Investigation of Suitable Substrate and Optimum Volumetric Water Content to Save Water in *Cymbidium* Orchid Production by Using Sensor-based Irrigation System

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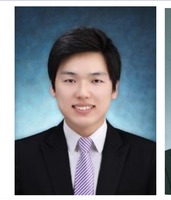

Introduction

Bark substrate was commonly used to grow *Cymbidium* in many countries. However, using the substrate spend a lot of water because of its physical properties. Thus, an alternative substrate is needed to prepare for upcoming water shortage problem. This study was conducted to select a suitable substrate and optimum volumetric water content (VWC) for cultivating *Cymbidium* using a sensor-based irrigation system (SIS).

Materials and Methods

❑ Plant

- *Cymbidium* 'Yang Guifei'

❑ Substrate

- Pine bark
- Coir
- Coconut chip
- Sphagnum moss

❑ Experimental greenhouse conditions

- Average temperature : 20°C
- Average relative humidity : 70%
- Day length: natural day length

❑ Step 1. Substrate water holding capacity and soil moisture sensor calibration

- Moisture retention curves
- Soil moisture sensor
  - 10HS (Decagon Devices Inc., Pullman, WA, USA)
- Soil moisture sensor calibration

❑ Step 2. Selecting suitable substrate for growing *Cymbidium* using SIS

- CR1000 (Campbell Scientific Co., Ltd, Logan, UT, USA)
- SDM-CD16AC (Campbell Scientific Co., Ltd., Logan, UT, USA)
- NDJ electric valve (Naan Danjain Irrigation Ltd., Israel)
- PC spray stake (Netafim Ltd., Co., Israel)

❑ Step 3. investigating the optimum VWC for growing *Cymbidium* using SIS

- Coir
- CR10X (Campbell Scientific Co., Ltd., Logan, UT, USA)
- SDM-CD16AC (Campbell Scientific Co., Ltd., Logan, UT, USA)
- AM416 (Campbell Scientific Co., Ltd., Logan, UT, USA)
- NDJ electric valve (Naan Danjain Irrigation Ltd., Israel)
- PC spray stake (Netafim Ltd., Co., Israel)

Results

❑ Step 1. Substrate water holding capacity and soil moisture sensor calibration to substrates

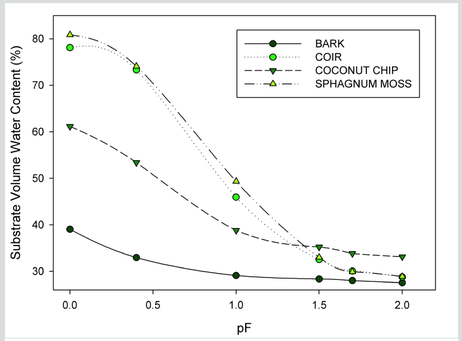

Fig. 1. Moisture characteristic data and nonlinear regression curves for bark, coir, coconut chip and sphagnum moss

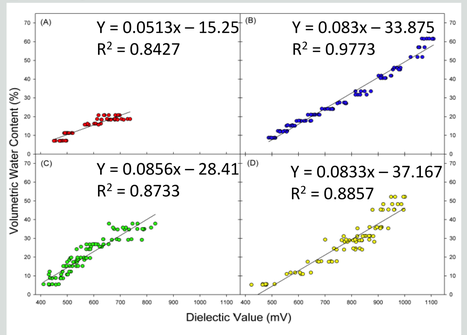

Fig. 2. Calibration data and linear calibration equation of four substrate, bark (A), coir (B), coconut chip (C) and sphagnum moss (D).

- Water holding capacity (Fig. 1)
  Coir ≥ Sphagnum moss > Coconut Chip > Bark
- Equation of each substrate by soil moisture sensor calibration (Fig. 2)
  - Coir : Y= 0.083x – 33.875
  - Sphagnum moss : Y = 0.0833x – 37.167
  - Coconut chip : Y = 0.0856x – 28.41
  - Bark : Y = 0.0513x – 15.25
- Bark could not hold water over approximately 20% (Fig. 2).

❑ Step 2. Determination of the suitable substrate for growing *Cymbidium* using SIS

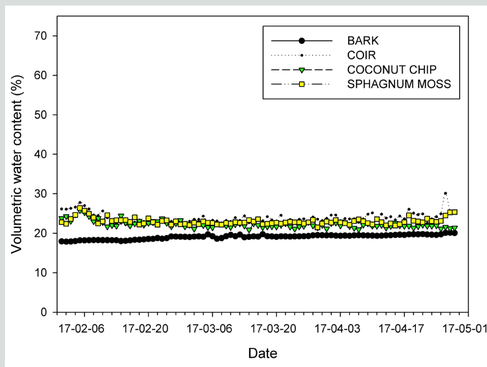

Fig. 3. Average substrate water content (%, n = 3) of *Cymbidium* 'Yang Guifei' in 15-cm containers as maintained by a capacitance sensor-based irrigation system. Plants were irrigated when VWC dropped below 20%.

