



## RESEARCH PAPER

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## Growth performance of orchid (*Dendrobium* Sp.) as influenced by different npk spray concentration

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**Key words:** Breeding, spray, formulation, *Dendrobium*, cultivars.

<http://dx.doi.org/10.12692/ijb/4.7.15-27>

Article published on April 01, 2014

### Abstract

A pot experiment was conducted at the net house of Plant Breeding and Biotechnology laboratory of Agrotechnology Discipline, Khulna University, during the period from October 2012 to May 2013 to study the growth performance of orchid (*Dendrobium* sp.) as influenced by different NPK spray concentration. Four spray formulations: control (Tap water), spray formulation 1 (N: P: K=90:90:45 or 2:2:1), spray formulation 2 (N: P: K=135:90:90 or 3:2:2), spray formulation 3 (N: P: K=180:135:90 or 4:3:2) and two cultivars (*Dendrobium* Red Bull and *Dendrobium* Sacula Pink) were used as treatment variables. The experiment was laid out in Completely Randomized Design (CRD) under factorial arrangement with three replications. Spray formulation had significant influence on growth of the two cultivars tested. The highest plant height (18.61 cm), stem diameter (1.01 cm), leaf number (11.17), leaf length (13.42 cm), leaf width (3.05 cm), leaf area (39.89 cm<sup>2</sup>), total leaf area (455.77 cm<sup>2</sup>), leaf area index (0.09), root length (3.12 cm) were found in *Dendrobium* Red Bull. *Dendrobium* Sacula Pink produced more number of roots and root diameter. The maximum plant height (19.03 cm), leaf number (11.83), leaf length (13.83 cm), leaf area (41.78 cm<sup>2</sup>), total leaf area (497.86 cm<sup>2</sup>), leaf area index (0.09) were recorded in spray formulation 3 (S<sub>3</sub>). In all the studied parameters control produced lower results. The results showed that *Dendrobium* Red Bull with spray formulation 3 performed better in most of the studied parameters. Further investigation is needed to find out the efficacy of spray formulation on both vegetative and reproductive stages of *Dendrobium* cultivars.

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## Introduction

Orchids belong to the largest and most diverse family orchidaceae consisting of about 700-800 genera and more than 25000 species (Begum, 2000). Orchids have occupied top position among the flowering plants valued for cut flowers as well as pot plants. They are famous for their longer lasting vase life and beauty which fetch a very high price from the international market. They account for 27% of global cut flower production in terms of value (Singh, 1986). In Bangladesh, the environmental conditions required for the survival and culture of orchid are adequately favourable throughout the year. Various species of orchids are abundantly distributed in the country (Chowdhury, 1975). Export potential of orchids from Bangladesh has a bright prospect in future.

The genera of orchids which are commercially important are *Cymbidium*, *Dendrobium*, *Phalaenopsis*, *Oncidium*, *Vanda*, *Mokara*, *Arachnis* and *Cattleya* (Laws, 2004). Among these genera, *Dendrobiums* are most popular tropical orchid getting fame as cut flowers in the world (Sugapriya *et al.*, 2012). Potted hybrid *Dendrobium* plants are being cultivated at an ever-increasing rate (Baker and Baker, 1996). Rapid growth, easiness of plantlet regeneration, beauty of flower, year round production in control flowering and long lasting of the flower stalk is the advantages of *Dendrobium* (Talukder 2002).

Orchid can't uptake nutrient significantly from root so foliar nutrient application is very widespread practice in orchid cultivation. Nitrogen, Phosphorus and Potassium with different concentration is commonly used as foliar spray. Orchid should be potted in small container according to the size of the plants. It prefers plastic pots which retain moisture longer than mud pots (Patil and Singh, 2003).

As the orchids are slow growing, slow release fertilizer mixtures (NPK) can be used to get best result (Hagaki, 2007). Application of spray nutrient containing NPK with different concentration varied

on the basis of growth stage of plants. During vegetative growth large quantities of nitrogen are required. Nutrient solution of NPK plays a vital role in the growth and development of orchid.

Growth features are the first concern for better comprehending about the potential mood of orchid variety. The basic information esteems the growth character and agreeable physiological traits are the almost momentous contemplation for orchid cultivation. Orchid can not uptake nutrient significantly from root so foliar nutrient application is very widespread practice in orchid cultivation. Nitrogen, phosphorus and potassium with different concentration are commonly used as foliar spray. Orchids having flowers of charming beauty and good keeping qualities, they are the most wonderful items for indoor decorations (Patil, 2001). As cut flower and pot plants orchids are high demandable items. They are also in different purposes as fragrant, glue, medicine, drinks and flavoring. Orchids are marketed globally and the orchid industry has contributed substantially to the economy of many Asian countries (Laws, 1995). Thailand is now most important centre for orchid trade and exports about over 100 million dollars in a year (Singh, 2008). There is a scope of large scale production of orchid in Bangladesh to meet the demand of international market and to earn foreign currency through export (Mondal, 2011). To be a prosperous orchid producer its first concern in to comprehend the growth feature and department of orchid.

