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The Effect of Different Growth Media on Calla Lily (*Zantedeschia* spp.)

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Abstract

Calla lily (*Zantedeschia* spp.) from the family of Araceae is an herbaceous perennial flowering plant commercially usedasa cut flower andfor green spaces. No research has studied the effects of different growth media on the calla lily. This study mainly aimed to investigate the effects of different growth media on growth parameters and nutritional status of the calla lily. The experimental design was laid as a randomized complete block design with three replications conducted in a semi-mechanized greenhouse (%RH= 70 ± 5, Temp= 24 ± 4 °C) during 2019-2020. The treatments included 13 growth media composed of perlite and cocopeat at ratios of 80:20, 60:60, 40:60, and 20:80, perlite and peat moss at ratios of 80:20, 60:40, 40:60, and 20:80, fine-grained perlite and perlite at ratios of 25:75, 50:50, and 75:25, fine-grained perlite alone, and perlite alone. The changes in the ratio of perlite to cocopeat from 80:20 to 20:80 increased shoot weight compared to perlite lonely. The changes from 80:20 to 40:60 of perlite to cocopeat raised leaf length, width, and number. Increasing cocopeat or peat moss to perlite led to an increase in rhizome diameter. However, this increase was lower in higher proportions of them. The ratios of 80:20, 60:40, and 40:60 of perlite to peat moss increased leaf nitrogen, phosphorous, and potassium contents. The use of different growth media (perlite, cocopeat, and peat moss) were suitable for this plant due to the better supply of the essential elements.

Keywords: Cocopeat, Nitrogen, Peat moss, Perlite, Phosphorous, Potassium.

INTRODUCTION

Calla lily (*Zantedeschia* spp.) from the family of Araceae is an herbaceous perennial flower, native to the mountainous regions of South Africa (Wei *et al*., 2017). This ornamental flower is popular among bulbous flowers in the world because of its extraordinary flower spathe (outer "petal" shaped like a funnel) and decorative leaves (Wei *et al*., 2017). It is generally classified into two groups: The *Zantedeschia* section (white calla lily) and the *Aestivea* section (colored calla lily). Two species of calla lily with white spathe and rhizome storage organs are *Zantedeschia aethiopica* Spreng. and *Zantedeschia odorata* Perry. The other six species (*Zantedeschia albomaculata* Baill., *Zantedeschia elliottiana* Engl., *Zantedeschia jucunda* Letty., *Zantedeschia pentlandii* Wittm., *Zantedeschia rehmannii* Engl., and *Zantedeschia valida* Singh.) have colored spathe and tuberous storage organs (Wei *et al*., 2017). This plant is commercially used as a cut flower and for green spaces (Wei *et al*., 2017).

Soilless culture and organic rooting media like perlite, peat moss, and cocopeat can be suitable for the vegetative propagation of some horticultural crops including ornamental flowers like *Calendula* (Maślanka and Magdziarz, 2017), East lilium (Karagüzel, 2020) and gerbera (Sirin, 2011). Soilless culture can be defined as a method of growing plants without the use of soil as a rooting medium. Rooting media is one of the most important factors for the production of rooted cuttings in this technique. Types of culture media significantly affect the rooting and vegetative growth of cuttings. Growing media should be considered an essential part of the propagation system because rooting competency depends on the type of medium used. Rooting media directly affect the rooting quality and percentage (Kumar and Chauhan, 2013). Growing media should be porous and uniform in texture, should hold sufficient moisture, and should be well drained to provide physical support, aeration, and water. In this technique, some mineral materials such as perlite, peat, coconut fiber (cocopeat), and vermiculite have also given good results. Commercial mixtures are habitually used because they are sterilized, easy to use, and may even contain some fertilizers. They also allow for relatively easy control of pH and nutrient availability in the root zone (Bar-Tal *et al*., 2019).

Perlite is a glassy volcanic rock with a hydrolytic composition and 2-5 % of combined water. This relatively expensive substrate is neutral with a pH of 7.0 - 7.5, but it has no buffering capacity and contains no mineral nutrients. The inert nature and neutrality of perlite make it a favorable medium for assessing the usefulness of various nutrient forms and levels. Perlite is a sterile product as it is produced at very high temperatures. Chemically, itis a stable material, which can last for several years. Its stability is not greatly affected by acids or microorganisms and poses no environmental problems (Bar-Tal *et al*., 2019).