Table. 1. Growth characteristics of *Cymbidium* 'Yang Guifei' within four different substrates (bark, coir, coconut chip, and sphagnum moss). VWC was controlled at 20% during 12 weeks.

Substrate	Mother bulb						Lead bulb					
	No. of leaves	Pseudobulb diameter (mm)	Leaf length (cm)	Leaf width (cm)	No. of new pseudobulb	SPAD	No. of leaves	Pseudobulb diameter (mm)	Leaf length (cm)	Leaf width (cm)	No. of new pseudobulb	SPAD
Bark	9.4b[z]	39.8	57.2	2.2	0.8	61.6a	11.2ab	28.7a	37.2	2.3	0.7	46.0a
Coir	9.4b	40.5	58.6	2.2	0.6	58.3ab	11.7ab	27.5a	38.6	2.2	0.7	36.7b
Coconut chip	7.1c	39.7	55.5	2.3	0.3	52.8c	10.4c	24.6b	36.8	2.1	0.7	36.6b
Sphagnum moss	11.4a	39.4	53.9	2.2	0.8	63.9a	12.2a	28.7a	37.0	2.2	0.6	42.5ab
Significance	***[y]	NS	NS	NS	NS	**	**	***	NS	NS	NS	**

[z]Mean seperation within columns by Tukey's honestly significant difference test at $P < 0.05$.

[y]NS, **, *** Non-significant difference or significant at $P < 0.01$ or < 0.001, respectively.

Table. 2. The daily amount of water use of each substrate (n = 3) to maintain substrate VWC at 20% during the experiment.

Substrate	Average no. of irrigation per day	Average water usage per day (mL)
Bark	57.2	11448.4
Coir	0.4	83.6
Coconut chip	0.4	80.5
Sphagnum moss	0.5	108.8

- VWC of all substrates was well controlled (Fig. 3).
- Except for coconut chip, most of the growth characteristics showed similar tendency (table 1).
- Bark was needed water about 140 times more than other substrates to maintain same VWC (table 2).

❑ Step 3. Examination of the optimum VWC for growing *Cymbidium* 'Yang Guifei' using SIS within coir substrate

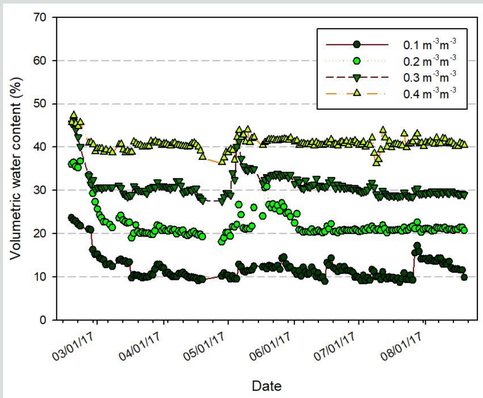

Fig. 4. The volumetric water content of coir substrate over the experiment. Dashed horizontal lines indicate the substrate water content at which the irrigation was turned on.

Table. 3. Growth characteristics of *Cymbidium* 'Yang Guifei' at the different set point of VWC 0.1, 0.2, 0.3, and 0.4 $m^{-3}\cdot m^{-3}$.

Volumetric water content ($m^{-3}\cdot m^{-3}$)	Mother bulb						Lead bulb					
	No. of leaves	Pseudobulb diameter (mm)	Leaf length (cm)	Leaf width (cm)	No. of new pseudobulb	SPAD	No. of leaves	Pseudobulb diameter (mm)	Leaf length (cm)	Leaf width (cm)	No. of new pseudobulb	SPAD
0.1							—[z]					
0.2	6.6	34.0b[y]	51.7	2.2	0.3	69.1	12.3b	24.0b	51.4b	2.1	0.9	54.5
0.3	6.8	37.0a	54.9	2.2	0.1	66.2	15.4a	27.2a	58.6a	2.1	1.3	53.6
0.4	6.6	39.2a	55.5	2.3	0.0	65.4	14.1a	26.6ab	55.3ab	2.2	1.1	51.6
Significance	NS	***[x]	NS	NS	NS	NS	***	*	**	NS	NS	NS

[z]They were excepted to ANOVA because almost plants were wilted after 24 weeks of 0.1$m^{-3}\cdot m^{-3}$ treatment.

[y]Mean seperation within columns by Tukey's henestly significant difference test at $P < 0.05$.

[x]NS, **, *** Non-significant difference or significant at $P < 0.01$ or < 0.001, respectively.

- The set point of VWC was controlled from Feb. 2017 to Aug. 2017 (Fig. 4).
- 0.1 $m^{-3}\cdot m^{-3}$ was a too dry condition to survive *Cymbidium* 'Yang Guifei' (Table 3).
- The *Cymbidium* was grown well at over 0.3 $m^{-3}\cdot m^{-3}$ of VWC significantly (Table 3).

Conclusion

- Coir and sphagnum moss can substitute bark substrate and save water use
- Considering water use, 0.3 $m^{-3}\cdot m^{-3}$ of VWC was recommended to grow *Cymbidium*

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