STANDARDISATION OF AGROTECHNIQUES IN *PHALAENOPSIS* ORCHIDS

By
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(2010-12-118)

THESIS

Submitted in partial fulfilment of the requirement for the degree of

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DECLARATION

I hereby declare that the thesis entitled **"Standardisation of agrotechniques in *Phalaenopsis* orchids"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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Certified that the thesis entitled **"Standardisation of agrotechniques in *Phalaenopsis* orchids"** is a bonafide record of research work done independently by **Mr. Narender Negi** under my guidance and supervision and that it has not formed the basis for the award of any degree, diploma, fellowship or associateship to him.

Place: Vellanikkara
Date: 17-8-2012

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Introduction

1. INTRODUCTION

Orchids, often referred to as 'royals' in the plant kingdom are the most beautiful flowers among God's creation. They are the most pampered of plants occupying top position among all flowering plants and are valued for cut flower production and as potted plants. They are known for their beautiful flowers, which exhibit an incredible range of size, shape and colour, long life of flowers on the plants and an amazingly long keeping quality which no other plants can claim.

Orchidaceae, the perennial family of monocots, includes about 800 genera and 25,000-35,000 species and has to its credit of being the largest assemblage of flowering plants. The family Orchidaceae accounts for above seven per cent of the species of flowering plants of the world (Pijl and Dodson, 1966). They are either epiphytic, terrestrial or lithophytes; a few are saprophytic, subterranean or semi-aquatic. Atwood (1986) finds that about 73 per cent of the species are epiphytes. Epiphytic orchids have showier and more flamboyant flowers than terrestrial types, and invariably these are the ones that are primarily grown indoors, as well as in greenhouses and conservatories.

Commercially important orchids for as cut flowers belong to relatively few genera *viz*., *Arachnis*, *Cattleya*, *Cymbidium*, *Dendrobium*, *Epidendrum*, *Oncidium*, *Phalaenopsis*, *Vanda* and intergeneric hybrids like *Ascocenda*, *Aranda*, *Aranthera*, *Mokara*, *Vascostylis* etc. Orchid plants of rare species and hybrids fetch remarkable appreciation and command excellent price in the international market. The small proportion of the total international trade of cut flowers occupied by orchids highlight its potential to take an even greater stride in flower trade. Their low perishability during transit to long distances has made orchids one of the most outstanding floricultural exportable.

In the West, for a layman the name orchid is synonymous with *Phalaenopsis*. The genus *Phalaenospis* has around 80 species and over 40,000 man made hybrids, *i.e.* over 25 per cent of orchid hybrids are contributed by

Phlaenopsis alone. The major growing countries are Taiwan, Netherlands, USA, Japan, Germany and Thailand. Today, *Phalaenopsis* occupies number one position as pot plant and is one among the top 10 in the cut flower segment (Naqvi, 2010). However, this has not gained popularity in the Indian markets. Some pioneer works on this are taken up in Kerala Agricultural University in which environmental conditions are given priority.

In India orchid cultivation is mainly confined to the West costal belt and North East states. Commercial cultivation of orchids gained momentum in Kerala during the early nineties. Tropical orchids of both monopodials and sympodials are in cultivation in the state. Kerala is one of the few places in the world where sophisticated infrastructure is not required for orchid cultivation (Rajeevan, 1995).

Phalaenopsis orchids are suited to the tropical and subtropical environments and got potential to use as home plants as well as for commercial cultivation in Kerala. However, specific agrotechniques and others requirements for the crop have not been prescribed.

Standardisation of agro techniques and identification of the optimum plant type of *Phalaenopsis* suited to Kerala will be an advantage to orchid growers of the State. The result obtained from such studies will have practical implication at house hold level, as well as on commercial level. With this background, a study was undertaken at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, Kerala Agricultural University during May 2011 to April 2012 with the following objectives;

1. To find out the best plant type and environment suited for commercial cultivation of *Phalaenopsis*, and
2. To standardise the agrotechniques like type of pot, growing media and growing method suited for better growth and quality spikes

2. REVIEW OF LITERATURE

Orchids are believed to be in an active state of 'evolutionary flux'. The family Orchidaceae is the largest among flowering plants in terms of species diversity with 600-800 genera and 25,000-35,000 species. In India, about 1,300 species of orchids are scattered all over north-east Himalayas (600 species), north-west Himalayas (300 species), Maharashtra (130 species), Andaman and Nicobar islands (70 species) and Western Ghats (200 species) (Rajeevan, 2007). Today, there exist over a lakh and a half man made hybrids.

Orchids have very wide range of distribution. They are found to occur in all parts of the world except, perhaps, in the Antarctica. Though the family is cosmopolitan in occurrence many more species are found in the tropics than in the temperate regions (Abraham and Vatsala, 1981). Majority of the cultivated orchids are native of tropical countries and occur in their greatest diversity in humid tropical forests of South and Central America, Mexico, India, Sri Lanka (Ceylon), Myanmar (Burma), China, Thailand, Malaysia, Philippines, New Guinea and Australia (Arditti, 1992). Brazilian Cattleyas, Mexican Laelias and Indian Dendrobiums, Cymbidiums and Vandas have played a major role in the development of modern orchid industry in the world. In India, Kerala, Karnataka, Tamil Nadu, Maharashtra, Sikkim, West Bengal, Andaman's, hilly regions of Uttar Pradesh, Himachal Pradesh and entire North-eastern region are suitable for commercial cultivation of orchids (Singh, 1991).

Phalaenopsis is native to the jungles of the tropical and sub-tropical Asia, from Sikkim in the Himalayas, Indonesian archipelago, Phillipines, Taiwan, northern parts of Australia extending up to the South Pacific islands. An island in Taiwan is referred to as the 'orchid island' because of the abundance of *Phalaenopsis* orchids growing wild over there. In their native habitat, tropical condition persists throughout the year (Wang *et al.*, 2007). During the past decade, commercial production of orchids as potted flowering plants has increased tremendously throughout the world.

Commercial cultivation of orchids was started in India in early eighties and is expanding very fast for cut flower production and export. There is tremendous scope for orchid improvement and development of industry based on orchids. Many orchids native to this country have already proved to be important parent plants and have contributed to the production of several outstanding hybrids in the world. Hybrids of certain Indian orchids, like species of *Aerides, Ascocentrum, Arachnis, Renanthera, Rhyncostylis and Vanda* are considered the monarchs in the orchid world (Bose *et al.*, 1999).

The Western Ghats due to salubrious climatic conditions make a natural home of about 300 species of orchids (Jain, 1986). Kerala is one of the few places in the world where, sophisticated infrastructure is not required for orchid cultivation. Here, orchids can grow well in open and because of good rainfall, high humidity, and salubrious temperature, so there is tremendous scope for the development of orchid industry in the region (Rajeevan, 1995).

Commercial cultivation of orchids gathered momentum in Kerala during the early nineties. Monopodials have recently gained popularity due to the availability of large number of varieties and hybrids including intergeneric ones that show a wide range of variability in floral characters. The genera of orchids and the varieties/hybrids, which could be commercially grown under the conditions prevailing in India, have also been described (Rajeevan *et al.*, 2002). *Phalaenopsis* orchids are suited to the tropical and subtropical environments and got potential to use as home plants as well as for commercial cultivation in Kerala.

2.1 Plant Character

Phalaenopsis is also called as the moth orchid. It is derived from the Greek words 'Phalaena' and 'opsis' meaning 'resembling moth'. The inflorescence swaying in breeze resembles moths in flight and hence the name. In commerce, the flowers are referred to as 'Phals'.

2.1.1 Habitat

The plants are found in the tropical humid forests. They are epiphytes growing under the canopy of trees with bright filtered sunlight. The roots anchor to the tree trunk for support and derive nutrients from decaying bark, bird or insect droppings.

2.1.2 Growth Parameters

2.1.2.1 Plant Height

Orchids are either monopodial or sympodial in nature. Phals are short stemmed monopodial orchids *i.e.* they exhibit indeterminate nature of growth without lateral branching. The plants in their native habitat are found growing on the trunks of trees where moisture stress is not uncommon during most parts of the year. Kaveriamma (2007) evaluated eight *Phalaenopsis* spp. *viz. Phalaenopsis* Taisuco Kochdian x Akatsuka Noon, *Phalaenopsis* Diana Pink, *Phalaenopsis* Hwafeng Red Jwel, *Phalaenopsis* Mount Lip, *Phalaenopsis Taipei Gold, Phalaenopsis* Ho's Happy Auckland, *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) for cut flower and observed that *Phalaenopsis* Diana Pink recorded the maximum increase in height (4.70 to 5.20 cm) while *Phalaenopsis* Taisuco Kochdian x Akatsuka Noon recorded the minimum (4.40 to 4.53 cm). Fadelah (2007) studied the performance of four tissue cultured Dendrobium orchid hybrids *viz.* Dendrobium Tuanku Najihah, Dendrobium Doctor Sharif, Dendrobium Tuanku Fauziah (miniature) and Dendrobium Abdullah Badawi. The results indicated that the all of them performed equally in terms of vegetative characters like plant height, number of pseudobulbs, leaf length, leaf breadth, and number of leaves.

2.1.2.2 Leaves

Phalaenopsis do not produce pseudo bulbs, but grow from a single rhizome from which new leaves are continually being produced at the apex. These leaves are thick, fleshy and broad. The old leaves are shed at the rate of one or two a year, often or just after flowering. These are always replaced by the younger leaves and average plant will retain three to six leaves at a time (Rittershausen, 1979). *Phalaenopsis* or moth orchids are epiphytic, Crassulacean acid metabolism (CAM) plants (Sayed, 2001). The stomata have a mechanism to help in the absorption of CO_2 with a reduced loss of water due to transpiration. It remains open during night hours and partly open during day break and at dusk. Throughout the day when the temperature is high, the stomata remains closed so as to conserve moisture within the plant.

An evaluation programme on 21 *Dendrobium* spp. at Orchid Research Station, Kalimpong revealed that *D. moschatum* followed by *D. fimbriatum* and *D. nobile* var. *alba* had the maximum plant height. Shoot production was more in *D. jenkinsii* followed by *D. Gibsoni* and *D. ochreatum*. The number of leaves per plant was highest in *D. chrysotoxum* followed by *D. farmeri* and *D. nobilescens* (Roychowdhury *et al.*, 2004).

Among eight *Phalaenopsis* spp. studied for cut flower *Phalaenopsis* Diana Pink recorded maximum leaf length (21.73 cm) and *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) recorded minimum leaf length (10.10 cm). While *Phalaenopsis* Hwafeng Red Jewel recorded the maximum leaf breadth (7.97 cm) *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) recorded the minimum (3.97 cm). Maximum leaf area was recorded in *Phalaenopsis* Hwafeng Red Jewel (125.03 cm^2) and minimum in *Phalaenopsis* (Pinlong Spring x Taisuco Kochdian) x *Phalaenopsis* (Miami Sunrise x Tiny Ivory) (25.63 cm^2) (Kaveriamma, 2007).

2.1.2.3 Roots

Phalaenopsis are epiphytic by nature and cling to the tree trunks with stout, flattened aerial roots which will grow to several feet in length. Roots are with spongy tissues called velamen, which helps in absorption of moisture; tips of roots have chlorophyll thus contributing to photosynthesis (Rittershausen, 1979). The roots of the genera *Phalaenopsis* become considerably flat and assist the plant to creep over the surface while those of *Aerides* and *Vanda* help the plants to climb on the tall trees (Bose *et al.*, 1999). Roots of *Phalaenopsis* can absorb large amounts of nitrogen directly in urea form probably because of the special nature of velamen (Trepanier *et al.*, 2009).

2.1.2.4 Inflorescence

It is a long, arching raceme with an indeterminate growth habit. The inflorescence usually emerges from the 3^{rd} or 4^{th} node. It stays on plant for 2 to 4 months (Bose *et al.*, 1999). But at times, it stays for as long as 8 months or more (Kaveriamma, 2007). But the spike becomes unruly, if left for longer periods on plant. The number of flowers per plant can vary from a few up to 30.

Development of inflorescence in Vanda and Arachnis tribe usually requires a period of two months. Their growth curve is typically sigmoid. During early and exponential growth period floral bud differentiation proceeds very slowly, but becomes much faster when growth of the inflorescence stalks terminates. In Arachnis cv. Maggie Oei, the average growth period of an inflorescence is 70.6 days. The first flower may open on 60th day (Ede, 1963).

Like other flowering plants, an orchid must reach a certain stage of maturity before it can flower. The period of juvenility varies among species and among hybrids (Holttum, 1949). Cattleya takes 4-7 years to reach maturity; Dendrobium needs 3-4 years while Phalaenopsis takes 24 months to bloom (Wang and Lee, 1994).

2.1.2.5 Flower

It has a zygomorphic (bilaterally symmetric) flower; a characteristic feature of the family Orchidaceae. The three sepals are similar is shape, size and colour. Petals are three in number; two are similar and the third petal is modified into labellum or a lip. Labellum is trilobed with two lateral lobes which are similar; mid-lobe is triangular with two tendril like structures and a bifid callus. Labellum serves as a perfect landing for pollinators.

The column like structure 'gynostemium' is positioned above the labellum. Gynostemium is a fusion of androecium and gynoecium, separated by a wall like structure called rostellum. It separates the male and female organs restricting self pollination.

Two new *D. phalaenopsis* hybrids *viz.,* Gigantic (with purple flower) and Ekapol (with white fuschia pink flowers) were compared under greenhouse. The hybrids flowered simultaneously in summer-autumn but Ekapol flowered again in late winter thereby doubling the yield of cut flower spikes (Talia *et al.*, 1999).

