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Influence of Plant Growth Promoters and Systems of Growing on Physiological Parameters of *Dendrobium* cv. Earsakul

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ABSTRACT

Dendrobium is an important orchid for cut flower and potted plant production. The study on 'Growth and physiological response of *Dendrobium* cv. Earsakul in different growing conditions' was conducted at College of Horticulture, Vellanikkara, Kerala. The experimental results revealed that, among physiological parameters, leaf area was highest in the treatment POP + OM + VW + PGPRE + Bone meal + GR in both stages of plants. Rate of photosynthesis and transpiration rate during day time were highest in the treatment POP + OM + VW + PGPRE + Bone meal in six month old plants. Rate of transpiration during day time was highest in the treatment NPK + GR + OM + VW+ PGPRE + Bone meal in three year old plants. Among the three systems of growing, maximum values for physiological parameters were recorded in top ventilated polyhouse (S_2). The interaction of plant growth promoters and systems of growing had significant effect on physiological parameters.

Key words : *Dendrobium* cv. Earsakul, Inorganic nutrients, Plant Growth Promoting Root Endophyte (*Piriformospora indica*) and growing systems.

In the orchid genera, *Dendrobium* is a very complex and extremely large genus which is widely used in the commercial 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.

In *Dendrobium* cv. Earsakul, among the physiological parameters, higher leaf area was resulted by the package of practices of KAU + organic mixture + *Piriformospora indica* + vermiwash + bone meal (Dhinesh, 2009). Many orchids are planted under shade since high light affects both vegetative and reproductive tissues. However, plants grown continuously under low light may suffer from reduction in the rate of photosynthesis and reduction in growth rate (Khoo *et al*., 1997). Leaf area is a direct indication of photosynthetic efficiency of a plant. In *Dendrobium*, it is more so, because, being an epiphytic plant, nutrition is little through the growing media. Instead, foliar spray is the common practice for supplying nutrients where increased leaf area favours increased absorption. Total leaf area showed an increase with the increase in nutrient concentration (Swapna, 2000).

Light intensity influences plant growth through photosynthesis. Good vegetative growth is an indication of the photosynthetic ability of plants. The photosynthetic rate of *Cymbidium sinense* is low and ranges between 2.0 and 2.6 µmol CO_2 m^{-2} s^{-1} which is about $^1/_5$ that of most of C_3 plants. There is no difference in the photosynthetic rates of one to two year old leaves, but the rate declines significantly in three-year–old leaves (Ye *et al*., 1992). Samasya (2000) in *Dendrobium* Sonia 17 reported that plants subjected to 50 per cent light intensity and less than 70 per cent relative humidity exhibited lesser transpiration rate.

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. However, we lack information on the rate of photosynthesis and transpiration of tropical orchids under green house cultivation, particularly at a commercial level. This information is crucial in the optimization of the growth and yield of orchids in commercial farms.

Keeping all these problems in view, the present experiment entitled 'Growth and physiological response of *Dendrobium* cv. Earsakul in different growing conditions' was taken up with an 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.

MATERIAL AND METHODS

The experiments were carried out at the orchidarium of All India Coordinated Floriculture Improvement Project (AICFIP) in the Dept. of Pomology and Floriculture, College of Horticulture, Vellanikkara, Thrissur, Kerala. Studies were conducted over a period from April 2011 to March 2013 in factorial CRD replicated thrice in three types of growing systems *viz.,* two level shade house (S_1), top ventilated polyhouse (S_2) and fan & pad system (S_3) were used. 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 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). In factor -2, 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 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 observation on 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 x breadth + 2.184 x length. The observation on photosynthetic rate was measured on the second leaf of the current shoot (Chang *et al*., 2010) and data on photosynthesis, rate of transpiration during night and day was recorded by using IRGA (Infra Red Gas Analyzer) at six months after planting in both the stages of plants. 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.