Coir is the material that forms the middle layers or mesocarp of coconut fruits (*Cocos nucifera* L.). These layers are composed of fibers embedded in the so-called coir pith, also referred to as coir dust in its dry state. Coir is one of the most abundant plant-derived organic waste materials in many tropical and subtropical countries (Carlile *et al*., 2019). There are no weeds and soil borne diseases in this growth media and it helps absorb nutritional elements and has a higher amount of water-holding capacity than perlite media (Mohammadi Ghehsareh *et al*., 2011).

Peat moss-based growth media are popular due to their high nutrient buffering capacity, good aeration, and suitability for various crops. When lightweight organic materials such as peat are used in substrate mixtures, fine sands or clay is often added to increase its bulk density for improved mechanical stability.

There is no reference for studying the effects of different growth media on the calla lily.

This study aimed to investigate the effects of different growth media on the growth parameters and nutritional status of the calla lily.

MATERIALS AND METHODS

The present study was conducted at the Ornamental Plants Research Center (OPRC) in Mahallat, Iran (33° 54' N, 50° 27' E, elevation 1747 m). The experimental design was based on a randomized complete block design with three replications carried out in a semi-mechanized greenhouse (%RH= 70 ± 5, Temp= 24 ± 4 °C) during 2019-2020. The treatments included 13 growth media composed of perlite and cocopeat at ratios of 80:20, 60:60, 40:60, and 20:80, perlite and peat moss at ratios of 80:20, 60:40, 40:60, and 20:80, fine-grained perlite and perlite at ratios of 25:75, 50:50, and 75:25, fine-grained perlite alone, and perlite alone.

Calla lily (*Zantedeschia* spp.) bulbs were cultivated in a greenhouse at 24 ± 4 °C and 70±5 % humidity in October. NPK fertilization from Crystal on brand was applied at a ratio of 13:40:13 in the first month and at a ratio of 18:18:18 along with $Ca(NO_3)_2$ and $Mg(NO_3)_2$ in the second month. Irrigation was performed at an interval of 5days in one step and the fertilization was applied as fertigation. Table 1 presents the physical and chemical properties of the growth media in this experiment.

Table 1. Physical and chemical properties of growth media used in this experiment.

	Growth media	Porosity (%)	CEC	EC (dS m^{-1})	pH	WHC (%)
1	80% perlite + 20% cocopeat	87.76	12.88	0.58	7.08	23.20
2	60% perlite + 40% cocopeat	89.32	20.76	0.76	6.96	46.40
3	40% perlite + 60% cocopeat	90.88	38.64	0.94	6.84	59.60
4	20% perlite + 80% cocopeat	92.44	51.52	1.12	6.72	72.80
5	80% perlite + 20% peat moss	85.60	23.80	0.46	6.86	33.40
6	60% perlite + 40% peat moss	85.00	47.60	0.52	6.52	46.80
7	40% perlite + 60% peat moss	84.40	71.40	0.58	6.18	60.20
8	20% perlite + 80% peat moss	83.80	95.20	0.64	5.84	73.60
9	25% fine-grained perlite + 75% mixed perlite	86.90	0	0.20	7.50	29.00
10	50% fine-grained perlite + 50% mixed perlite	87.60	0	0.10	7.00	38.00
11	75% fine-grained perlite + 25% mixed perlite	88.30	0	0.10	7.40	47.00
12	100% fine-grained perlite	89.00	0	0.20	7.50	56.00
13	100% mixed perlite	86.20	0	0.40	7.20	20.00

*CEC: Cation exchange capacity; WHC: Water Holding Capacity

Measurements of growth parameters

The leaf length and width, leaf area, root and shoot weight, leaf and sucker number, and crown diameter of the *Zantedeschia* spp. seedlings were measured at the end of the experiment. The leaf length and width and crown diameter were measured with a digital caliper and ruler. The root and shoot weight were measured with a digital balance.

Measurement of total chlorophyll content

Chlorophyll content was obtained by a chlorophyll meter and stated as SPAD units.

Considering the methods for measuring macro-elements, nitrogen, phosphorous, and potassium were obtained by the protocols previously stated by Tekaya *et al*. (2014) using a Kjeldahl device, a spectrophotometer, and a flame-photometer, respectively.

Data were analyzed by Duncan's multiple range test using the SAS statistical package.

RESULTS AND DISCUSSION

The highest shoot (15.667 g) and root (26 g) weight were related to the perlite: cocopeat ratio of 80:20 (Table 2).

Table 2.The effects of different growth media on growth characteristics of calla lily (*Zantedeschia*).

