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Research Article

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Effect of various plant growth promoters and growing conditions on flowering of *Dendrobium* cv. EARSAKUL

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ABSTRACT : The investigation on 'Flowering response of *Dendrobium* cv. EARSAKUL to plant growth promoters in different growing conditions' was conducted at College of Horticulture, Vellanikkara, Kerala. Results revealed that, among plant growth promoters, the treatment POP + OM + VW + PGPRE + Bone meal + GR (T_4) resulted in longer spike (31.34 cm), more flower count (6.54) and longer vase life (30.00 days), whereas, the treatment NPK + GR + OM + VW + PGPRE + Bone meal (T_6) was the best with respect to time taken for first flower opening (14.52 days) and number of spikes per plant (2.62) in six month old plants. In three year old plants, the treatment POP + OM + VW + PGPRE + Bone meal + GR (T_4) was the best with respect to time taken for flowering (283.91 days), days to last flower opening (10.98 days), number of spikes (2.63) and vase life (28.26 days), whereas, length of the spike (30.46 cm) and number of flowers (5.08) were the highest in the treatment NPK + GR + OM + VW + PGPRE + Bone meal (T_6). Among three systems of growing, top ventilated polyhouse (S_2) had maximum influence on flower characters. In interaction, the combination of POP + OM + VW + PGPRE + Bone meal + GR (T_4) and top ventilated polyhouse (S_2) was significantly superior in flower characters irrespective of the age of the plants.

KEY WORDS : *Dendrobium* cv. EARSAKUL, Three growing systems, Nutrients, *Piriformospora indica*, Flowering

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INTRODUCTION

Floriculture has become one of the important high value agricultural industries in many countries of the world. Due to globalization and its effect on income enhancement in different regions of the world, a growing per capita consumption of floricultural products is witnessed in most of the countries. 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.

The type of nutrients, their quality and frequency of application play an important role on the growth and quality of flower. 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 reproductive biology of orchids. Regulation of light intensity is essential for successful orchid culture. During plant development, the transition from vegetative to reproductive

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growth is triggered by a number of environmental and endogenous signals. 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. Micro climate inside the growing system may drastically influence the growth, flowering and quality of flowers (Femina Rajeevan, 2006). In their natural habitat, epiphytes usually meet with a greater degree of environmental stress.

Optimization of the production processes and ensuring a quality product for the market is equally important. To achieve this goal, it is necessary to study the influence of various inputs and growing systems are important for better flowering in *Dendrobium* cv. EARSAKUL.

Keeping in view all these problems, the present experiment was taken up with the objective 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.

EXPERIMENTAL METHODS

The experiments were carried out at the orchidarium of All India Co-ordinated Floriculture Improvement Project (AICFIP) in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, Thrissur, Kerala. Studies were conducted over a period from April 2011 to March 2013 in three types of growing systems *viz.,* two level shade house (S_1), top ventilated polyhouse (S_2) and fan and pad system (S_3). Commercially cultivated orchid hybrid variety *Dendrobium* cv. EARSAKUL was used for the study. Plants having two stages of growth *viz.,* six month and three year old plants (during the start of investigation) were used. Plants were grown under 50 per cent shade in two level shade house (size: 21.00 m x 6.00 m x 3.50 m x 2.00 m, top one layer shade net, lower one layer poly film 200 micron with misting system), top ventilated polyhouse (size: 21.00 m x 6.00 m x 3.50 m x 2.00 m, poly film 200 micron covering with shade net and misting system) and in 75 per cent shade in fan and pad system (size: 12.50 m x 8.00 m x 6.00 m x 4.00 m, poly film 200 micron covering, UV stabilized shade net with fan and pad for cooling 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.

The treatments consists 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 % 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 days to flowering, days to first flower opening, days to last flower opening, length of the spike, number of flowers, size of the flower, number of spikes and vase life. The experimental data were analyzed by the ANOVA (Analysis of Variance technique (Panse and Sukhatme, 1985). MSTATC and MS-Excel software were used for computation of data.

