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Impact of micronutrient application on growth and flowering of *Dendrobium* hybrid -'Airy white' in the Terai region of West Bengal

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ABSTRACT: *Dendrobium* is a well-known tropical epiphytic orchid and one of the largest genera in the Orchidaceae family. It is grown professionally for the purpose of producing cut flowers. Recently, *Dendrobium* is gaining popularity as a potted plant for attractive foliage as well as flowers in hotels and restaurants for interior landscaping. Also stated that in orchids, growth, development and production were significantly influenced by micronutrients. Due to their significant nutritional support and ability to guarantee a greater harvest and return, micronutrients are steadily gaining popularity among flower growers. There are some challenges when studying orchid nutrition, including slow growth consistent with low nutritional demands and a lower response to additional nutrients compared to plants with rapid development such as annual crops. Another problem is that there are few studies on the interactions of nutrients and their perfect balance in this plant. Therefore, an experiment was carried out on the *Dendrobium* hybrid during the year 2019 to 2021 in the Instructional Farm of Floriculture, Medicinal and Aromatic Plants, UBKV, Pundibari, Coochbehar, West Bengal, India under medium cost polyhouse. The experiment was laid out in a Completely Randomized Design (CRD) which was replicated thrice having 13 treatments. The major nutrients namely NPK (19:19:19) @ 2g/l (foliar spray) at vegetative stage and NPK (0:52:34) from mono-potassium phosphate @ 1g/l at the flowering stage were sprayed at 7 days interval for all treatments. Micronutrients like Ca@ 500mg/l and 1000mg/l, Mg@ 50mg/l and 100mg/l, Fe@250mg/l and 500mg/l, Zn@ 250mg/l and 500mg/l, Cu@ 100mg/l and 200mg/l, as well as B@ 750mg/l and 150mg/l, were sprayed along with NPK at fortnightly interval as per the treatment except for control where only NPK was applied. The vegetative growth trend at the monthly interval was analysed using a completely randomized design (CRD). To observe the effect of nutrients in the year of cultivation, the data was analysed by using Factorial CRD in which years of cultivation (Y) and different treatments (T) were taken as factors. According to the findings, it was found that the treatment T_2 [NPK + Ca (500 mg/l)] resulted in the maximum plant height (cm) in all the recorded months. The interval of leaf production (days) was minimum when treated with NPK + Ca @500 mg/l (T_2). The maximum leaf length (cm) and breadth (cm) were found when the *Dendrobium* hybrid plants were sprayed with NPK + Zn @250 mg/l (T_8). The minimum days taken for the first flowering after planting was also observed in the treatment T_8[NPK + Zn (250 mg/l)]. For proper vegetative growth of *Dendrobium,* application of NPK (19:19:19) @ 2g/l at the vegetative stage once a week and NPK (0:52:34) from mono-potassium phosphate @ 1g/l at the flowering stage once a week along with Zn @ 250mg/l as spray may be recommended for cultivation under protected condition.

Keyword: *Dendrobium* hybrid, plant nutrients, micronutrients, spraying.

INTRODUCTION

One of nature's most exquisite creations and the "queen of flowers", the orchid is renowned for its diversity. This is mostly caused by the plant's ability to adapt to various climatic conditions and pollinators, resulting in variance in the range of vegetative and floral structures necessary for survival (Kachari *et al.*, 2020). Orchids belong to the family Orchidaceae which has about 700-800 genera and 2500-3500 species (Begum, 2000). As stated by De *et al.* (2014), orchids are traded both as cut flowers and as potted plants, making up around 10% of the global fresh-cut flower market. *Dendrobium* is a well-known tropical orchid and one of the largest genera in the Orchidaceae family. It is grown professionally for the purpose of producing cut flowers. Recently *Dendrobium* is getting popularity as a potted plant in hotels and restaurants for interior landscaping (Medhi, 2011). Proper and regular application of nutrition is essential for successful production in respect of vegetative as well as floral attributes of floricultural crops under open and protected conditions. For proper plant growth and yield and to maximize the effective utilization of given N, P, and K, plants must take micronutrients from the soil or supplement through foliar spray (Ganesh and Kannan 2013). Primary macronutrients (NPK) are vital at the vegetative stage and flower development stage of orchids. Apart from these primary macronutrients, secondary macronutrients and other micronutrients are equally crucial for plants' vegetative and flowering development due to their stimulatory and catalytic effect on metabolic processes and cellular functions (Kosha *et al*., 2011; Zende, 1996). Micronutrients are required in smaller quantities. Not only the proper growth and development of the orchid plants but also the availability of the major nutrients in the form of mobility (Patil and Kalaivanan 2019). Due to their significant nutritional support and ability to guarantee a greater harvest and return, micronutrients are steadily gaining popularity among flower growers. Their deficiency can bring about typical symptoms adding to the adverse market acceptance and leading to low profits from flower plants (Ganesh and Kannan 2013). Supply of foliar nutrient delivery is a fairly standard approach in orchid cultivation because orchids cannot significantly absorb nutrients from the roots. Therefore, the use of water-soluble fertilizers is crucial for the optimal growth and development of orchids. Due to the slow-growing nature of orchid plants, slow-release fertilizers in combination with macro and micronutrients can produce the most remarkable results (Hagakl and Imamura 1987). During rapid growth, the plant can accept and use large amounts of fertilizers, but less frequent and more dilute applications are appropriate when growth is slower. Thus, the correct composition of the nutrient mixture produces the best vegetative growth and good-quality flower spikes (Higaki and Imamura 1987). There are some challenges when studying orchid nutrition, including slow growth consistent with low nutritional demands and a lower response to additional nutrients compared to plants with rapid development such as annual crops (Arditti, 1992). Another problem is that there are few studies on the interactions of nutrients and their perfect balance in this plant. The climatic condition of Terai regions of West Bengal is quite congenial for the cultivation of *Dendrobium* but according to research, there is a lack of information on the cultivation of *Dendrobium* in this region. Hence, through this experiment, we can recommend the nutrients which can enhance *Dendrobium's* vegetative growth in a proper way.

