملة الري بـ 200 مل/نبات هي الاكثر تاثيرا فقد أعطت أطول النباتات و أكبر عدد و طول للأفرع و أثقل الأوزان لأعضاء النبات المختلفة (نمو خضري، جذور، درنات) في كلا موسمي الدراسة. أيضاً، كان لمعاملات التفاعل (بين البيئات و كمية مياه الري) تأثيراً إيجابياً على النمو و بمستويات معنوية متفاوته، لكن احسن مخلوط الرمل+كمبوست ألياف جوز الهند يليه مخلوط الرمل+الفيرمكيوليت+كمبوست ألياف جوز الهند مع الري إما بمعدل 150 أو 200 مل/نبات حيث أعطت هذه التوليفات/التفاعلات الأربعة أعلى المتوسطات، مع بعض الإستثناءات القليلة مقارنة بالتوليفات الآخرى في كلا الموسمين. و لقد تم الحصول على إتجاه مشابه لإتجاه قياسات النمو الخضري و الجذري فيما يتعلق بتركيزات الصبغات (كلوروفيل أ، ب، الكاروتينويدات)، ومحتوي الكربوهيدرات الكلية، النتروجين، الفوسفور والبوتاسيوم في الأوراق، بإستثناء الكاروتينويدات في كلا الموسمين و التي أظهرت إتجاهاً معاكساً. إضافة إلى ذلك، فقد تحسن إنتاج المادة الجافة بتحسين بيئة الرمل عند إضافة كمبوست ألياف جوز الهند بمفرده إليها، و كذلك عند إضافة الفيرمكيوليت+كمبوست ألياف جوز الهند، كما زاد إنتاجها بزيادة معدل مياه الري من 100 مل إلى 150، 200 مل/نبات. و عليه، فإن أفضل كفاءة لإستخدام الماء في هذه الدراسة (WUE) لنبات الاسبرجس حققتها في كلا الموسمين عند الزراعة في بيئتي النمو سالفتا الذكر مع الري بمعدلات 150، 200 مل/نبات حيث خفضت هذه التفاعلات الأربعة كمية المياه اللازمة لأنتاج 1 جم مادة جافة إلى آدنى القيم. توصى الدراسة بزراعة نبات الأسبرجس ذيل القط (مايرز) *Asparagus densiflorus* "Myers" (Kunth.) Jessop إما في مخلوط الرمل+ كمبوست ألياف جوز الهند (1:1 حجماً) أو مخلوط الرمل+فيرمكيوليت+كومبوست ألياف جوز الهند (1:1:1 حجماً) مع الري بمعدل 150 مل ماء/نبات يوم بعد يوم في شهور الصيف ومره كل ثلاثة ايام في شهور الشتاء للحصول على نبات أصص ذو جودة عالية.

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