Amin *et al.* (2004) studied six ephiphytic monopodial orchids *viz. Aerides odoratum, A. multiflorum, A. jaintapuri, Rhynchostylis retusa alba, R. retusa pink* and *Vanda teres for their floral and vegetative characters and recorded that A. multiflorum* produced the longest inflorescence (29.67 cm), maximum flowering area (21.83 cm) and maximum number of flowers (60.44) whereas *V. teres* produced the largest floret (3 cm across).

Barman *et al.* (2007) made an attempt to evaluate the performance of 31 Cymbidium hybrids for floral characters under partially modified greenhouse. Maximum number of florets was recorded in the hybrid Yankalilla and the biggest size of flowers in Stanley fouraker white Magic and Fantasia Deserio Dulmar.

2.2 Growing Structures

Green house technology developed over last two centuries, which promises control over all the climatic parameters for commercial ornamental crop production. A greenhouse is a framed inflated structure covered with a transparent or translucent material such that crop could be grown in it under at least partially controlled environmental conditions and which is large enough to permit a person to enter into it to carry out crop cultural practices (Dalrymple, 1973).

Greenhouses used for ornamentals in India belong to two categories. The first category of greenhouse are used is in the natural ornamental growing area to prevent damage from weather aberrations and other natural agents. This category of greenhouse does not have any artificial environment control system except the provision of adequate ventilation. The second category of greenhouses for ornamentals are those which helps to extend the growing season or permit off-season production by way of controlling microclimatic parameters to a significant extent. The microclimate refers to light, temperature, humidity, carbon dioxide *etc.* The extent of microclimatic control in a given situation depends on the local climate and crop requirement.

Management of shading and cooling of tropical and subtropical greenhouses is quite possible by choosing the right covering material. Coloured plastic films containing absorbing pigments are available, which reduce PAR (Photosynthetically Active Radiation) hence contribute to a shading effect. Plastic films containing interference pigments are able to reduce NIR and therefore also lead to a cooling effect in the greenhouse (Hoffmann and Waaijenberg, 2002).

Kittas *et al.*, (2003) succeeded to keep the internal greenhouse temperature at 28 °C level by using fan-pad cooling system. By calculating the system efficiency to become 80%, they obtained a 10 °C decrease with respect to the external temperature. The moisture content in the environment is an important point in determining efficiency of cooling with using fan-pad systems. The lower the moisture contents in the area, the higher is the performance we can get from the fan-pad system.

Harzadin (1986) stated that in order to obtain a sustainable plant production in greenhouses, the suitable environmental conditions during summer time should be maintained by cooling the greenhouses using different precautions. These environmental conditions can be maintained by keeping the internal greenhouse temperature and humidity within certain limits, as well as by maintaining necessary ventilation, cooling and shading in the summer season (Aydincioglu, 2004).

Fan and pad systems consisted of exhaust fans at one end of the greenhouse and a pump circulating water through and over a porous pad installed at the opposite end of the greenhouse. The fan-pad cooling systems which are properly designed and utilized can boost up the efficiency level in greenhouses to 85 per cent. When the external moisture indications reach 50 per cent level and the temperature rises up to 32 °C, a vapour cooling system can lower the temperature down to 24°C (Yagcioglu, 2005).

2.3 Methods of Growing

Method of orchid growing is very important on the basis of various aspects like ventilation, disease and pest management, quality of florets on spike *etc.*

Constant air movement around orchid is a must to keep the plants in good health. Irrespective of what type of orchid it is, a stale surrounding is very harmful. Most of the commonly cultivated species are epiphytic and a free circulation of fresh air is essential. Many tropical orchids like *Vanda, Phalaenopsis, Aerides etc.* with aerial roots were found to grow well when exposed to current of fresh air (Bose *et al.*, 1999). They do the best when grown in baskets kept hanging from the beams of the greenhouse or lath house (Mukherjee, 2002).

2.4 Types of Pots

Plastic pots are convenient for handling and they last very long. Orchid roots in an earthen pot will access to more air, which is good for growth of orchid as compared to plastic pots, therefore it should have extra holes on the sides to ensure sufficient air supply to the roots. Plastic pots require less frequent watering as it retains more water (Fighetti, 2000).

Blanchard and Runkle (2008a) reported the effects of container opacity and different media components on rooting and vegetative growth of several clones of *Phalaenopsis* orchids. *Doritaenopsis* White Moon and *Phalaenopsis* Sharon Bay were grown in 12 cm translucent and opaque pots containing a bark-based media. After 30 weeks at 29 °C, plants in opaque pots had formed >7 roots outside of each container, whereas <2 roots per pot had developed outside the translucent containers.

2.5 Growing Media

Several potting materials have been used for orchids world wide with good result. However, its use depends on the availability, quality and cost of the material. Potting materials that can be used for growing orchids include tree bark, osmunda fibre, tree charcoal, brick or stone chips, sphagnum moss, polystyrene granules, coconut husk, rock wool, perlite, vermiculite, peanut shells, poultry or horse or cow dung manure, leaf mould, top soil, sand *etc*.

The epiphytic orchids spread their roots over the branches of trees, exposing them fully. The type of media used for growing epiphytic orchids should provide a surface over which the plants can cling to. Certain types of orchids will have affinity towards certain type of media. Since main quality of media for epiphytic orchids is retention and supply of adequate moisture for a long period.

Media is primarily essential for anchorage and for holding moisture. Porous media is a must so as to provide enough aeration and drainage for roots. Other desirable characters of media are low cost, stability, good capillary action *etc.* Usually sphagnum moss is considered ideal. Coir, charcoal and tiles make a good mix for growing orchids in Kerala.

Jawaharlal *et al.* (2001) studied the effect of different media *viz.* brick pieces, charcoal, coir dust, brick pieces + charcoal, brick pieces + coir dust, coir dust + charcoal, gravel pieces, coir dust + charcoal + brick pieces and tree fern bark + moss on vegetative and floral characters of *Vanda rothschildiana.* Results showed that the potting media comprising of brick pieces and coir dust was the best medium for growing in terms of number of leaves per plant, number of inflorescence per plant, length of inflorescence and flower diameter.

2.5.1 Coconut Husk

Coconut husk absorbs sufficient quantity of moisture and is widely used in places where coconut is grown. In case of monopodial orchids like *Vanda* and *Arachnis*, grown in open, longitudinal splits (three or four form each husk) can be used. For plants grown in pots, bits of smaller size are to be used. The proportion of husk has to be adjusted in such a way that it does not make media soggy.

Coconut husk holds moisture and supply food for the growing plants and found very suitable for growing monopodial orchids like *Phalaenopsis* and *Vanda* (Bose and Bhattacharjee, 1980).

2.5.2 Bricks

Bricks are common ingredients for media used for growing epiphytic orchids. They absorb moisture, facilitate easy drainage and aeration. It is cheaper and easily available.

2.5.3 Charcoal

Though charcoal is costly, they are handy and safe with hanging pots. They also have capacity to purify the media. Certain orchids like *Oncidium*, *Phalaenopsis etc.* have an affinity towards charcoal (Rajeevan *et al.*, 2002)

Results on study of potting media indicated large pieces of charcoal alone are excellent as growing medium for *Cattleya, Epidendrum, Phalaenopsis, Dendrobium, Rhynchostylis* and *Vanda* (Bose and Bhattacharjee, 1972).

Wang and Wang (1995) reported that *Phalaenopsis* planted with equal volume of No. 3 perlite, metromix 700 and charcoal (PMC) produced twice the number of new leaves and 1.5 fold more leaf area than that in coarse bark (CB). PMC and rock wool (RM) produced similar shoot weight but RM enhanced more lateral inflorescences. Flower produced on PMC and RM was 10 per cent larger than those on CB.

Monopodial epiphytic orchids such as *Aerides multiflorum* and *Rhynchostyles gigantean* exihibited good growth on hardwood charcoal chunks alone (Bhattacharjee, 1980).

A good growing media should support the plants, supply water and nutrients to the roots; and should provide good drainage and aeration. The type of medium will vary according to the habit of the orchids. The media suitable for growing epiphytic orchids should hold moisture but not remain soggy and wet. The media to grow epiphytic orchids like *Vanda, Dendrobium, Oncidium, Cattleya, Phalaenopsis, etc.* are mainly charcoal, coconut husk, fern fibre and brick pieces. Sphagnum moss can be used to hold moisture in summer months (Bose *et al.*, 1999). A growing medium consisting of brick pieces, coir dust and charcoal is recommended for best growth and flowering in *Vanda* spp. (Rajeevan *et al.*, 2002)

Wang and Konow (2002) evaluated *Phalaenopsis* Atien Kaala [*Phalaenopsis* (*Snow Swallow* x *Hisa Nasu*)] in two media *viz*, Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) bark and bark + peat mix along with four different fertilizer formulations. Regardless of fertilizer applied, the bark + peat medium found better with respect to holding and releasing nutrients and better plant growth than those grown in the bark alone. Fir bark alone does not hold much water initially and so pose problems to newly planted orchids.

Jin and Ichihashi (2002) reported that *Doritaenopsis* (Dtps.) potted with New Zealand sphagnum moss grew better than when potted with New Zealand bark, coconut husk chips or rock wool. These results were due to better moisture holding capacity and content and release of minerals from the media.

Most commercial growers mix their own growing media and most of the mixes still contain bark, but they also have one or more other materials such as perlite, sphagnum peat, sphagnum moss and coconut husk chips, *etc.* that absorb water (Wang *et al.*, 2005).

Hawang and Jeong (2007) studied five different media for the mass production of *Phalaenopsis* orchids. The media *viz.*, New Zealand sphagnum moss (SM), coir mixes (CM), CM partially mixed with SM, granular rockwool mixes and perlite mixes were examined using clonal plants of two cultivars, 'Stripe' and 'White Red Lip'. Two-month old and eight-month-old plants were evaluated. The results indicated that CM partially mixed with SM yielded significantly greater number of leaves, and fresh and dry weights of both cultivars at the two growth stages because of its higher potential to support the superior growth of *Phalaenopsis*.

Effect of medium on the size of plant, hydratation of leaf tissue and flowering was evaluated by using three media *viz.* New Zealand sphagnum moss, mixture of expanded clay pellets and New Zealand sphagnum moss (v:v = 1:1) and expanded clay pellets in *Phalaenopsis* sp. From the studies, it was concluded that orchids grown in New Zealand sphagnum moss had a significantly greater vegetative and root growth and it was most favourable for flowering also (Trelka *et al.*, 2010).

2.6 Production Environment

Growth, development and productivity depend on the interaction between environmental factors and genetic constitution of the plants. Orchid is one such crop, which expresses a high magnitude of diversity and responds very well to the environment (Abraham and Vatsala, 1981).

The growth and development of orchids is markedly influenced by the physical (temperature, light, humidity, topography), chemical (nature of substratum), and biotic (rhizosphere, associated vegetation, pollinators) factors and their avidity to specific ecological niches varies with the species (Chadha and Bhattacharjee, 1995). Plants often respond to changes in photoperiod and temperature so that they naturally flower when environmental conditions are favorable for reproduction. Once flower buds have initiated, flower development time is dependent upon genotype and temperature (Lopez and Runkle, 2004).

2.6.1 Aeration

Most of the commonly cultivated species are epiphytic; free circulation of fresh air is essential. Many tropical orchids like *Vanda, Phalaenopsis, Aerides etc.* with aerial roots were found to grow well when exposed to current of fresh air (Bose *et al.*, 1999). They do the best when grown in baskets kept hanging from the beams of the greenhouse or lath house (Mukherjee, 2002).

2.6.2 Irrigation

Orchids usually are epiphytes or lithophytes and attach their roots to the surface. When it rains, water runs off freely and quickly past their roots and leaves. Therefore, orchids prefer to be drenched with water that runs quickly through the pot, rather than light application of water (White, 1996). Majority of the commercial growers employ some form of overhead watering in their greenhouse. The frequency of watering depends on several factors such as climatic conditions, type of growing medium, type and size of container, growth habit of orchid *etc.* (Bose *et al.*, 1999).

Increased watering can prevent possible dehydration and burning when temperatures reach the higher levels. According to Yoneda *et al.* (1992), various irrigation methods influenced the growth and inflorescence emergence in *Phalaenopsis* and *Doritaenopsis*.

2.6.3 Climate

Vegetative structure of an orchid plant is modified according to the diversified habit of growth, which has close relation with the climate. The majority of orchids occurring in temperate climates are terrestrial while those in tropical regions are found frequently on trees or rocks (Bose *et al.*, 1999). Majority of the orchids under cultivation are native to the tropical countries. The area covered by the zone between 30°N and 30°S latitudes includes the home of practically all the orchids of horticultural interest (Mukherjee, 2002).

Sugapriya *et al.* (2012) reported that out of nine verities evaluated under green house condition of Dendrobium orchid, Sonia-17 recorded maximum plant height, length of internode, and number of pseudobulbs per plant, where as Medame Uraiwan recorded more number of leaves and maximum pseudobulb girth. While Sonia-17 exhibited free-flowering nature and seasonal flowering was observed in rest of the varieties. The number of spikes per plant per year was recorded maximum in the variety Sonia-17.

2.6.3.1 Temperature

The effect of temperature on *Dendrobium nobile* is critical during both vegetative growth and flower initiation. During the spring and summer in both Hawaii and Japan, nobile dendrobiums are grown in lower elevations where the pseudobulbs can mature completely in a warmer climate before being taken to higher elevations where flower initiation can begin under cooler conditions (Nash, 1996).