Therefore, fertilizer application as spray should be considered wisely. However, there is not much available information on fertilizer application as spray in *Dendrobium* sp. (*Dendrobium* Red Bull and *Dendrobium* Sacula Pink) in Bangladesh.

The present study is est the effect of N, P and K in spray concentration for proper growth of two *Dendrobium* cultivars.

## Materials and methods

The pot experiment was conducted to study the

growth performance of orchid (*Dendrobium* sp.) as influenced by different NPK spray concentration at the net house of Plant Breeding and Biotechnology Laboratory of Agrotechnology Discipline, Khulna University, Khulna during the period from October 2012 to May 2013.

#### *Experimental Material*

Two cultivars of Orchid (*Dendrobium* sp.) were collected from Dipto Orchid Nursery, Valuka, Mymensingh in the month of October, 2012. Age of clone was about three months. These clones were separated from mother plants and cultured for eight months with coconut husk as a supporting material. The plants were potted singly in 6 inches standard round light brown plastic pots on 4 October, 2012 in a root substrate consisting of coconut husk and hanged with the help of wire from a bamboo stem. Immediately after potting, plants were watered by tap water with the help of hand sprayer.

#### *Experimental Site*

The experiment was conducted in the net house of Plant Breeding and Biotechnology Laboratory of Agrotechnology Discipline, Khulna University, Khulna during the period from October 2012 to May 2013 to determine the effect of nitrogen, phosphorus and potassium spray formulations on the growth of orchid (*Dendrobium* sp.).

#### *Experimental Treatments*

There were two factors used in this experiment viz. orchid variety and spray formulation. In the present experiment two cultivars of *Dendrobium* sp. and three spray formulations were used along with a control where only tap water was used.

Factor A: Two Orchid cultivars

1. Dendrobium Red Bull
2. Dendrobium Sacula Pink

Factor B: Four levels of spray formulation

- a. Control (Tap water)
- b. Spray formulation 1 (N:P:K=90:90:45 or 2:2:1)

c. Spray formulation 2 (N:P:K=135:90:90 or 3:2:2)

d. Spray formulation 3 (N:P:K=180:135:90 or 4:3:2)

A single plant represented an experimental unit and each treatment was replicated three times. Thus, the total numbers of plants were 24 (8×3) in the experiment.

#### *Spray Nutrient Formulation*

The spray solution was prepared by mixing of urea, triple super phosphate and muriate of potash. Formulation was prepared by following guide line of BARI, where total amount of fertilizer to be 700 g/ 172 liters water was recommended for use as spray (Sanaullah, 2001). The formulation used in present research contained different ratio of nitrogen, phosphorus and potassium. The total amount of nitrogen, phosphorus and potassium ratio required for eight months was subdivided in respect of growth period.

#### *Subdivision of spray formulation composition*

##### *Water Management*

Frequent application of water is essential in orchid cultivation. During the period, October, 2012 – February, 2013, watering was done once a day and February-May 2013 watering was done twice a day. Watering was done by hand sprayer.

##### *Shading*

As epiphytes most orchids avoid direct sunlight under natural condition. Orchids prefer dappled shade. Jute cloth was used for covering net house and creating artificial shade.

##### *Plant Protection Measures*

To control Brown rot, towin 50WP @10 mg/500 ml was sprayed at an interval of 7 days started from March 2013 to April 2013.

##### *Collection of Data*

Data was collected periodically during the growing period of orchid. The data was recorded on the following growth parameters Such as Plant height,

Stem diameter, Number of leaves plant<sup>-1</sup>, Leaf length, Leaf width, Leaf area, Total leaf area, Total leaf area, Leaf area index, Number of roots plant<sup>-1</sup>, Root length and Root diameter.

#### *Plant Height*

The height of plant was measured in centimeter from ground level to top of the main stem by measuring scale at the interval of 40 days during the study period.

#### *Leaf Length*

Length of leaves was measured with a measuring scale in centimeter of 5 randomly selected leaves from each pot at the interval of 40 days and their average was calculated and expressed in centimeter.

#### *Leaf Width*

Width of leaves was measured with a measuring scale in centimeter of 5 randomly selected leaves from each pot at the interval of 40 days and their average was calculated and expressed in centimeter.

#### *Leaf Area*

The leaf area was determined by multiplying leaf length with leaf width and expressed in square centimeter.

#### *Total Leaf Area*

Total leaf area was determined by summation of all leaf area and as expressed in square centimeter.