EXPERIMENTAL RESULTS AND ANALYSIS

The results obtained from the present study have been discussed in detail under following heads :

Days to flowering :

Data recorded on days to flowering revealed that, in six month old plants, the days to flowering did not vary significantly among various plant growth promoters, whereas the treatment POP + OM + VW + PGPRE + Bone meal + GR took minimum period (283.91 days) for flowering in three year old plants (Table 2). This result could be explained by the phenomenon that the *Dendrobium* plants normally bloom one year after planting. Since the age of the plant is below one year (vegetative phase), the treatment had no significant effect on blooming, whereas in three year old plants, significant influence was observed in the treatment POP + OM + VW + PGPRE + Bone meal + GR due to the reason that the growth regulators *viz.,* BA and GA_3 would have accelerated the flowering. A similar trend was observed in *Dendrobium* by Swapna (2000) and Dhinesh (2009).

A perusal of the data indicated that, among three systems of growing, top ventilated polyhouse had significant influence on days to flowering irrespective of the age of the plants (252.95, 225.42 days). The reason for this finding could be attributed that temperature is the most important factor coupled with light which controls the performance of the plant both in terms of growth and development in top ventilated polyhouse. Similar type of findings was reported by Leonhardt (2000) and

Sugapriya *et al*. (2012) in *Dendrobium*.

In T x S interaction, in six month old plants, the combination of POP + OM + VW + PGPRE + Bone meal and top ventilated polyhouse took minimum time for days to flowering (128.06 days). In three year old plants, POP + OM + VW + PGPRE + Bone meal + GR and top ventilated polyhouse took minimum days (118.08 days). The possible reason that could be attributed to this phenomenon is that the days to flowering in six month old and three year old plants was purely influenced by the system of growing.

Days to first flower opening :

The influence of plant growth promoters showed that the combination of NPK + GR + OM + VW + PGPRE + Bone meal took minimum period for first flower opening in six month old plants (14.52 days). The reason might be due to positive influence of nutrients along with *P. indica* may favour the plants for luxurious growth and ultimately for earliest time for the plants to come to show first flower opening. This was in confirmation with the findings of Binisha (2003), Dhinesh (2009), Sugapriya *et al*. (2012) and Nambiar *et al*. (2012) in *Dendrobium*. None of the treatments showed significant influence on days to first flower opening in three year old plants (Table 2).

An examination of the data showed, among systems of growing, days to first flower opening did not vary significantly due to the influence of growing systems irrespective of the age of the plants (Tables 1 and 2). This might be due to the reason that systems of growing had no effect on days to first flower opening in both stages of plants.

In interaction of inputs and growing systems, the combination of NPK + GR + OM + VW + PGPRE + Bone meal and two level shade house took minimum time (12.76 days) for first flower opening in six month old plants. However, interaction treatments had no significant influence on days to first flower opening in three year old plants (Table 2).

Days to last flower opening :

Among various inputs, in six month old plants, days to last flower opening did not vary significantly (Table 1).

Table 1 : Influence of plant growth promoters (T), growing systems (S) and T x S interaction on flower characters in six month old plants of *Dendrobium* cv. EARSAKUL