In *Cymbidium* orchids, a positive diurnal fluctuation of 10–14 °C was suggested as a requirement for flower initiation; *Cymbidium* Astronaut 'Radjah' grown at 20/12 °C, 26/12 °C, 26/18 °C (14 h day/10 h night) developed an average of 3.3, 11.7, 6.2 inflorescences per plant, respectively (Powell *et al.*, 1988).

Depending upon their preference for a particular range of temperature, the cultivated species are categorized as cool, intermediate and warm types. Low temperature requirements for flower induction have been documented in tropical orchids (Kronenberg, 1976). For many orchids, temperature variation has a decidedly more pronounced effect than day length on flowering. Chilling is necessary for flowering in many orchids whose natural habitats are more than 500 meters above sea level. *Ascocentrum curvifolium, Ascocentrum ampullaceum, Vanda coerulae, Rhynchostylis gigantean, Vandopsis parishi, Phalaenopsis lindenii* and *Phalaenopsis schillerana* are examples of the beautiful monopodial orchids which require cool night temperature to flower (Soon, 1980). Effect of high light intensity and elevated temperature on growth of *Cattleya* and *Phalaenopsis* observed that temperature was a more limiting factor than light intensity for growth of both the orchids (Krizek and Lawson, 1974). Uniform spiking can be achieved in *Phalaenopsis* grown at day/night temperature of either 25/20 ^{0}C or 20/15 ^{0}C for four to five weeks (Lee and Lin, 1994).

Temperature influences not only proper vegetative growth, but also production of flowers in quite a good number of species. Under natural conditions, for optimum growth and flowering, the night temperature should be lower than the day temperature. Lopez and Runkle (2004) reported that a decrease in time from visible inflorescence to flower opening in *Zygopetalum* Hook. (*Zygopetalum Redvale* 'Fire Kiss') when there was an increase in temperature (14 °C to 26 °C). The average number of flowers were not notably affected by temperature.

High temperature environments strongly affect oxidative stress in *Phalaenopsis* orchids, resulting in inhibition of flower development (Su *et al.*, 2001; Ali *et al.*, 2005).

The best flowering performance in two nobile dendrobium cultivars, D. Snowflake 'Red Star' and D. Hinode 'Toutenkôu', was achieved when cooling plants at 15 to 20 °C/ 10 to 12.5 °C (8 h day/16 h night) for 40 days (Sinoda *et al.*, 1988).For many orchids, temperature has more pronounced effect than day length on flowering. In California, night temperature of 13 °C are employed to stimulate flowering in *Phalaenopsis* while in Florida, night temperature of 18 °C is adequate. In Singapore, night temperature does not fall below 20 °C and even during the cool season night temperature are around 21 °C. *Phalaenopsis* does flower fairly well in Singapore although admittedly not to the same degree as in Florida and California (Soon, 1980).

Temperature can also be used to manipulate timing of flower bud initiation and flowering. Raising or lowering the air temperature in the greenhouse can be used to manipulate the flowering date once spiking has taken place (Wang, 1998). Wang (1997) reported that spiking can be delayed by maintaining temperatures above 28 °C all day. Flowering of a first generation *Phalaenopsis pulcherrima* hybrid is delayed by cool day temperatures of 25 °C and warm night temperatures of 30 °C (Wang, 2007). Cool day temperature of 20 °C and warm night temperature of 25 °C induced flowering, whereas warm day of 25 °C and cool night of 20 °C inhibit flowering. Flower induction begins as temperatures fall below 26 °C for four to five weeks. *Phalaenopsis* plants with a young inflorescence can become an aerial shoot known as a keiki, in place of a flower bud when temperatures remain at 28 °C or higher (Lopez *et al.*, 2005).

Christine *et al.* (2008) studied the effects of cooling temperature and duration on flowering of Dendrobium orchid and suggest that 3 weeks at 13 °C has saturated the cooling requirement, and 3 weeks at 13 °C or 15 °C is a recommended cooling treatment that saves production cost without retarding flower development.

Phalaenopsis requires a period of exposure to relatively moderate temperature (<26 °C) to trigger the initiation of the inflorescence or spiking (Sakanishi *et al.*, 1980; Lee and Lin, 1984; Yoneda *et al.*, 1992; Wang, 1995). *Phalaenopsis* orchids remain vegetative above 27 °C to 29 °C and can tolerate temperature as high as 32 °C to 35 °C for short periods before exhibiting signs of heat stress (Baker and Baker, 1991). The inhibition of flowering when the day temperature was 29 °C and the night temperature was 17 °C or 23 °C suggests that a warm day temperature inhibits flower initiation in *Phalaenopsis* (Blanchard and Runkle, 2006). But temperature had little or no effect on spike length or flower size (Robinson, 2002).

2.6.3.2 Relative Humidity

Humid warm atmosphere is essential for the growth of most of the tropical orchids which do not have well established root system.

Orchids in general prefer high humidity for their growth and flowering. Monopodial types like *Vanda*, *Phalaenopsis etc.* require high humidity (70-75 per cent) than sympodial types like *Cattleya*, *Laelia etc.* which require only 40-55 per cent. In the wild, the majority of orchids flourish in regions of perpetual mist (Abraham and Vatsala, 1981).

2.6.3.3 Light Intensity

Light intensity affects both the growth and flowering of tropical orchids. There is a minimum light energy required for proper growth and flowering in orchids. However, many tropical monopodials, particularly members of the *Vanda –Arachnis* tribe (Sarcantheae-Vandinae) require extended periods of full sun for flowering. If this requirement is not met, plants continue vigorous vegetative growth but seldom flower (Soon, 1980). Many species of *Arachnis, Ascocentrum,* *Renanthera* and *Vanda* require full sun for free flowering and any shading delay or suppress the flowering process. Many of their hybrids, such as *Aranda* and *Aranthera* are known to behave in the same manner (Soon, 1980). Effect of high light intensity and elevated temperature on growth of *Cattleya* and *Phalaenopsis* observed that temperature was a more limiting factor than light intensity for growth of both the orchids (Krizek and Lawson, 1974).

The optimum light requirement varies for different genera. *Arachnis, Cattleya, Oncidium,* most species of *Dendrobium* and *Vanda* grow and flower well at a light intensity ranging from 25000 to 38000 lux, *Cymbidium* prefers high light intensity. The optimum requirement of light for *Paphiopedilium* varies between 19000 to 25000 lux while *Phalaenopsis* showed satisfactory growth and flowering at 16000 lux light intensity (Sheehan and Sheehan, 1979).

In *Aranda* cv. Wendy Scott, plants which received only 3 hours of direct sunlight remained vegetative whereas those exposed to full sun for 8 hours produced inflorescences regularly. When the former were transferred to 8 hours of direct sun, all plants produced floral buds in 7 to 10 days. These buds continued to develop to mature inflorescences (Goh *et al.*, 1981). Shade loving orchids such as *Dendrobium, Oncidium* and *Phalaenopsis* do not tolerate direct exposure to tropical full sun and they would be scorched within hours if exposed to the strong mid-day sun directly (Bose *et al.*, 1999). Plants of some species of *Vanda* and *Bulbophyllum* naturally adapted to shade conditions had smaller leaf areas, thinner leaves, cuticles and palisade layers and lower concentrations of total starch, soluble sugars, proteins, amino acids and lipids than those naturally adapted to sunny conditions (Radha *et al.*, 1994).

Wang (1995) reported that if plants are subjected to low light or darkness, spiking of *Phalaenopsis* does not occur even under optimum temperature conditions. To obtain 100 per cent flowering of *Phalaenopsis*, a light level of 250 $\mu mol\ m^{-2}\ s^{-1}$ or higher is necessary (Wang, 1997).

Light can be used to manipulate the timing of flowering. Wang (1998) performed five experiments giving *Phalaenopsis* TAM Butterfly various cycles of darkness and light. Cycles were, 1 day darkness/1 day light; 4 days darkness/3 day light; 7 days darkness/7 days light, and the control (natural photoperiod). The greenhouse was provided with shade and the maximum *PPF* was 360 μmol m^{-2} s^{-1}. Results showed that plants subjected to four days of darkness followed by three days of light for three months suspended spiking for three months without a decrease in flower number when plants were finally brought to flowering.

Delaying anthesis in *Phalaenopsis* is possible by the dark treatment but length of stalk and flower size were unaffected at 20 °C (Hisamatsu *et al.*, 2001). Kubota *et al.* (2005) reported that large quantity of sugar and starch were reserved in pseudobulbs of back shoots under high light intensity, but the contents decreased while current shoot was developing new leaves in *Odontioda* orchid. Lalengmawia *et al.* (2008) studied growth performances of the *Vanda coerulea*, *Renanthera imschootiana*, *Dendrobium chrysotoxum* and *Dendrobium formosum* at different light intensities and moisture levels for a period of 24 months and concluded that each species requires different intensity of light and moisture level for its proper growth.

Lin *et al.* (2011) studied flowering time and flower quality of three hybrid *Dendrobium nobile* cultivars in relation to light intensity during cooling and duration of vernalization and concluded that darkness during vernalization slightly delayed flowering and resulted in fewer but larger flowers while Longer cooling duration delayed flowering, decreased flower longevity, and produced more and larger flowers.

2.6.3.4 Photoperiodism

Photoperiodic response is important in controlling flowering in many plant species. According to Sanford (1974), tropical plants of equatorial origin are believed to be more sensitive to small differences in day length than those from temperate regions. Such sensitivity would confer on evolutionary advantage since the day length differences are less pronounced in the tropics. However, tropical orchid hybrids like a few species of *Arachnis, Vanda, Aranda, etc.* are all day neutral plants and are indifferent to day length.

Rotor (1952) found that *Phalaenopsis amabilis* (L.) Bl. grown in an 18 °C greenhouse supplied with uninterrupted short days encouraged flowering and inflorescence stalks and old stalks to produce lateral flowering branches throughout the year. Long days gave the plants a specific once-a-year flowering period, but did not hinder flowering. Short photoperiod might have slight beneficial effect of accelerating spiking (Yoneda *et al.*, 1991) when air temperature is close to the upper limit. Some of the *Dendrobium* hybrids are considered day neutral and not affected by day length for flowering (Hew and Yong, 2004).

Some tropical orchid hybrids like *Arachnis* cv. Maggie Oei, *Aranda* cv. Deborah, *Aranda* cv. Wendy Scott, and *Vanda* cv. Miss Joaquim as well as *Dendrobium* hybrids are indifferent to day length (Byramji and Goh, 1976). Bose and Mukhopadhyay (1977) studied the effects of day length on flowering of some tropical orchids and recorded early flowering (42-49 days earlier than plants kept in long days) in *Aerides multiflorum, Renanthera imschootiana* and *Rhynchostylis retusa* by short day (9-hr light) treatment.

According to Sessler (1978), well developed, firm, long lasting flowers with strong stems indicated that the light had been adequate throughout the growing period for orchids. Most hybrid orchids which grow in the tropical lowlands appear to be uninfluenced by day length and thus probably day neutral plants (Soon, 1980). A number of tropical orchid species are known to be short day (long night) plants, but other factors such as temperature may also stimulate flowering (Dressler, 1981). A few studies reported that short days enhance spiking and spike length and long days promote vegetative growth and development of aerial plantlets in

Phalaenopsis (Griesbach, 1985; Yoneda *et al.*, 1991). Flowering in certain species of *Dendrobium* and *Phalaenopsis* was also hastened by 47 days to 59 days under short day (8 hr light) treatments. The flower spike length and number of flowers per spike however have been observed to increase by long day (16 hr) treatments (Bhattacharjee, 1995).

Commercially important tropical orchids for cut flower production such as *Aranda, Dendrobium, Mokara, Oncidium* are all day neutral plants and are indifferent to day length (Yong and Hew, 2004).

However, information on growing structure and agrotechniques required for *Phalaenopsis* are not available under Kerala conditions and hence this study was taken up.

Materials and Methods

3. MATERIALS AND METHODS

The present study entitled "Standardisation of agrotechniques in *Phalaenopsis* orchids" was carried out at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara from May 2011 to April 2012. The studies were conducted to find out the response of two plant types and assess the best environment suited for commercial cultivation of *Phalaenopsis* and to standardise the agrotechniques like type of pot, growing media and growing method for better growth and quality spikes. The materials used and methodology adopted for the investigations are described below.

3.1 Location

Vellanikkara is situated at a latitude of 10°31' N and longitude of 76°13' E. The area lies 22.25 m above MSL. The weather parameters recorded during the period are presented in (Table 9).

3.2 Experiment

The study involved comparison of two plants types, two types of pots, two types of potting media, two growing conditions and two methods of growing. Altogether, 32 treatment combinations were evaluated as detailed below.

3.2.1. Growing structure/ Environment

Two types of growing structures *i.e.* top ventilated rain shelter and fan and pad system were used for conducting experiment.

3.2.1.1 Top ventilated rain-shelter

Top ventilated rain-shelter does not have any artificial system to control environment except the provision of adequate ventilation and shade. The size of the rain shelter was 21 m x 6 m and it was covered on top with poly ethylene sheets and provided with 80 percent shade inside the structure (Plate 1a).

3.2.1.2 Fan and pad system

Fan and pad system consisted of a greenhouse with its exhaust fans at one end of the greenhouse and a pump circulating water through and over a porous pad installed at the opposite end of the greenhouse. The structure was made up of GI frames, covered on sides and top with poly ethylene with a floor area of sand. Size of the fan and pad is 12.5 m x 8 m (Plate 1b).

3.2.2 Methods of growing

Two types of growing methods were *i.e.* on bench method and hanging method for conducting experiment.