#### *Leaf Area Index*

Leaf area index is the ratio of total leaf area to total ground area. Leaf area index was determined by dividing individual leaf area to individual ground area.

$$\text{Leaf Area Index} = \frac{\text{Total Leaf area}}{\text{Total Ground area}}$$

#### *Stem Diameter*

Stem diameter was measured by electronic digital caliper at the middle portion of stem and express in centimeter.

#### *Number of Roots Plant<sup>-1</sup>*

Number of roots per plant was measured by counting manually all roots in plant from each pot at the interval of 40 days.

#### *Number of Leaves Plant<sup>-1</sup>*

Number of leaves plant<sup>-1</sup> was measured by counting manually all leaves in plant from each pot at the interval of 40 days.

#### *Root Length*

Root length was measured with a measuring scale in centimeter of 5 randomly selected roots from each pot at the interval of 40 days and their average was calculated and expressed in centimeter.

#### *Root Diameter*

Root diameter was measured by slide calipers at the middle portion of root and expressed in centimeter.

#### *Experimental Design*

The experiment was laid out in factorial completely randomized design (CRD) with eight treatments and three replications.

#### *Statistical Analysis*

The collected data for growth parameters was analyzed for variance (ANOVA) with the help of computer package program MSTAT-C and mean difference was compared by Duncan's New Multiple Range Test (DMRT).

### **Results and discussion**

This chapter comprises the discussion of result obtained from the experiments conducted during October, 2012 to May, 2013 to study the growth performance of orchid (*Dendrobium* sp.) as influenced by different NPK spray concentration. The results are discussed below.

#### *Plant Height*

The plant height varied significantly between the two cultivars of orchids namely *Dendrobium* Red Bull (V<sub>1</sub>) and *Dendrobium* Sacula Pink (V<sub>2</sub>). At 90 DAP, plant height of *Dendrobium* Red Bull (V<sub>1</sub>) and *Dendrobium* Sacula Pink (V<sub>2</sub>) was 11.13 cm and 10.10 cm,

respectively. With the increase of age the plant height gradually increased. At 290 DAP, plant height of Dendrobium Red Bull (V<sub>1</sub>) was 18.61 cm and was statistically higher than the height of Dendrobium Sacula Pink (15.60 cm) (Table 1). In case of plant

height Dendrobium Red Bull performed better than Dendrobium Sacula Pink. The variation in plant height between the varieties might be attributed to the genetic constitution.

**Table 1.** Effect of cultivar on plant height and stem diameter.

Cultivar	Plant height (cm) at DAP						Stem Diameter (cm) at DAP					
	90	130	170	210	250	290	90	130	170	210	250	290
Dendrobium Red Bull	11.13	12.20	13.70	15.26	16.90	18.61	0.94	0.95	0.96	0.98	0.99	1.01
Dendrobium Sacula Pink	10.10	10.86	11.92	12.93	14.13	15.60	0.93	0.94	0.95	0.96	0.97	0.99
Level of Significance	**	**	**	**	**	**	**	**	**	**	**	**
CV%	3.49	2.93	3.67	3.94	4.56	5.51	1.07	1.22	1.19	0.92	0.83	1.25

N. B. \*\* = significant at 1% level of probability, DAP = Days after Planting.

Different treatments of spray formulation had significant effects on plant height (Table 2). At 90 DAP, maximum plant height (10.97 cm) was recorded in spray formulation 1 (S<sub>1</sub>) which was statistically similar with spray formulation 3 (10.90 cm) and minimum (9.82 cm) was observed in control. Finally, at 290 DAP, the maximum plant height (19.03 cm) was recorded in spray formulation 3 (S<sub>3</sub>) and the

minimum (12.67 cm) where only water was applied (Table 2). Plant height of orchids was lesser in control than with the application of spray formulation which indicated that different nutrients as spray formulation showed significant effect on plant height. These findings are in agreement with the investigation of Manik (2009).

**Table 2.** Effect of spray formulation on plant height and stem diameter.

Spray Formulation	Plant height (cm) at DAP						Stem Diameter (cm) at DAP					
	90	130	170	210	250	290	90	130	170	210	250	290
Control (S <sub>0</sub> )	9.82c	10.33c	10.88c	11.47c	12.02c	12.67c	0.93c	0.94	0.95c	0.96c	0.96d	0.98c
Spray formulation 1 (S <sub>1</sub> )	10.97a	11.87a	13.37b	14.88a	16.52b	18.32b	0.93c	0.94	0.95c	0.97b	0.98c	1.00b
Spray formulation 2 (S <sub>2</sub> )	10.77b	11.78a	13.35b	14.70a	16.38b	18.40b	0.95a	0.95	0.97a	0.98a	1.0a	1.02a
Spray formulation 3 (S <sub>3</sub> )	10.90a	11.60b	13.63a	15.32b	17.15a	19.03a	0.94b	0.95	0.96b	0.98a	0.99b	1.02a
Level of Significance	**	**	**	**	**	**	*	NS	*	**	**	**
CV%	3.49	2.93	3.67	3.94	4.56	5.51	1.07	1.22	1.19	0.92	0.83	1.25

N. B. In a column figures having similar letters do not differ significantly whereas figures having dissimilar letters differ significantly as per DMRT, \*\* = significant at 1% level of probability, \* = significant at 5% level of probability, NS = Non Significant, DAP = Days after Planting.