MATERIALS AND METHODS

The present experiment was conducted in Uttar Banga Krishi Viswavidyalaya, Department of Floriculture, Medicinal and Aromatic Plants, Faculty of Horticulture, Pundibari, Cooch Behar, West Bengal during the years 2018-19 and 2020-21 under low-cost polyhouse. The planting materials used were 6 month old *Dendrobium* hybrid Airy White. The plants were treated with fungicide for 30 minutes before planting. Orchid pots of 4 inches in size were used for planting, which was filled with coconut husk, charcoal and brick pieces at a ratio of 1:1:1 ratio. After planting, irrigation was done thoroughly. The experiment was laid out in a completely randomized design (CRD) with thirteen treatments (including control) which were replicated thrice. The details of the treatments were : T_1-Control (NPK (19:19:19) @ 2g/l (foliar spray) at vegetative stage & (0:52:34) from mono-potassium phosphate @ 1g/l at flowering stage once a week), T_2- NPK + Ca (500mg/l), T_3- NPK + Ca (1000mg/l), T_4- NPK + Mg (50 mg/l), T_5-NPK + Mg (100 mg/l), T_6- NPK + Fe (250 mg/l), T_7- NPK + Fe (500 mg/l), T_8-NPK + Zn (250 mg/l), T_9- NPK + Zn (500 mg/l), T_{10}- NPK + Cu (100 mg/l), T_{11}- NPK + Cu (200 mg/l), T_{12}-NPK + Bo (750 mg/l) and T_{13}- NPK + Bo (150 mg/l). The major nutrients like NPK (19:19:19) @ 2g/l at the vegetative stage and (0:52:34) from mono-potassium phosphate @ 1g/l at the flowering stage were sprayed in all the treatments as foliar sprays, respectively, at weekly intervals. Other nutrients like Calcium in the form of calcium sulphate, magnesium in the form of magnesium sulphate, iron in the form of ferrous sulphate, zinc in the form of zinc sulphate, copper in the form of copper sulphate and boron in the form of boric acid were sprayed at fortnightly interval. Calcium and magnesium were diluted in single distilled water; on the other hand, iron, zinc and copper were diluted in double distilled water and boron was diluted in normal water. For one treatment, 250 ml of solution was used per spray for 18 plants. During summer, irrigation was applied twice a week, and during winter, irrigation was done once a week. In this experiment, observations for plant height (cm), leaf length (cm), leaf breadth (cm), the interval of leaf production (days) and days required for first flowering after planting (days) were recorded. Data were recorded at monthly intervals after spraying of nutrients as per the treatments. For parameters like plant height (cm), leaf length (cm) and leaf breadth (cm) the data were presented at three months intervals. The data were statistically analysed by using a completely randomized design (CRD). The data at three months intervals was statistically analysed by using OPSTAT to observe the growth trend of plant height (cm), leaf length (cm) and leaf breadth (cm). Wherever the F- test was found to be significant, the critical difference (CD) at a 5 per cent significance level was calculated. The observations of perennial plants of *Dendrobium* hybrid Airy White were measured at several stages of the plants and plant sampling was done at each stage, the resulting set of the data was referred to as measurement over time with plot sampling suggested by Gomez and Gomez (1983). On the basis of the design, the observations had been analysed as a two-factor CRD using OPSTAT, where the first factor was years of cultivation and the second factor was 13 different treatments.

