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Evaluation of Pot Phalaenopsis Orchids for Vegetative and Flowering characteristics under Shadenet House and Poly House Condition

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ABSTRACT: Phalaenopsis (*Phalaenopsis* sp.) is an economically significant ornamental potted plant around the world. Though Phalaenopsis orchids are slow in growth, the appropriate growing environmental condition greatly helps in hastening the vegetative phase because the growth of phalaenopsis is greatly influenced by environmental signals. A study was conducted at the Botanical Garden, Department of Floriculture and Landscape Architecture, Tamil Nadu Agricultural University, Coimbatore to evaluate the effect of two different environmental conditions *viz.*, Shade net house and polyhouse on plant growth and development during the flowering phase with 8 varieties of Phalaenopsis orchid. Among the eight varieties evaluated in the study, Washington showed the maximum plant height (28.67 cm), leaf length (23.08 cm), leaf breath (6.94 cm), internodal length (1.49 cm) and no. of roots (20.98) under shade-net house condition whereas under the poly house condition Bilbao showed the maximum plant height (26.75 cm), leaf length (23.02 cm), leaf breath (6.84 cm) and internodal length (1.41 cm). Under shade- net house, the flowering parameters *viz.*, floret length (7.09 cm) and floret diameter (7.55 cm) recorded maximum in the variety Volterra, while spike longevity (62.99 days), no. of flowers per spike (4.96) and no. of spikes per plant (2.00) recorded maximum in the variety Washington and the days taken for spike emergence (307.64 days) and first floret opening (360.98 days) was earlier than other varieties. Under poly house condition, the variety Bilbao had better performance in flowering parameters than the others. Evaluation of vegetative and flowering parameters resulted in the conclusion that the variety Washington, Bilbao, Nottingham, Andorra and Durban had the great adaptability under the tropical condition. While evaluating the performance of two different environmental conditions, the shade-net house recorded maximum vegetative growth and flowering of Phalaenopsis orchid than the polyhouse. The study aids in determining the ideal pot Phalaenopsis orchid variety for tropical climatic condition as well as the favourable growing environment for better growth and development of Phalaenopsis orchid.

Keywords: Phalaenopsis, Orchids, Environmental conditions, Shadenet house, Poly house, Vegetative parameters, Flowering parameters.

INTRODUCTION

Floriculture is one of the booming sectors because of its steady increase in demand of floriculture products such as loose flowers, cut flowers, pot plant, foliage plants, and dry flowers as well as the rising desire for the creation of both indoor and outdoor gardens (Rajendran and Smitha2016). The floriculture industry in India shows great promise for providing small and marginal farmers with profitable new sources of income. In recent years, it has developed into a lucrative agricultural enterprise both domestically and internationally. Human existence is not complete without flowers and ornaments. In Indian culture, flowers have great significance. India is a country that is abundant of flowers. Many of them have symbolic significance often represents love, peace or compliment.

Orchids, the most intriguing and stunning flowers in God's creation are exceptionally peculiar for their great variety of exotic colour, form, size, and shape, as well as capacity to thrive in a variety of settings, from

terrestrial to epiphytic. They are a part of one of the largest families of flowering plants, the Orchidaceae. With 600–800 genera and 25,000–35,000 species, it is the most highly evolved family of monocotyledons in terms of taxonomy. The world's multibillion-dollar floriculture industry is dominated by orchids. Today, orchids like *Cymbidium, Dendrobium, Oncidium,* and *Phalaenopsis* are sold all over the world, and the orchid business has made a significant contribution to the economies of many nations.

Phalaenopsis orchids, which is commonly called as moth orchid became the most popular commercial potted orchid because of its long-lasting blossoms, delicate texture, and high market value (Griesbach, 2002; Laws, 2004. According to De *et al.* (2013), the Phalaenopsis has about 70 species that are spread across Asia, the Philippines, Indonesia, Malaysia, Australia, and New Guinea. It is naturally cultivated in humid, warm, and continuously shaded evergreen woods in tropical and subtropical Asia. It is growing in popularity around the world and has significant commercial value due to its exotic form of flower, variety of colours, and durability, which allow for marketing and long-distance transportation.

