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GROWTH AND PHYSIOLOGICAL RESPONSE OF *DENDROBIUM* CV. *EARSAKUL* IN DIFFERENT GROWING CONDITIONS

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Abstract

The present investigation was carried out to study the response of *Dendrobium* cv. Earsakul to nutrients, plant growth promoting root endophyte (PGPRE) (*Piriformospora indica*) and plant growth regulators under three microclimatic conditions. Results revealed that among growth parameters, plant height, number of shoots per plant and girth of shoot was highest in the treatment $\mathbf{T_3}$. Among three systems of growing, maximum growth parameters were recorded in S_2. In TxS interaction, number of leaves per plant was highest in the treatment combination T_4S_2 (7.33 at 18 MAT). Highest leaf area (29.99 cm^2), relative growth rate (0.013 g g^{-1} day^{-1}), dry matter production (14.27 g $plant^{-1}$) and crop growth rate (0.131 g m^{-2} day^{-1}) were recorded in plants treated with $\mathbf{T_4}$ and $\mathbf{T_3}$. Highest diffusive resistance (13.66 S cm^{-1}) was obtained in $\mathbf{T_6}$. Among various micro-climatic conditions, maximum values for physiological parameters were recorded in S_2. The interaction of plant growth promoters and systems of growing had significant influence on all physiological parameters. It can be concluded from the above findings that the nutrient and growing system combination (T_4S_2) may be considered as the suitable combination for growth of *Dendrobium* cv. Earsakul.

Key words : *Dendrobium* cv. Earsakul, growth, *Piriformospora indica,* three growing systems.

Introduction

Among the orchid genera, *Dendrobium* is a very complex and extremely large genus widely used in the commercially cut flower production. It is the second largest genus in the family with nearly 1600 species is one of the commercially important species. Most *Dendrobium* species are epiphytic and are from tropical and sub-tropical regions. It is a popular genus for cut flower production. Many growers in the states of Kerala, Tamil Nadu and Coastal Karnataka are cultivating *Dendrobium* on a commercial scale. Dendrobiums occupy nearly 90 per cent of the area under orchid cultivation in Kerala due to the easy management practices and plant material availability (Rajeevan and Sobhana, 1993). These hybrids are in the foremost position in floriculture trade especially in ornamental cut flower sprays and its capability in blooming continuously and a prolonged post-harvest life relative to other orchid hybrids (Puchooa, 2004).

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The type of nutrients, their quality and frequency of application play an important role on the growth and quality of flower. Fertilizer application is effective for better growth and flower production in commercial cultivation of *Dendrobium* sp. Foliar sprays of supernatent liquid of cowdung slurry, inorganic nutrients of $N:P_2O_5:K_2O$ 3:1:1 during vegetative stage, 1:2:2 during flowering period @ 0.2 per cent weekly twice are recommended for orchids (KAU, 2011).

In orchids, growth and floral initiation is determined by the genotype and its interaction with the environmental conditions. Temperature, humidity, light and photoperiod are some of the important environmental conditions that influence growth and reproductive biology of orchids. Regulation of light intensity is essential for successful orchid culture (Bose and Yadav, 1986). During plant development, the transition from vegetative to reproductive growth is triggered by a number of environmental and endogenous signals (Bernier *et al.,* 1993; Levy and Dean, 1998). Under controlled conditions of greenhouse, the flowers exhibit the best quality

attributes required for the market. For better growth, yield and quality of the flowers, the system of growing is very important (Rajeevan, 1997). Micro climate inside the growing system may drastically influence the growth, flowering and quality of flowers (Femina *et al*., 2006). In most *Dendrobium* orchids, rapid vegetative growth occurs at temperatures between 24°C and 30°C (Leonhardt, 2000). In their natural habitat, epiphytes usually meet with a greater degree of environmental stress. Fernandez (2001) reported that in *Dendrobium*, remarkable increase in plant height was noticed in treatments with 35 per cent and 50 per cent shading (both at double level) and 50 per cent single level shading. The plant height was considerably less in intense light conditions.