3.2.2.1 On bench

Pots were placed on bench of 2.30 m x 1 m size at 0.80 m height in a tilted position to remove excess water through holes at bottom of the pot and were arranged at 15 cm x 25 cm distance (Plate 2a).

3.2.2.2 Hanging

Potted plants were hung at equal height (1 – 1.30 m from ground level) using nylon thread. The pots were hung by tying two nearest holes, to provide a tilted position (Plate 2b).

3.2.3 Types of *Phalaenopsis*

Two commercial types of *Phalaenopsis i.e.* pot plant or multiflora type and cut flower or grandiflora type were used for conducting experiment.

3.2.3.1 Pot plant

Pot plant or multiflora type have short stemmed inflorescence, small, less rounded more number of florets per spike and colour are more pronounced. Eighteen months old, hardened tissue culture plants of variety *Phalaenopsis* 'Lin Jessica' were used (Plate 3a).

a) Top ventilated rain shelter

b) Fan and pad system

Plate 1. Growing structures

a) On bench

b) Hanging

Plate 2. Methods of growing

3.2.3.2 Cut flower

Cut flower or grandiflora types have long inflorescence and they branch occasionally, flowers are large and almost round in shape. Eighteen months old, hardened tissue culture plants of variety *Phalaenopsis* 'Taisuco Confidence' were used (Plate 3b).

3.2.4 Types of pots

Two types of plastic pots were used *i.e.* white pot and black pot for conducting experiment.

3.2.4.1 White – transparent plastic pots (translucent)

White transparent plastic pots of 12 cm diameter and 12 cm height were used having holes on sides and lower part of pot for proper drainage of excess water (Plate 4a).

3.2.4.2 Opaque (black) plastic pots

Black (opaque) plastic pots of 15 cm diameter and 15 cm height having holes on sides and lower part of pot were used (Plate 4b).

3.2.5 Media

Two types of media were used i.e. brick + charcoal and brick + coconut husk bits medium for conducting experiment.

3.2.5.1 Brick + charcoal

In this treatment, brick and charcoal was used as medium at 1:2 proportion. Brick was used in the bottom of pot and a combination of brick and charcoal was used in the upper surface (Plate 5a).

3.2.5.2 Brick + coconut husk bits

In this case, brick and coconut husk bits were used as medium at 1:2 proportion. Brick was used in the bottom of pot and a combination of brick and coconut husk bits

a) Pot plant (Lin Jessica)

b) Cut flower (Taisuco Confidence)

Plate 3. Types of *Phalaenopsis*

a) White (translucent) plastic pots

b) Opaque (Black) plastic pots

Plate 4. Types of pot

a) Charcoal

b) Coconut husk bits

Plate 5. Growing media

were used in the upper surface (Plate 5b).

Treatment combinations tested:

Thirty two treatment combinations involving five factors were evaluated in the study.

Factor A - Growing structure 1. Top ventilated rain shelter (RS); 2. Fan and pad (FP)

Factor B - Growing method 1. On bench (B); 2. Hanging (H)

Factor C - Type of plant 1. Pot plant type (PP); 2. Cut flower type (CF)

Factor D - Type of pot 1. White (translucent) pot (WP); 2. Black (opaque) pot (BP)

Factor E - Media 1. Brick + charcoal (B + CH); 2. Brick + coconut husk bits (B + CP)

Treatment combinations

RS – B – PP – WP – B + CH

RS – B – PP – WP – B + CP

RS - B – PP – BP – B + CH

RS – B – PP – BP – B + CP

RS – B – CF – WP – B + CH

RS – B – CF – WP – B + CP

RS – B – CF – BP – B + CH

RS – B –CF – BP – B + CP

RS – H – PP – WP – B + CH

RS – H – PP – WP – B + CP

RS – H – PP – BP – B + CH

RS – H – PP – BP – B + CP

RS – H – CF – WP – B + CH

RS – H – CF – WP – B + CP

RS – H – CF – BP – B + CH

RS – H –CF – BP – B + CP

FP – B – PP – WP – B + CH

FP – B – PP – WP – B + CP

FP - B – PP – BP – B + CH

FP – B – PP – BP – B + CP

FP – B – CF – WP – B + CH

FP – B – CF – WP – B + CP

FP – B – CF – BP – B + CH

FP – B –CF – BP – B + CP

FP – H – PP – WP – B + CH

FP – H – PP – WP – B + CP

FP – H – PP – BP – B + CH

FP – H – PP – BP – B + CP

FP – H – CF – WP – B + CH

FP – H – CF – WP – B + CP

FP – H – CF – BP – B + CH

FP – H –CF – BP – B + CP

3.3 Design of the experiment

The study was conducted in a completely randomized block design involving three replications and four plants per replication.

3.4 Observations

Observations on the following vegetative and floral characters were recorded at monthly interval from all the plants.

3.4.1 Vegetative characters

3.4.1.1. Plant Height

The height of the plant was measured from the base to the growing apex at monthly intervals and expressed in centimeter.

3.4.1.2 Number of leaves

The total number of leaves present on the plant was counted and recorded

3.4.1.3 Leaf length

Length of the 3rd leaf was measured from base to the tip and expressed in centimetre.

3.4.1.4 Leaf breadth

The maximum width of the 3rd leaf at the centre was measured and expressed in centimetre.

3.4.1.5 Leaf area

Dot method (Bleasdale, 1973) was used to measure the leaf area and the same was expressed in square centimetre.

3.4.1.6 Interval of leaf production

The interval between the production of two successive leaves (phyllochron) was taken as the interval of leaf production and expressed in days.

3.4.1.7. Rooting pattern

Visual observations on pattern of root growth (roots inside or outside pots) at the time of flowering were recorded.

3.4.2 FLOWERING CHARACTERS

The following flower characters were observed and recorded during the period of study.

3.4.2.1 Time for emergence of spike

The number of days taken to emergence of spike from date of planting was counted and recorded in days.

3.4.2.2 Time for first bud opening

Days taken of first floret open after spike emergence was recorded in days.

3.4.2.3 Flowering duration

Time taken from opening of first floret to complete (100 %) opening of all the florets on the spike was recorded in days.

3.4.2.4 Spike length

Length of spike after 100 percent was measured from the point of emergence to the tip of spike and expressed in centimetre.

3.4.2.5 Flower size

Size of individual floret was recorded as the product of length (vertically) and width (across) of the flower and expressed in centimetre.

3.4.2.6 Number of florets per spike

The number of florets per spike in each plant was counted and the mean values were expressed as the number of florets per spike.

3.4.2.7 Longevity of spike on plant

Longevity was measured in terms of days from the opening of the first floret to wilting of last floret in the spike.

3.4.3 Weather parameters inside the structures

3.4.3.1 Temperature

Maximum and minimum temperature was recorded daily using thermo-hygro meter and expressed in °C.

3.4.3.2 Relative Humidity

Maximum and minimum relative humidity was recorded daily using thermo-hygro meter and expressed in per cent.

3.4.3.3 Light intensity

Light intensity was recorded twice in a day at 09.00 and 15.00 hr using lux

Results

meter and expressed in lux.

3.4.3.4 Day length

Day length was recorded as the duration from Sun rise to Sun set and expressed as hours.

3.4.4 Incidence of pests and diseases

General surveillance was made to keep plants in healthy condition.

3.5 General management

3.5.1 Nutrients

Major nutrients (NPK) and liquid *Pseudomonas* with cow dung slurry was applied at fortnight interval to all plants uniformly. During vegetative phase, NPK was applied in the ratio of 20:10:10 at fifteen days interval @ 0.1% while during flowering phase; nutrient combination involving a lower dose of nitrogen was applied in the ratio of 10:10:10.

3.5.2 Irrigation

Sufficient watering was done in pots to keep media moist along with over head irrigation to reduce transpiration rate.

3.6 Statistical analysis:

The data from the study was subjected to analysis of variance suggested by Panse and Sukhatme (1985). Treatment means were compared using DMRT wherever necessary. MSTAT software was made use of for this purpose.

Results

4. RESULTS

Studies were conducted at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, during 2011-2012 to standardise the agrotechniques in *Phalaenopsis* orchids.

Various vegetative and flowering characters were recorded at monthly interval and documented during the study. Results of the study supported by statistical analysis are furnished below:

4.1 Vegetative characters

4.1.1 Number of leaves per plant

Data on mean number of leaves per plant at monthly interval during the period of study (May 2011 to April 2012) are presented in Table 1.

Effect of growing structure *viz.* rain shelter and fan and pad system on number of leaves showed no significant difference in plants for the first five months (May to September) but it was significantly higher under rain shelter (2.97, 3.25, 3.26, 2.97, 2.87) and lower in fan and pad (2.70, 2.74, 2.73, 2.65, 2.38) from sixth to tenth month respectively (September 2011 to January 2012).

The plant types differed significantly with respect to number of leaves per plant during the first five months (May to September). In general, cut flower type had more number of leaves (3.80, 3.69, 3.59, 3.42 and 3.07) than pot plant (3.29, 3.19, 3.06, 2.98 and 2.81) during May to September respectively.

Influence of method of growing (on bench and hanging), types of pot (white pot and black pot) and growing media (brick + charcoal and brick + coconut husk bits) on number of leaves per plant did not differ significantly. Similarly interaction of structure x method, structure x type of plant, structure x type of pot, method x type of pot, type of plant x type of pot, structure x media, method x media, type of plant x media and type of pot x media were also not statistically different.

Table 1. Number of leaves influenced by different factors at monthly interval of *Phalaenopsis*

Month → Factor ↓		May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April
		Number of leaves											
A	1	3.53	3.42	3.37	3.21	2.97	2.97*	3.25*	3.26*	2.97**	2.87**	2.53	2.53
	2	3.57	3.46	3.27	3.18	2.90	2.70*	2.74*	2.73*	2.65**	2.38**	2.39	2.32
CD		0.16	0.15	0.14	0.16	0.18	0.20	0.21	0.21	0.17	0.20	0.22	0.21
B	1	3.51	3.40	3.41	3.23	2.99	2.94	3.08	3.08	2.90	2.72	2.42	2.49
	2	3.59	3.44	3.33	3.16	2.88	2.73	2.92	2.91	2.72	2.53	2.50	2.35
CD		0.16	0.15	0.14	0.16	0.18	0.20	0.21	0.21	0.17	0.20	0.22	0.21
A x B	1 x 1	3.57	3.40	3.41	3.22	3.10	3.12	3.34	3.34	3.07	3.06	2.47	2.51
	1 x 2	3.49	3.44	3.34	3.19	2.85	2.83	3.18	3.18	2.88	2.67	2.58	2.54
	2 x 1	3.45	3.40	3.23	3.25	2.89	2.76	2.83	2.83	2.73	2.38	2.36	2.47
	2 x 2	3.69	3.52	3.32	3.13	2.91	2.64	2.66	2.64	2.57	2.35	2.43	2.18
CD		0.23	0.21	0.20	0.23	0.26	0.29	0.31	0.31	0.25	0.29	0.32	0.29
C	1	3.29**	3.19**	3.06**	2.98**	2.81**	2.80	2.91	2.91	2.74	2.57	2.39	2.39
	2	3.80**	3.69**	3.59**	3.42**	3.07**	2.87	3.09	3.08	2.88	2.68	2.52	2.47
CD		0.16	0.15	0.14	0.16	0.18	0.20	0.21	0.21	0.17	0.20	0.22	0.21
A x C	1 x 1	3.29	3.33	3.15	3.05	2.85	2.97	3.14	3.14	2.89	2.87	2.56	2.57
	1 x 2	3.77	3.60	3.60	3.36	3.09	2.98	3.37	3.37	3.05	2.86	2.49	2.49
	2 x 1	3.30	3.15	2.98	2.91	2.76	2.64	2.69	2.68	2.59	2.26	2.23	2.19
	2 x 2	3.83	3.77	3.57	3.47	3.04	2.77	2.80	2.78	2.71	2.51	2.56	2.45
CD		0.23	0.21	0.20	0.23	0.26	0.29	0.31	0.31	0.25	0.29	0.32	0.29
B x C	1 x 1	3.24	3.12	3.08	3.08	2.93	2.98	3.09	3.09	2.84	2.56	2.33	2.45
	1 x 2	3.78	3.67	3.55	3.35	3.06	2.90	3.08	3.08	2.96	2.88	2.51	2.54
	2 x 1	3.35	3.25	3.04	2.88	2.68	2.62	2.74	2.74	2.64	2.57	2.47	2.33
	2 x 2	3.82	3.71	3.62	3.45	3.08	2.84	3.09	3.07	2.81	2.48	2.54	2.39