The market for Phalaenopsis orchids is expanding quickly, making it the most significant potted orchid in the world (Wang, 2004). This orchid is being produced and imported more domestically than before.Initially, Phalaenopsis was primarily grown by orchid-focused nurseries. But now-a-days, this orchid is being grown alongside conventional flower crops because to the expanding supply of less expensive materials and the rising market demand.

In the US, the price and output of potted, blooming orchids have been rising. According to the United States Department of Agriculture (USDA), 8.6 million pots of orchids were sold as potted flowering plants in 1996. Phalaenopsis orchids made up the majority of the $79 million in wholesale value of potted orchids in 1999 (USDA, 2000), a 22% increase over 1998. According to Hew and Yong (1997), the total auction sales of potted Phalaenopsis orchids in Japan in 1993 were worth $103 million (U.S. dollars). In 1957, James Shoemaker wrote, "Orchid growing has not fully achieved the transition from a hobby to an industry." The cultivation of orchids is now a global business, not just a sector of the economy.

The drawback of the Phalaenopsis orchid is the lengthy period of time needed to create a flowering potted plant from a tissue cultured plant. Any crop or variety performance is highly influenced by the interaction of its genotype and environment. Therefore, the performance of variety alters as environmental conditions change. The adaptability of various cultivars under location-specific conditions must therefore be evaluated. When the plants are fully grown and are exposed to the right temperatures and amounts of light, phalaenopsis produce spike and bloom (Lin, 1984; Wang, 1995). The third and/or fourth basipetal mature leaves are typically where the potential flower spikes first appear (Lee and Lee 1996). According to Kataoka *et al.* (2004), temperature, photoperiod, and light intensity are all factors that influence the commencement of orchid flowers.

There has only been a limited amount of prior research on Phalaenopsis under the Tamil Nadu climatic conditions and further research is still required to create standardised commercial production methods. With greater information about this orchid, better production methods, and lower costs, similar success with Phalaenopsis orchids may be feasible. Keeping the previously mentioned details in consideration, the current study has been carried out with the goals of achieving early flowering and learning the impact of environmental conditions on various growth and flowering parameters.

METHODS AND MATERIALS

The study on potted Phalaenopsis orchid was carried out at the Botanical Garden**,** Department of Floriculture and Landscape Architecture, Tamil Nadu Agricultural University, Coimbatore. The trial on pot plant experiment was investigated between January 2023 and July 2023. The pots were kept under two different environmental conditions *viz*., 75% Shade net house and polyhouse to evaluate the vegetative and flowering phase of eight different varieties of Phalaenopsis orchid. The varieties used for evaluation were Andorra, Bilbao, Cali, Durban, Nottingham, Torino, Volterra and Washington. One-year-old tissue cultured plants of uniform size were used for the experiment. The planting materials were from M/s. Florance Flora Pvt. Ltd., a well-known, publicly recognized ornamental plant supplier in Bengaluru, Karnataka, India. The average height of the plants was 21 cm with 4-5 dark green coloured leaves and actively growing roots. The experiment was carried out in Factorial Completely Randomized Block Design (FCRD) with the two factors of eight varieties and two different environmental conditions, three replications and five plants in each replication. Throughout the experimentation period, weekly measurements of temperature, relative humidity (RH) were taken using Hygro-thermometer and light intensity using the light meter. During the crop time, under shade-net house and polyhouse the weekly mean temperatures, relative humidity, and light intensity varied from 25 to 34 degrees, 50 to 75%, 3000 to 6000 foot candles (fc), and 24 to 37 degrees, 40 to 85%, 5000 to 6500 foot candles (fc), respectively.

Observations were taken at flowering stage on the vegetative and flowering parameters and analysed statistically. The vegetative parameters are plant height (cm), number of leaves per plant, leaf length (cm), leaf breadth (cm), internodal length (cm), and number of roots per plant while the flowering parameters are days taken for spike emergence, days taken for first floret opening, spike longevity, floret length (cm), floret diameter (cm), spike length (cm), rachis length(cm), number of spikes per plant and number of flowers per spike. By using the ANOVA (analysis of variance) technique, the experimental data were statistically analysed (Panse and Sukhatme 1985).