The major constraints encountered in *Dendrobium* orchid cultivation are growing conditions, long pre blooming period and susceptibility to pest and diseases. It is envisaged that growing tropical orchids for cut flower production and potted plants will benefit from the recent advances in plant physiology and biotechnology. For the orchid industry, producing an improved hybrid, through conventional breeding or genetic engineering, is only the beginning. Optimization of the production processes and ensuring a quality product for the market is equally important. To achieve this goal, a good basic understanding of orchid physiology is essential to solve key physiological issues. This information is crucial in the optimization of the growth and yield of orchids in commercial farms. Keeping in view all these problems, the present investigation was planned.

Materials and Methods

The present investigation was undertaken at the orchidarium of All India Coordinated Floriculture Improvement Project (AICFIP) in the Dept. of Pomology and Floriculture, College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur (Kerala), India. Studies were conducted in three types of growing systems *viz.,* two level shade house (S_1), top ventilated polyhouse (S_2) and fan & pad system (S_3). Commercially cultivated orchid hybrid variety *Dendrobium* cv. Earsakul was used for the study. Plants were grown under 50 per cent shade in two level shade house, top ventilated polyhouse and in 75 per cent shade in fan and pad system. The major nutrients N:P_2O_5:K_2O at two different ratios, *viz.,* 3:1:1 and 1:2:2 @ 0.2 per cent were applied as foliar sprays during vegetative and flowering stages, respectively. The frequency of application was weekly twice. Nutrient combinations were made using ammonium nitrate, ortho-phosphoric acid and potassium nitrate (KAU, 2011).

The treatments consisted of **T_1**- POP recommendations of KAU (foliar feeding with fertilizer mixture of N:P_2O_5:K_2O 3:1:1 during vegetative period and 1:2:2 during flowering period @ 0.2 per cent, spraying at weekly twice as ammonium nitrate, ortho-phosphoric acid and potassium nitrate respectively), **T_2**- POP + PGPRE (the fungal culture of *Piriformospora indica* was mixed with vermiculite @ 1 g per 100 g of vermiculite and applied near the root zone at the time of planting) + bone meal (15 g per plant applied near root zone at the time of planting), **T_3**- POP + OM (bone meal, neem cake and ground nut cake 100 g each, soaked in water for 3-4 days and diluted to 10-15 times with water, filtered and sprayed over plants at 15 days interval) + vermiwash (diluted to 3 per cent and sprayed at 15 days interval) + PGPRE + bone meal, **T_4**- POP + OM + VW + PGPRE + bone meal + GR (BA 50 mg l^{-1} and GA_3 10 mg l^{-1} sprayed at monthly intervals), **T_5**- 10:20:10 NPK + GR and **T_6**- NPK + GR + OM + VW + PGPRE + bone meal. The experiment was laid out in completely randomized design comprising six treatments, three replications and five plants per treatment for recording observations. The observations were recorded on plant height, number of leaves per plant, number of shoots per plant; shoot girth, internodal length at 9 MAT and 18 MAT, respectively (months after treatment). The experimental data were analysed by the methods of (Panse and Sukhatme, 1985).

The observations on physiological parameters were recorded and methodology followed as detailed below.

Leaf area

The length and breadth of leaf was measured and the area of leaf was computed by using the following regression equation developed as part of the present study (R^2).

Leaf area (a) = – 25.857 + 8.95 × breadth + 2.184 × length.

Chlorophyll content

The chlorophyll content of the leaves was determined using 80 per cent acetone (Porra, 2002). The most recent, fully developed leaf was taken and cut into small pieces (100 mg), the leaf sample pieces digested in 10 ml acetone and ground well using mortar and pestle. Then ground material was poured into centrifuge tube and centrifuged at 5000 rpm for 10 minutes. The supernatent solution was poured into vial (cuvette). The absorbance was read at 646.6 nm and 663.6 nm using distilled water as blank with spectrophotometer. Chlorophyll a, b and total

chlorophyll was calculated using the formula and expressed in mg g^{-1} fresh weight.

Chlorophyll a = 12.25 ($A_{663.6}$) – 2.55 ($A_{646.6}$) × 10 ml acetone/100 mg leaf tissue.

Chlorophyll b = 20.31 ($A_{646.6}$) – 4.91 ($A_{663.6}$) × 10 ml acetone/100 mg leaf tissue.

Total chlorophyll = 17.76 ($A_{646.6}$) + 7.34 ($A_{663.6}$) × 10 ml acetone/100 mg leaf tissue.

