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Effect of Plant Growth Regulators on *Dendrobium orchids* cv. Sonia 17 for Vegetative Growth Under Shade Net Conditions in High Altitude Tribal Zone of Andhra Pradesh, India

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A B S T R A C T

The present investigation entitled "Effect of plant growth regulators on *Dendrobium orchid* cv. Sonia 17 for vegetative growth and flower yield under shade net conditions in high altitude tribal zone of Andhra Pradesh" was carried out at Horticulture Research station, Chintapalli, Visakhapatnam district of Andhra Pradesh during two consecutive years of 2016-17 and 2017-18. The experiment was laid out in a completely randomized design with 13 treatments and each treatment replicated thrice. The data recorded on various vegetative parameters *viz.,* Plant height, Number of leaves per plant, Number of shoots per plant, Shoot girth, Leaf length, Leaf width and were statistically analyzed. Significant differences were observed among different plant growth regulators on various vegetative parameters in *Dendrobium orchids* cv. Sonia 17. Among all the treatments GA3 @ 50 ppm showed significantly best results with respect to Plant height, Number of leaves per plant, Number of shoots per plant, Leaf length and Leaf breadth and Shoot girth was recorded more with application of Benzyl adenine 200 ppm.

Introduction

Orchids are the most beautiful flowers in God's creation and have conquered the cut flower industry all over the world during the last few decades. *Orchid* cut flowers have emerged as leader in the International market and have immensely contributed to the economy of several developed and developing countries. They are valued for cut flower production and as potted plant in commercial floriculture owing to the wide range of colours, shapes, sizes and fragrance they display. *Orchids* are excellent for garden and can be grown in beds, pots, baskets, split hollows of bamboo pieces etc. They are marketed globally as cut flowers for making corsages, floral arrangements and boquets. They are also suitable for interior decoration and remain fresh for many days. They comprise the largest family (*Orchid*aceae) of flowering plants with 25,000 to 35,000 species belonging to 600-800 genera (Chowdhery, 2001). *Dendrobium* is the second largest *orchid* genera consisting of more than 16,000 species (Puchooa, 2004). Countries including Thailand, Taiwan, China, Phillipines, Germany, United States, Japan and India are major producers of *Dendrobium orchids*. Most *Dendrobium* species are

epiphytic, sympodial *orchids* and are from subtropical and tropical regions and is a popular genus for cut flower production. Many growers in the states of Karnataka, Kerela, Tamil Nadu and Andhra Pradesh are cultivating *Dendrobium* on a commercial scale. The flower spikes of *Dendrobium* are extremely beautiful, medium sized with flowers numbering between 5-20, in colours such as white, mauve, pink, red, blue, purple, yellow and are highly popular in the National and International market. *Orchids* are used in Indigenous system of medicine, particularly in Ayurveda. However, under normal conditions *Dendrobium* hybrids passed with long Juvenile period (at least two to five years) for maturity and flowering stage (Hee *et al.,* 2007). Therefore the present research was conducted to study the effect of plant growth regulators on vegetative growth and flower yield of *Dendrobium orchids* cv. Sonia 17.