RESULTS AND DISCUSSION

Vegetative parameters. The experimental data of vegetative parameters include plant height, number of leaves per plant, leaf length, leaf breadth, intermodal length and number of roots per plant were recorded under two different environmental condition *viz.*, Shade-net house and Poly house during the flowering phase of the plant and statistically analyzed and is shown in Table 1 and 2 respectively.

The variations among the eight varieties of Phalaenopsis orchid under two different environmental condition were evaluated (Table 1& Table 2).

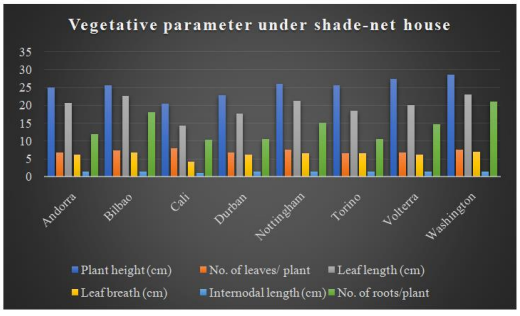
Table 1: Vegetative growth parameters of eight different pot Phalaenopsis varieties under shade net condition

Variety	Plant height(cm)	No. of leaves/plant	Leaf length(cm)	Leaf breath(cm)	Internodal length(cm)	No. of roots/plant
Andorra	24.97	6.79	20.66	6.08	1.33	11.84
Bilbao	25.61	7.29	22.59	6.73	1.39	18.05
Cali	20.54	7.89	14.26	4.17	1.04	10.33
Durban	22.87	6.77	17.73	6.14	1.34	10.58
Nottingham	26.06	7.46	21.31	6.53	1.47	15.13
Torino	25.53	6.49	18.47	6.61	1.36	10.56
Volterra	27.39	6.73	20.00	6.13	1.40	14.68
Washington	28.67	7.49	23.08	6.94	1.49	20.98
SEd	0.157	0.223	0.370	0.133	0.041	0.304
CD (0.05)	0.372	0.527	0.873	0.270	0.083	0.619

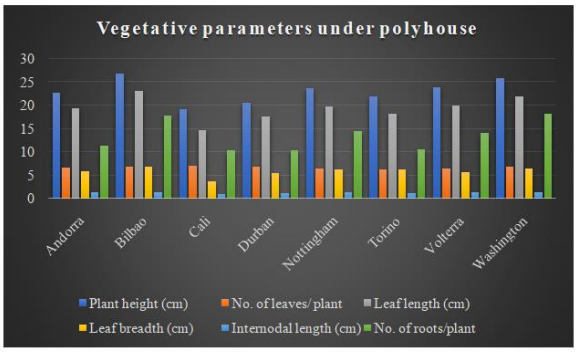
Table 2: Vegetative growth parameters of eight different pot Phalaenopsis varieties under poly house condition.

Variety	Plant height(cm)	No. of leaves/plant	Leaf length(cm)	Leaf breadth(cm)	Internodal length(cm)	No. of roots/plant
Andorra	22.74	6.68	19.37	5.76	1.30	11.36
Bilbao	26.75	6.83	23.02	6.84	1.41	17.76
Cali	19.08	7.06	14.59	3.72	0.98	10.30
Durban	20.50	6.76	17.58	5.50	1.13	10.34
Nottingham	23.72	6.43	19.79	6.23	1.25	14.49
Torino	21.90	6.29	18.16	6.15	1.21	10.49
Volterra	23.82	6.44	19.99	5.65	1.27	14.07
Washington	25.83	6.81	21.93	6.40	1.33	18.14
SEd	0.157	0.223	0.370	0.133	0.041	0.304
CD (0.05)	0.372	0.527	0.873	0.270	0.083	0.619