RESULTS

The two years observations with respect to plant height (cm), leaf length (cm) and leaf breadth (cm) at three month interval are presented in Table 1-3, to observe their growth trend. To observe the effect of treatments on plant growth over the years of cultivation the data was recorded in the first and the second year and presented in Table 4. The interval of leaf production (days) and days required for first flowering after planting (days) is presented in Table 5 and Table 6 respectively**.** The mean data concerning plant height were recorded at 3, 6, 9, 12, 27, 30, 33 and 36 months after treatment (MAT) and presented in Table 1. The data showed significant variation in plant height in all the recorded months by the effect of different nutrients. At different growth stages, the height of the plant was improved. Among the various treatments, on 3 MAT, the treatment T_7 (11.48 cm) had maximum plant height and after that, T_2 recorded maximum plant height from 6 MAT to 36 MAT *viz*., 13.38 cm (6 MAT), 20.61cm (9 MAT), 22.77 cm (12 MAT), 35.06 cm (27 MAT), 36.56 cm (30 MAT), 38.77 cm (33 MAT) and 40.01 cm (36 MAT) whereas in control (T_1) the minimum plant height from 9.95 cm (3 MAT) to 33.15 cm (36 MAT) was recorded. Statistically at par results with the treatment T_7 (11.48 cm) on 3 MAT were observed in T_8 (11.43 cm), T_9 (11.09 cm), T_2 (11.03 cm), T_{10} (10.63 cm) and T_{13} (10.52 cm). The treatments T_7 (13.36 cm), T_{12} (12.92 cm), T_8 (12.82 cm), T_{11} (12.55cm), T_{10} (12.35 cm) and T_6 (12.02 cm) showed statistically at par results with the treatment T_2 on 6 MAT. 0n 9 MAT, statistically at par results with the highest value of plant height were given by T_8 (20.42 cm), T_{11} (20.13 cm), T_7 (19.10 cm) and T_{13} (18.65 cm). Statistically at par results with the treatment T_2 on 12 MAT were observed in T_8 (22.73 cm), T_7 (22.456cm), T_{11} (22.45 cm), T_9 (21.43 cm), T_5 (21.15 cm), T_{13} (20.56 cm) and T_{10} (20.53 cm). 27 MAT, the treatments T_8 (34.02 cm), T_{10} (33.91 cm), T_7 (33.85 cm), T_9 (33.11 cm), T_5 (32.96 cm) and T_3 (32.42 cm) observed statistically at par results with T_2. Statistically at par results with the maximum plant height on 30 MAT were shown by the treatments T_8 (36.22 cm), T_{10} (36.20 cm), T_7 (36.18 cm), T_4 (36.11 cm), T_5 (34.66 cm), T_3 (33.89 cm) and T_9 (33.60 cm). Treatments that observed statistically at par results on 33 MAT with T_2 were T_8 (38.54 cm), T_7 (38.21 cm), T_{10} (37.83 cm), T_4 (37.54 cm), T5 (37.46 cm), T_3 (35.95 cm), T_{13} (35.20 cm), T_{12} (35.91 cm) and T_9 (35.68 cm). On 36 MAT statistically at par results with the highest value (40.01cm) were found in T_8 (39.64 cm), T_7 (39.55 cm), T_{10} (38.99 cm), T_4 (38.63 cm), T_5 (38.18 cm), T_9 (37.00 cm), T_{13} (36.66 cm), T_3 (36.54 cm) and T_{12} (36.36 cm). The plant height of *Dendrobium* hybrid Airy White significantly differed between the first year and second year of cultivation (Y_1 and Y_2) and among the treatments (T) (Table no.4). But in the case of interaction between two factors, the response was non-significant. Among the years (Y), the more average height (37.25 cm) was obtained in Y_2. Treatment T_2 gave the maximum plant height (31.39 cm) and the minimum plant height (25.17 cm) was given by T_1. Statistically at par results among treatments with the highest value (T_2) were shown by T_8 (31.18 cm), T_7 (31 cm) and T_{10} (29.76 cm). Interaction between year and different treatments, Y_1T_2 and Y_2T_2 observed maximum plant height i.e., 22.77 cm and 40.01 cm respectively while Y_1T_1 and Y_2T_1 showed minimum plant height (17.18 cm and 33.15 cm respectively). The results on the effect of nutrients on leaf length are presented in Table 2. The recorded data revealed significant differences among all the treatments from 3 MAT to 36 MAT. Maximum leaf length was obtained in T_5 on 3 MAT and 6 MAT (9.35 cm and 9.73 cm respectively), T_8 on 9 MAT (10.42 cm), 12 MAT (11.02 cm), 27MAT (15.28 cm) and 30 MAT (15.51 cm), 33 MAT (16.10 cm) and 36 MAT (16.31 cm). While T_1 recorded minimum leaf length from 3 MAT to 36 MAT with an average of 7.59 cm to 14.67 cm. Treatments T_8 (9.14 cm), T_2 (9.12 cm), T_{12} (8.30 cm), T_9 (8.28 cm) and T_3 (8.21 cm) on 3 MAT recorded statistically at par results with which was the highest value of the leaf length (9.35 cm). 6 MAT at par data with the highest value i.e., T_5 were shown by T_8 (9.55 cm), T_2 (9.44 cm) and T_4 (9.18 cm). Statistically at par results with T_8 on 9 MAT were given by T_2 and T_5 i.e., 10.18 cm. On 12 MAT, T_5, T_2 and T_{10} (10.72 cm, 10.65 cm and 10.50 cm respectively) had statistically at par results with the maximum value. Statistically at par results on 27 MAT and 30 MAT were recorded by T_2 (14.88 cm and 15.48 cm respectively), T_{10} (14.99 cm and 15.46 cm respectively) and T_5 (14.78 cm and 15.15 cm respectively). On 33 MAT, T_2 and T_{10} gave statistically at-par results with T_8 having values of 16.07 cm and 15.46 cm respectively. Statistically at par results with T_8 on 36 MAT were recorded in treatments T_2 (16.31 cm), T_{10} (16.15 cm) and T_{11} (15.95 cm). The year of cultivation (Y) and the different treatments (T) had a significant effect on the leaf length of *Dendrobium* hybrid Airy White but the interaction between year (Y) and treatments (T) had a non-significant effect (Table no.4). The year Y_2 observed the longest average leaf length (15.81 cm). Among various treatments, T_8 showed the longest leaf length (13.74 cm) which was followed by T_2 (13.48 cm) and T_{10} (13.33 cm). The shortest leaf length (12.29 cm) was observed in T_1. Among the combinations of year (Y) and treatment (T), the values ranged from 9.91 (Y_1T_1) cm to 11.02 cm (Y_1T_8) and 14.67 cm (Y_2T_1) and 16.46 cm (Y_2T_8). As per the data presented in Table 3, with the application of nutrients, the difference among various treatments regarding leaf breadth was significant from 6 MAT to 36 MAT. The highest value for leaf breadth was found in T_4 (1.62cm) after 6 MAT, T_8 after 9 MAT (1.96 cm), 12 MAT (2.28 cm), 27 MAT (2.76 cm), 30 MAT (3.00 cm), 33 MAT (3.21 cm) and 36 MAT (3.43 cm). The lowest average leaf breadth of 1.49 cm to 3.15 cm from 6 MAT to 36 MAT was given by T_1 (control). Statistically at par results were given by T_8 (1.61 cm), T_{11} (1.60 cm), T_5 and T_7 having the value of 1.59 cm, T_{13} (1.58 cm), T_2 (1.57 cm) and T_{12} (1.54 cm) with T_4 on 6 MAT. The treatments T_2 (1.95 cm), T_7 (1.94 cm), T_{11} (1.94 cm), T_4 (1.91 cm), T_{13} (1.91 cm), T_{12} (1.90 cm), T_5 (1.89 cm) and T_3 (1.86 cm) showed statistically at par results with T_8 on 9 MAT. On 12 MAT, at par results with maximum value were recorded with the treatment of T_2 (2.25 cm), T_7 (2.24 cm), T_{12} (2.23 cm), T_5 (2.22 cm) and T_{11} (2.19 cm). Statistically at par results on 27 MAT were given by T_7 (2.70 cm), T_2 (2.68 cm), T_4 (2.66 cm), T_{11} (2.64 cm) and T_3 (2.63 cm) and T_{10} (2.63 cm). On 30 MAT, treatments T_2 (2.97 cm), T_7 (2.95 cm), T_{10} (2.87 cm) and T_5 (2.85 cm) and T_{11} (2.85 cm) recorded statistically at par results with T_8. Statistically at par results with the highest value on 33 MAT were recorded in T_2 (3.20 cm), T_7 (3.18 cm), T_{10} (3.13 cm), T_5 (3.12 cm) and T_{11} (3.10 cm). On 36 MAT, statistically at par results were found in T_2 (3.42 cm), T_7 (3.41 cm), T_{10} (3.37 cm), T_5 (3.36 cm), T_6 (3.34 cm) and T_{12} (3.33 cm) with the highest value of treatment T_8 (3.43 cm).