Materials and Methods

The experimental site was located at the Horticulture Research Station, Chintapalli (Humid sub tropical zone), Visakhapatnam District, Andhra Pradesh and experiment was carried out during two consecutive years of 2016-17 and 2017-18. Eighteen months old tissue cultured plants which were originally imported from Thailand were used as planting material for conducting experiment. Sonia-17 is one of the popular hybrids of the genus. It is a cross between *Dendrobium caesar* × *Dendrobium tomiedrake*. The plant shows sympodial (upright) growth with club shaped pseudobulbs. Leaves are bright green, broad and acute. Flowers are white and purple coloured, sepals are creamy white with purple markings, petals purple in colour. Shade net house was used for growing *orchid* under partially controlled atmosphere and environment by reducing light intensity and heat radiation during day time. Plants were potted and placed on the benches of 40 m length, 18 cm width and 1 m height. Planting was taken up in plastic pots of size 16 cm diameter with 10 drainage holes each of 2 cm diameter (to drain the excess water and for free movement of air). *Orchids* require a suitable potting medium for growth and development and it varies with type of *orchid* and the environmental conditions (Kang, 1972). Growing medium for *Dendrobium* should be moist but never be soggy. The potting media used in this experiment was coconut husk + brickpieces + charcoal + garvel (1:1:1:1). After planting, the potting media were immediately irrigated thoroughly to maintain the optimum moisture condition. During vegetative phase N, P2O5 and K2O at the ratio of 3:1:1 and during blooming phase at the ratio of 1:2:2 (0.2% concentration) were provided weekly once. Nutrient combinations were made using ammonium nitrate, orthophosphoric acid and potassium nitrate. The commercially available water soluble fertilizers (19-19-19, 13-0-45) of different grades were also used as source for nutrients. Micronutrients were sprayed monthly once. Calcium nitrate and Magnesium sulphate @ 0.1% was given once in a month. Completely randomized design was set with three replications having fifteen plants in each replication and each replication contains thirteen different treatments. The data recorded on various vegetative parameters like Plant height, Number of leaves per plant, Number of shoots per plant, Shoot girth, Leaf length, Leaf breadth and were statistically analyzed.

Results and Discussion

Plant Height

The data pertaining to the effect of plant growth regulators on *Dendrobium orchids* cv. Sonia 17 is presented in Table 1. The data was recorded at two months interval from date of planting to harvesting for two consecutive years of 2016-17 and 2017-18. A gradual increase in plant height was recorded in all the treatments from 2 to 16 months after planting. Among all the treatments, increase in plant height with application of Gibberellic Acid (GA_3) might be due to enhanced cell division, cell enlargement, increased plasticity of cell, promotion of protein synthesis coupled with higher apical dominance (Mishra *et al.,* 2018 in *Phalaenopsis* hybrid). The positive effect of GA_3 on growth may be due to increase in the auxin level of tissue or enhanced conversion of tryptophan to IAA which results in increased cell division and cell elongation (Kuraishi and Muir, 1964). Similar results were observed in gladiolus (Sindhu and Verma, 1998 and Maurya and Nagda, 2002).

Number of leaves per plant

The data pertaining to the effect of plant growth regulators on number of leaves per plant of *Dendrobium orchids* cv. Sonia 17 is presented in Table 2. Significant differences were observed in number of leaves at the end of vegetative stage.

Tabulated data clearly indicated that significantly the maximum number of leaves per plant (13.09) was recorded with foliar application of GA_3 @ 50 ppm

followed by Benzyl adenine @ 200 ppm (11.39) while, T_{13} control (water spray) recorded significantly the minimum number of leaves per plant (6.33).

Leaves play a major role in the synthesis and translocation of carbohydrates to different parts of the plants. Maximum number of leaves produced translocated maximum energy which directly co-relate with maximum number of shoots per plant and shoot girth. Gibberellins activated several enzymes and involved themselves in chlorophyll synthesis and various physiological activities resulted in an increased plant growth and development through overall promotion of parameters like number of leaves per plant (Saravanan, 2001 in *Dendrobium*). Sable *et al.,* (2015) in gladiolus and Barman *et al.,* (2014) in *Dendrobium orchid* Thongchai Gold reported similar findings.

Number of shoots per plant

The data pertaining to the effect of plant growth regulators on number of shoots per plant of *Dendrobium orchid* cv. Sonia 17 is presented in Table 2. Significant differences were observed in number of shoots per plant at the end of vegetative stage in *Dendrobium orchid* cv. Sonia 17.

Treatments had marked influence on number of shoots per plant and among all the treatments GA_3 @ 50 ppm recorded significantly the highest number of shoots per plant (11.28) followed by Benzyl adenine @ 200 ppm (8.74) while, the plants sprayed with water (control) recorded significantly the lowest number of shoots per plant (4.51) which was on par with Cycocel @1250 ppm (5.48).