Under shade-net house, the variety Washington had the highest plant height (28.67 cm), followed by Volterra (27.39 cm), while under poly house, Bilbao had the highest plant height (26.75 cm), followed by Washington (25.83 cm). Out of all the varieties Cali had the lowest plant height (20.54 cm). Among the different growing structures, the plants grown under the shade-net house (25.20 cm) had the highest mean plant height as compared to polyhouse (23.04 cm), which may be due to the favourable growing conditions under the shade-net house. A similar result was observed by Fitch (2004), who reported better plant growth under the prevalence of favourable environmental conditions. The variation in the plant height among the varieties may be due to the genetic factors or biotic and abiotic factors. This finding correlates with the conclusions of Singh *et al.* (2014), who evaluated ten different varieties of Phalaenopsis in West Bengal, Anand *et al.* (2013), who examined orchid species in the Shevaroy Hills of the Eastern Ghats, and Sahare *et al.* (2018), who has carried out evaluation of anthurium under South Gujarat condition, Chen and Chen (2023), who examined Phalaenopsis orchid under Taiwan condition. Additionally, it has been shown that when plants are grown in a shade net house, the majority of the types showed greater plant height than when grown in a polyhouse. Identical findings in monopodial orchids were made by Kaveriamma (2007). According to Kano (2001), many subtropical and tropical hybrid plants flourish in temperatures about 30 °C.



(A) Vegetative parameters under shade-net house condition



(B) Vegetative parameters under polyhouse condition

Fig. 1. Graphical representation of vegetative parameters of eight different pot Phalaenopsis varieties.

Leaves are the primary functional component for photosynthesis, respiration, and transpiration which have a significant impact on growth and flowering. The number of leaves were recorded during the flowering period varied among the varieties which may be due to the genetic and environmental factors. Bose *et al.*, (1999) reported that environmental parameters including temperature, relative humidity, and light intensity also have an impact on number of leaves grow. The plants grown under the shade-net house (7.12) had the maximum number of leaves as compared to polyhouse (6.66) which may be due to the favorable growing condition under the shade-net house and the similar result was observed by Fitch (2004), who reported better plant growth under prevalence of favorable environmental condition. Among the varieties studied, the maximum number of leaves per plant were recorded in the variety Cali (7.89) and (7.06) under shade-net house and polyhouse respectively. The second highest number of leaves per plant were observed in the variety Washington under shade-net house (7.49) and the variety Bilbao under polyhouse (6.81). The least number of leaves per plant were observed in the variety Volterra (6.73) under shade-net house and Torino (6.29) under the poly house condition. Similar variation in number of leaves were observed in Dendrobium by Fadelah (2007); Agasimini *et al.* (2011) in anthurium under greenhouse condition at Dharwad, Sugapriya *et al.* (2012) in Dendrobium orchid at Dharwad, Singh *et al.* (2014) in Phalaenopsis orchid under controlled environmental condition at West Bengal, Nataraj *et al.* (2019) in anthurium at hilly zone of Karnataka.

Leaf length and leaf breadth of the plant plays an important role in photosynthetic efficiency. The area occupied by the plant under the growing environment is also influenced by the leaf length and breadth and thus it determines the plant density. The variation in leaf length and breadth among the varieties may be due to the result from the interaction of genotype and environment, as well as from genotypic differences in phenotypic expression (Henley and Robinson, 1995).