CD		0.23	0.21	0.20	0.23	0.26	0.29	0.31	0.31	0.25	0.29	0.32	0.29
D	1	3.63	3.47	3.39	3.24	2.96	2.86	3.06	3.06	2.81	2.64	2.44	2.44
	2	3.46	3.40	3.25	3.16	2.91	2.81	2.94	2.93	2.81	2.60	2.48	2.41
CD		0.16	0.15	0.14	0.16	0.18	0.20	0.21	0.21	0.17	0.20	0.22	0.21
A x D	1 x 1	3.58	3.39	3.44	3.26	2.97	2.95	3.28	3.28	2.93	2.78	2.43	2.48
	1 x 2	3.48	3.44	3.31	3.16	2.98	3.00	3.23	3.23	3.02	2.95	2.62	2.57
	2 x 1	3.69	3.55	3.35	3.21	2.95	2.79	2.85	2.84	2.70	2.51	2.45	2.40
	2 x 2	3.45	3.36	3.19	3.16	2.85	2.61	2.64	2.62	2.60	2.26	2.34	2.25
CD		0.23	0.21	0.20	0.23	0.26	0.29	0.31	0.31	0.25	0.29	0.32	0.29
B x D	1 x 1	3.69	3.51	3.38	3.20	2.97	2.95	3.06	3.09	2.81	2.68	2.38	2.53
	1 x 2	3.34	3.28	3.20	3.26	2.98	2.93	3.07	3.07	2.99	2.77	2.45	2.45
	2 x 1	3.59	3.44	3.41	3.27	2.95	2.78	3.03	3.03	2.82	2.62	2.49	2.35
	2 x 2	3.58	3.52	3.26	3.06	2.85	2.68	2.81	2.79	2.63	2.44	2.51	2.37
CD		0.23	0.21	0.20	0.23	0.26	0.29	0.31	0.31	0.25	0.29	0.32	0.29
C x D	1 x 1	3.38	3.23	3.13	3.03	2.83	2.84	3.01	3.01	2.73	2.53	2.38	2.39
	1 x 2	3.21	3.15	2.99	3.93	2.78	2.76	2.82	2.82	2.75	2.60	2.41	2.37
	2 x 1	3.88	3.72	3.66	3.45	3.08	2.89	3.11	3.11	2.89	2.76	2.50	2.48
	2 x 2	3.72	3.66	3.52	3.39	3.05	2.85	3.06	3.04	2.87	2.60	2.55	2.45
CD		0.23	0.21	0.20	0.23	0.26	0.29	0.31	0.31	0.25	0.29	0.32	0.29
E	1	3.59	3.47	3.34	3.23	2.98	2.90	3.04	3.03	2.85	2.67	2.50	2.47
	2	3.50	3.41	3.31	3.17	2.89	2.77	2.96	2.96	2.78	2.58	2.42	2.38
CD		0.16	0.15	0.14	0.16	0.18	0.20	0.21	0.21	0.17	0.20	0.22	0.21
A x E	1 x 1	3.52	3.36	3.34	3.21	3.02	3.03	3.27	3.27	3.01	2.89	2.54	2.61
	1 x 2	3.54	3.47	3.41	3.21	2.93	2.91	3.24	3.24	2.93	2.83	2.51	2.44
	2 x 1	3.67	3.53	3.33	3.25	2.95	2.77	2.79	2.79	2.68	2.45	2.46	2.33
	2 x 2	3.47	3.34	3.21	3.12	2.86	2.63	2.69	2.69	2.62	2.32	2.33	2.32
CD		0.23	0.21	0.20	0.23	0.26	0.29	0.31	0.31	0.25	0.29	0.32	0.29
B x E	1 x 1	3.58	3.41	3.36	3.27	3.03	3.04	3.18	3.18	2.98	2.81	2.48	2.56

	1 x 2	3.44	3.85	3.27	3.19	2.96	2.85	2.99	2.99	2.82	2.63	2.35	2.43
	2 x 1	3.60	3.53	3.31	3.19	2.93	2.78	2.98	2.87	2.72	2.53	2.53	2.39
	2 x 2	3.57	3.43	3.50	3.14	2.83	2.69	2.94	2.94	2.73	2.52	2.48	2.33
CD		0.23	0.21	0.20	0.23	0.26	0.29	0.31	0.31	0.25	0.29	0.32	0.29
C x E	1 x 1	3.32	3.19	3.07	2.94	2.85	2.89	2.92	2.92	2.76	2.59	2.44	2.37
	1 x 2	3.72	3.18	3.05	3.02	2.76	2.71	2.91	2.91	2.72	2.54	2.36	2.40
	2 x 1	3.86	3.74	3.60	3.52	3.12	2.92	3.15	3.13	2.94	2.75	2.57	2.58
	2 x 2	3.74	3.63	3.57	3.31	3.02	2.82	3.02	3.02	2.83	2.61	2.48	2.35
CD		0.23	0.21	0.20	0.23	0.26	0.29	0.31	0.31	0.25	0.29	0.32	0.29
D x E	1 x 1	3.65	3.49	3.37	3.34	3.13	3.04	3.18	3.18	2.93	2.74	2.59	2.57
	1 x 2	3.65	3.45	3.42	3.13	2.79	2.70	2.94	2.94	2.69	2.55	2.29	2.30
	2 x 1	3.54	3.45	3.30	3.12	2.84	2.77	2.89	2.87	2.77	2.60	2.41	2.37
	2 x 2	3.38	3.35	3.20	3.20	2.99	2.84	2.99	2.99	2.85	2.60	2.55	2.45
CD		0.23	0.21	0.20	0.23	0.26	0.29	0.31	0.31	0.25	0.29	0.32	0.29
C V %		11.66	11.29	10.82	12.86	15.71	18.09	18.30	18.34	15.81	19.92	23.13	21.65

Factor A Growing structure/ Environment (1. Top ventilated rain-shelter; 2. Fan and pad system);

Factor B Methods of Growing (1. On bench; 2. Hanging);

Factor C Types of *Phalaenopsis* (1. Pot plant; 2. Cut flower);

Factor D Types of pots (1. White – transparent plastic pots (translucent); 2. Opaque (Black) plastic pots);

Factor E Media (1. Brick + charcoal medium; 2. Brick + coconut husk bits medium);

** Significant at 1 % level * Significant at 5 % level

4.1.2 Interval of leaf production

Data on mean interval of leaf production in (days) per plant during the period of study (May 2011 to April 2012) are presented in Table 2.

Time required for the emergence of first leaf showed significant difference in plants grown under rain shelter and under fan and pad structure. Under rain shelter, time taken for emergence of first leaf was less (79.89 days) while plants under fan and pad took more time for emergence of first leaf (91.12 days).

Emergence of first leaf did not differ significantly with respect to the method of growing (on bench and hanging), type of plant (pot plant and cut flower) types of pot (white pot and black pot) and growing media (brick + charcoal and brick + coconut husk bits).

Significant difference in emergence of the first leaf was observed in interaction between method of growing and type of plant. Interaction between cut flower type grown by hanging method recorded the minimum days for first leaf production (73.50 days), where as interaction between on bench and cut flower type recorded the maximum number of days for the first leaf production (100.16 days).

Emergence of first leaf did not differ significantly with respect to the method of growing (on bench and hanging), types of pot (white pot and black pot) and growing media (brick + charcoal and brick + coconut husk bits). Similarly, interaction of structure x method, structure x type of plant, structure x type of pot, type of plant x type of pot, structure x media, method x media, type of plant x media and type of pot x media were also not statistically different.

Emergence of second leaf did not differ significantly in any of the factor or their interaction. Time taken for emergence of the third leaf differed significantly between growing structures. Fan and pad took the minimum (22.54 days) and rain shelter took the maximum (65.18 days) for emergence of third leaf, other factors and their interactions were at par.

Table 2. Interval of leaf production (days) of *Phalaenopsis* as influenced by different factors

Interval of leaf production (days)				
Interval→ Factors ↓		1st (days)	2nd (days)	3rd (days)
A	1	79.89*	105.04	65.18**
	2	91.12*	106.47	22.54**
CD		0.50	0.87	2.04
B	1	89.52	109.87	39.52
	2	81.50	101.75	48.20
CD		0.50	0.87	2.04
A x B	1 x 1	85.66	115.12	62.20
	1 x 2	74.12	95.08	68.16
	2 x 1	93.37	104.54	16.83
	2 x 2	88.87	108.41	28.25
CD		0.71	1.24	2.89
C	1	84.18	107.77	50.54
	2	86.83	103.81	37.18
CD		0.50	0.87	2.04
A x C	1 x 1	81.00	102.12	61.62
	1 x 2	78.79	108.08	68.75
	2 x 1	87.37	113.41	39.45
	2 x 2	94.87	99.54	5.62
CD		0.71	1.24	2.89
B x C	1 x 1	78.87	115.70	43.66
	1 x 2	100.16	103.95	35.37
	2 x 1	89.50	99.83	57.41
	2 x 2	73.50	103.66	39.00
CD		0.71	1.24	2.89
D	1	83.45	105.33	47.68
	2	87.56	106.25	40.04
CD		0.50	0.87	2.04
A x D	1 x 1	73.16	99.25	74.75
	1 x 2	86.62	110.95	55.62
	2 x 1	93.75	111.41	20.62
	2 x 2	88.50	101.54	24.45
CD		0.71	1.24	2.89
B x D	1 x 1	89.58	112.16	36.33
	1 x 2	89.45	107.50	42.70
	2 x 1	77.33	98.50	59.04
	2 x 2	85.66	105.00	37.37
CD		0.71	1.24	2.89
C x D	1 x 1	82.91	108.00	51.33
	1 x 2	85.45	107.54	49.75

	2 x 1	84.00	102.66	44.04
	2 x 2	89.66	104.95	30.33
CD		0.71	1.24	2.89
E	1	84.10	103.93	34.68
	2	86.91	107.64	53.04
CD		0.50	0.87	2.04
A x E	1 x 1	81.12	98.50	57.66
	1 x 2	78.66	111.70	72.70
	2 x 1	87.08	109.37	11.70
	2 x 2	95.16	103.58	33.37
CD		0.71	1.24	2.89
B x E	1 x 1	86.83	104.50	25.12
	1 x 2	92.20	115.16	53.91
	2 x 1	81.37	103.37	44.25
	2 x 2	81.62	100.12	52.16
CD		0.71	1.24	2.89
C x E	1 x 1	87.12	101.41	43.41
	1 x 2	81.25	114.12	57.66
	2 x 1	81.08	106.45	25.95
	2 x 2	92.58	101.16	48.41
CD		0.71	1.24	2.89
D x E	1 x 1	81.62	108.70	31.54
	1 x 2	85.29	101.95	63.83
	2 x 1	86.58	99.16	37.83
	2 x 2	88.54	113.33	42.25
CD		0.71	1.24	2.89
C V %		13.73	21.74	123.70

Factor A Growing structure/ Environment (1. Top ventilated rain-shelter; 2. Fan and pad system);

Factor B Methods of Growing (1. On bench; 2. Hanging);

Factor C Types of *Phalaenopsis* (1. Pot plant; 2. Cut flower);

Factor D Types of pots (1. White – transparent plastic pots (translucent); 2. Opaque (Black) plastic pots);

Factor E Media (1. Brick + charcoal medium; 2. Brick + coconut husk bits medium);

** Significant at 1 % level * Significant at 5 % level

4.1.3 Plant height

Data on the plant heig ht recorded during the period of study (May 2011 to April 2012) are presented in Table 3.

Plant height showed no statistical difference in two methods of growing for the first five months (May to September) but, it showed significant difference in last seven months (October to April). In general, plant height on bench method of growing was higher (2.12, 2.17, 2.19, 2.22, 2.25, 2.30, 2.34 cm) than hanging method of growing (2.06, 2.11, 2.12. 2.15, 2.18, 2.21, 2.27 cm) from October to April respectively.

Plant height showed significant difference with respect to types of plant (pot plant and cut flower) and type of pots (white pot and black pot) during the entire period of the study. During the first month (May) cut flower showed the maximum plant height (1.69 cm) and pot plant showed minimum (1.55 cm) respectively. The height of plants grown in black pot was recorded higher (1.66 cm) and that in white pot showed lower (1.58 cm). During the 12th month (April), plant·height reached to 2.27 cm and 2.34 cm in pot plant and cut flower type respectively whereas in case of black pot and white pot it increased up to 2.28 cm and 2.33 cm respectively.

Interaction between effect of growing structure and method of growing were not statistically different for first two months (May and June) but for next three months it statistically differed. Among statistically significant interaction, rain shelter x on bench recorded the maximum plant height (1.81 cm) while rain shelter x hanging recorded the minimum plant height (1.71 cm) during month of July and after three months (September) interaction between rain shelter x on bench recorded the maximum plant height (2.02 cm) and rain shelter x hanging recorded the minimum plant height (1.92 cm).