Table 1: Effect of different nutrients on plant height (cm) of *Dendrobium* hybrid –'Airy White' in Terai Region of West Bengal.

Plant Height (CM)								
Treatments	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**	**27 MAT**	**30 MAT**	**33 MAT**	**36 MAT**
T_1	9.95	10.78	15.50	17.18	29.07	30.61	31.60	33.15
T_2	11.03	**13.38**	**20.61**	**22.77**	**35.06**	**36.56**	**38.77**	**40.01**
T_3	10.40	11.94	15.84	17.91	32.42	33.89	35.95	36.54
T_4	10.00	11.96	18.47	20.40	33.77	36.11	37.57	38.18
T_5	10.17	11.51	17.67	21.15	32.96	34.66	37.46	38.99
T_6	10.21	12.02	15.74	18.04	31.89	32.42	33.44	34.06
T_7	**11.48**	13.36	19.10	22.46	33.85	36.18	38.21	39.55
T_8	11.43	12.82	20.42	22.73	34.02	36.22	38.54	39.64
T_9	11.09	11.89	17.22	21.43	33.11	33.60	35.68	37.00
T_{10}	10.63	12.35	17.94	20.53	33.91	36.20	37.83	38.99
T_{11}	10.19	12.55	20.13	22.45	32.04	33.15	33.80	35.04
T_{12}	10.43	12.92	17.37	20.73	31.58	33.04	35.91	36.36
T_{13}	10.52	11.85	18.65	20.56	31.61	32.94	35.20	36.66
SE(m) ±	**0.33**	**0.46**	**0.73**	**0.77**	**0.94**	**1.15**	**1.41**	**1.25**
C.D. at 5%	**0.98**	**1.36**	**2.12**	**2.24**	**2.74**	**3.35**	**4.11**	**3.65**