Relative growth rate

Relative growth rate (RGR) is the rate of increase in dry weight per unit time expressed in g^{-1} day. It is calculated by the formula suggested by Blackman (1919).

$$RGR = \frac{\text{Loge } W_2 - \text{Loge } W_1}{(t_2 - t_1)}$$

Where, W_1 and W_2 are the dry weight of the whole plant at time t_1 and t_2, respectively.

Net assimilation rate

Net assimilation rate (NAR) refers to the change in dry weight of the plant per unit leaf area per unit time. NAR can be determined by measuring plant dry weight and leaf area periodically during the growth and is commonly expressed in g m^{-2} day^{-1} (Williams, 1946).

$$NAR = \frac{W_2 - W_1}{(LA_2 - LA_1)} \times \frac{\text{Loge } W_2 - \text{Loge } W_1}{t_2 - t_1}$$

Where, LA_1 and LA_2 are the leaf area of plant and W_1 and W_2 are the whole plant dry weight at time t_1 and t_2, respectively.

Crop growth rate

Crop growth rate (CGR) was calculated using the formula of Yaduraju and Ahuja (1996) and expressed in g m^{-2} day^{-1}.

$$CGR = \frac{W_2 - W_1}{T_2 - T_1}$$

Dry matter production

Pseudo stems, leaves and roots of the uprooted plants were dried to a constant weight at 70°C–80°C in a hot air oven. The sum of the dry weights of component parts gave total dry matter production and expressed as g $plant^{-1}$.

Diffusive resistance

Diffusive resistance of the leaf was measured using Infra Red Gas Analyzer (IRGA) and expressed as S cm^{-1}.

Results and Discussion

Plant height

A perusal of the data in table 1 indicated that plant height was not significantly influenced by various plant growth promoters used at 9 MAT. However, the treatment $\mathbf{T_3}$ recorded longer plant (23.55 cm) at 18 MAT. As reported by Dhinesh (2009) in *Dendrobium*, the positive influence of combination of organic manures, inorganic nutrients and *P. indica* might have influenced plant height. Similar observations were made by Sugapriya *et al*. (2012) and Kabir *et al*. (2012) in *Dendrobium.* Out of the three systems of growing, the system (S_2) had the maximum influence on plant height at 18 MAT (25.50 cm). This phenomenon could be attributed to the favorable environmental conditions *viz*., high temperature, low relative humidity and high light intensity (figs. 1-5) and proper air circulation inside the growing system. Proper shade (35-50 per cent) might also be possible reason for highest plant height. Working with *Dendrobium*, Samasya (2000), Leonhardt (2000), Fernandez (2001) and Roychowdhary *et al*. (2004) put forward similar results. None of the interaction treatments showed significant influence on plant height at both periods (table 1).

Number of leaves per plant

Data presented in table 1 revealed that the input $\mathbf{T_4}$ produced significantly higher number of leaves per plant (8.07, 5.44 at 9 and 18 MAT, respectively). The growth regulator cytokinin might have influenced the production of number of leaves per plant as reported by Sobhana (2000), Swapna (2000), Binisha (2003), Nair and Sujatha (2010) in *Dendrobium*. Among systems, significantly higher leaf count (7.73, 5.11 at 9 and 18 MAT, respectively) was recorded in S_2. Similar type of results was reported by Umesha *et al*. (2011) and Zheng *et al*. (2012a, b). In interaction, T_4S_2 recorded higher number of leaves per plant (7.33) at 18 MAT. This interaction effect result reinforces the effects of inorganic and organic manures + vermiwash had a positive influence under the congenial system of growing under top ventilated polyhouse with high temperature, light intensity and low relative humidity (figs. 1-5). These findings were in consonance with Kabir *et al*. (2012) in *Dendrobium*.

Number of shoots per plant

Number of shoots per plant varied significantly among plant growth promoters at 9 MAT (table 1). Plants nourished with $\mathbf{T_3}$ developed higher shoot count per plant (5.52) at 9 MAT. Application of *P. indica* induces growth of the root system and proportionately the shoot production also. The results of present study also collaborate with

the findings of Naik *et al*. (2010) in *Cymbidium,* Nair and Sujatha (2010) in *Dendrobium*. Among systems, S_2 at 9 MAT (5.56) and S_1 at 18 MAT (7.46) produced significantly higher number of shoots per plant. Possible reason could be due to high light intensity (fig. 5) stimulated the growth and tillering of the plants. This was in accordance with the findings of Deinum *et al*. (1996), Xia *et al*. (1999), Runkle (2010) and Rogers (2012). The interaction effect of plant growth promoters and growing systems was non significant (table 1).