RESULTS AND DISCUSSION

Leaf area

The treatment POP + OM + VW + PGPRE + Bone meal + GR recorded significantly highest leaf area irrespective of the age of the plants (Tables 1 and 2). This could be well explained that

Plate 1. Plant materials used for the study

Six month old plant

Three year old plant

Plate 2. Plants inside the three growing systems

the leaf area was determined by a number of leaves per plant. Similar observations were made by Swapna (2000) and Dhinesh (2009) in *Dendrobium*.

Among system of growing, top ventilated polyhouse had maximum influence on leaf area in six month old plants (28.92 cm^2). This might be due to the increased number of leaves per plant, naturally leading to maximum leaf area.

The combination of POP + OM + VW + PGPRE + Bone meal and top ventilated polyhouse in six month old plants (34.41 cm^2), POP + OM + VW + PGPRE + Bone meal + GR and two level shade house in three year old plants recorded significantly higher leaf area (32.73 cm^2). In six month old plants, the *P. indica* influenced the production of more number of leaves per plant which in turn enhanced the high leaf area in top ventilated polyhouse with the condition of high temperature, high light intensity and low relative humidity (Fig. 1, 2 and 3). Foliar feeding of organic manures might have highest leaf area, whereas in three year old plants, the effect of *P. indica* and growth regulators could influence the production of more number of leaves which ultimately resulted in more leaf area.

Rate of photosynthesis

Among various treatments, the treatment POP + OM + VW + PGPRE + Bone meal recorded significantly highest rate of photosynthesis in six month old plants (6.36 µmol CO_2 m^{-2} s^{-1}). The positive effect of POP + OM + VW + PGPRE + Bone meal in increasing dry matter production and crop growth rate were recorded in earlier results which indicated that higher the rate of photosynthesis would increase the food reserves subsequently leading to highest dry matter production and crop growth rate.

Among three systems of growing, top ventilated polyhouse in six month old plants (6.86 µmol CO_2 m^{-2} s^{-1}) and fan and pad system in three year old plants (5.20 µmol CO_2 m^{-2} s^{-1}) recorded highest photosynthetic rate (Table 1 and 2). This could be explained that the six month old plants were in active growth stage and also under top ventilated polyhouse with high temperature, high light intensity (Fig. 1, 3) resulted in higher the rate of photosynthesis, whereas in three year old plants under uniform environmental conditions of fan and pad system resulted in highest rate of photosynthesis.

In interaction, the combination of POP + OM + VW + PGPRE + Bone meal and top ventilated polyhouse in six month old plants (9.73 µmol CO_2 m^{-2} s^{-1}), POP + OM + VW + PGPRE + Bone meal + GR and fan pad system in three year old plants recorded maximum rate of photosynthesis (8.72 µmol CO_2 m^{-2} s^{-1}). The interaction results in the six month old plants conformed the earlier results in independent observations, whereas in three year old plants, the treatment POP + OM + VW + PGPRE + Bone meal + GR was performed well

Table 1. Influence of plant growth promoters (T), growing systems (S) and T x S interaction on physiological parameters in six month old plants of *Dendrobium* cv. Earsakul at six months after treatment.

Treatments	Leaf area (cm^2)				Rate of photosynthetic rate ($\mu mol\ CO_2\ m^{-2}\ s^{-1}$)				Rate of transpiration at night time ($\mu mol\ m^{-2}\ s^{-1}$)				Rate of transpiration at day time ($\mu mol\ m^{-2}\ s^{-1}$)			
	S_1	S_2	S_3	Mean	SS_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	4.24	8.86	3.73	5.61	0.14	0.23	0.11	0.16	1.73	4.40	3.15	3.09
T_2	23.71	29.66	28.94	27.43	4.83	6.10	3.49	4.81	0.16	0.45	0.18	0.26	3.81	5.27	3.11	4.06
T_3	24.85	34.41	28.95	29.33	4.94	9.73	4.41	6.36	0.14	0.23	0.10	0.16	8.83	7.77	3.09	6.56
T_4	31.25	30.46	28.27	29.99	3.62	6.01	3.26	4.29	0.21	0.46	0.07	0.25	3.88	5.39	3.24	4.17
T_5	21.49	27.42	16.51	21.81	2.48	6.90	3.88	4.42	0.10	0.37	0.12	0.19	4.46	9.19	2.47	5.37
T_6	23.25	25.72	18.23	22.06	4.20	3.58	2.58	3.45	0.15	0.14	0.15	0.15	2.41	3.95	2.96	3.10
Mean	23.97	28.92	24.94		4.05	6.86	3.55		0.15	0.32	0.12		4.18	6.00	3.00	
CD (P=0.05)	T: 2.71 S: 1.91 T x S: 4.69				T: 1.72 S: 1.21 T x S: 2.98				T: 0.032 S: 0.023 T x S: 0.056				T: 1.29 S: 0.91 T x S: 2.23			