* MAT- Months after treatment

Table 2: Effect of different nutrients on leaf length (cm) of *Dendrobium* hybrid-'Airy White' in Terai Region of West Bengal.

Leaf Length (CM)								
Treatments	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**	**27 MAT**	**30 MAT**	**33 MAT**	**36 MAT**
T_1	7.59	8.04	9.13	9.91	13.62	14.04	14.36	14.67
T_2	9.12	9.44	10.18	10.65	14.88	15.48	16.07	16.31
T_3	8.21	8.56	9.09	10.08	14.45	14.75	15.14	15.76
T_4	8.08	9.18	9.75	10.29	14.38	14.95	15.50	15.95
T_5	**9.35**	**9.73**	10.18	10.72	14.78	15.15	15.56	15.85
T_6	7.64	8.25	9.26	10.09	14.46	14.90	15.19	15.55
T_7	7.59	8.22	9.34	10.16	14.71	15.01	15.40	15.80
T_8	9.14	9.55	**10.42**	**11.02**	**15.28**	**15.51**	**16.10**	**16.46**
T_9	8.28	8.66	9.42	10.07	14.12	14.79	15.29	15.61
T_{10}	7.34	8.33	9.71	10.50	14.99	15.46	15.95	16.15
T_{11}	7.25	7.77	9.03	10.11	14.67	15.10	15.70	15.95
T_{12}	8.30	8.62	9.36	10.27	13.84	14.36	15.12	15.72
T_{13}	8.13	8.64	9.10	10.01	14.39	14.67	15.38	15.77
SE(m)±	**0.41**	**0.26**	**0.20**	**0.20**	**0.18**	**0.16**	**0.12**	**0.22**
C.D. at 5%	**1.19**	**0.75**	**0.59**	**0.58**	**0.53**	**0.47**	**0.35**	**0.64**

* MAT- Months after treatment

Table 3: Effect of different nutrients on leaf breadth (cm) of *Dendrobium* hybrid Airy White in Terai Region of West Bengal.

Leaf Breadth (CM)								
Treatments	**3 MAT**	**6 MAT**	**9 MAT**	**12 MAT**	**27 MAT**	**30 MAT**	**33 MAT**	**36 MAT**
T_1	1.32	1.49	1.78	2.07	2.47	2.66	2.91	3.15
T_2	1.36	1.57	1.95	2.25	2.68	2.97	3.20	3.42
T_3	1.33	1.51	1.86	2.15	2.63	2.82	3.06	3.30
T_4	**1.44**	**1.62**	1.91	2.16	2.66	2.81	3.07	3.32
T_5	1.38	1.59	1.89	2.22	2.58	2.85	3.12	3.36
T_6	1.29	1.51	1.82	2.09	2.59	2.79	3.06	3.34
T_7	1.30	1.59	1.94	2.24	2.70	2.95	3.18	3.41
T_8	1.32	1.61	**1.96**	**2.28**	**2.76**	**3.00**	**3.21**	**3.43**
T_9	1.27	1.51	1.79	2.12	2.58	2.79	3.01	3.26
T_{10}	1.31	1.53	1.83	2.15	2.63	2.87	3.13	3.37
T_{11}	1.34	1.60	1.94	2.19	2.64	2.85	3.10	3.30
T_{12}	1.31	1.54	1.90	2.23	2.62	2.84	3.09	3.33
T_{13}	1.33	1.58	1.91	2.21	2.58	2.80	3.06	3.29
SE(m)$\pm$	**0.03**	**0.03**	**0.04**	**0.03**	**0.04**	**0.05**	**0.04**	**0.03**
C.D. at 5%	**N/A**	**0.08**	**0.12**	**0.09**	**0.13**	**0.15**	**0.11**	**0.10**

* MAT- Months after treatment

Table 4: Effect of the years of cultivation and different treatments on plant height (cm), leaf length (cm) and leaf breadth (cm) of *Dendrobium* hybrid -'Airy White' in Terai Region of West Bengal.