Girth of shoot

The information made available in table 1 revealed that the treatment $\mathbf{T_3}$ recorded higher girth of the shoot (3.30 cm, 3.77 cm at 9 MAT and 18 MAT, respectively). Application of inorganic nutrients and organic manures along with *P. indica* showed positive influence on girth of shoot as reported by Dhinesh (2009) and Kabir *et al*. (2012) in *Dendrobium.* Further, this might also be due to the reason that microbial association of the plants in turn help in absorption of nutrients thereby increasing storage of nutrients in pseudo bulb resulting in more shoot girth. In systems, S_1 at 9 MAT (3.39 cm) and S_2 at 18 MAT (3.83 cm) recorded higher girth of shoot. This could be due to vigorous growth of the plant due to congenial environmental conditions prevailing inside the systems which in turn could develop the highest girth of the shoot. An interaction effect was not explicit on girth of shoot at both periods (table 1).

Internodal length

The internodal length did not vary significantly due to the influence of plant growth promoters at 9 MAT and 18 MAT, respectively (table 1). The highest internodal length (4.57 cm) at 18 MAT was observed under S_2. The interaction of plant growth promoters and systems of growing was not explicit in both stages of growth (table 1).

Leaf area

From the table 2, data revealed that the treatment $\mathbf{T_4}$ recorded significantly higher leaf area (29.99 cm^2). This finding might be attributed that the leaf area was determined by a number of leaves per plant. Similar results were reported by Dhinesh (2009) and Sugapriya *et al*. (2012) in *Dendrobium*. Among system of growing, S_2 had maximum influence on leaf area (28.92 cm^2). The increase in leaf number resulted in increase in leaf area (or) increase in leaf area can be attributed to increase in leaf number. In T × S interaction, maximum leaf area was noticed under T_3S_2 (34.41 cm^2). The *P. indica* would influence the production of more number of leaves per plant which in turn enhance the leaf area in S_2 with the condition of high temperature, high light intensity and low relative humidity (figs. 1, 2 , 3). Foliar feeding of organic manures may also the reason for highest leaf area.

Dry matter production (DMP)

Plants applied with plant growth promoter $\mathbf{T_3}$ gave significantly maximum DMP (14.27 g $plant^{-1}$). This finding might be due to plant height and number of shoots per plant was more in the treatment $\mathbf{T_3}$ whereas, the number of leaves per plant, leaf area was more in the treatment $\mathbf{T_4}$ in earlier results (tables 1, 2). This might be the reason for more DMP observed in those treatments. Top ventilated polyhouse (S_2) had maximum influence on DMP (11.92 g $plant^{-1}$). The plant height, number of leaves, number of shoots and leaf area were maximum in S_2 which might have resulted in increased DMP in plants grown under top ventilated polyhouse (tables 1, 2). These findings are in conformity with the results obtained by Fernandez (2001) in *Dendrobium*. In T × S interaction, the combination of T_3S_2 recorded higher DMP (16.07 g $plant^{-1}$). These results are in conformity with earlier results of plant growth promoters and systems of growing on DMP.

Crop growth rate (CGR)

The input combination $\mathbf{T_3}$ recorded significantly higher CGR (0.131 g m^{-2} day^{-1}). The CGR is the proportion of dry matter production and time period of growth. The results of DMP also proved that the treatment $\mathbf{T_3}$ recorded more DMP. A similar trend was also observed in the case of CGR. This was in accordance with the findings of Dhinesh (2009) in *Dendrobium*. Among systems, maximum CGR (0.115 g m^{-2} day^{-1}) was registered under S_2. These findings are in line with the reports of Samasya (2000) in *Dendrobium*. The combination of T_6S_1 recorded higher CGR (0.179 g m^{-2} day^{-1}).