Table 2. Influence of plant growth promoters (T), growing systems (S) and T x S interaction on physiological parameters in three year old plants of *Dendrobium* cv. Earsakul at six months after treatment.

Treatments	Leaf area (cm^2)				Photosynthetic rate ($\mu mol\ CO_2\ m^{-2}\ s^{-1}$)				Rate of transpiration at night time ($\mu mol\ m^{-2}\ s^{-1}$)				Rate of transpiration at day time ($\mu mol\ m^{-2}\ s^{-1}$)			
	S_1	S_2	S_3	Mean	SS_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
T_1	20.72	25.66	18.66	22.36	3.72	5.92	4.49	4.71	0.12	0.09	0.26	0.15	2.40	2.33	3.56	2.76
T_2	25.43	27.52	24.01	26.13	3.78	3.58	3.22	3.53	0.19	0.12	0.04	0.12	3.88	6.15	3.28	4.44
T_3	25.05	31.41	31.53	27.17	3.71	3.63	4.93	4.09	0.15	0.09	0.05	0.10	3.14	6.71	2.64	4.16
T_4	32.73	26.30	23.80	30.58	2.82	3.51	8.72	5.01	0.22	0.06	0.29	0.19	7.20	1.42	1.96	3.53
T_5	22.15	19.36	23.48	21.22	2.87	2.96	6.58	4.14	0.11	0.20	0.23	0.17	4.05	0.57	3.10	2.57
T_6	18.84	20.81	20.81	19.49	2.95	3.98	3.26	3.40	0.16	0.06	0.22	0.14	8.73	3.06	3.40	5.06
Mean	24.15	25.18	24.14		3.30	3.93	5.20		0.16	0.10	0.18		4.90	3.37	2.98	
CD (P=0.05)	T: 2.28 S: NS T x S: 3.96				T: NS S: 1.84 T x S: 4.51				T: NS S: NS T x S: 0.301				T: 0.81 S: 0.57 T x S: 1.41			