#### Stem Diameter

Varietal effect of stem diameter was found significant.

With the advancement of growing period stem diameter increased gradually in both the cultivars.

Throughout the studied period stem diameter was found higher in Dendrobium Red Bull ( $V_1$ ) than Dendrobium Sacula Pink ( $V_2$ ). At 290 DAP, stem

diameter of Dendrobium Red Bull ( $V_1$ ) increased upto 1.01 cm and Dendrobium Sacula Pink ( $V_2$ ) upto 0.99 cm. (Table 1).

**Table 3.** Effect of cultivar on number of Leaves Plant<sup>-1</sup> and leaf length.

Cultivar	Number of Leaves Plant <sup>-1</sup> at DAP						Leaf Length (cm) at DAP					
	90	130	170	210	250	290	90	130	170	210	250	290
Dendrobium Red Bull	4.33	5.50	6.58	7.92	9.50	11.17	11.08	11.43	11.79	12.46	12.84	13.42
Dendrobium Sacula Pink	3.50	4.42	5.33	6.33	7.83	9.42	9.65	10.16	10.84	11.46	11.98	12.57
Level of Significance	**	**	**	**	**	**	**	**	**	**	**	**
CV%	10.42	13.65	9.06	6.41	6.66	3.97	4.31	4.52	4.10	3.80	3.53	3.36

N. B. \*\*= significant at 1% level of probability, DAP = Days after Planting.

Stem diameter varied statistically. Although stem diameter significantly varied between spray formulation 2 ( $S_2$ ) and spray formulation 3 ( $S_3$ ) at 90, 170, 250 DAP, but ultimately at 290 DAP, stem diameter was found similar (1.02 cm) in both the

treatments. Later minimum stem diameter of stem was found in control (Table 2). Kabir (2007) investigated that the liquid fertilizers a significant effect on stem diameter.

**Table 4.** Effect of spray formulation on number of Leaves Plant<sup>-1</sup> and leaf length.

Spray Formulation	Number of Leaves Plant <sup>-1</sup> at DAP						Leaf Length(cm) at DAP					
	90	130	170	210	250	290	90	130	170	210	250	290
Control ( $S_0$ )	3.33c	4.00c	4.33d	5.33c	6.17d	7.33d	9.98c	10.16c	10.44c	10.76c	11.01c	11.23c
Spray formulation 1 ( $S_1$ )	4.33a	5.50a	6.67b	8.00a	9.83b	11.17b	10.28b	10.81b	11.34b	11.99b	12.48b	13.19b
Spray formulation 2 ( $S_2$ )	3.67b	4.67b	5.83c	7.17b	8.67c	10.83c	10.68a	11.08a	11.67a	12.46a	13.00a	13.73a
Spray formulation 3 ( $S_3$ )	4.33a	5.67a	7.00a	8.00a	10.00a	11.83a	10.52b	11.13a	11.81a	12.64a	13.15a	13.83a
Level of Significance	**	**	**	**	**	**	*	**	**	**	**	**
CV%	10.42	13.65	9.06	6.41	6.66	3.97	4.31	4.52	4.10	3.80	3.53	3.36

N. B. In a column figures having similar letters do not differ significantly whereas figures having dissimilar letters differ significantly as per DMRT, \*\*= significant at 1% level of probability, \*=significant at 5% level of probability, DAP = Days after Planting.

#### Number of leaves plant<sup>-1</sup>

The number of leaves plant<sup>-1</sup> was statistically significant at 90, 130, 170, 210, 250 and 290 DAP. The numbers of leaves were 4.33, 5.50, 6.58, 7.92, 9.50 and 11.17 in Dendrobium Red Bull ( $V_1$ ) and 3.50, 4.42, 5.33, 6.33, 7.83 and 9.42 in Dendrobium Sacula

Pink ( $V_2$ ), respectively (Table 3). It was observed that leaf number increased progressively with the advancement of age. Dendrobium Red Bull ( $V_1$ ) produced more number of leaves plant<sup>-1</sup> compared to Dendrobium Sacula Pink ( $V_2$ ). It might be cultivars impact on number of leaves plant<sup>-1</sup>.