Similarly interaction between growing system and type of plant was not statistically significant different for the first five months (May 2011 to September 2011) and last two months (March 2012 and April 2012) but during October 2011 to February 2012, it was statistically significant. Interaction between rain shelter x

Table 3. Plant height (cm) of *Phalaenopsis* as influenced by different factors at monthly interval

		Plant height (cm)											
Month → Factor ↓		May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April
A	1	1.61	1.62	1.76	1.89	1.97	2.07	2.13	2.14	2.18	2.21	2.26	2.31
	2	1.64	1.68	1.77	1.86	1.99	2.11	2.16	2.18	2.20	2.22	2.25	2.30
CD			0.06	0.06	0.05	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.03
B	1	1.63	1.64	1.77	1.88	2.00	2.12*	2.17**	2.19**	2.22**	2.25**	2.30**	2.34**
	2	1.62	1.65	1.76	1.87	1.96	2.06*	2.11**	2.12**	2.15**	2.18**	2.21**	2.27**
CD			0.06	0.06	0.05	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.03
A x B	1 x 1	1.62	1.64	1.81*	1.94**	2.02*	2.11	2.16	2.17	2.21	2.25	2.30	2.34
	1 x 2	1.60	1.60	1.71*	1.83**	1.92*	2.03	2.10	2.10	2.14	2.17	2.21	2.28
	2 x 1	1.64	1.65	1.74*	1.82**	1.98*	2.14	2.19	2.21	2.23	2.25	2.29	2.34
	2 x 2	1.64	1.71	1.80*	1.90**	1.99*	2.09	2.12	2.14	2.17	2.19	2.21	2.25
CD			0.08	0.08	0.08	0.08	0.07	0.06	0.06	0.06	0.04	0.06	0.05
C	1	1.55**	1.58**	1.70**	1.81**	1.90**	2.01**	2.07**	2.08**	2.12**	2.16**	2.21**	2.27**
	2	1.69**	1.72**	1.83**	1.94**	2.06**	2.17**	2.21**	2.23**	2.25**	2.27**	2.31**	2.34**
CD		0.06	0.06	0.05	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.04
A x C	1 x 1	1.54	1.56	1.70	1.81	1.87	1.96**	2.03*	2.03**	2.08*	2.13*	2.20	2.26
	1 x 2	1.67	1.68	1.82	1.96	2.08	2.18**	2.22*	2.24**	2.27*	2.29*	2.32	2.36
	2 x 1	1.56	1.60	1.70	1.80	1.92	2.06**	2.11*	2.14**	2.15*	2.19*	2.22	2.27
	2 x 2	1.72	1.76	1.84	1.93	2.05	2.16**	2.20*	2.22**	2.24*	2.25*	2.28	2.32
CD			0.08	0.08	0.08	0.08	0.07	0.06	0.06	0.06	0.04	0.06	0.05
B x C	1 x 1	1.55	1.57	1.71	1.82	1.90	2.03	2.08	2.09	2.12	2.18	2.24	2.28
	1 x 2	1.71	1.72	1.84	1.95	2.10	2.21	2.27	2.29	2.31	2.33	2.36	2.40
	2 x 1	1.56	1.59	1.69	1.80	1.89	1.99	2.06	2.08	2.11	2.14	2.18	2.25
	2 x 2	1.68	1.72	1.82	1.94	2.03	2.13	2.16	2.17	2.20	2.22	2.24	2.28

CD			0.08	0.08	0.08	0.08	0.07	0.06	0.06	0.06	0.04	0.06	0.05
D	1	1.58*	1.61**	1.72**	1.83**	1.94**	2.07*	2.11**	2.13*	2.16*	2.19*	2.22*	2.28*
	2	1.66*	1.69**	1.81**	1.92**	2.02**	2.12*	2.17**	2.18*	2.21*	2.24*	2.29*	2.33*
CD			0.06	0.06	0.05	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.03
A x D	1 x 1	1.57	1.59	1.72	1.84	1.92	2.03	2.09	2.10	2.14	2.18	2.21	2.27
	1 x 2	1.64	1.65	1.79	1.93	2.02	2.11	2.13	2.17	2.21	2.24	2.31	2.35
	2 x 1	1.60	1.62	1.71	1.81	1.95	2.10	2.16	2.16	2.17	2.20	2.23	2.28
	2 x 2	1.68	1.74	1.83	1.91	2.03	2.12	2.18	2.20	2.22	2.24	2.27	2.31
CD			0.08	0.08	0.08	0.08	0.07	0.06	0.06	0.06	0.04	0.06	0.05
B x D	1 x 1	1.58	1.61	1.73	1.84	1.95	2.11	2.16	2.17	2.20	2.24	2.27	2.33
	1 x 2	1.68	1.68	1.82	1.93	2.05	2.14	2.20	2.21	2.24	2.17	2.32	2.35
	2 x 1	1.59	1.61	1.71	1.82	1.92	2.03	2.08	2.09	2.12	2.14	2.16	2.22
	2 x 2	1.65	1.70	1.80	1.92	2.00	2.09	2.16	2.16	2.19	2.22	2.25	2.31
CD			0.08	0.08	0.08	0.08	0.07	0.06	0.06	0.06	0.04	0.06	0.05
C x D	1 x 1	1.52	1.54	1.67	1.78	1.86	1.99	2.04	2.06	2.09	2.14	2.17	2.24
	1 x 2	1.59	1.62	1.74	1.83	1.93	2.03	2.10	2.11	2.14	2.18	2.24	2.30
	2 x 1	1.65	1.67	1.77	1.88	2.01	2.14	2.18	2.19	2.22	2.24	2.27	2.31
	2 x 2	1.74	1.76	1.89	2.01	2.12	2.20	2.25	2.26	2.29	2.30	2.33	2.36
CD			0.08	0.08	0.08	0.08	0.07	0.06	0.06	0.06	0.04	0.06	0.05
E	1	1.63	1.66	1.77	1.88	1.97	2.08	2.13	2.14	2.17	2.20	2.24	2.29
	2	1.61	1.63	1.76	1.87	1.99	2.11	2.15	2.17	2.20	2.23	2.27	2.32
CD		0.06	0.06	0.05	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.04
A x E	1 x 1	1.64	1.65	1.77	1.88	1.97	2.05	2.11	2.11	2.15	2.19	2.23	2.28
	1 x 2	1.57	1.59	1.75	1.89	1.98	2.09	2.14	2.16	2.20	2.23	2.28	2.34
	2 x 1	1.63	1.68	1.77	1.88	1.97	2.10	2.15	2.17	2.19	2.22	2.24	2.30
	2 x 2	1.66	1.68	1.77	1.85	2.01	2.13	2.17	2.19	2.21	2.22	2.25	2.29
CD			0.08	0.08	0.08	0.08	0.07	0.06	0.06	0.06	0.04	0.06	0.05
B x E	1 x 1	1.66	1.67	1.79	1.91	2.02	2.14	2.18	2.20	2.22	2.26	2.29	2.33

	1 x 2	1.60	1.61	1.75	1.85	1.98	2.11	2.18	2.18	2.22	2.25	2.30	2.35
	2 x 1	1.61	1.65	1.75	1.85	1.91	2.01	2.07	2.08	2.12	2.15	2.19	2.34
	2 x 2	1.63	1.66	1.76	1.88	2.01	2.11	2.15	2.16	2.18	2.20	2.23	2.29
CD			0.08	0.08	0.08	0.08	0.07	0.06	0.06	0.06	0.04	0.06	0.05
C x E	1 x 1	1.59	1.63	1.74	1.84	1.89	1.99	2.05	2.07	2.10	2.15	2.18	2.25
	1 x 2	1.52	1.54	1.66	1.78	1.90	2.03	2.09	2.10	2.14	2.17	2.23	2.28
	2 x 1	1.68	1.70	1.80	1.92	2.05	2.16	2.20	2.21	2.24	2.26	2.29	2.32
	2 x 2	1.71	1.73	1.86	1.96	2.08	2.18	2.22	2.24	2.27	2.28	2.31	2.35
CD			0.08	0.08	0.08	0.08	0.07	0.06	0.06	0.06	0.04	0.06	0.05
D x E	1 x 1	1.62	1.64	1.75	1.85	1.93	2.05	2.10	2.12	2.15	2.19	2.21	2.26
	1 x 2	1.55	1.57	1.69	1.81	1.94	2.08	2.12	2.14	2.17	2.19	2.23	2.29
	2 x 1	1.65	1.69	1.80	1.92	2.00	2.10	2.15	2.16	2.19	2.22	2.26	2.31
	2 x 2	1.68	1.70	1.82	1.93	2.05	2.13	2.19	2.21	2.24	2.26	2.31	2.35
CD			0.08	0.08	0.08	0.08	0.07	0.06	0.06	0.06	0.04	0.06	0.05
C V %			9.73	9.60	8.40	8.38	6.34	5.72	5.02	5.07	5.04	4.86	4.38

Factor A Growing structure/ Environment (1. Top ventilated rain-shelter; 2. Fan and pad system);

Factor B Methods of Growing (1. On bench; 2. Hanging);

Factor C Types of *Phalaenopsis* (1. Pot plant; 2. Cut flower);

Factor D Types of pots (1. White – transparent plastic pots (translucent); 2. Opaque (Black) plastic pots);

Factor E Media (1. Brick + charcoal medium; 2. Brick + coconut husk bits medium);

** Significant at 1 % level * Significant at 5 % level

cut flower recorded the maximum plant height (2.18 cm) and rain shelter x pot plant recorded the minimum plant height (1.96 cm) during October, after four months same interaction had recorded the maximum and minimum plant height increase *i.e.* rain shelter x cut flower (2.29 cm) and rain shelter x pot plant (2.13 cm).

Plant height did not showed significant difference with respect to growing structures and media, similarly interaction between growing methods and type of plant, growing structure and type of pot, growing method and type of pot, type of plant and type of pot, growing structure and media, growing method and media, type of plant and media, type of pot and media were not statistically significant.

4.1.4 Leaf length

Data on the mean leaf length during the period of study at monthly interval (May 2011 to April 2012) are presented in Table 4.

Leaf length of the plant varied statistically in plants grown under rain shelter and fan and pad system for first eight months (May 2011 to December 2011) and for last four months, leaf length showed no statistical difference. During first month (May) plants grown under fan and pad system recorded the highest growth (8.13 cm) than the rain shelter (6.92 cm). During eight month (December) plants grown under fan and pad system recorded the highest growth (9.88 cm) and rain shelter recorded the lowest growth (9.25 cm).

The plant types *i.e.*, pot plant and cut flower showed statistically significant difference with respect to leaf length during entire period of study. In case of pot plant, leaf length was the lowest (6.22 cm) in May and increased up to (9.30 cm) during April while, leaf length of cut flower type was the highest (8.83 cm) in May and increased up to (11.92 cm) in April.

Leaf length of plants did not show any statistical difference grown under different media (brick + charcoal and brick + coconut husk bits) for first eleven months (May 2011 to March 2012) but it showed significant difference in April.

Table 4. Leaf length (cm) of *Phalaenopsis* as influenced by different factors at monthly interval

		Leaf length (cm)											
Month → Factor ↓		May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April
A	1	6.92**	7.34**	7.75**	8.11**	8.40**	8.71**	8.96**	9.25*	9.57	9.89	10.21	10.52
	2	8.13**	8.44**	8.72**	8.99**	9.23**	9.47**	9.69**	9.88*	10.07	10.25	10.49	10.70
CD		0.40	0.41	0.40	0.40	0.42	0.41	0.41	0.41	0.40	0.39	0.40	0.39
B	1	7.39	7.79	8.14	8.49	8.82	9.07	9.31	9.55	9.80	10.07	10.36	10.60
	2	7.66	7.99	8.34	8.61	8.81	9.10	9.34	9.59	9.84	10.07	10.34	10.62
CD		0.40	0.41	0.40	0.40	0.42	0.41	0.41	0.41	0.40	0.39	0.40	0.39
A x B	1 x 1	7.26**	7.72**	8.10**	8.49**	8.88**	9.13**	9.38**	9.66**	9.97**	10.27**	10.58**	10.85**
	1 x 2	6.57**	6.96**	7.40**	7.73**	7.93**	8.28**	8.54**	8.85**	9.18**	9.50**	9.84**	10.18**
	2 x 1	7.52**	7.86**	8.17**	8.49**	8.76**	9.01**	9.24**	9.44**	9.63**	9.86**	10.14**	10.34**
	2 x 2	8.75**	9.02**	9.28**	9.49**	9.70**	9.92**	10.14**	10.32**	10.51**	10.64**	10.84**	11.06**
CD		0.57	0.58	0.57	0.57	0.60	0.58	0.58	0.58	0.57	0.56	0.56	0.55
C	1	6.22**	6.58**	6.92**	7.24**	7.49**	7.79**	8.02**	8.25**	8.52**	8.76**	9.05**	9.30**
	2	8.83**	9.20**	9.55**	9.86**	10.14**	10.38**	10.62**	10.88**	11.12**	11.38**	11.65**	11.92**
CD		0.40	0.41	0.40	0.40	0.42	0.41	0.41	0.41	0.40	0.39	0.40	0.39
A x C	1 x 1	5.97	6.20	6.58	6.94	7.19	7.55	7.80	10.06	8.38	8.69	9.00	9.29
	1 x 2	8.04	8.48	8.92	9.28	9.61	9.86	10.12	10.45	10.76	11.09	11.42	11.74
	2 x 1	6.65	6.96	7.26	7.53	7.79	8.03	8.25	8.44	8.66	8.84	9.10	9.31
	2 x 2	9.62	9.93	10.19	10.42	10.67	10.90	11.13	11.32	11.48	11.67	11.88	12.10
CD		0.57	0.58	0.57	0.57	0.60	0.58	0.58	0.58	0.57	0.56	0.56	0.55
B x C	1 x 1	5.89	6.30	6.67	7.06	7.44	7.70	7.95	8.20	8.49	8.77	9.10	9.35
	1 x 2	8.89	9.28	9.60	9.92	10.20	10.45	10.67	10.90	11.11	11.36	11.62	11.85
	2 x 1	6.54	6.86	7.17	7.42	7.55	7.89	8.10	8.31	8.56	8.75	9.00	9.25
	2 x 2	8.78	9.12	9.51	9.80	10.08	10.32	10.58	10.87	11.13	11.39	11.69	11.99