Fig. 1. Yearly mean temperature (^{0}C) in different growing systems

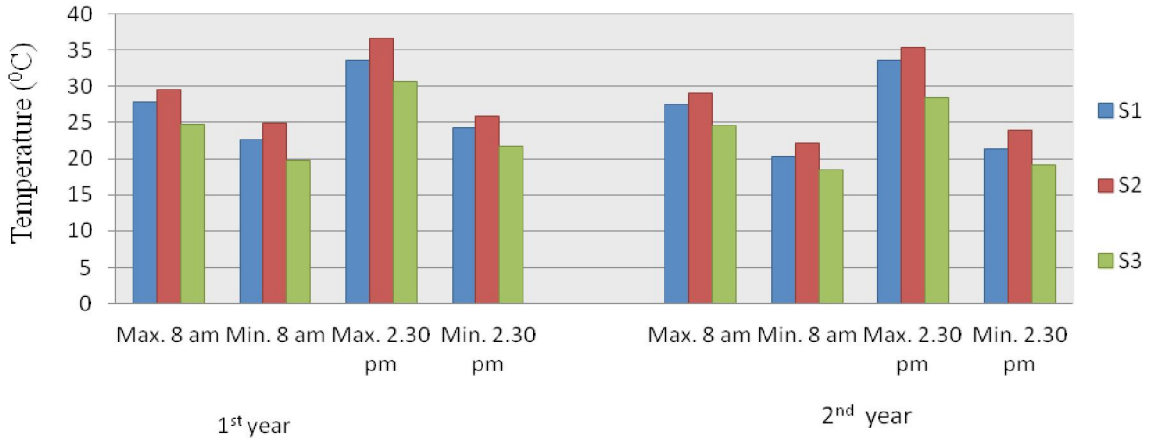


Fig. 2. Yearly mean relative humidity (%) in different growing systems