Shoots or pseudobulbs of sympodial *orchids* such as *Dendrobium* is an important sink for assimilates (Saravanan, 2001 in *Dendrobium*). Application of GA_3 @ 50 ppm produced more number of shoots which might be due to increased cell division and cell elongation in plants resulted in more number of cells. The results were in conformity with the findings of Barman *et al.,* (2014) in *Dendrobium orchid* Thongchai Gold, Saravanan (2001) in *Dendrobium* hybrid Sonia 17 and Bhatt and Chauhan (2012) in *Dendrobium* hybrid Sonia 17.

Shoot girth (cm)

The data pertaining to the effect of plant growth regulators on shoot girth of *Dendrobium orchids* cv. Sonia 17 is presented in Table 3. Significant differences were observed in shoot girth at the end of vegetative stage in *Dendrobium orchids* cv. Sonia 17.

Among all the treatments, the maximum shoot girth was recorded with Benzyl adenine @ 200 ppm (4.05 cm) which was on par with Benzyl adenine 400 ppm (3.76 cm) and Benzyl adenine 600 ppm (3.66 cm). Further, control (water spray) recorded significantly the minimum shoot girth (2.09 cm).

Increased thickness of pseudobulbs is an indicative of storage of more assimilates and thereby enhanced the growth and development (Saravanan, 2001 in *Dendrobium*). Increased shoot girth by foliar application of Benzyl adenine which might be due to the physiological effect of Benzyl adenine as it induced cell division. This was supported by Poole and Sheshan (1977) in *orchids*. In addition to Benzyl adinine, GA_3 also increased the shoot girth which might be due to the presence of more number of leaves which translocated maximum energy, which directly correlated with maximum number of shoots and shoot girth as reported by El- Quesni *et al.,* (2007) in bougainvillea. The results are in agreement with findings of Saravanan and Amit (2009) in *Dendrobium* hybrid Sonia 17.

Leaf length (cm)

The data pertaining to the effect of plant growth regulators on leaf length of *Dendrobium orchids* cv. Sonia 17 is presented in Table 3. Significant differences were observed in leaf length at the end of vegetative stage in *Dendrobium orchids* cv. Sonia 17.

Foliar application of plants with GA_3 @ 50 ppm recorded significantly the maximum leaf length (13.15 cm) while, control (plants sprayed with water) recorded significantly the minimum leaf length (6.68 cm) which was on par with Cycocel @ 1250 ppm (6.73 cm), Cycocel @ 1000 ppm (6.90 cm) and Maleic hydrazide @ 600 ppm (6.83 cm).

Foliar application of GA_3 increased leaf length which might be due to an increase in photosynthetic activity and supply of photo assimilates to meristematic and cambial tissue increased the number of cells. The maintenance of high turgor potential in the cell leads to cell expansion thereby increased leaf length (Sable *et al.,* 2015 in gladiolus). The results are in agreement with the findings of Mishra *et al.,* (2018) in *Phalaenopsis* hybrid, Cardoso *et al.,* (2012) in *Phalaenopsis* hybrid.

Table.1 Effect of Plant growth regulators on Plant height of *Dendrobium orchids* cv. Sonia 17

Treatments	Plant height (cm)									
	2MAT	**4MAT**	**6MAT**	**8MAT**	**10MAT**	**12MAT**	**14MAT**	**16MAT**	**18MAT**	**Mean**
T_1	23.00	23.80	24.90	25.96	26.13	27.66	28.70	30.20	31.00	26.81
T_2	20.63	22.20	23.56	24.33	24.50	25.63	26.70	28.30	29.04	24.98
T_3	20.23	20.73	21.46	22.96	23.13	24.10	25.03	25.63	26.93	23.35
T_4	25.40	26.56	27.53	28.53	28.80	30.36	31.50	32.96	33.25	29.43
T_5	22.50	23.33	24.33	25.43	25.60	27.16	28.16	29.23	30.14	26.20
T_6	19.86	20.46	21.13	22.53	22.70	24.16	25.43	26.10	27.93	23.36
T_7	18.30	19.23	20.13	20.36	20.46	20.50	20.50	20.53	20.95	20.10
T_8	17.83	18.36	19.30	19.73	19.90	19.93	19.93	19.93	20.20	19.45
T_9	17.00	17.86	19.10	19.56	19.56	19.56	19.56	19.56	19.98	19.08
T_{10}	17.73	18.90	19.73	20.33	20.43	20.50	20.50	20.56	20.96	19.96
T_{11}	16.93	18.03	18.93	19.16	19.23	19.23	19.23	19.23	19.96	18.88
T_{12}	16.20	17.33	17.96	18.10	18.10	18.10	18.46	18.46	18.65	17.92
T_{13}	18.33	19.36	20.33	21.10	21.23	22.86	23.40	24.53	24.90	21.78
Mean	**19.53**	**20.47**	**21.41**	**22.21**	**22.29**	**23.05**	**23.62**	**24.24**	**24.91**	**22.41**
SEm±	0.71	0.72	0.70	0.67	0.67	0.73	0.76	0.71	0.75	0.65
CD at 5%	2.08	2.11	2.06	1.96	1.97	2.15	2.24	2.09	2.10	1.90