Relative growth rate (RGR)

A critical examination of the data showed that, among the various treatments, $\mathbf{T_4}$ recorded significantly higher RGR (0.013 g g^{-1} day^{-1}) (table 2). Since, the plants were in active growth phase, it was significantly showing the unit increasing DMP. This may lead to increase in RGR. The result in the present study was parallel with the findings of Dhinesh (2009) in *Dendrobium*. Growing systems had no significant effect on RGR. In TxS interaction, T_4S_3 recorded maximum RGR (0.019 g g^{-1} day^{-1}).Under S_3, a uniform environmental condition with high relative humidity may facilitating the maximum RGR in plants, which are in active growth stage.

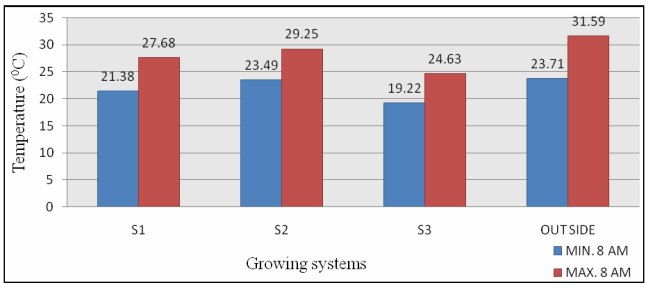

Fig. 1 : Minimum and maximum temperature inside and outside of the growing systems at 8 am.

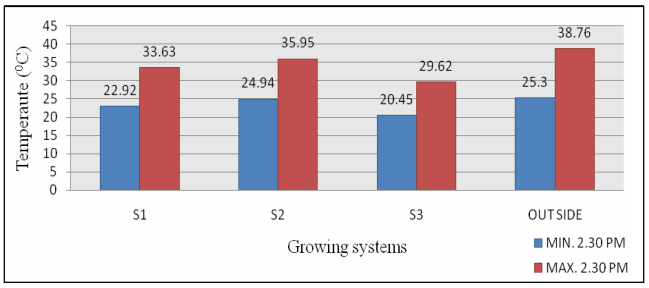

Fig. 2 : Minimum and maximum temperature inside and outside of the growing systems at 2.30 pm.

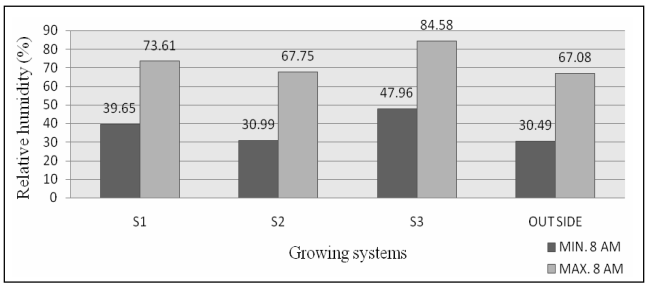

Fig. 3 : Minimum and maximum relative humidity inside and outside of the growing systems at 8 am.

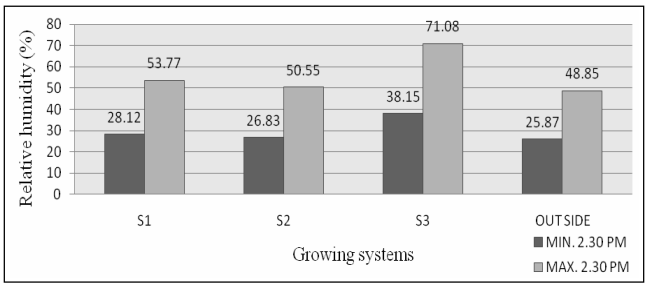

Fig. 4 : Minimum and maximum relative humidity inside and outside of the growing systems at 2.30 pm.

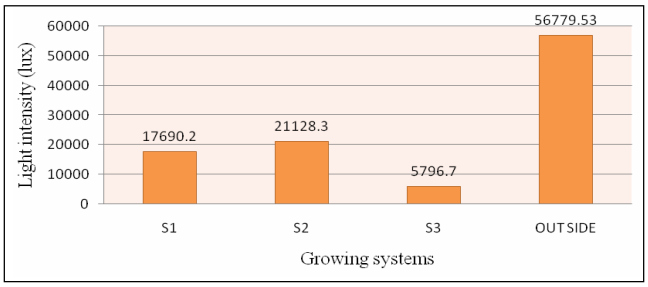

Fig. 5 : Light intensity inside and outside of the growing systems at 12.30 pm.