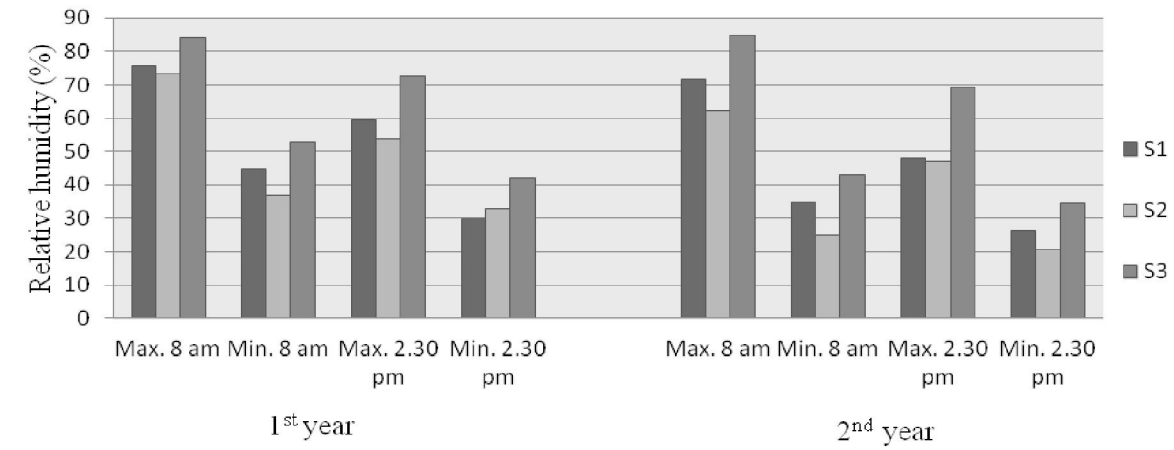
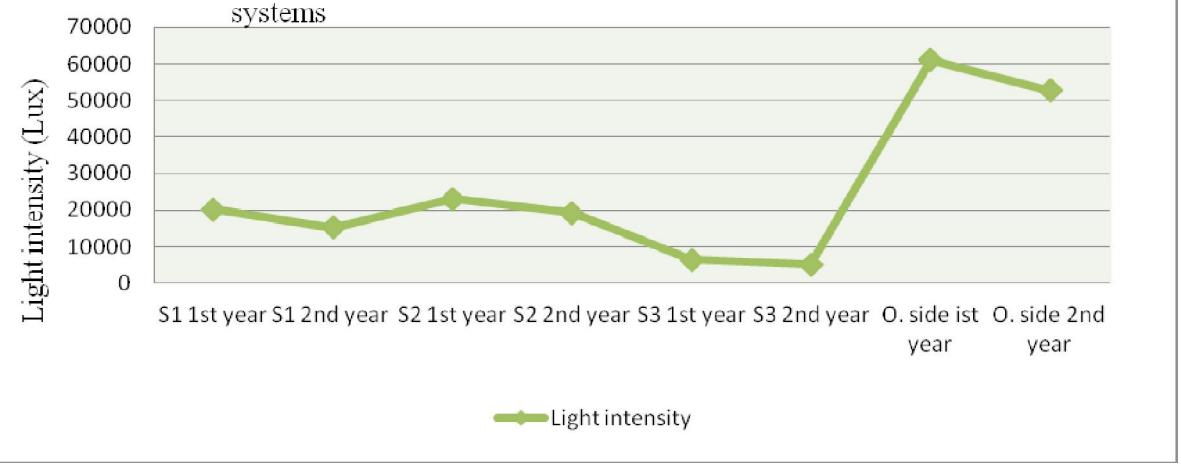
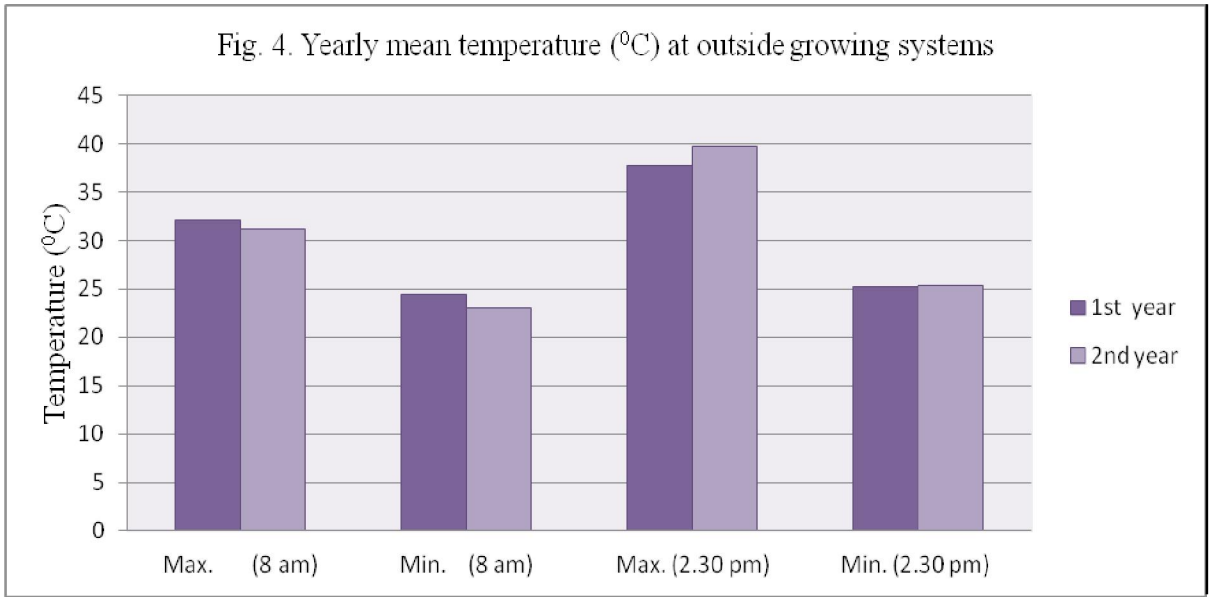
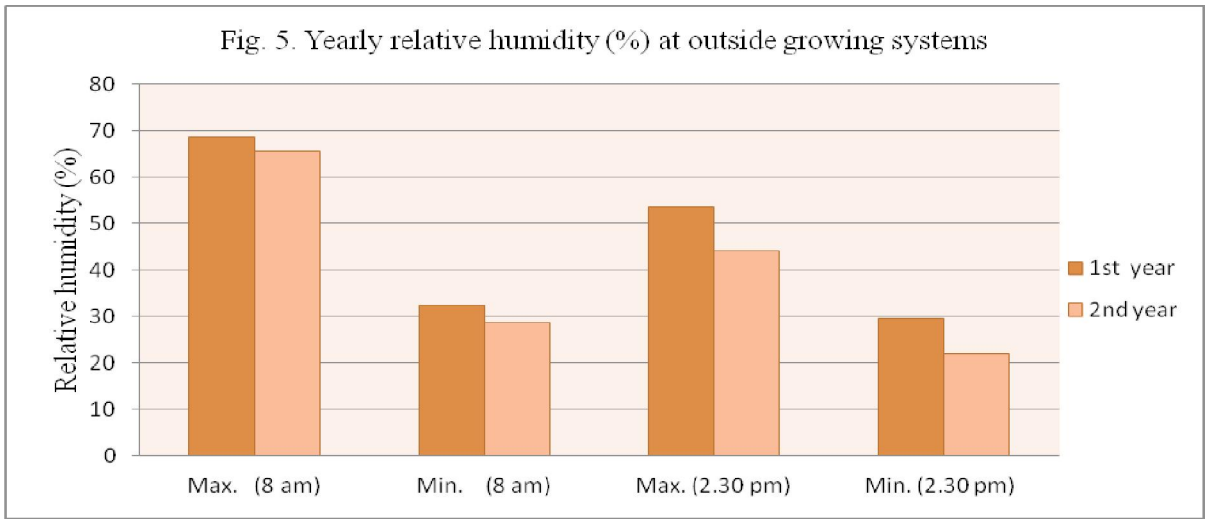