Media		Shoot weight (g)	Rootweight (g)	Corm diameter (cm)	Leaf length (cm)	Leaf width (cm)	Leaf number	Sucker number
Pr80+Coco20		15.667 ±2.02a	26.000±2.89 a	3.0667±0.29 a-d	18.333±1.45 ab	3.2±0.21 bcd	9.667±0.88 ab	5.667±0.33± a
Pr60+Coco40		10.333 ±3.21bc	21.333±3.92 abc	3.333±0.29 abc	17±0.88 abc	2.833±0.3 bcd	8.000±0.88 bc	5.333±0.33 abc
Pr40+Coco60		10.333 ±3.17bc	19.333±4.5 a-d	2.7333±0.29 b-e	15.333±1.85 bc	2.333±0.3 d	7.333±0.67 cd	5.000±0.33 a-d
Pr20+Coco80		6.667±1.45cd	14.000±3.84 bcd	2.4333±0.6 cde	13.333±2 bc	2.500±0.33 cd	5.000±0.67 de	4.000±0.00 cd
Pr80+Peat20		11.333±0.88 b	24.333±3.52 a	3.833±0.65 a	21.000±1.73 a	4.167±0.33 a	11.333±0.88 a	6.333±0.33 a
Pr60+Peat40		10.000±1.2 bcd	23.333±3.84 a	3.567±0.18 ab	14.333±0.88 bc	3.000±0.00 bcd	7.333±0.58 cd	4.000±0.33 bcd
Pr40+Peat60		9.000±1.76 bcd	19.000±2.84 a-d	3.300 ±0.26 abc	13.333±1.2 bc	3.667±0.17 ab	6.000±0.88 cde	4.333±0.00 bcd
Pr20+Peat80		6.333±2.00 d	12.667±0.88 d	2.200±0.26 de	12.667±1.2 c	3.167±0.28 bcd	5.000±0.58 de	3.333±0.00 d
Prsh25+Pr75		9.667±2.00 bcd	22.000±0.88 ab	2.4±0.18 cde	21.333±1.45 a	3.000±0.28 bcd	7.000±0.58 cde	4.667±0.33 a-d
Prsh50+Pr50		6.333±0.33 d	13.667±1.154 cd	2.233±0.18 de	15.000±1.45 bc	2.333±0.58 d	6.333±1.76 cde	4.667±0.88 a-c
Prsh75+Pr25		9.333±1.20 bcd	18.333±4.48 a-d	2.233±0.40 de	18.333±2.4 ab	3.500±0.58 abc	4.667±2.18 e	4.667±0.58 a-d
Prsh		7.333±1.52 cd	19.333±4.33 a-d	2.817±0.23 b-e	14.833±2.4 bc	2.833±0.88 bcd	5.667± cde	4.333±0.88 bcd
Pr		6.333±0.88 d	13.667±2.18 cd	1.9 e	14.000±1.15 bc	2.333±0.44 d	6.333±0.88 cde	3.667±1.45 cd
SoV	df							
Treatment	12	***	***	***	***	***	***	***
CV (%)	-	22.05	22.42	18.8	17.07	17.42	18.28	20.23

Pr: Perlite, Coco: Cocopeat, Peat: Peat moss, Prsh: Fine-grained perlite. In each column, means with similar letter(s) are not significantly different ($P < 0.05$) using Duncan's multiple range test. *** = Significance at $P < 0.001$.

The lowest shoot weight (6.33 g), corm diameter (1.9 g), leaf width (2.33 g), and chlorophyll content (57 SPAD unit) were related to perlite alone. The changes in the ratio of perlite: cocopeat from 80:20 to 20:80 increased shoot weight by 147, 63, 63, and 5.27 % as compared with perlite alone, respectively. Shoot weight was increased by 78, 57, and 42 % for the perlite: peat moss ratios of 80:20, 60:40, and 20:80 in comparison with perlite alone, respectively. The fine-grained perlite: perlite ratios of 25:75 and 75:25 also raised shoot and root weight (Table 2). Fine-grained perlite as a sole media growth also increased shoot weight by 15.8 % and root weight by 41.45 %. Increased root weight was seen under different ratios of perlite: cocopeat, but this increase was lower when the proportion of cocopeat increased. The same trend was also seen in root weight except for the ratio of 20:80 and root weight increased by 78, 70, and 39 % by the perlite: peat moss ratios of 80:20, 60:40, and 20:80, respectively.

Improved vegetative traits could be attributed to good water-holding capacity and proper drainage of media containing cocopeat and vermiculite either with soil or perlite which provide better conditions for root development and the production of a long root system. These findings are in agreement with the reports of Nazari *et al*. (2011) about hyacinth, Chaudry *et al*. (2018), and Thumar *et al*. (2020).