Treatments	Days to flowering				Days to first flower opening				Days to last flower opening				Length of the spike (cm)			
	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	406.87	282.92	477.33	389.04	17.45	19.33	23.39	20.06	17.48	15.26	12.50	15.08	22.03	26.06	24.45	24.18
T_2	381.44	138.06	407.70	309.06	15.22	16.50	16.44	16.06	14.85	11.50	13.90	13.42	26.88	28.48	17.79	24.38
T_3	382.75	128.06	433.28	314.69	15.18	15.58	19.17	16.64	12.07	10.35	13.17	11.86	28.91	31.21	26.92	29.01
T_4	318.25	373.44	381.45	357.71	14.87	16.29	15.11	15.42	10.76	12.63	12.44	11.94	33.16	36.05	24.82	31.34
T_5	347.98	344.50	434.50	375.66	16.76	18.39	15.39	16.84	11.02	13.02	12.33	12.12	27.64	25.96	17.90	23.84
T_6	341.76	250.75	427.94	340.15	12.76	13.04	17.75	14.52	11.37	9.62	17.67	12.89	29.51	30.98	25.65	28.71
Mean	363.17	252.95	427.03		15.37	16.52	17.88		12.93	12.06	13.67		28.02	29.79	22.92	
C.D.	T: NS				T: 4.38				T: NS				T: 5.14			
(P=0.05)	S: 56.56				S: NS				S: NS				S: 3.63			
	T x S: 145.90				T x S: 7.58				T x S: 6.27				T x S: 8.90			

Treatments	Number of flowers per spike				Size of the flower (cm) lxb				Number of spikes per plant				Vase life (days)			
	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	3.85	3.54	3.83	3.74	7.70x6.87	7.97x6.60	7.80x6.90	7.82x6.79	2.22	2.22	1.17	1.87	22.81	22.14	19.12	21.36
T_2	4.70	4.42	2.50	3.87	8.01x7.05	7.65x6.22	5.49x5.00	7.05x6.08	2.56	2.89	0.67	2.04	24.37	24.37	20.56	23.09
T_3	5.11	8.11	4.28	5.07	7.25x6.60	8.16x7.06	8.01x6.93	7.81x6.86	2.22	3.22	1.33	2.26	25.88	26.55	23.30	25.24
T_4	7.19	5.81	4.33	6.54	8.46x7.36	8.49x7.28	7.81x7.17	8.25x7.23	3.33	3.56	0.67	2.52	30.72	33.06	26.22	30.00
T_5	4.48	5.07	2.00	3.85	7.78x6.85	8.14x7.03	5.45x4.97	7.12x6.28	1.89	2.00	1.22	1.70	26.74	28.07	22.33	25.72
T_6	6.07	6.44	3.67	5.39	8.09x6.91	8.16x7.17	8.18x7.67	8.14x7.29	3.22	3.30	1.33	2.62	30.41	32.07	24.33	28.94
Mean	5.24	5.57	3.44		7.88x6.90	8.09x6.89	7.12x6.44		2.57	2.86	1.07		26.82	27.71	22.64	
C.D.	T: 0.74				T: NS x NS				T: 0.35				T: 0.55			
(P=0.05)	S: 0.53				S: NS x NS				S: 0.25				S: 0.39			
	T x S:1.29				T x S: NS x NS				T x S: 0.61				T x S: 0.96			

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

However, the treatment POP + OM + VW + PGPRE + Bone meal + GR took minimum days (10.98 days) for last flower opening in three year old plants. This might be due to the positive influence of nutrients and *P. indica* help the plants for taking shorter period for last flower opening on the spike. This is in agreement with the findings of Dhinesh (2009) in *Dendrobium*.

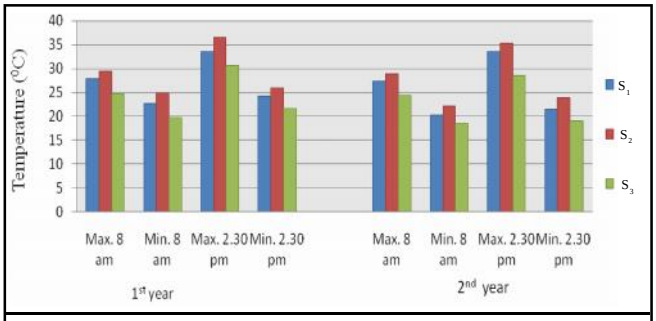

Fig. 1 : Yearly mean temperature (°C) in different growing systems

Systems of growing had no significant influence on days to last flower opening in six month old plants (Table 1). Among different systems of growing, two level shade house showed limited period (12.58 days) for last flower opening in three year old plants.