	Plant Height (Cm)			**Leaf Length (Cm)**			**Leaf Breadth (Cm)**		
Years (Y)	**Y_1**	**Y_2**	**Mean**	**Y_1**	**Y_2**	**Mean**	**Y_1**	**Y_2**	**Mean**
	20.64	**37.25**	28.94	10.299	**15.813**	13.056	2.18	**3.33**	2.76
SE(m)$\pm$ of Y	**0.29**			**0.058**			**0.01**		
CD at 5% of Y	**0.82**			**0.165**			**0.03**		
Treatments (T)	**Y_1**	**Y_2**	**Mean**	**Y_1**	**Y_2**	**Mean**	**Y_1**	**Y_2**	**Mean**
T_1	17.18	33.15	25.17	9.91	14.67	12.29	2.07	3.15	2.61
T_2	**22.77**	**40.01**	**31.39**	10.65	16.31	13.48	2.25	3.42	2.83
T_3	17.91	36.54	27.23	10.08	15.76	12.92	2.15	3.30	2.73
T_4	20.40	38.18	29.29	10.29	15.95	13.12	2.16	3.32	2.74
T_5	21.15	38.99	30.07	10.72	15.85	13.29	2.22	3.36	2.79
T_6	18.04	34.06	26.05	10.09	15.55	12.82	2.09	3.34	2.71
T_7	22.46	39.55	31.00	10.16	15.80	12.98	2.24	3.41	2.82
T_8	22.73	39.64	31.18	**11.02**	**16.46**	**13.74**	**2.28**	**3.43**	**2.85**
T_9	21.43	37.00	29.22	10.07	15.61	12.84	2.12	3.26	2.69
T_{10}	20.53	38.99	29.76	10.50	16.15	13.33	2.15	3.37	2.76
T_{11}	22.45	35.04	28.75	10.11	15.95	13.03	2.19	3.30	2.75
T_{12}	20.73	36.36	28.55	10.27	15.72	13.00	2.23	3.33	2.78
T_{13}	20.56	36.66	37.25	10.01	15.77	12.89	2.21	3.29	2.75
SE(m)$\pm$ of T	**0.73**			**0.15**			**0.02**		
CD at 5% of T	**2.09**			**0.42**			**0.07**		
SE(m)$\pm$ of Y X T	**1.04**			**0.21**			**0.03**		
CD at 5% of Y X T	**NS**			**NS**			**NS**		

The years of cultivation (Y) and treatments (T) significantly increased the leaf breadth and in combination, the response was non-significant (Table 4). The maximum leaf breadth (3.33 cm) was found in Y_2 which significantly differed from Y_1. Treatment T_8 observed the maximum leaf breadth (2.85 cm) between the treatments and T_1 observed the minimum leaf breadth (cm).

Statistically at par results with T_8 were found in T_2 (2.83 cm), T_7 (2.82 cm), T_5 (2.79) and T_{12} (2.78 cm). In combination between year (T) and treatments (T), Y_1T_8 and Y_3T_8 observed the maximum leaf breadth (2.28 cm and 3.43 cm respectively) and the minimum leaf breadth was given by Y_1T_1 and Y_2T_1 (2.07 cm and 3.15 cm). On the interval of leaf production, the response of years of cultivation (Y) and different treatments (T) and their interaction were significant (Table 5). In the years of cultivation, Y_2 took the minimum of days (16.19 days) for the production of new leaves which significantly differed from Y_1.

Among the use of different treatments minimum days taken for leaf production (14.10 days) was by treatment

T_2 which was followed by T_8 (14.83 days) and the maximum days taken for leaf production were by T_{13} (19.87 days). The combination of years of cultivation and treatments, the minimum days (13.16 days) for leaf production were taken by Y_2T_2 which was statistically at par with Y_2T_3 (13.94 days), Y_2T_9 (13.69 days), Y_2T_8 (14.11 days) and Y_1T_2 (15.04 days). The maximum days for the production of leaves (21.03 days) were observed in Y_1T_{13}. It was also observed that the interval of leaf production in the first year was more as compared to the second year. The data for days required for first flowering after planting (days) is presented in Table 6 and Fig. 2. The effect of different nutrients was significant on days required for first flowering. The minimum days for first flowering after planting (297.21 days) was taken by the treatment T_8 which was followed by T_2 (303.22 days), T_7 (306.72 days) and T_9 (311.92 days). The maximum days for first flowering after planting (357.50 days) was taken by control (T_1).

Table 5: Effect of the years of cultivation and different treatments on the interval of leaf production (days) of *Dendrobium* hybrid Airy White in Terai Region of West Bengal.