Application of different spray formulation significantly affected the number of leaves plant<sup>-1</sup>. The maximum number of leaves plant<sup>-1</sup> was produced with spray formulation 3 (S<sub>3</sub>) which was similar with spray formulation 1 (S<sub>1</sub>) at 90, 130, 210 DAP. Finally maximum (11.83) number of leaf plant<sup>-1</sup> was obtained

from spray formulation 3 (S<sub>3</sub>) and minimum (7.33) from control (Table 4). Sobhana and Rajeevan (1993) reported that number of leaves plant<sup>-1</sup> was influenced by spray formulation which was similar to the present findings.

**Table 5.** Effect of cultivar on leaf width and leaf area.

Cultivar	Leaf Width(cm) at DAP						Leaf Area(cm <sup>2</sup> ) at DAP					
	90	130	170	210	250	290	90	130	170	210	250	290
Dendrobium Red Bull	2.53	2.60	2.68	2.77	2.88	3.05	28.06	29.76	31.65	34.64	37.07	39.89
Dendrobium Sacula Pink	2.52	2.58	2.65	2.72	2.79	2.87	24.29	26.18	28.76	31.22	33.56	36.56
Level of Significance	NS	NS	NS	*	**	**	**	**	**	**	**	**
CV%	2.51	2.23	2.31	2.52	2.74	2.60	4.23	4.48	4.86	4.43	4.83	10.32

N. B. \*\*= significant at 1% level of probability, DAP = Days after Planting.

#### Leaf length

Significant differences were observed between the two cultivars of orchid namely Dendrobium Red Bull (V<sub>1</sub>) and Dendrobium Sacula Pink (V<sub>2</sub>). At 90 DAP, leaf length was higher in Dendrobium Red Bull (V<sub>1</sub>) (11.08 cm) than Dendrobium Sacula Pink (V<sub>2</sub>) (9.65 cm). Length of the leaf gradually increased with the advancement of experiment period. At 290 DAP, the average leaf length was recorded 13.42 cm and 12.57

cm in Dendrobium Red Bull (V<sub>1</sub>) and Dendrobium Sacula Pink (V<sub>2</sub>), respectively (Table 3). It was observed that during the whole period of the experiment, the leaf length was relatively higher in Dendrobium Red Bull (V<sub>1</sub>) than Dendrobium Sacula Pink (V<sub>2</sub>). Therefore, it was concluded that Dendrobium Red Bull (V<sub>1</sub>) performed better than Dendrobium Sacula Pink (V<sub>2</sub>) in respect of leaf length.

**Table 6.** Effect of spray formulation on leaf width and leaf area.

Spray Formulation	Leaf Width (cm) at DAP						Leaf Area (cm <sup>2</sup> ) at DAP					
	90	130	170	210	250	290	90	130	170	210	250	290
Control (S <sub>0</sub> )	2.41b	2.46b	2.51b	2.57b	2.62b	2.69b	24.08c	25.01c	26.32d	27.58d	28.82d	30.13c
Spray formulation 1 (S <sub>1</sub> )	2.56a	2.64a	2.72a	2.82a	2.94a	3.07a	26.34b	28.50b	30.88c	33.86c	36.68c	40.59b
Spray formulation 2 (S <sub>2</sub> )	2.56a	2.63a	2.70a	2.79a	2.89a	3.04a	27.26a	29.08a	31.53b	34.76b	37.66b	40.42b
Spray formulation 3 (S <sub>3</sub> )	2.57a	2.63a	2.72a	2.81a	2.90a	3.04a	27.01a	29.28a	32.08a	35.62a	38.11a	41.78a
Level of Significance	**	**	**	**	**	**	**	**	**	**	**	**
CV%	2.51	2.23	2.31	2.52	2.74	2.60	4.23	4.48	4.86	4.43	4.83	10.32

N. B. In a column figures having similar letters do not differ significantly whereas figures having dissimilar letters differ significantly as per DMRT, \*\*= significant at 1% level of probability, \*=significant at 5% level of probability, NS = Non Significant, DAP = Days after Planting.



Leaf length varied significantly for different treatments (Table 4). At 90 DAP, the highest leaf length was 10.68 cm in spray formulation 2 (S<sub>2</sub>) and the lowest was 9.98 cm in control. At 130, 170, 210, 250 and 290 DAP, higher value of leaf length was found in spray formulation 3 (S<sub>3</sub>) which was

statistically similar with spray formulation 2 (S<sub>2</sub>) (Table 4). Leaf length increased slowly in composition to different spray formulations which indicated that different spray formulations had effect on leaf length. Minimum leaf length was observed in control.