The interaction of treatments and systems of growing showed significant influence on days to last flower opening in both stages (Tables 1and 2). The combination of NPK + GR + OM + VW + PGPRE + Bone meal and top ventilated polyhouse took few days (9.62, 9.15 days) for last flower opening in both stages of plants. This might be due to positive influence of nutrients and congenial environmental conditions (Fig. 1, 2 and 3) could be the reason for taking minimum period for last flower opening in plants grown under top ventilated polyhouse.

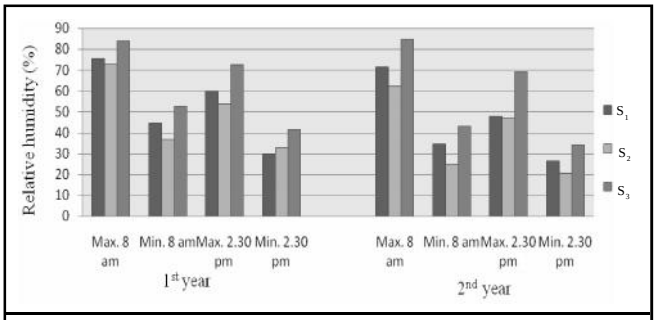

Fig. 2 : Yearly mean relative humidity (%) in different growing systems

Length of the spike :

From the investigation it was observed that, among various treatments, the treatment POP + OM + VW + PGPRE +

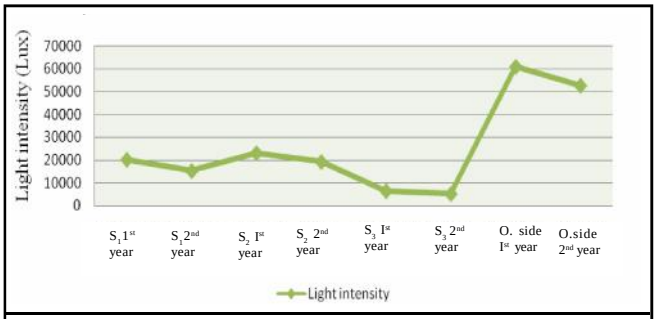

Fig. 3 : Yearly mean light intensity (lux) inside and outside of the growing systems

Bone meal + GR in six month old plants (31.34 cm) and NPK + GR + OM + VW + PGPRE + Bone meal in three year old plants (30.46 cm) recorded significantly longer spikes. This result could be explained that the length of the spike was directly influenced by the growth characters of the plant which was determined by nutrients, growth regulators and *P. indica*. A similar type of finding was reported by Swapna (2000), Ramachandrudu (2008), Meghana (2008), Nair and Sujatha (2010) in *Dendrobium*.

Among three systems of growing, top ventilated polyhouse produced significantly longer spikes irrespective of the age (29.79 cm, 29.50 cm). This could be due to the influence of high temperature, high light intensity and low relative humidity prevailing in top ventilated polyhouse (Fig. 1, 2 and 3). This was in accordance with the findings of Arumugam and Jawaharlal (2004) in *Dendrobium*.

The interaction of plant growth promoters and systems of growing showed significant influence on spike length in both stages (Tables 1and 2). The combination of POP + OM + VW + PGPRE + Bone meal + GR and top ventilated polyhouse in six month old plants (36.05 cm), NPK + GR + OM + VW + PGPRE + Bone meal and top ventilated polyhouse (34.80 cm) in three year old plants recorded significantly longer spikes.

Number of flowers per spike :

The information made available in the Tables revealed that flower count varied significantly among various treatments in both stages. The treatment POP + OM + VW + PGPRE + Bone meal + GR in six month old plants (6.54) and NPK + GR + OM + VW + PGPRE + Bone meal in three year old plants (5.08) produced significantly higher flower count per spike. The number of flowers per spike was directly proportionate to the length of spike. This could be the reason for more number of flowers per spike was observed in the treatments. This was in conformation with Bichsel and Starman (2008) and Kumar *et al*. (2009) in *Phalaenopsis*. The plant growth promoter contains growth regulators which enhanced the production of flowers per spike in both stages of plants. Similar type of finding was reported by Swapna (2000), Rajeevan and Swapna (2003) in

Dendrobium.