Interval of leaf production (days)			
Years (Y)	**Y_1**	**Y_2**	**Mean**
	18.60	16.19	17.40
SE(m)$\pm$ of Y	**0.19**		
CD at 5% of Y	**0.53**		
Treatments (T)	Y_1	Y_2	Mean
T_1	20.70	18.17	19.44
T_2	**15.04**	**13.16**	**14.10**
T_3	18.18	13.94	16.06
T_4	20.51	15.42	17.97
T_5	21.32	17.39	19.35
T_6	21.08	18.52	19.80
T_7	16.88	14.89	15.88
T_8	15.55	14.11	14.83
T_9	19.54	13.69	16.62
T_{10}	20.25	18.55	19.40
T_{11}	15.26	16.93	16.09
T_{12}	16.52	16.94	16.73
T_{13}	21.03	18.70	19.87
SE(m)$\pm$ of T	**0.48**		
CD at 5% of T	**1.36**		
SE(m)$\pm$ of Y X T	**0.69**		
CD at 5% of Y X T	**1.92**		

Table 6: Effect of different nutrients in days required for flower bud initiation after planting of *Dendrobium* hybrid- 'Airy White' in Terai Region of West Bengal.

Flower Bud Initiation From Planting (Days)	
Treatments	**Days**
T_1	357.50
T_2	303.22
T_3	331.89
T_4	330.06
T_5	349.33
T_6	336.94
T_7	306.72
T_8	297.21
T_9	311.92
T_{10}	340.75
T_{11}	354.17
T_{12}	336.06
T_{13}	325.94
SE(m)$\pm$	**4.96**
CD at 5%	**14.49**

DISCUSSION

Numerous physiological processes of plants involve nutrient status within the plants. Mengel and Kirkby (2001) stated that it activates many enzyme systems that control leaf and root growth. The application of micronutrients along with NPK on the *Dendrobium* Hybrid Airy White had a significant effect on the vegetative characters as compared with the control (T_1). The growing year or season also had a significant response to the growth attributes. In the 2nd year (Y_2), the vegetative parameters significantly increased from the 1st year (Y_1). The vegetative parameters increased in the 2nd year as orchid is a perennial crop. In the combination of the growing year (Y) and the treatment (T), the vegetative parameters like plant height, leaf length, leaf breadth and interval of leaf production showed non significant effect. The application of nutrients significantly influenced the height of the plant as compared to the control. With the application of NPK + Calcium @500 mg/l (T_2), there was an increase in the height of the *Dendrobium* hybrid in all the recorded months. Naik *et al.*, (2013) in *Cymbidium* hybrid, and Saikia *et al.*, (2018) in *Rhynchostylis retusa* reported similar observations of increasing plant height due to the application of calcium.

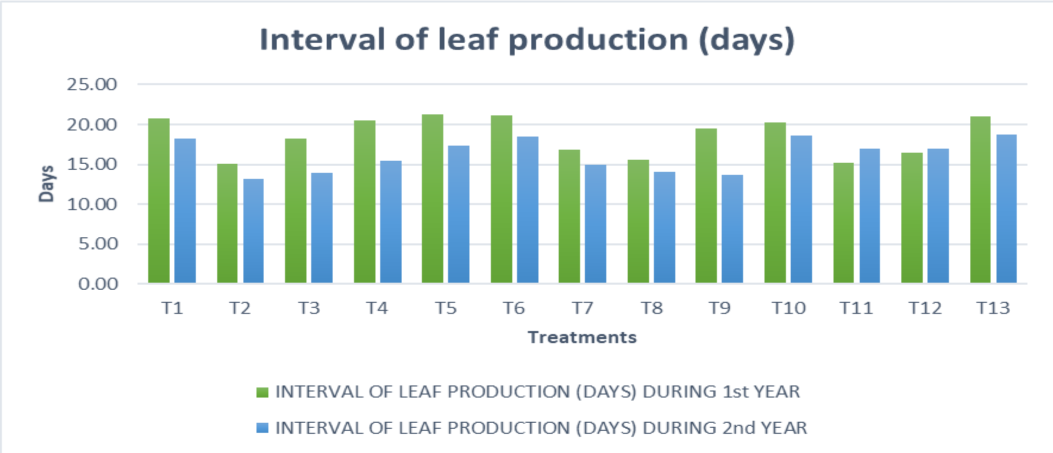

Fig. 1. Graphical representation Interval of leaf production in 1st Year and 2nd Year as influenced by spraying of different foliar nutrients in *Dendrobium* hybrid–'Airy White' in Terai Region of West Bengal.