The leaves with more breadth and less leaf length are ideal for efficient photosynthetic activity, because the more narrowed leaves become droopy and affect the photosynthetic activity by reducing the surface area of the leaves. Similar results were noticed earlier by Dewi *et al.* (2014) and reported that the existence of leaves that are longer and narrower than the older leaves indicates that the light level is less than ideal and Singh *et al.* (2014) reported the similar effect in Phalaenopsis orchid. The maximum leaf length and breadth were observed in the variety Washington (23.08 cm) and (6.94 cm) respectively under the shade-net house condition whereas under the poly house condition Bilbao had the maximum leaf length (23.02 cm) and breadth (6.84 cm). Under both environmental conditions, Cali recorded the least leaf length (14.26 cm & 14.59 cm) and leaf breath (4.17 cm & 3.72 cm). Similar variation in leaf length was observed by Sebastian (2015) in the orchid Vanda Pompimol at Kerala, De *et al.* (2019) in Phalaenopsis orchid under Sikkim condition, Roni *et al.* (2016) in anthurium and Thirugnanavel *et al.* (2019) in Dendrobium at lower hills of Nagaland. The parallel results on leaf breadth variation were reported by Kaveriamma (2007) in monopodial orchid under Kerala condition, Anand *et al.* (2013) in *Rhyncostylis retusa* at the Eastern Ghats, Akshata *et al.* (2018) under Western Ghats and Seeja *et al.* (2019) in Spathoglottis under Thiruvananthapuram condition and Gowthami *et al.* (2022) in Phalaenopsis orchid under Coimbatore condition. Among the growing environmental condition, the shade net house (19.76 cm) & (6.16 cm) had demonstrated greatest mean leaf length and breadth compared to the polyhouse (19.30 cm) & (5.78 cm) respectively. Similar variations were also noted by Fitch (2004), who noted that quicker vegetative development was observed under higher temperatures when correlated with good air movement, bright light, and ideal humidity.

The internodal length determines the height of the plant and orientation of the leaf. Longer internodal length helps in better aeration and sunlight to the plant. As the phalaenopsis orchids grow slowly, the elongation of internode takes longer time. The highest internodal length was observed in the variety Washington (1.49 cm) followed by Nottingham (1.47 cm) under the shade net house condition while the highest internodal length under poly house was observed in Bilbao (1.41 cm) followed by Washington (1.33 cm). Under these two environmental conditions, Cali exhibited the least internodal length (1.04 cm & 0.98 cm). These observations were confirmed with the results of Thomas and Lekharani (2008) in monopodial orchids and Singh *et al.*, (2014) in Phalaenopsis orchid at West Bengal.

Additionally, it was noted that most types reported longer internodal lengths when grown in shade net houses as compared to polyhouse condition. These results are in parallel with the results of Roy chowdhury *et al.* (2004) in Dendrobium hybrids under polyhouse condition in North-East hills, Barman *et al.* (2007) in Cymbidium hybrids under mid hill zone in Sikkim and Thirugnanavel *et al.* (2019) in Dendrobium for its growth and yield under Nagaland conditions.

Since Phalaenopsis is an epiphyticorchid, the roots are mostly exposed outside. Its root possess chlorophyll content and they may also aid in the photosynthesis activity. The roots have specialized structure called velamen tissue which helps to absorb moisture and air from the atmosphere which is essential for proper growth of the plant. Among the environmental conditions, the maximum mean number of roots per plant was found in the shade net house (14.02), which was higher to the polyhouse (13.37). This result may be attributed to genetic differences and favourable growing environment elements like adequate air flow around the roots, good exposure of sunlight into the media for enhanced growth of partially photosynthetic roots, and ideal temperature and relative humidity. In the Phalaenopsis orchid, Ochsenbauer (2010) found a similar set of findings. Under the two environmental conditions, Washington recorded the maximum number of roots per plant (20.98 & 18.14) followed by Bilbao (18.05 & 17.76) respectively while variety Cali recorded the least number of roots per plant (10.33 & 10.30). Similar variation were noticed in Dendrobium by Thirugnanavel *et al.* (2019); Gowthami *et al.* (2022) in Phalaenopsis orchid under Coimbatore condition.

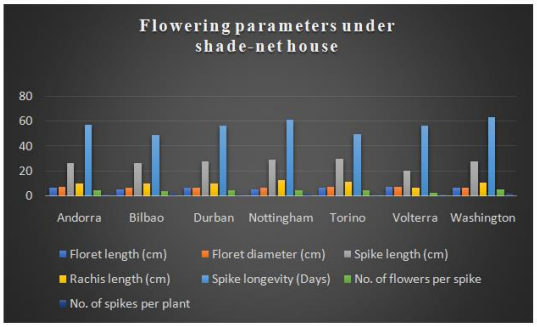
Flowering parameters: The flowering parameters which include days taken for spike emergence, days taken for first floret open, floret length, floret diameter, spike length, rachis length, spike longevity, number of flowers per spike and number of spikes per plant were recorded under two growing conditions and statistically analyzed which is presented in the Table 3&4 respectively.