CD		0.57	0.58	0.57	0.57	0.60	0.58	0.58	0.58	0.57	0.56	0.56	0.55
D	1	7.61	7.96	8.30	8.61	8.87	9.14	9.39	9.63	9.89	10.15	10.45	10.73
	2	7.44	7.82	8.17	8.49	8.73	9.04	9.25	9.51	9.75	9.99	10.25	10.49
CD		0.40	0.41	0.40	0.40	0.42	0.41	0.41	0.41	0.40	0.39	0.40	0.39
A x D	1 x 1	7.06	7.47	7.84	8.21	8.52	8.82	9.11	9.40	9.73	10.05	10.42	10.77
	1 x 2	6.76	7.21	7.66	8.01	8.29	8.59	8.81	9.11	9.41	9.72	10.00	10.26
	2 x 1	8.16	8.45	8.76	9.02	9.23	9.45	9.68	9.86	10.06	10.24	10.47	10.68
	2 x 2	8.11	8.44	8.69	8.97	9.23	9.48	9.70	9.90	10.09	10.27	10.50	10.72
CD		0.57	0.58	0.57	0.57	0.60	0.58	0.58	0.58	0.57	0.56	0.56	0.55
B x D	1 x 1	7.52	7.91	8.25	8.60	8.91	9.19	9.45	9.69	9.95	10.23	10.54	10.79
	1 x 2	2.26	7.67	8.02	8.38	9.72	8.96	9.17	9.41	9.65	9.90	10.18	10.41
	2 x 1	7.70	8.02	8.35	8.62	8.83	9.09	9.33	9.57	9.84	10.06	10.36	10.67
	2 x 2	7.62	7.97	8.33	8.60	8.79	9.12	9.34	9.60	9.85	10.08	10.33	10.57
CD		0.57	0.58	0.57	0.57	0.60	0.58	0.58	0.58	0.57	0.56	0.56	0.55
C x D	1 x 1	6.19	6.53	6.89	7.20	7.47	7.75	8.03	8.26	8.53	8.79	9.10	9.39
	1 x 2	6.25	6.64	6.95	7.27	7.52	7.84	8.02	8.25	8.52	8.73	9.00	9.21
	2 x 1	9.04	9.40	9.71	10.02	10.24	10.53	10.75	11.01	11.26	11.50	11.79	12.07
	2 x 2	8.63	9.01	9.40	9.70	10.00	10.24	10.49	10.76	10.98	11.25	11.51	11.77
CD		0.57	0.58	0.57	0.57	0.60	0.58	0.58	0.58	0.57	0.56	0.56	0.55
E	1	7.57	7.91	8.22	8.51	8.78	9.02	9.22	9.46	9.67	9.91	10.15	10.39*
	2	7.48	7.88	8.25	8.59	8.85	9.16	9.43	9.68	9.97	10.23	10.55	10.82*
CD		0.40	0.41	0.40	0.40	0.42	0.41	0.41	0.41	0.40	0.39	0.40	0.39
A x E	1 x 1	6.84	7.22	7.57	7.91	8.19	8.43	8.66	8.94	9.20	9.52	9.82	10.11
	1 x 2	7.00	7.46	7.93	8.31	8.62	8.98	9.26	9.57	9.94	10.25	10.60	10.92
	2 x 1	8.30	8.60	8.87	9.12	9.38	9.60	9.78	9.97	10.14	10.29	10.47	10.68
	2 x 2	7.97	8.29	8.58	8.86	9.06	9.33	9.59	9.79	10.00	10.21	10.51	10.73
CD		0.57	0.58	0.57	0.57	0.60	0.58	0.58	0.58	0.57	0.56	0.56	0.55
B x E	1 x 1	7.38	7.77	8.12	8.47	8.79	9.02	9.21	9.45	9.66	9.91	10.14	10.36

	1 x 2	7.40	7.81	8.15	8.50	8.85	9.12	9.41	9.65	9.94	10.23	10.58	10.83
	2 x 1	7.76	8.04	8.32	8.55	8.78	9.01	9.24	9.47	9.68	9.91	10.15	10.42
	2 x 2	7.56	7.95	8.36	8.67	8.85	9.19	9.44	9.71	10.00	10.23	10.53	10.81
CD		0.57	0.58	0.57	0.57	0.60	0.58	0.58	0.58	0.57	0.56	0.56	0.55
C x E	1 x 1	6.18	6.50	6.84	7.14	7.43	7.69	7.88	8.11	8.34	8.57	8.79	9.01
	1 x 2	6.25	6.66	7.00	7.33	7.55	7.89	8.17	8.39	8.71	8.95	9.30	9.59
	2 x 1	8.96	9.31	9.60	9.88	10.13	10.34	10.56	10.80	11.01	11.24	11.50	11.78
	2 x 2	8.71	9.09	9.51	9.84	10.15	10.42	10.69	10.97	11.23	11.51	11.81	12.06
CD		0.57	0.58	0.57	0.57	0.60	0.58	0.58	0.58	0.57	0.56	0.56	0.55
D x E	1 x 1	7.67	7.99	8.33	8.65	8.92	9.16	9.39	9.62	9.84	10.09	10.36	10.64
	1 x 2	7.56	7.93	8.27	8.57	8.83	9.11	9.39	9.64	9.95	10.20	10.53	10.82
	2 x 1	7.47	7.82	8.11	8.38	8.65	8.87	9.04	9.29	9.51	9.73	9.93	10.15
	2 x 2	7.41	7.82	8.24	8.60	8.87	9.21	9.46	9.72	9.99	10.26	10.58	10.83
CD		0.57	0.58	0.57	0.57	0.60	0.58	0.58	0.58	0.57	0.56	0.56	0.55
C V %		13.39	13.00	12.43	11.96	12.12	11.38	11.04	10.74	10.34	9.83	9.69	9.24

Factor A Growing structure/ Environment (1. Top ventilated rain-shelter; 2. Fan and pad system);

Factor B Methods of Growing (1. On bench; 2. Hanging);

Factor C Types of *Phalaenopsis* (1. Pot plant; 2. Cut flower);

Factor D Types of pots (1. White – transparent plastic pots (translucent); 2. Opaque (Black) plastic pots);

Factor E Media (1. Brick + charcoal medium; 2. Brick + coconut husk bits medium);

** Significant at 1 % level * Significant at 5 % level

Leaf length of plants grown in brick + coconut husk bits was higher (10.82 cm) and that was lower in brick + charcoal (10.39 cm).

Similarly, interaction of growing system and method of growing also showed statistical difference throughout the study. During first month (May), leaf length recorded was maximum in fan and pad x hanging (8.75 cm) and minimum in rain shelter x hanging (6.57 cm). During the last month (April) of study, maximum leaf length was recorded in fan and pad x hanging (11.06 cm) and minimum leaf length was recorded in rain shelter x hanging (10.18 cm).

Leaf length exhibited no significant difference with respect to growing methods and type of pots. Similarly, interaction of growing structure x type of plant, growing method x type of plant, growing structure x type of pot, growing method x type of pot, type of plant x type of pot, method x media, type of plant x media and type of pot x media were also not statistically different.

4.1.5 Leaf breadth

Data on the mean leaf breadth during the period of study at monthly interval (May 2011 to April 2012) are presented in Table 5.

Leaf breadth of the plants showed statistical difference in plants grown under rain shelter and fan and pad system for first five months (May 2011 to September 2012) and thereafter for seven months (October 2011 to April 2012) leaf breadth showed no significant difference. In general, plants grown under rain shelter showed low leaf breadth; and that in fan and pad was higher. During first month (May) plants grown under fan and pad system recorded the highest growth (4.52 cm) and rain shelter recorded the lowest growth (4.19 cm). During fifth month (September) plants grown under fan and pad system recorded the highest growth (5.28 cm) and rain shelter recorded the lowest growth (5.19 cm).

Leaf breadth of plant did not exhibit statistical difference grown under different media (brick + charcoal and brick + coconut husk bits) for the first eleven months (May to March) but, it was statistically different in April. Leaf breadth of

Table 5. Leaf breadth (cm) of *Phalaenopsis* as influenced by different factors at monthly interval

		Leaf breadth (cm)											
Month → Factor ↓		May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April
A	1	4.19**	4.46**	4.74**	4.96*	5.15*	5.32	5.47	5.64	5.84	6.02	6.18	6.35
	2	4.52**	4.74**	4.96**	5.11*	5.28*	5.39	5.51	5.67	5.83	5.99	6.15	6.33
CD			0.13	0.13	0.13	0.12	0.12	0.12	0.13	0.12	0.12	0.12	0.12
B	1	4.33	4.56	4.80	5.02	5.21	5.36	5.51	5.68	5.87	6.05	6.22	6.38
	2	4.38	4.63	4.90	5.04	5.22	5.35	5.47	5.62	5.81	5.95	6.11	6.30
CD			0.13	0.13	0.13	0.12	0.12	0.12	0.13	0.12	0.12	0.12	0.12
A x B	1 x 1	4.23	4.49*	4.75	5.00	5.21	5.40*	5.57*	5.75*	5.96*	6.14*	6.29*	6.44
	1 x 2	4.16	4.42*	4.74	4.91	5.09	5.23*	5.38*	5.53*	5.73*	5.90*	6.06*	6.25
	2 x 1	4.43	4.63*	4.86	5.04	5.21	5.32*	5.45*	5.61*	5.77*	5.96*	6.14*	6.32
	2 x 2	4.61	4.84*	5.06	5.17	5.35	5.46*	5.57*	5.72*	5.89*	6.01*	6.16*	6.34
CD			0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.17	0.17	0.17
C	1	4.34	4.58	4.82	5.01	5.19	5.32	5.49	5.65	5.82	5.97	6.12	6.31
	2	4.37	4.61	4.88	5.05	5.24	5.38	5.50	5.66	5.86	6.04	6.20	6.37
CD		0.13	0.13	0.13	0.12	0.12	0.12	0.13	0.12	0.12	0.12	0.12	0.11
A x C	1 x 1	4.16	4.42	4.68	4.91	5.09	5.26	5.44	5.60	5.79	5.93	6.08	6.25*
	1 x 2	4.23	4.49	4.81	5.01	5.21	5.37	5.51	5.67	5.90	6.10	6.28	6.44*
	2 x 1	4.52	4.73	4.97	5.11	5.29	5.38	5.54	5.69	5.85	6.00	6.17	6.37*
	2 x 2	4.52	4.74	4.94	5.10	5.28	5.40	5.49	5.64	5.81	5.97	6.13	6.30*
CD			0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.17	0.17	0.17
B x C	1 x 1	4.28	4.52	4.76	5.01	5.20	5.35	5.54	5.72	5.88	6.04	6.19	6.37
	1 x 2	4.38	4.62	4.84	5.04	5.22	5.38	5.48	5.65	5.85	6.06	6.24	6.39
	2 x 1	4.40	4.64	4.88	5.02	5.18	5.30	5.44	5.58	5.76	5.89	6.05	6.25
	2 x 2	4.36	4.62	4.91	5.07	5.27	5.39	5.51	5.67	5.86	6.01	6.17	6.34

CD			0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.17	0.17	0.17
D	1	4.39	4.63	4.89	5.07	5.25	5.38	5.50	5.66	5.85	6.02	6.18	6.35
	2	4.32	4.56	4.84	5.00	5.19	5.32	5.48	5.65	5.83	5.99	6.14	6.33
CD			0.13	0.13	0.13	0.12	0.12	0.12	0.13	0.12	0.12	0.12	0.12
A x D	1 x 1	4.20	4.47	4.75	4.97	5.15	5.31	5.46	5.59	5.80	5.96*	6.12*	6.28*
	1 x 2	4.19	4.45	4.73	4.95	5.15	5.32	5.49	5.68	5.89	6.08*	6.23*	6.41*
	2 x 1	4.58	4.80	5.03	5.17	5.34	5.46	5.55	5.72	5.90	6.07*	6.25*	6.41*
	2 x 2	4.46	4.68	4.89	5.04	5.22	5.33	5.47	5.61	5.76	5.90*	6.05*	6.26*
CD			0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.17	0.17	0.17
B x D	1 x 1	4.30	4.54	4.78	5.02	5.20	5.37	5.49	5.68	5.89	6.08	6.24	6.40
	1 x 2	4.36	4.59	4.82	5.03	5.22	5.36	5.53	5.69	5.85	6.02	6.19	6.36
	2 x 1	4.48	4.72	5.00	5.12	5.29	5.40	5.51	5.64	5.81	5.96	6.12	6.29
	2 x 2	4.29	4.53	4.79	4.96	5.15	5.29	5.44	5.61	5.81	5.95	6.10	6.30
CD			0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.17	0.17	0.17
C x D	1 x 1	4.36	4.60	4.83	5.03	5.20	5.34	5.50	5.64	5.83	5.97	6.12	6.30
	1 x 2	4.31	4.55	4.81	5.00	5.18	5.30	5.47	5.65	5.81	5.97	6.12	6.32
	2 x 1	4.41	4.66	4.95	5.11	5.29	5.42	5.50	5.67	5.87	6.07	6.25	6.40
	2 x 2	4.34	4.57	4.81	4.99	5.20	5.35	5.49	5.65	5.84	6.01	6.16	6.44
CD			0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.17	0.17	0.17
E	1	4.38	4.62	4.87	5.05	5.25	5.38	5.51	5.65	5.84	5.99	6.12	6.28*
	2	4.34	4.57	4.83	5.01	5.19	5.33	5.47	5.66	5.83	6.01	6.21	6.40*
CD		0.13	0.13	0.13	0.12	0.12	0.12	0.13	0.12	0.12	0.12	0.12	0.11
A x E	1 x 1	4.25	4.51	4.77	4.99	5.20	5.37	5.51	5.65	5.88	6.05	6.17	6.31
	1 x 2	4.14	4.41	4.71	4.93	5.11	5.26	5.44	5.63	5.81	5.99	6.18	6.38
	2 x 1	4.51	4.73	4.97	5.12	5.30	5.39	5.52	5.65	5.81	5.93	6.07	6.24
	2 x 2	4.53	4.74	4.94	5.10	5.27	5.39	5.50	5.68	5.86	6.04	6.23	6.43
CD			0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.17	0.17	0.17
B x E	1 x 1	4.35	4.58	4.83	5.04	5.24	5.39	5.54	5.68	5.87	6.04	6.18	6.34