Fig. 3. Yearly mean light intensity (lux) inside and outside of the growing systems







under fan and pad system for increasing the photosynthetic rate.

Transpiration rate at night time

Among various plant growth promoters, the treatment POP + PGPRE + Bone meal recorded highest rate of transpiration during night in six month old plants (0.26 µmol m^{-2} s^{-1}). The *P. indica* and plant growth promoter enhance plant growth and absorb more water leading to higher rate of transpiration.

Among three growing systems, top ventilated polyhouse recorded highest rate of transpiration in six month old plants (0.32 µmol m^{-2} s^{-1}). This could be due to higher temperature, lower relative humidity (Fig. 1, 2) would result in gradient in vapour pressure deficit resulting in higher rate of transpiration. The result in the present study was parallel with the findings of Nagoaka *et al*. (1984) and Samasya (2000) in *Dendrobium*. None of the growing systems showed significant influence on rate of transpiration during night in three year old plants (Table 2).

In interaction, the combination of POP + OM + VW + PGPRE + Bone meal + GR and top ventilated poly house in six month old plants (0.46

µmol m^{-2} s^{-1}), POP + OM + VW + PGPRE + Bone meal + GR and fan and pad system in three year old plants recorded highest transpiration rate during night time (0.29 µmol m^{-2} s^{-1}). This might be due to the reason that positive influence of plant growth promoter which favour better growth of the plants with increased number of leaves per plant, leaf area and number of stomata. Higher temperature and lower relative humidity prevailing inside top ventilated polyhouse favoured higher transpiration rate in six month old plants.

Transpiration rate at day time

Among the various treatments, POP + OM + VW + PGPRE + Bone meal in six month old plants (6.56 µmol m^{-2} s^{-1}) and NPK + GR + OM + VW + PGPRE + Bone meal in three year old plants recorded significantly higher rate of transpiration during day time (5.06 µmol m^{-2} s^{-1}). This might be due to positive influence of all applied plant growth promoters which favour for luxurious growth of the plants thereby resulting in increased rate of transpiration during day time and which is an indication of healthy growth of the plants.

Among systems of growing, top ventilated polyhouse in six month old plants (6.00 µmol m^{-2} s^{-1}) and two level shade house in three year old plants recorded maximum rate of transpiration during day time (4.90 µmol m^{-2} s^{-1}). The reasons for highest transpiration rate under top ventilated polyhouse are higher temperature, high light intensity and low relative humidity (Fig. 1,2, 3). In high light intensity, the water present in mesophyll cells diffuses rapidly resulting in increase in humidity of internal air and this increases the rate of transpiration (Cho and Kwack, 1996). In three year old plants also, the environmental conditions prevailing in two level shade house would have influenced for higher rate of transpiration during day time.

Among interaction treatments, the combination of NPK + GR and top ventilated polyhouse in six month old plants (9.19 µmol m^{-2} s^{-1}), NPK + GR + OM + VW + PGPRE + Bone meal and two level shade house in three year old plants recorded significantly highest rate of transpiration during day time (8.73 µmol m^{-2} s^{-1}). From this study it can be concluded that the treatment combination POP + OM + VW + PGPRE + Bone meal + GR and top ventilated polyhouse had maximum influence on physiological parameters leading to better growth.

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