Among systems of growing, top ventilated polyhouse produced more number of flowers per spike irrespective of the age of the plants (5.57 and 5.47). The reason might be due to the effect of high temperature, high light intensity and low relative humidity prevailing inside the top ventilated polyhouse (Fig. 1, 2 and 3). This was in agreement with the report of Fernandez (2001) in *Dendrobium* and Hew and Yong (2004) in *Phalaenopsis.*

It was noticed that interaction treatments showed significant influence on flower count. In the interaction of plant growth promoters and systems of growing, the combination of POP + OM + VW + PGPRE + Bone meal and top ventilated polyhouse recorded maximum number of flowers in six month old plants (8.11). In three year old plants, the combination of NPK + GR + OM + VW + PGPRE + Bone meal and top ventilated polyhouse recorded significantly higher number of flowers (6.46). This may perhaps due to the influence of nutrients, *P. indica* and congenial environmental conditions prevailing inside top ventilated polyhouse could have influenced for more flower count per spike.

Size of the flower :

Size of the flower did not vary significantly among different treatments, growing systems and interactions in both six month old and three year old plants (Tables 1 and 2). This might be due to the genetic factors limiting the size of the flowers in *Dendrobium.*

Number of spikes per plant :

The input NPK + GR + OM + VW + PGPRE + Bone meal in six month old plants (2.62) and POP + OM + VW + PGPRE + Bone meal + GR in three year old plants (2.63) recorded significantly higher number of spikes per plant. This could be attributed to the role of *P. indica* in both the plant growth promoters would have influenced the root system and absorption of nutrients which further enhances the more number of shoots per plant which in turn favoured the production of spikes. This finding was in agreement with the observations of Dhinesh (2011) in *Dendrobium,* Chansean *et*

Table 2 : Influence of plant growth promoters (T), growing systems (S) and T x S interaction on flower characters in three year old plants of *Dendrobium* cv. EARSAKUL

Treatments	Days to flowering				Days to first flower opening				Days to last flower opening				Length of the spike (cm)			
	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	361.87	271.83	410.70	348.13	21.46	18.36	16.67	18.83	12.53	16.67	14.67	14.62	23.74	23.66	23.02	23.47
T_2	297.59	362.00	427.55	362.38	18.15	17.22	16.00	17.12	10.19	14.47	13.50	12.72	27.15	27.55	29.72	28.14
T_3	408.50	254.86	476.94	380.09	14.95	15.60	18.75	16.43	14.02	12.32	12.22	12.85	25.59	28.29	28.59	27.49
T_4	369.98	118.08	363.68	283.91	13.47	15.39	15.17	14.68	9.16	11.86	11.92	10.98	32.90	32.26	9.52	24.89
T_5	313.00	127.89	414.46	285.12	16.64	16.52	15.56	16.24	19.23	11.67	14.44	15.11	30.60	30.44	15.89	25.65
T_6	358.31	217.83	341.63	305.93	13.74	14.20	14.67	14.20	10.35	9.15	14.33	11.28	27.34	34.80	29.23	30.46
Mean	351.54	225.42	405.83		16.40	16.22	16.13		12.58	12.69	13.51		27.88	29.50	22.66	
C.D.	T: 74.17				T: NS				T: 0.29				T: 5.00			
(P=0.05)	S: 52.45				S: NS				S: 1.00				S: 3.54			
	T x S: 128.47				T x S: NS				T x S: 0.46				T x S: 8.68			