**Table 7.** Effect of cultivar on total leaf area.

Cultivar	Total Leaf Area (cm <sup>2</sup> ) at DAP					
	90	130	170	210	250	290
Dendrobium Red Bull	121.88	164.67	211.02	281.45	358.55	455.77
Dendrobium Sacula Pink	85.18	116.1	155.04	199.84	264.82	345.31
Level of Significance	**	**	**	**	**	**
CV%	9.50	12.93	10.29	8.05	5.79	10.89

N. B. \*\* = significant at 1% level of probability, DAP = Days after Planting.

#### Leaf Width

The width of leaves of two varieties showed nonsignificant results initially at 90, 130 and 170 DAP. Later with the advancement of growing period from 210 to 290 DAP the width of the leaves varied significantly (Table 5). Finally at 290 DAP, the width

of the leaves of plants terminated at 3.05 and 2.87 cm in Dendrobium Red Bull (V<sub>1</sub>) and Dendrobium Sacula Pink (V<sub>2</sub>), respectively (Table 5). Therefore, Dendrobium Red Bull (V<sub>1</sub>) performed better than Dendrobium Sacula Pink (V<sub>2</sub>) in respect of width of the leaves.

**Table 8.** Effect of spray formulation on total leaf area.

Spray Formulation	Total Leaf Area (cm <sup>2</sup> ) at DAP					
	90	130	170	210	250	290
Control (S <sub>0</sub> )	80.57d	99.82d	114.32d	147.37d	177.88d	221.15d
Spray formulation 1 (S <sub>1</sub> )	114.63b	157.56b	207.03b	272.48b	361.95b	455.95b
Spray formulation 2 (S <sub>2</sub> )	100.63c	136.42c	184.57c	250.47c	323.97c	427.20c
Spray formulation 3 (S <sub>3</sub> )	118.31a	167.74a	226.20a	292.27a	382.94a	497.86a
Level of Significance	**	**	**	**	**	**
CV%	9.50	12.93	10.29	8.05	5.79	10.89

N. B. In a column figures having similar letters do not differ significantly whereas figures having dissimilar letters differ significantly as per DMRT, \*\* = significant at 1% level of probability, \* = significant at 5% level of probability, DAP = Days after Planting.

Leaf width varied significantly due to spray formulation (Table 6). Three spray formulations showed statistically similar results. The leaf width was found lowest in control. Kabir (2007) reported that spraying with liquid fertilizer at 2-3 times per month facilitate large leaf width which was in agreement with the present findings.

#### Leaf area

The leaf area varied significantly between the two cultivars studied (Table 5). At 90 DAP, the total leaf area of Dendrobium Red Bull (V<sub>1</sub>) and Dendrobium Sacula Pink (V<sub>2</sub>) was recorded 28.06 cm<sup>2</sup> and 24.29 cm<sup>2</sup>, respectively. At 130 DAP, the average leaf area increased to 29.76 and 26.18 cm<sup>2</sup>, respectively for those two cultivars. Finally at 290 DAP average leaf area reached at 39.89 and 36.56 cm<sup>2</sup> of these two studied cultivars respectively (Table 5). The variation



in leaf area might occur due to variation in number of leaves and their expansion. The result obtained from the present study is consistent with the results of Sharma and Haloi (2001) who stated that variation in

leaf area might be attributed to the difference in number of leaves. Similar variation in respect of leaf area among varieties was also observed by Sugapriya *et al.* (2012).

**Table 9.** Effect of cultivar on leaf area index and number of roots plant<sup>-1</sup>.

Cultivar	Leaf Area Index at DAP						Number of Roots plant <sup>-1</sup> at DAP					
	90	130	170	210	250	290	90	130	170	210	250	290
Dendrobium Red Bull	0.02	0.03	0.04	0.05	0.07	0.09	4.25	5.50	7.42	9.00	11.50	13.50
Dendrobium Sacula Pink	0.01	0.02	0.02	0.04	0.05	0.06	5.50	7.08	8.75	10.67	12.67	14.75
Level of Significance	**	**	**	**	**	**	**	**	**	**	**	**
CV%	18.45	18.75	10.48	8.08	7.20	7.70	11.84	12.57	10.41	9.51	7.74	5.60

N. B. \*\* = significant at 1% level of probability, DAP = Days after Planting, NS = Non Significant.

Significant variation was observed in spray formulations in respect of leaf area (Table 6). Leaf area was higher in spray formulation 2 (S<sub>2</sub>) and spray formulation 3 (S<sub>3</sub>) at 90 and 130 DAP. Finally, the maximum leaf area (41.78 cm<sup>2</sup>) was observed in spray formulation 3 (S<sub>3</sub>) and minimum in control at 290 DAP (Table 6). In all treatments, in later stage

average leaf area increased which might be due to full growth of plants. Balance in spray formulation suitable for vegetative growth might also be responsible for leaf growth. Sobhana and Rajeevan (1993) reported that spray formulation enhanced the length of leaves, number of leaves per plant as well as leaf area which was in-line with the present findings.