Table 3: Flowering parameters of eight different pot Phalaenopsis varieties under shade net condition.

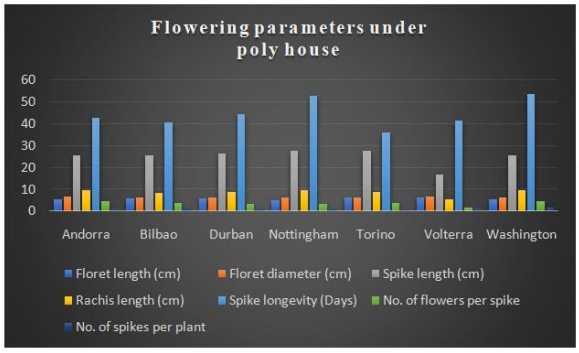
Variety	Days taken for spike emergence (Days)	Days taken for first floret open (Days)	Floret length (cm)	Floret diameter (cm)	Spike length (cm)	Rachis length (cm)	Spike longevity (Days)	No. of flowers per spike	No. of spikes per plant
Andorra	324.28	381.95	6.88	7.19	26.47	10.00	57.02	4.52	1.40
Bilbao	316.01	377.35	5.56	6.42	26.58	9.73	48.44	3.90	1.60
Durban	330.54	399.87	6.39	6.59	27.65	9.94	55.97	4.45	1.20
Nottingham	328.27	383.94	5.41	6.77	28.77	12.81	60.85	4.49	1.60
Torino	339.48	436.14	6.30	7.06	29.84	11.50	49.71	4.90	1.00
Volterra	350.58	447.58	7.09	7.55	20.55	6.64	56.31	2.42	1.00
Washington	307.64	360.98	6.35	6.73	27.52	10.80	62.99	4.96	2.00
Sed	2.316	4.507	0.292	0.230	0.587	0.720	1.229	0.218	0.109
CD (0.05)	5.477	10.659	0.691	0.543	1.388	1.702	2.906	0.516	0.260

Table 4: Flowering parameters of eight different pot Phalaenopsis varieties under poly house condition.

Variety	Days taken for spike emergence (Days)	Days taken for first floret open (Days)	Floret length (cm)	Floret diameter (cm)	Spike length (cm)	Rachis length (cm)	Spike longevity (Days)	No. of flowers per spike	No. of spikes per plant
Andorra	356.55	443.22	5.47	6.42	25.43	9.68	42.56	4.46	1.00
Bilbao	316.38	384.38	5.58	6.19	25.47	8.42	40.62	3.77	1.40
Durban	360.55	447.22	5.95	6.28	26.51	8.57	44.34	3.38	1.20
Nottingham	352.27	452.37	5.05	6.25	27.52	9.71	52.79	3.45	1.20
Torino	377.48	461.33	6.10	6.29	27.56	8.75	36.06	3.63	1.00
Volterra	395.91	488.37	6.17	6.69	16.60	5.42	41.58	1.49	1.00
Washington	322.64	390.21	5.51	6.24	25.59	9.37	53.69	4.61	1.40
SEd	2.316	4.507	0.292	0.230	0.587	0.720	1.229	0.218	0.109
CD (0.05)	5.477	10.659	0.691	0.543	1.388	1.702	2.906	0.516	0.260



(C) Flowering parameters under shade-net house condition



(D) Flowering parameters under polyhouse condition.

Fig. 2. Graphical representation of flowering parameters of eight different pot Phalaenopsis varieties.

Among all the varieties of Phalaenopsis orchid which were used for research, variety Cali did not bear spike throughout the trail period and hence it was not considered in the statistical analysis.