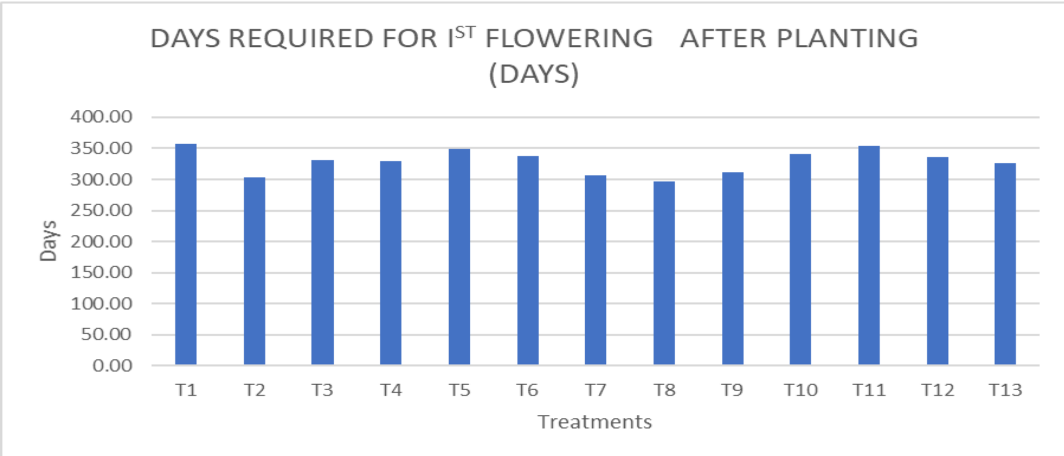

Fig. 2. Graphical representation of days required for 1st flowering after planting as influenced by spraying of different foliar nutrients in *Dendrobium* hybrid – 'Airy White' in Terai Region of West Bengal.

Calcium serves as the foundation for cell walls in orchids. Due to its interaction with the pectin in cell walls, it is related to the tissue's hardness. Calcium may have a beneficial effect on cell metabolism, cell wall construction, and the internal portion of the cell wall, which is involved in the cross-linking of pectic molecules, contributing to calcium's ability to promote plant growth (Saikia *et al.*, 2018). Additionally, Ferguson and Drobag (1998) stated that calcium played a role in different types of growth responses, such as mitosis, cytoplasmic streaming, gravitropism, phytochrome responses and the actions of cytokines gibberellin and auxin. The leaf length and breadth of the *Dendrobium* hybrid also differed significantly by the application of different nutrients and it was also statistically at par with NPK + Calcium @500 mg/l (T_2). The plants which were treated with NPK + Zinc @ 250 mg/l (T_8) produced the maximum leaf length and breadth. It has been found that zinc contributes to the coagulation of nitrogen metabolism and auxin concentration, which might have expanded the length and breadth of leaves in orchid plants. Similar findings were reported by Saud *et al.,* (2016) in *Dendrobium* hybrid Sonia; Ganga *et al*., (2009) in *Dendrobium* hybrid cv. Sonia 17; Sharova *et al*., (1977) in gladiolus. Data on the interval of leaf production (days) and days required for first flowering after planting (days) clearly showed significant influences due to the applications of nutrients as spraying. The interval of leaf production was also affected by the production of new leaves. Leaf production at the minimum interval was observed in the *Dendrobium* hybrid treated with NPK and Calcium at 15 days intervals (T_2). Calcium has a significant impact on cell metabolism, cell wall construction, and the internal portion of the cell wall which is involved in the cross-linking of pectic molecules, which might explain why calcium has a positive effect on encouraging plant growth as suggested by Saikia *et al.,* (2018). The minimum days taken for the first flowering after planting were observed when treated with NPK + Zinc (T_8). Zinc application has a favourable impact on *Dendrobium* hybrid for early flowering. The application of zinc enhances plant nutrition, which travels from the leaves to the shoot apical meristem to promote early flowering (Aimsworth, 2006). According to Cakmak (2000), zinc showed correct hormonal levels in plants, which promotes early maturation and as a result, early flowering might have occurred. Chen *et al.,* (1982) also found that zinc plays a role in the manufacture of plant hormones, which caused and brought for shortening of the gap between shoot to matured (fully developed) for initiation of flower buds. These findings were also supported by Saikia *et al*., 2018in *Rhynchostylis retusa* and Saud *et al.* (2016) in *Dendrobium* hybrid Sonia. Similar to this, Khosa *et al*. (2011) showed that the days to first flower emergence in *Gerbera jamesonii* were positively influenced by the foliar application of micronutrients (Zn, Bo, Fe and Mn) in conjunction with macronutrients. Kumar and Haripriya (2010) in Nerium found early flowering with the application of Zinc.

CONCLUSION

From this experiment, it might be concluded that under the environmental conditions of Cooch Behar, West Bengal, India, Calcium in the form of calcium sulphate (500 mg/l) and Zinc in the form of zinc sulphate (250 mg/l) applied as a foliar spray at an interval of 15 days along with NPK (19:19:19) @ 2g/l at the vegetative stage once in a week and (0:52:34) from mono-potassium phosphate @ 1g/l at the flowering stage once in a week is suitable for improving vegetative attributes and initiation of flowering of *Dendrobium* hybrid orchid. The standard as well as balanced nutrients including macro and micronutrient application enhance proper growth and development; as a result, it can increase the return of the farming communities who are engaged with the production of *Dendrobium* hybrid orchids. Further, the experiment can be carried out to observe the effect of nutrients on *Dendrobium* hybrid Airy White over its commercial production continuing up to 8 years from planting and also experiments can be carried out to see the effect of the interaction of different micronutrients on *Dendrobium* hybrid Airy White.

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