**Table 10.** Effect of spray formulation on leaf area index and number of roots plant<sup>-1</sup>.

Spray Formulation	Leaf Area Index at DAP						Number of Roots plant <sup>-1</sup> at DAP					
	90	130	170	210	250	290	90	130	170	210	250	290
Control (S <sub>0</sub> )	0.01b	0.02b	0.02b	0.03b	0.03c	0.04c	4.50	5.17d	6.00d	7.17d	8.33d	9.33d
Spray formulation 1 (S <sub>1</sub> )	0.02a	0.03a	0.04a	0.05a	0.07a	0.08b	5.17	7.00a	9.17a	11.33a	14.00a	15.83a
Spray formulation 2 (S <sub>2</sub> )	0.02a	0.03a	0.04a	0.05a	0.06b	0.08b	5.00	6.67b	8.83b	10.83b	13.50b	16.00c
Spray formulation 3 (S <sub>3</sub> )	0.02a	0.03a	0.04a	0.05a	0.07a	0.09a	4.83	6.33c	8.33c	10.00c	12.50c	15.33b
Level of Significance	**	**	**	**	**	**	NS	**	**	**	**	**
CV%	18.45	18.75	10.48	8.08	7.20	7.70	11.84	12.57	10.41	9.51	7.74	5.60

N. B. In a column figures having similar letters do not differ significantly whereas figures having dissimilar letters differ significantly as per DMRT, \*\* = significant at 1% level of probability, \* = significant at 5% level of probability, DAP = Days after Planting.

#### Total leaf area

Cultivar effect was statistically significant in respect of total leaf area (Table 7). At 90 DAP, the total leaf area of Dendrobium Red Bull (V<sub>1</sub>) and Dendrobium Sacula Pink (V<sub>2</sub>) was 121.88 cm<sup>2</sup> and 85.18 cm<sup>2</sup>,

respectively. At 130 DAP, the total leaf area increased to 164.67 cm<sup>2</sup> and 116.10 cm<sup>2</sup>, respectively for those two cultivars. The total leaf area gradually increased with the increase of the age of plants. Finally at 290 DAP, the average total leaf area attained to 455.77

and 345.31 cm<sup>2</sup> in those two cultivars respectively (Table 7). Results revealed that between the two cultivars, total leaf area was much higher in

Dendrobium Red Bull (V<sub>1</sub>) than Dendrobium Sacula Pink (V<sub>2</sub>). Total leaf area was higher due to higher number of leaves and increased leaf area plant<sup>-1</sup>.

**Table 11.** Effect of cultivar on root length and root diameter.

Cultivar	Root Length (cm) at DAP						Root Diameter (cm <sup>2</sup> ) at DAP					
	90	130	170	210	250	290	90	130	170	210	250	290
Dendrobium Red Bull	2.56	2.67	2.83	2.95	3.07	3.12	0.13	0.16	0.16	0.17	0.19	0.22
Dendrobium Sacula Pink	2.51	2.59	2.69	2.78	2.90	3.02	0.19	0.18	0.21	0.23	0.24	0.26
Level of Significance	*	**	**	**	**	**	**	NS	**	**	**	NS
CV%	14.68	14.76	16.44	16.09	15.49	12.50	9.99	22.52	7.86	8.33	6.98	13.28

N. B. \*\*= significant at 1% level of probability, DAP = Days after Planting, NS = Non Significant.

Significant variation was noticed among the treatments in respect of total leaf area (Table 8). From 90 to 290 DAP, total leaf area was consistently higher in spray formulation 3 (S<sub>3</sub>) and lower in irrigation with water. At 290 DAP, the maximum total leaf area reached at 497.86a cm<sup>2</sup> while minimum was

221.15 in control (Table 8). Data found that trend of leaf area increment was relatively higher in spray formulation 3 (S<sub>3</sub>) over the growing period. This might be due to increased number of leaves and their expansion. These results were in agreement with the findings of Wang and Know (2004).

**Table 12.** Effect of spray formulation on root length and root diameter.

Spray Formulation	Root Length (cm) at DAP						Root Diameter (cm <sup>2</sup> ) at DAP					
	90	130	170	210	250	290	90	130	170	210	250	290
Control (S <sub>0</sub> )	1.87c	1.91c	2.09c	2.15c	2.21c	2.12c	0.14c	0.15c	0.15b	0.16b	0.16b	0.17b
Spray formulation 1 (S <sub>1</sub> )	2.61b	2.71b	2.81b	2.94b	3.08b	3.21b	0.17a	0.19a	0.20a	0.21a	0.23a	0.25a
Spray formulation 2 (S <sub>2</sub> )	2.87a	3.01a	3.12a	3.23a	3.37a	3.52a	0.17a	0.19a	0.21a	0.22a	0.23a	0.25a
Spray formulation 3 (S <sub>3</sub> )	2.80a	2.87a	3.02a	3.16a	3.28a	3.43a	0.16a	0.18b	0.19a	0.21a	0.22a	0.24a
Level of Significance	**	**	**	**	**	**	**	*	**	**	**	**
CV%	14.68	14.76	16.44	16.09	15.49	12.50	9.99	22.52	7.86	8.33	6.98	13.28

N. B. In a column figures having similar letters do not differ significantly whereas figures having dissimilar letters differ significantly as per DMRT, \*\*= significant at 1% level of probability, \*=significant at 5% level of probability, NS = Non Significant, DAP = Days after Planting.