Table.2 Effect of Plant Growth regulators on Number of leaves per plant and Number of shoots per plant of Dendrobium orchids cv. Sonia 17

Treatments		Number of leaves per plant		Pooled	Number of shoots per plant		Pooled
		2016-17	2017-18		2016-17	2017-18	
T_1 :	Benzyl adenine 200 ppm	10.86	11.93	11.39	8.56	8.93	8.74
T_2 :	Benzyl adenine 400 ppm	9.66	10.73	10.19	8.20	8.56	8.38
T_3 :	Benzyl adenine 600 ppm	9.63	10.70	10.16	8.16	8.53	8.34
T_4 :	GA_3 50 ppm	12.56	13.63	13.09	11.10	11.46	11.28
T_5 :	GA_3 100 ppm	8.46	9.53	8.99	7.00	7.36	7.18
T_6 :	GA_3 150 ppm	8.16	9.23	8.69	6.73	7.10	6.91
T_7 :	Maliec hydrazide 200 ppm	8.10	9.16	8.63	6.63	7.00	6.81
T_8 :	Maliec hydrazide 400 ppm	7.93	9.00	8.46	6.46	6.83	6.64
T_9 :	Maliec hydrazide 600 ppm	7.90	8.96	8.43	6.43	6.80	6.61
T_{10} :	Cycocel 750 ppm	7.13	8.20	7.66	5.66	6.03	5.84
T_{11} :	Cycocel 1000 ppm	7.00	8.06	7.53	5.53	5.90	5.71
T_{12} :	Cycocel 1250 ppm	6.76	7.83	7.29	5.30	5.66	5.48
T_{13} :	Control (Water spray)	5.80	6.86	6.33	4.33	4.70	4.51
	Mean	**8.45**	**9.52**	**8.98**	**6.93**	**7.29**	**7.11**
	SEm±	0.42	0.43	0.41	0.49	0.49	0.48
	CD at 5%	1.24	1.27	1.22	1.44	1.45	1.44

Table.3 Effect of plant growth regulators on shoot girth (cm), leaf length (cm) and leaf breadth (cm) of *Dendrobium orchid* cv. Sonia 17