The highest leaf length (21.33 cm) was seen in the fine-grained perlite: perlite ratio of 25:75. The lowest leaf length (4.667 cm) and sucker number (3.33) were related to the fine-grained perlite: perlite ratio of 75:25 and the perlite: peat moss ratio of 20:80, respectively (Table 2). Although, the changes in perlite: cocopeat ratio from 80:20 to 40:60 raised leaf length, width, and number, this increase was lost as the ratio of cocopeat to perlite was increased (Table 2).

The highest number of leaves (11.33) and suckers (6.33) and chlorophyll content (72.33 mg g^{-1} FW) were related to the perlite: peat moss ratio of 80:20 (Table 2). This result is consistent with Nikrazm *et al*. (2011) and Rajera and Sharma (2017) who reported the maximum number of leaves in Lilium cultivars grown on a medium amended by cocopeat.

The highest corm diameter (3.83 cm) was attributed to the perlite: peat moss ratio of 80:20 (Table 2). Increasing cocopeat or peat moss to perlite led to an increase in corm diameter. However, the increase was lower in higher proportions of them. Fine-grained perlite alone caused a higher increase in corm diameter than the mixture of fine-grained perlite with perlite. Promising bulb attributes could be due to better physical, chemical, and biological properties of the media containing cocopeat and vermiculite either with soil or perlite which supplied a congenial root environment for proper growth of bulbs and bulblets (Chaudhary *et al*., 2018). The results of studies reported by Nikrazm *et al.* (2011) about *Lilium* and Nongdhar *et al*. (2019) about increasing bulb size (perimeter) in cocopeat are in agreement with our results.

The number of suckers increased by 54 % in the perlite: cocopeat ratio of 80:20, by 45 % in the perlite: cocopeat ratio of 60:40, by 36% in the perlite: cocopeat ratio of 40:60, and by 9 % in the perlite: cocopeat ratio of 20:80. Higher proportions of peat moss to perlite led to lower increase in the number of suckers as it was seen that the perlite: peat moss ratio of 20:80 decreased this parameter. The effect of different ratios of fine-grained perlite to perlite on the number of suckers was higher than that of fine-grained perlite alone in the growth media.

The changes in the ratio of perlite: cocopeat from 80:20 to 20:80 increased total chlorophyll content by 13, 9, 9, and 6.43 %, nitrogen by 23, 5, 3, and 2%, potassium by 60, 40, 16, and 15 %, respectively (Fig. 1). Total chlorophyll increased with the decrease in the peat moss: perlite ratio from 80:20 to 20:80 by 13.45, 18.12, 19.12, and 26.9 %, respectively. The fine-grained perlite: perlite ratio of 75:25 or 25:75 increased chlorophyll to a greater extent than its 50:50 ratio. Fine-grained perlite alone raised chlorophyll content by 14 % in comparison with perlite alone. A higher amount of chlorophyll content along with enhanced bulb growth of cymbidium orchids are essential for retaining water in pseudo bulbs for spike initiation. Enhanced bulb diameter (4.0 cm) was observed with coco chips + cocopeat +brick pieces + green moss. Enhanced vegetative and reproductive growth with coconut-based products as potting media could be due to the availability of potassium (0.95 %), calcium (2.70 %), magnesium (1.32 %), and nitrogen (0.17 %) (De *et al.*, 2018).

Table 3. ANOVA for the effects of different growth media on leaf nutritional status of calla lily (*Zantedeschia*).

SoV	df	Chlorophyll content	Nitrogen	Phosphorous	Potassium
	12	*	***	***	***
CV (%)	-	6.58	5.67	8.91	10.72

*, *** = Significance at P<0.05and P<0.001, respectively.

The lowest nitrogen (15.44 mg kg^{-1} DW) and phosphorous (1.83 mg kg^{-1} DW) were seen in the perlite: peat moss ratio of 40:60 (Table 3, Fig. 1). The greatest nitrogen (21.67) and potassium (2.52 mg kg^{-1} DW) were seen in the perlite: peat moss of 80:20, but the highest phosphorous content was observed in the perlite: peat moss ratio of 80:20 (Table 3). The perlite: peat moss ratios of 80:20, 20:80, and 60:40 increased nitrogen by 29, 4.75, and 4.27 %, phosphorous by 56.5 and 3 %, and potassium by 63.39 and 22 %, respectively. Although the ratio of 40:60 increased potassium by 1.066 %, this ratio decreased nitrogen and phosphorous.