The days taken for spike emergence and first floret opening differed among the varieties. These variations in spike emergence and opening of first floret days reported may be due to genetic diversity among the several genotypes under investigation. Earlier mean spike emergence and floret open was observed in shade-net house (287.10 days) than the polyhouse (310.22 days). The variety Washington was observed to show early spike emergence (307.64 days) and first floret open (360.98 days) followed by Bilbao (316.01 days) & (377.35 days) under shade net house condition respectively. Under polyhouse condition, Bilbao showed the earlier spike emergence (316.38 days) and first floret opening (384.38 days). Furthermore, under both condition Volterra took a longer day for spike emergence (350.58 days & 395.91 days) and first floret open (447.58 days & 488.37 days) respectively than the other varieties. The beginning of the spike, its length, and its rate of growth all play a major role in determining the number of days until the first bloom opens (Singh *et al.,* 2014). The outcomes are on par with those of Roychowdhury *et al.* (2004), who observed comparable outcomes in Dendrobium N-E Indian hills, Singh *et al.* (2014) in Phalaenopsis under West Bengal condition and Thirugnanavel *et al.* (2019) in Dendrobium orchid at lower hills of Nagaland.

The variety Volterra recorded maximum floret length (7.09 cm) and floret diameter (7.55 cm) under the shade-net which was at par with Andorra in floret length (6.88 cm) and floret diameter (7.19 cm). Under polyhouse condition, the floret length (6.17 cm) and floret diameter (6.69 cm) were maximum in Volterra. Under both conditions, the least floret length was observed in Nottingham (5.41 cm & 5.05 cm) while the floret diameter was least in Bilbao (6.42 cm & 6.19 cm). According to the length and diameter of the floret were observed to be greater in some varieties of Phalaenopsis than in others, which may be related to the lengthening of the dorsal and lateral sepals of the floret and vice versa (De *et al.,* 2013) which is attributable to the genetic makeup of different varieties (Griesbach, 2002).

Similar difference in floret length and diameter among different genotypes were also observed by Fadelah (2007) in Dendrobium orchid, Tiwari *et al.* (2011) in *Cymbidium elegans*, De *et al.* (2019) in Phalaenopsis under protected environmental condition and Biswal *et al.* (2017) in Dendrobium.

The spike length is the important factor for cut flower purpose whereas for pot plants optimum spike length is required. The ideal spike size for pot plants is said to be superior so that it can stand strongly (Laws, 2004). The mean spike length was maximum under the shade net house (23.42 cm) compared to the polyhouse (21.84 days) condition. In Phalaenopsis orchid the flowering and inflorescence growth were delayed by the high temperature during the induction phase, and these negative impacts of high temperature on flowering exacerbated as temperature and duration increased (Qin *et al.,* 2012). Plant vegetative development is also a factor in the production of quality spikes. The variety Torino had the maximum spike length under shade net (29.84 cm) as well as under polyhouse (27.56 cm) condition followed by Nottingham (28.77 cm & 27.52 cm) respectively. The least spike length was observed in Volttera (20.55 cm & 16.60 cm).

In Dendrobium similar outcomes were mentioned by Patil *et al.* (2001); Roychowdhury *et al.* (2004); Kumar and Sharma (2013); Mehraj *et al.* (2014); and Thirugnanavel *et al.* (2019) in various agro climatic conditions.

The Rachis length was observed maximum in Nottingham under shade net (12.81 cm) and polyhouse (9.71 cm) which is followed by Torino (11.50 cm) under shade-net and Andorra (9.68 cm) under polyhouse condition. Similar to this, the report of varietal variation in rachis length was reported by Sugapriya *et al.* (2012) in Dendrobiumand De *et al.* (2019) in Phalaenopsis orchid.

For potted plants, the longevity of the flower spikes is a crucial consideration (Wang, 2004). The variety Washington recorded the maximum spike longevity under shade-net (62.99 days) and poly house (53.69 days) followed by Nottingham (60.85 days& 52.79 days). Under shade-net house, the least spike longevity was observed in Bilbao (48.44 days) while under poly house Torrino (36.06 days) had the least longevity of spike. According to Sakai *et al.,* (1995) and Nagare and Pal (2008), the genetic makeup of the variety determines how long the spikes remain on the plant. The long-lasting flower spike that Phalaenopsis is known for makes it the ideal pot plant. The total amount of carbohydrates may also be contributing factors.