Net assimilation rate (NAR)

Treatments had no significant influence on NAR. Among systems of growing, top ventilated polyhouse recorded higher NAR (0.009 g m^{-2} day^{-1}). The combination of T_6S_2 had more influence on NAR (0.011 g m^{-2} day^{-1}). The interaction effect was clearly suggesting the results of plant growth promoters and systems of growing in independent cases on NAR.

Diffusive resistance

It was an indication that the input $\mathbf{T_6}$ recorded significantly higher diffusive resistance (13.66 S cm^{-1}) (table 3). If the rate of transpiration is lower and the diffusive resistance was generally higher. This is most likely because of the lower water absorption by the plants. These results are in conformity with the findings of Stancato *et al*. (2002) in *Cattleya*. Two level shade house (S_1) recorded higher diffusive resistance (10.98 S cm^{-1}). In TxS interaction, the combination of T_6S_1 had significant influence on diffusive resistance (16.17 S cm^{-1}). This might be due to the influence of plant growth promoters and systems of growing influenced diffusive resistance.

Chlorophyll content

The influence of various plant growth promoters and microclimatic conditions on chlorophyll 'a' content was not significant (table 3). The combination of T_6S_1 and T_2S_2, respectively recorded significantly higher chlorophyll 'a' content (0.25 mg g^{-1} leaf weight).

None of the plant growth promoters had significant influence on chlorophyll 'b' content (table 3). Among systems of growing, S_1 had maximum influence on chlorophyll 'b' content (0.47 mg g^{-1} leaf weight). The interaction treatment T_4S_1 recorded maximum chlorophyll 'b' content (0.75 mg g^{-1} leaf weight). The ratio of chlorophyll 'a' to chlorophyll 'b' in the chloroplast is normally 3:1. It is known that the chlorophyll a to b ratio is higher in high-light growth conditions than in low - light growth conditions (i.e. more chlorophyll b in shade plants). Chlorophyll 'b' absorbs light at different wavelengths than chlorophyll 'a' and extends the range of light that could be used for photosynthesis.

It is inferred that, application of different plant growth promoters had no significant effect on total chlorophyll content (table 3). Two level shade house recorded significantly higher total chlorophyll content (0.68 mg g^{-1} leaf weight). The reason might be explained that due to favorable weather conditions in the system, the growth of the plants is luxurious because of the higher total

Table 1 : Influence of plant growth promoters (T), growing systems (S) and TxS interactions on growth parameters in *Dendrobium* cv. Earsakul.