Treatments		Shoot girth (cm)		Pooled	Leaf length (cm)		Pooled	Leaf breadth (cm)		Pooled
		2016-17	2017-18		2016-17	2017-18		2016-17	2017-18	
T_1 :	Benzyl adenine 200 ppm	3.99	4.12	4.05	11.46	11.60	11.53	3.78	3.84	3.81
T_2 :	Benzyl adenine 400 ppm	3.64	3.83	3.76	10.56	10.73	10.62	3.74	3.82	3.78
T_3 :	Benzyl adenine 600 ppm	3.70	3.68	3.66	10.46	10.66	10.60	3.70	3.76	3.73
T_4 :	GA_3 50 ppm	2.20	2.30	2.25	12.97	13.33	13.15	3.98	4.03	4.01
T_5 :	GA_3 100 ppm	2.13	2.30	2.21	10.50	10.63	10.57	3.55	3.63	3.59
T_6 :	GA_3 150 ppm	2.09	2.26	2.17	8.83	8.93	8.88	3.54	3.60	3.57
T_7 :	Maliec hydrazide 200 ppm	2.23	2.36	2.29	8.46	8.60	8.53	3.39	3.46	3.42
T_8 :	Maliec hydrazide 400 ppm	2.81	2.51	2.46	7.63	8.06	7.84	3.25	3.32	3.28
T_9 :	Maliec hydrazide 600 ppm	3.15	3.27	3.20	6.73	6.93	6.83	3.08	3.14	3.11
T_{10} :	Cycocel 750 ppm	2.41	2.95	2.88	7.66	8.00	7.83	3.03	3.14	3.08
T_{11} :	Cycocel 1000 ppm	3.13	3.25	3.20	6.83	6.96	6.90	2.72	2.85	2.78
T_{12} :	Cycocel 1250 ppm	3.47	3.57	3.52	6.56	6.93	6.73	2.70	2.80	2.75
T_{13} :	Control (Water spray)	1.85	2.06	2.09	6.43	6.90	6.68	2.55	2.68	2.61
	Mean	**2.83**	**2.95**	**2.90**	**8.85**	**9.09**	**9.05**	**3.30**	**3.39**	**3.34**
	SEm±	0.12	0.14	0.13	0.56	0.44	0.50	0.07	0.08	0.07
	CD at 5%	0.35	0.41	0.39	1.65	1.29	1.40	0.23	0.23	0.23

Leaf breadth (cm)

The data pertaining to the effect of plant growth regulators on leaf breadth of *Dendrobium orchids* cv. Sonia 17 is presented in Table 3. Significant differences were observed in leaf breadth at the end of vegetative stage in *Dendrobium orchids* cv. Sonia 17.

Plants sprayed with GA_3 @ 50 ppm recorded significantly the maximum leaf breadth (4.01 cm) which was on par with Benzyl adenine @ 200 ppm (3.81 cm) and Benzyl adenine @ 400 ppm (3.78 cm) while, control (plants sprayed with water) recorded significantly the minimum leaf breadth (2.61 cm).

GA_3 enhances cell division and also involved in leaf expansion (Yamaguchi, 2008) which led to elongated leaves (Sarkar *et al.,* 2014). The growth controlled by gibberellins is multidirectional in expanding leaves as per the findings of King *et al.,* (2001) in *Arabidopsis thaliana*.

The results were in agreement with the findings of Sable *et al.,* (2015) in gladiolus, Mishra *et al.,* (2018) in *Phalaenopsis* hybrid, Cardoso *et al.,* (2012) in *Phalaenopsis* hybrid. The length and breadth of the leaf decreased with increase in concentration GA_3 and narrowest leaf was observed which is similar to the findings of Vichiato *et al.,* (2007) in *Dendrobium nobile* and Cardoso *et al.,* (2012) in *Phalaenopsis*.

In addition to GA_3, Benzyl adenine application also increased the leaf breadth might be due the activity of cell division. The result is similar to the findings of Saravanan (2001) in *Dendrobium* hybrid Sonia 17.

GA_3 application enhanced the vegetative growth parameters such as plant height, number of leaves per plant, number of shoots per plant, shoot girth, leaf length and leaf breadth which in turn enhanced the photosynthetic activity and translocated food materials to shoot apex for the development of floral primordia which advanced the bud formation and onset of flowering.

The inhibitory effect of Cycocel on the vegetative growth as observed in the present study might be due to a regulated carbohydrate and mineral metabolism there by reduced levels of growth regulator *i.e.* gibberellin content in plants. Pronounced growth inhibition and suppression of apical dominance with the application of Cycocel in chrysanthemum was reported by Talukdar and Paswan (1998). Similar results were also obtained by certain of the earlier workers *viz.* Sagar *et al.,* (2005) and Reddy *et al.,* (1997) in tuberose and support these findings.

Author Contribution

M. Sanghamitra: Investigation, formal analysis, writing—original draft. J. Dilip Babu: Validation, methodology, writing—reviewing. B. V. K. Bhagavan:—Formal analysis, writing—review and editing. D. R. Salomi Suneetha: Investigation, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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