Among the eight varieties, Washington had the maximum number of flowers per spike under both shade-net (4.96) and polyhouse (4.61) condition. While the least number of flowers per spike was recorded in the variety Volterra under both environmental condition (2.42 & 1.49) respectively. Jeong *et al.* (2020) found that number of flowers per spike declined up to 37% with increasing temperature at 34 °C in Phalaenopsis at Korea, suggesting that distinct variation in the number of flowers per spike may be caused by climatological as well as physical factors controlling growth and flowering (Berman *et al.*, 2007). In dendrobium similar results were achieved by Patil *et al.* (2001), Amin *et al.* (2004); Roychowdhury *et al.* (2004); Kumar and Sharma (2013); Mehraj *et al.* (2014); Thirugnanavel *et al.* (2019) under various agro-climatic conditions.

According to Patil (2001), variations in the number of spikes per plant per year may be attributed to larger leaf area, more leaves per plant, and leaf chlorophyll content. These factors would have produced and accumulated the most photosynthates, which in turn led to the production of more spikes. The variety Cali did not form a spike; hence, it may be concluded that the inadequate vegetative growth of plant led to their blindness. The maximum number of spikes per plant was observed in the variety Washington (2.00) under shade net house followed by Bilbao &Nottingham (1.60 & 1.60). Under poly house condition, both Washington (1.40) and Bilbao (1.40) recorded the highest number of spikes per plant. Conclusions from other studies in dendrobium by Moniruzzaman and Ara (2012); Sugapriya *et al.* (2012); Nataraj *et al.* (2019) in anthurium in Karnataka, support the conclusions of this study.

Overall, the shade net condition was superior to the polyhouse condition for flowering. Phalaenopsis has a low light need because it has evolved to thrive in the low light of tropical underbrush (Pridgeon, 2000). In a few orchid species, photoperiod has been found to control the onset of flowering. Floral spikes are initiated more successfully by 9-h light treatment than 12-h light treatment in *Doritis pulcherrima* (now *Phalaenopsis pulcherrima*) under the 30 °C/20 °C (day/night) environment (Wang *et al.*, 2003). The flower development and initiation are temperature-dependent processes; inflorescence initiation, also known as spiking, happens in mature plants after at least two to four weeks of temperatures below 26°C under otherwise favourable conditions (Runkle,2010). According to Tongerlo *et al.* (2021), the increase in light and temperature during the vegetative phase increased the number of flowers, flower buds and the number of spikes per plant.

CONCLUSIONS

The findings of this study provide practical implications for Phalaenopsis farmers to cultivate under tropical condition. From the study has been revealed that shade-net house showed the better performance of Phalaenopsis orchid than polyhouse in terms of both vegetative and flowering characters under tropical condition. It is concluded that among the eight varieties studied, the variety Washington showed the maximum vegetative and flowering parameters *viz*., Plant height, Leaf length, Leaf breadth, Internodal length, Number of roots per plant, Spike longevity, Number of flowers per spike and Number of spikes per plant under shade-net house condition. While under polyhouse condition, the variety Bilbao showed the maximum vegetative and flowering parameters *viz*., Plant height, Leaf length, Leaf breadth, Internodal length and Number of spikes per plant. Therefore, from the current investigation it is interfered that the variety Washington showed the better adaptability under tropical condition followed by Bilbao, Nottingham, Andorra and Durban while Cali was the least performing variety which did not even produce the spike during the trial period. Thus, this variety does not suit the tropical growing conditions.

FUTURE SCOPE

Houseplants and indoor gardening are becoming more and more popular around the world. Phalaenopsis orchids, with their exquisite and durable blossoms, quickly gains popularity among plant lovers seeking to spruce up and colour their indoor environments. The potted Phalaenopsis orchids have a vast and promising future because of this widespread use, versatility, and aesthetic appeal. As more people value them as houseplants or gifts for various occasions, the demand for these plants is increasing. The horticulture sector has experienced a significant economic impact as a result of the commercial production and international commerce of Phalaenopsis orchids. These orchids have been widely exported from nations like the Netherlands, Taiwan, and Thailand. Thus, phalaenopsis orchid production has recently become a lucrative industry both domestically and globally and the future potent scope is vast and promising.

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