#### Leaf Area Index

The leaf Area Index (LAI) recorded at different growth period i.e. 90,130,170, 210, 250 and 290 DAP, significantly varied between the two cultivars (Table 9). The leaf area index of Dendrobium Red Bull (V<sub>1</sub>) and Dendrobium Sacula Pink (V<sub>2</sub>) were 0.02 and

0.01, respectively at 90 DAP. Gradually the leaf area index was increased and finally reached at 0.09 and 0.06 for of Dendrobium Red Bull (V<sub>1</sub>) and Dendrobium Sacula Pink (V<sub>2</sub>) at 290 DAP, respectively (Table 9).

Leaf area index was influenced significantly with various levels of treatments (Table 10). From 90 to 210 DAP, leaf area index was statistically similar among all the treatments except control. At the end of the experiment, the maximum leaf area index (0.09) was found in spray formulation 3 ( $S_3$ ) and the lowest (0.04) in control (Table 10).



**Fig. 1.** Dendrobium Red Bull.



**Fig. 2.** Dendrobium Sacula Pink.

#### *Number of roots plant<sup>-1</sup>*

The root number of Dendrobium Red Bull ( $V_1$ ) and Dendrobium Sacula Pink ( $V_2$ ) ranged from 4.25-13.50 and 5.50-14.75, respectively over growing period (Table 9). Dendrobium Sacula Pink ( $V_2$ ) performed better than Dendrobium Red Bull ( $V_1$ ) in respect of root number.



**Fig. 3.** Control (Tap water) and prepared different spray formulations.

At 90 DAP, number of roots did not vary significantly. From 130 to 290 DAP, the number of roots showed significant result due to application of spray. Spray formulation 1 ( $S_1$ ) performed better than other treatments. Control showed the lowest value (Table 10). Thus root number increased in all level of nutrients. Higher level of nitrogen might affect root number adversely. The results were in agreement with Wang (1998).



**Fig. 4.** Plant height.

#### *Root length*

The root length varied significantly with the growing period. The average root length of Dendrobium Red Bull ( $V_1$ ) and Dendrobium Sacula Pink ( $V_2$ ) were 2.56 cm and 2.51 cm, respectively at 90 DAP. Gradually root length was increased and reached maximum at 3.12 cm at 290 DAP in Dendrobium Sacula Pink ( $V_2$ ) (Table 11). It was observed that during the whole period of the experiment the root length was relatively higher in Dendrobium Red Bull ( $V_1$ ) than Dendrobium Sacula Pink ( $V_2$ ).



**Fig. 5.** Leaf length.

Effect of spray formulation on length of roots was found significant (Table 12). Throughout the studied period the maximum root length (3.52 cm) was found in spray formulation 2 ( $S_2$ ) which showed statistically similar results with spray formulation 3 ( $S_3$ ) (Table

12).



**Fig. 6.** Leaf width.

#### *Root Diameter*

The average root diameter of *Dendrobium Red Bull* ( $V_1$ ) and *Dendrobium Sacula Pink* ( $V_2$ ) were 0.13 and 0.19 cm, respectively at 90 DAP. Gradually the diameter of root was increased. At the end of study period, higher root diameter was found in *Dendrobium Sacula Pink* ( $V_2$ ) (Table 11). It was observed during the whole period of the experiment that the root diameter was relatively higher in *Dendrobium Sacula Pink* ( $V_2$ ) than *Dendrobium Red Bull* ( $V_1$ ). Therefore, it is concluded that *Dendrobium Sacula Pink* ( $V_1$ ) may be superior to *Dendrobium Red Bull* ( $V_2$ ) in respect of root diameter.



**Fig. 7.** Number of roots.

From 90 to 290 DAP, similar root diameter was observed from three spray formulations throughout the experiment and lowest was in control. Root diameter did not vary significantly among the three spray formulations. Only control showed dissimilar results among the four studied treatments (Table 12).

#### **Acknowledgement**

The author reveals immense pleasure to express heartfelt indebtedness and deepest sense of gratitude to his honorable teachers, Dr. Mahtalat Ahmed,

Professor and other affiliated teachers and lab technicians, Agrotechnology Discipline, Khulna University, for their kind and painstaking guidance, compassionate help and inspiration in all phases of the study and preparation of the manuscript.

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