NS =Non-significant

Treatments	Number of flowers per spike				Size of the flower (cm) lxb				Number of spikes per plant				Vase life (days)			
	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	3.84	4.01	3.67	3.84	7.69x6.85	7.38x6.55	7.55x6.58	7.54x6.66	1.67	2.56	1.33	1.85	18.57	20.24	17.89	18.90
T_2	4.28	5.14	3.33	4.25	7.34x6.49	7.46x6.68	7.93x7.30	7.58x6.82	1.94	2.56	0.50	1.67	26.19	25.52	19.89	23.86
T_3	4.80	5.40	4.11	4.75	8.06x7.11	7.80x6.86	8.09x7.50	7.98x7.16	2.44	2.78	1.33	2.19	25.67	26.33	22.63	24.88
T_4	5.89	6.33	1.25	4.49	8.31x7.19	8.13x7.30	7.93x6.97	8.13x7.13	3.22	3.00	1.67	2.63	28.44	30.44	25.89	28.26
T_5	4.91	5.46	2.28	4.22	8.38x7.28	7.57x6.93	5.36x4.97	7.10x6.39	2.22	2.39	0.67	1.76	25.33	25.33	20.33	23.67
T_6	5.11	6.46	3.67	5.08	8.29x7.27	7.63x6.65	8.04x6.57	7.98x6.83	2.33	1.89	1.00	1.74	29.22	29.17	23.67	27.35
Mean	4.80	5.47	3.04		8.01x7.03	7.66x6.82	7.48x6.65		2.31	2.53	1.08		25.57	26.17	21.72	
	T: 0.72				T: NS x NS				T: 0.53				T: 0.75			
CD (0.05)	S: 0.51				S: NS x NS				S: 0.37				S: 0.53			
	T x S: 1.24				T x S: NS x NS				T x S: 0.91				T x S: 1.30			

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

al. (2006) and Wang (2008) in *Phalaenopsis*.

Top ventilated polyhouse recorded significantly higher spike count per plant irrespective of the age of the plants (2.86, 2.53). This might be due to the high light intensity and temperature would have influenced the more number of shoots per plant which in turn favourable for more number of spikes per plant. Similar trend of report was made by Sugapriya *et al*. (2012) in *Dendrobium*.

In interaction, the combination of POP + OM + VW + PGPRE + Bone meal + GR had more influence on number of spikes per plant in top ventilated polyhouse in six month old plants and in two level shade house in three year old plants (Tables 1and 2). This result further reinforced the findings of independent effects of plant growth promoters and systems of growing.

Vase life :

The data presented in the Tables indicated that the treatment POP + OM + VW + PGPRE + Bone meal + GR recorded significantly highest vase life in both stages of plants (30.00 and 28.26 days). This might be due to the reason that the influence of *P. indica* and growth regulators in the nutrient combination increased the vase life. Similar finding was reported by Dhinesh (2009) in *Dendrobium*.

Top ventilated polyhouse recorded significantly highest vase life irrespective of the age of the plants (27.71 and 26.17 days) among the growing systems. Favourable temperature, lower relative humidity and higher light intensity was observed under top ventilated polyhouse (Fig. 1, 2 and 3). This could be the reason for maximum vase life of the flowers recorded in top ventilated polyhouse. The findings are in conformity with the observations of Fernandez (2001) in *Dendrobium*.

In interaction, the combination of POP + OM + VW + PGPRE + Bone meal + GR and top ventilated polyhouse recorded significantly higher vase life in both stages of plants (33.06 and 30.44 days). The attributes explained for plant growth promoters and systems of growing for vase life might be the reason for the result.

From the above investigation, it was concluded that plant growth promoters POP + OM + VW + PGPRE + Bone meal + GR and top ventilated polyhouse (T_4S_2) had maximum influence on flower parameters and is considered to be an optimum treatment combination for better flowering. The association of *P. indica* in root system of *Dendrobium* cv. EARSAKUL was highly significant and the *P. indica* fungus enhanced higher root absorption and facilitates the flower parameters significantly.

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