Treatments		Plant height (cm)		Number of leaves		Number of shoots		Girth of shoot (cm)		Internodal length (cm)	
		9 MAT	18 MAT	9 MAT	18 MAT	9 MAT	18 MAT	9 MAT	18 MAT	9 MAT	18 MAT
Plant growth promoters (T)	T_1	19.41	21.28^{x}	5.52^{xy}	3.67^{z}	4.30^{z}	5.96	3.29^{x}	3.38^{xy}	4.00	3.99
	T_2	19.60	21.30^{x}	5.96^{xy}	4.00^{yz}	5.15^{xy}	6.74	3.20^{xy}	3.50^{xy}	4.03	3.95
	T_3	19.57	23.55^{x}	6.44^{xy}	4.33^{yz}	5.52^{x}	7.04	3.30^{x}	3.77^{x}	3.70	4.41
	T_4	19.20	21.57^{x}	8.07^{x}	5.44^{x}	5.30^{x}	6.85	3.10^{xyz}	2.89^{y}	3.70	3.37
	T_5	16.64	17.66^{y}	5.06^{z}	4.74^{xy}	4.37^{z}	6.48	2.72^{z}	3.07y	3.35	3.68
	T_6	19.09	20.79^{x}	6.59^{y}	4.89^{xy}	4.70^{yz}	6.22	2.86^{yz}	3.16^{xy}	3.73	3.68
CD (0.05)		NS	3.50	1.36	0.97	0.49	NS	0.37	0.62	NS	NS
Growing systems (S)	S_1	19.45	23.09^{m}	4.59^{n}	4.57^{l}	4.85^{m}	7.46^{l}	3.39^{l}	3.51^{l}	3.84	4.09^{l}
	S_2	19.47	25.50^{l}	7.73^{l}	5.11^{l}	5.56^{l}	6.59^{m}	2.58^{m}	3.83^{l}	3.57	4.57^{l}
	S_3	17.83	14.49^{n}	6.50^{m}	3.85^{m}	4.26^{n}	5.59^{n}	3.27^{l}	2.54^{m}	3.85	2.89^{m}
CD (0.05)		NS	2.48	0.95	0.68	0.34	0.72	0.26	0.44	NS	0.54
T × S	T_1S_1	18.06	22.98	4.11	3.44^{b}	4.56	8.11	3.50	3.34	3.79	3.99
	T_2S_1	19.54	23.54	4.89	3.56^{b}	5.56	7.22	3.59	3.68	3.92	4.16
	T_3S_1	19.38	26.73	4.78	4.11^{b}	5.67	7.44	3.56	3.87	3.90	4.67
	T_4S_1	19.71	21.97	6.67	5.89_{ab}	5.00	7.44	3.17	3.53	3.90	3.99
	T_5S_1	20.15	20.49	2.78	5.44^{ab}	3.89	7.56	3.40	3.78	3.70	4.18
	T_6S_1	19.85	22.78	4.33	5.00^{ab}	4.44	7.00	3.07	3.04	3.83	3.57
	T_1S_2	20.06	24.80	6.89	4.33^{ab}	4.78	5.44	3.07	3.79	4.14	4.81
	T_2S_2	19.48	27.53	6.00	4.00^{b}	5.44	6.22	2.95	4.04	4.32	4.93
	T_3S_2	20.86	27.77	8.33	4.89^{ab}	6.11	7.67	2.54	4.04	3.30	4.84
	T_4S_2	20.66	26.17	10.67	7.33^{a}	6.00	7.33	2.47	3.69	3.57	4.19
	T_5S_2	16.11	20.45	6.17	4.67^{ab}	5.22	6.78	2.23	3.62	2.85	4.49
	T_6S_2	19.60	26.26	8.33	5.44^{ab}	5.78	6.11	2.21	3.80	3.22	4.16
	T_1S_3	20.08	16.07	5.56	3.22^{b}	3.56	4.33	3.32	3.00	4.05	3.18
	T_2S_3	19.75	12.81	7.00	4.44^{ab}	4.44	6.78	3.06	2.77	3.85	2.76
	T_3S_3	18.45	16.14	6.22	4.00^{b}	4.78	6.00	3.76	3.41	3.91	3.71
	T_4S_3	17.22	16.54	6.89	3.11^{b}	4.89	5.78	3.63	1.45	3.64	1.95
	T_5S_3	13.65	12.03	6.22	4.11^{b}	4.00	5.11	2.52	2.00	3.51	2.38
	T_6S_3	17.81	13.30	7.11	4.22^{b}	3.89	5.56	3.28	2.61	4.14	3.33
CD (0.05)		NS	NS	NS	1.67	NS	NS	NS	NS	NS	NS

MAT – Months after treatment

1. Figures with same alphabets/no superscripts form a homogenous group.
2. All comparisons along the column based on DMRT.
3. Use super script x, y, z,..... for comparison of treatments.
4. Use super script l, m, n,..... for comparison of growing systems.
5. Use super script a, b, c, d, e, f ..... for comparison of interactions.

Table 2 : Influence of plant growth promoters (T), growing systems (S) and T x S interaction on physiological parameters in *Dendrobium* cv. Earsakul.

S_1- Two level shade house, S_2- Top ventilated poly house, S_3- Fan and pad system