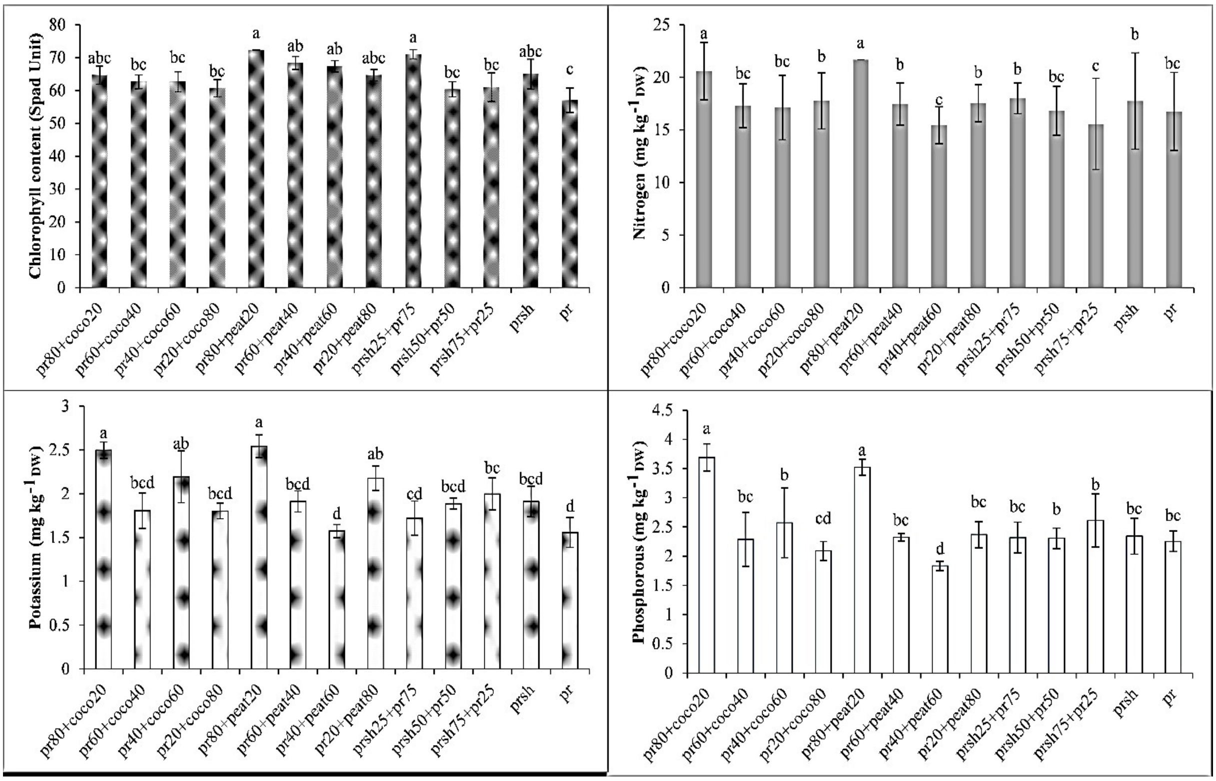

Fig. 1. The effects of different growth media on leaf nutritional status of calla lily (*Zantedeschia* spp.).

It was also observed that higher ratios of fine-grained perlite to perlite raised phosphorous and potassium, but their higher ratios had a negative effect on nitrogen content. The increased effect of fine-grained perlite alone was higher than the fine-grained perlite: perlite ratio of 50:50.

The higher content of N (1.30 %) and K (0.35 %) increased bulb diameter in orchids (De *et al*., 2018) which is consistent with the present results. Enhanced vegetative and reproductive growth with coconut-based products as potting media could be due to the availability of potassium, calcium, magnesium, and nitrogen (De *et al*., 2018). In fact, cocopeat and date-palm peat media have higher amounts of water-holding capacity which causes poor air-water relationship, resulting in low aeration within the medium, which affected oxygen diffusion to the roots (De *et al*., 2018).The results were also in agreement with Fadil Khalaf *et al*. (2020), who reported that the growth medium (peat+perlite) had the highest percentage of carbohydrates, which is an index of high N.

CONCLUSION

The changes in the ratio of perlite to cocopeat from 80:20 to 40:60 increased total fresh shoot weight, leaf length, leaf width, and leaf number. Increasing cocopeat or peat moss to perlite led to an increase in corm diameter. The perlite: peat moss ratios of 80:20, 60:40, and 40:60 increased nitrogen, phosphorous, and potassium contents.

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