Treatments	Leaf area (cm^2)				Dry matter production (g $plant^{-1}$)				Crop growth rate (g m^{-2} day^{-1})				Relative growth rate (g g^{-1} day^{-1})				Net assimilation rate (g m^{-2} day^{-1})			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
T_1	19.26	26.88	28.73	25.03	5.38	9.27	7.93	7.53	0.076	0.104	0.089	0.090	0.009	0.010	0.007	0.009	0.004	0.009	0.004	0.006
T_2	23.71	29.66	28.94	27.43	7.10	12.43	6.92	8.82	0.067	0.107	0.080	0.085	0.012	0.012	0.009	0.011	0.006	0.009	0.004	0.006
T_3	24.85	34.41	28.95	29.33	13.93	16.07	12.80	14.27	0.169	0.130	0.093	0.131	0.011	0.011	0.008	0.010	0.007	0.009	0.005	0.007
T_4	31.25	30.46	28.27	29.99	6.72	15.47	6.12	9.43	0.084	0.116	0.075	0.091	0.018	0.013	0.019	0.013	0.009	0.009	0.006	0.008
T_5	21.49	27.42	16.51	21.81	5.10	10.25	6.93	7.43	0.071	0.085	0.079	0.078	0.008	0.009	0.007	0.008	0.006	0.006	0.003	0.005
T_6	23.25	25.72	18.23	22.06	14.80	8.05	7.98	10.28	0.179	0.147	0.011	0.125	0.007	0.008	0.006	0.007	0.004	0.011	0.002	0.006
Mean	23.97	28.92	24.94		8.84	11.92	8.11		0.107	0.115	0.078		0.010	0.010	0.008		0.006	0.009	0.004	
CD(0.05)	T: 2.71 S: 1.91 T x S: 4.69				T: 1.95 S: 1.38 T x S: 3.38				T: 0.040 S: 0.028 T x S: 0.069				T: 0.003 S: NS T x S: 0.005				T: NS S: 0.002 T x S: 0.007			

Table 3 : Influence of plant growth promoters (T), growing systems (S) and T x S interaction on diffusive resistance and chlorophyll content in *Dendrobium* cv. Earsakul.

Treatments	Diffusive resistance (S cm^{-1})				Chlorophyll a (mg g^{-1} leaf weight)				Chlorophyll b (mg g^{-1} leaf weight)				Total chlorophyll (mg g^{-1} leaf weight)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
T_1	11.33	4.47	4.07	6.62	0.22	0.19	0.17	0.19	0.28	0.10	0.09	0.16	0.50	0.30	0.26	0.34
T_2	13.24	7.04	8.82	9.70	0.21	0.25	0.21	0.22	0.51	0.12	0.09	0.24	0.73	0.37	0.30	0.47
T_3	5.76	9.86	6.21	7.28	0.22	0.22	0.22	0.22	0.50	0.16	0.01	0.22	0.71	0.38	0.23	0.44
T_4	8.30	8.36	8.61	8.42	0.21	0.19	0.18	0.19	0.75	0.10	0.04	0.30	0.96	0.29	0.22	0.49
T_5	11.12	8.68	10.29	10.03	0.08	0.22	0.15	0.18	0.49	0.09	0.07	0.22	0.57	0.31	0.23	0.41
T_6	16.17	12.51	12.29	13.66	0.25	0.18	0.22	0.22	0.29	0.09	0.04	0.14	0.53	0.27	0.26	0.36
Mean	10.98	8.48	8.38		0.21	0.21	0.19		0.47	0.10	0.06		0.68	0.32	0.24	
CD (0.05)	T: 2.31 S: 1.63 T x S: 4.00				T: NS S: NS T x S: 0.12				T: NS S: 0.11 T x S: 0.28				T: NS S: 0.11 T x S: 0.27			

S_1- Two level shade house, S_2- Top ventilated poly house, S_3- Fan and pad system

chlorophyll content. The combination of T_4S_1 recorded significantly higher total chlorophyll content (0.96 mg g^{-1} leaf weight). This is explained that, when there is a higher total chlorophyll content and naturally higher the plant growth, higher rate of photosynthesis, more transpiration occur as per previous results and hence the result for higher total chlorophyll content in the leaves. The amount of chlorophyll present had a direct relationship with the rate of photosynthesis because, it is the pigment which is photoreceptive and is directly involved in trapping the light energy. Similar type of observations was also made by Suthar (2010).

Conclusion

From the above investigation, it can be concluded that the plant growth promoters POP + OM + VW + PGPRE + Bone meal + GR and top ventilated polyhouse (T_4S_2) had maximum influence on growth and physiological parameters like leaf area, DMP, CGR and RGR. The association of *P. indica* in root system of *Dendrobium* cv. Earsakul was highly significant and the *P. indica* fungus enhances higher root absorption and facilitates the growth parameters significantly. Therefore the nutrient and growing system combination (T_4S_2) may be considered as the suitable combination for vegetative growth of *Dendrobium* cv. Earsakul.

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