	1 x 2	4.30	4.55	4.77	5.00	5.18	5.33	5.48	5.68	5.87	6.06	6.25	6.43
	2 x 1	4.40	4.66	4.91	5.07	5.25	5.36	5.49	5.62	5.82	5.94	6.06	6.22
	2 x 2	4.37	4.60	4.88	5.02	5.19	5.33	5.46	5.63	5.80	5.96	6.16	6.38
CD			0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.17	0.17	0.17
C x E	1 x 1	4.35	4.59	4.82	5.00	5.19	5.32	5.46	5.60	5.78	5.92	6.05	6.22
	1 x 2	4.33	4.57	4.83	5.03	5.19	5.32	5.52	5.69	5.86	6.02	6.20	6.40
	2 x 1	4.40	4.66	4.93	5.11	5.30	5.44	5.57	5.70	5.90	6.06	6.19	6.33
	2 x 2	4.34	4.57	4.82	5.00	5.19	5.33	5.42	5.62	5.81	6.01	6.22	6.41
CD			0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.17	0.17	0.17
D x E	1 x 1	4.43	4.67	4.93	5.11	5.29	5.42	5.55	5.68	5.97	6.02	6.15	6.30
	1 x 2	4.34	4.59	4.85	5.04	5.20	5.34	5.46	5.63	5.83	6.01	6.22	6.40
	2 x 1	4.32	4.57	4.81	5.00	5.20	5.33	5.48	5.62	5.81	5.96	6.09	6.26
	2 x 2	4.33	4.55	4.81	4.99	5.17	5.21	5.48	5.68	5.84	6.01	6.20	6.41
CD			0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.17	0.17	0.17
C V %			7.56	7.24	6.85	6.41	6.20	6.02	6.17	5.68	5.43	5.19	4.99

Factor A Growing structure/ Environment (1. Top ventilated rain-shelter; 2. Fan and pad system);

Factor B Methods of Growing (1. On bench; 2. Hanging);

Factor C Types of *Phalaenopsis* (1. Pot plant; 2. Cut flower);

Factor D Types of pots (1. White – transparent plastic pots (translucent); 2. Opaque (Black) plastic pots);

Factor E Media (1. Brick + charcoal medium; 2. Brick + coconut husk bits medium);

** Significant at 1 % level * Significant at 5 % level

plant grown in brick + coconut husk bit was high (6.40 cm) and brick + charcoal was low (6.28 cm).

Other interactions like growing structure and type of plant was not significantly different for initial eleventh months (May 2011 to March 2012) but, it was significantly different at 12th month (April) having rain shelter x cut flower with maximum leaf breadth (6.44 cm) and rain shelter x pot plant with minimum leaf breadth (6.25 cm). Interaction between growing structure and type of pot had not shown any significant difference for initial nine months but, it was statistically significant for last three months. During February, rain shelter x black pot recorded maximum leaf breadth (6.08 cm) and fan and pad x black pot recorded minimum leaf breadth (5.90 cm). But during last month, interaction between rain shelter x black pot recorded maximum leaf breadth (6.41 cm) while fan and pad x black pot recorded minimum leaf breadth (6.26 cm).

Leaf breadth did not differ significantly with respect to method of growing, type of plant and type of pot. Similarly, interaction of growing structure x type of plant, growing method x type of plant, growing method x type of pot, type of plant x type of pot, structure and media, method x media, type of plant x media and type of pot x media were also not statistically different.

4.1.6 Leaf area

Data on the total area of physiologically mature leaf during the period of study at monthly interval (May 2011 to April 2012) are presented in Table 6.

Leaf area of the plant showed statistical difference in plants grown under rain shelter and fan and pad system for first four months of growth (May to August). But for the last eight months (September 2011 to April 2012) leaf area has shown no statistical difference. During the first month (May), mean leaf area was recorded the maximum in fan and pad (27.10 cm^2) and minimum in rain shelter (23.71 cm^2). During the fourth month (August), the maximum leaf area was recorded in fan and pad (33.88 cm^2) and minimum in rain shelter (31.77 cm^2).

The plant type (pot plant and cut flower) showed statistically significant difference with respect to leaf area for the entire study period. During first month (May), leaf area was recorded the maximum in cut flower (29.32 cm^2) and minimum in pot plant (21.48 cm^2). During the 12th month (August), leaf area was recorded the maximum in cut flower (53.71 cm^2) and minimum in pot plant (44.48 cm^2).

Leaf area of plant did not exhibit statistical difference grown under different media (brick + charcoal and brick + coconut husk bits) for the first nine months (May to January), but significant difference was recorded from February to April. During the 10th month (February), leaf area was recorded the maximum in brick + coconut husk bits medium (45.98 cm^2) and minimum in brick + charcoal (43.77 cm^2). During the 12th month (August), leaf area was recorded maximum in brick + coconut husk bits (50.50 cm^2) and minimum in brick + charcoal (47.69 cm^2).

Similarly, interaction of growing structure and method of growing had shown statistical difference throughout the study period. During the first month (May), leaf area was recorded the maximum in fan and pad x hanging (28.25 cm^2) and minimum in rain shelter x hanging (22.10 cm^2). During the April, leaf area was recorded the maximum in rain shelter x on bench (51.73 cm^2) minimum in fan and pad x on bench (47.71 cm^2).

Other interactions like type of plant and media did not show any statistical difference for first ten months of growth (May to February). But for the last two months it was significantly different (March and April). During the March cut flower x brick + coconut husk bits recorded the maximum leaf area (51.76 cm^2) and pot plant x brick + charcoal recorded minimum leaf area (40.11 cm^2). During the April, cut flower x brick + coconut husk bits recorded the maximum leaf area (53.98 cm^2) and pot plant x brick + charcoal recorded minimum leaf area (41.93 cm^2).

Leaf area did not differ significantly with respect to method of growing, type of pot. Similarly, interaction of growing structure x type of plant, growing

Table 6. Leaf area (cm^2) of *Phalaenopsis* as influenced by different factors at monthly interval

Month → Factor ↓		May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April
		Leaf area (cm^2)											
A	1	23.71**	26.56**	29.21*	31.77*	33.71	35.97	38.26	40.70	43.27	45.35	47.70	50.04
	2	27.10**	29.38**	31.86*	33.88*	35.87	37.78	39.37	40.61	42.71	44.40	46.20	48.15
CD		1.76	1.67	1.71	1.75	1.73	1.79	1.89	2.35	1.93	1.94	1.98	1.96
B	1	25.34	27.87	30.28	32.69	34.69	37.00	39.02	40.63	43.51	45.32	47.65	49.72
	2	25.47	28.07	30.76	32.96	34.89	36.75	38.62	40.68	42.47	44.43	46.25	48.48
CD		1.76	1.67	1.71	1.75	1.73	1.79	1.89	2.35	1.93	1.94	1.98	1.96
A x B	1 x 1	25.32**	28.07**	30.34**	32.85	34.95**	37.56**	40.02**	42.65**	45.18**	47.21**	49.71**	51.73**
	1 x 2	22.10**	25.07**	28.08**	30.69	32.48**	34.37**	36.51**	38.75**	41.36**	43.48**	45.68**	48.36**
	2 x 1	25.35**	27.68**	30.23**	32.54	34.43**	36.44**	38.02**	38.62**	41.85**	43.43**	45.58**	47.71**
	2 x 2	28.85**	31.08**	33.49**	35.23	37.30**	39.13**	40.72**	42.60**	43.58**	45.37**	46.83**	48.59**
CD		2.50	2.37	2.41	2.47	2.45	2.53	2.67	3.33	2.73	2.75	2.80	2.77
C	1	21.48**	24.00**	26.44**	28.62**	30.52**	32.50**	34.48**	36.63**	38.67**	40.39**	42.47**	44.48**
	2	29.32**	31.95**	34.62**	37.03**	39.06**	41.25**	43.16**	44.68**	47.31**	49.36**	51.43**	53.71**
CD		1.76	1.67	1.71	1.75	1.73	1.79	1.89	2.35	1.93	1.94	1.98	1.96
A x C	1 x 1	20.45	23.04	25.44	27.89	29.83	31.96	34.32	36.53	39.04	40.97	43.23	45.55
	1 x 2	26.97	30.10	32.98	35.65	37.60	39.98	42.21	44.88	47.50	49.73	52.17	54.54
	2 x 1	22.52	24.95	27.45	29.35	31.21	33.05	34.64	36.73	38.30	39.81	41.71	43.41
	2 x 2	31.68	33.81	36.26	38.41	40.53	42.52	44.11	44.49	47.13	48.99	50.70	52.89
CD		2.50	2.37	2.41	2.47	2.45	2.53	2.67	3.33	2.73	2.75	2.80	2.77
B x C	1 x 1	21.00	23.52	25.97	28.36	30.37	32.56	34.62	37.00	39.47	41.18	43.44	45.37
	1 x 2	29.67	32.23	34.59	37.02	39.01	41.44	43.42	44.27	47.55	49.46	51.86	54.06
	2 x 1	21.97	24.48	26.92	28.88	30.67	32.45	34.34	36.26	37.86	39.60	41.50	43.59
	2 x 2	28.97	31.67	34.65	37.04	39.11	41.05	42.89	45.10	47.08	49.26	51.00	52.36

CD		2.50	2.37	2.41	2.47	2.45	2.53	2.67	3.33	2.73	2.75	2.80	2.77
D	1	25.78	28.23	30.73	32.99	34.86	37.19	39.08	41.24	43.30	45.13	47.29	49.33
	2	25.03	27.71	30.33	32.66	34.72	36.56	38.55	40.07	42.69	44.62	46.61	48.86
CD		1.76	1.67	1.71	1.75	1.73	1.79	1.89	2.35	1.93	1.94	1.98	1.96
A x D	1 x 1	24.41	27.07	29.61	32.12	33.94	36.51	38.78	41.21	43.83	45.85	48.31	50.59
	1 x 2	23.00	26.07	28.81	31.41	33.49	35.43	37.75	40.20	42.71	44.84	47.08	49.49
	2 x 1	27.15	29.40	31.85	33.85	35.78	37.87	39.39	41.28	42.76	44.41	46.27	48.07
	2 x 2	27.05	29.36	31.86	33.91	35.35	37.69	39.61	39.94	42.67	44.39	46.14	48.23
CD		2.50	2.37	2.41	2.47	2.45	2.53	2.67	3.33	2.73	2.75	2.80	2.77
B x D	1 x 1	25.78	28.16	30.57	32.95	34.93	37.54	39.57	42.04	44.25	46.08	48.71	50.72
	1 x 2	24.89	27.59	30.00	32.44	34.45	36.46	38.47	39.23	42.78	44.55	46.59	48.72
	2 x 1	25.78	28.30	30.89	33.03	34.80	36.85	38.59	40.45	42.34	44.18	45.87	47.95
	2 x 2	25.17	27.84	30.67	32.89	34.98	36.65	38.64	40.91	42.60	44.68	46.64	49.01
CD		2.50	2.37	2.41	2.47	2.45	2.53	2.67	3.33	2.73	2.75	2.80	2.77
C x D	1 x 1	21.35	23.67	25.85	28.12	29.93	32.18	34.40	36.66	38.67	40.41	42.75	44.64
	1 x 2	21.62	24.33	27.04	29.12	31.11	32.83	34.58	36.60	38.67	40.36	42.19	44.32
	2 x 1	30.21	32.80	35.62	37.85	39.80	42.20	43.77	45.83	47.92	49.85	51.83	54.02
	2 x 2	28.44	31.10	33.63	36.21	38.33	40.29	42.55	43.54	46.70	48.87	51.03	53.41
CD		2.50	2.37	2.41	2.47	2.45	2.53	2.67	3.33	2.73	2.75	2.80	2.77
E	1	25.53	27.85	30.50	32.43	34.19	36.32	38.18	40.16	42.01	43.77*	45.61**	47.69**
	2	25.28	28.10	30.56	33.22	35.39	37.43	39.46	41.15	43.97	45.98*	48.29**	50.50**
CD		1.76	1.67	1.71	1.75	1.73	1.79	1.89	2.35	1.93	1.94	1.98	1.96
A x E	1 x 1	23.80	26.16	28.96	31.01	32.80	34.98	37.20	39.50	42.04	44.26	46.30	48.62
	1 x 2	23.61	26.98	29.45	32.52	34.63	36.96	39.33	41.91	44.50	46.44	49.10	51.47
	2 x 1	27.25	29.53	32.04	33.84	35.58	37.66	39.15	40.83	41.98	43.28	44.92	46.76
	2 x 2	26.95	29.23	31.67	33.92	36.15	37.90	39.59	40.39	43.45	45.52	47.49	49.54
CD		2.50	2.37	2.41	2.47	2.45	2.53	2.67	3.33	2.73	2.75	2.80	2.77
B x E	1 x 1	25.46	27.67	30.23	32.23	34.09	36.34	38.33	40.41	42.48	44.44	46.62	48.81

	1 x 2	25.21	28.08	30.34	33.15	35.29	37.66	39.71	40.86	44.54	46.20	48.68	50.62
	2 x 1	25.60	28.02	30.78	33.62	34.29	36.30	38.03	39.92	41.54	43.10	44.60	46.56
	2 x 2	25.35	28.13	30.79	33.29	35.49	37.20	39.20	41.44	43.40	45.76	47.91	50.39
CD		2.50	2.37	2.41	2.47	2.45	2.53	2.67	3.33	2.73	2.75	2.80	2.77
C x E	1 x 1	21.59	23.78	26.10	27.83	29.43	31.37	33.17	35.09	36.88	38.45	40.11*	41.93*
	1 x 2	21.38	24.21	26.79	29.40	31.60	33.64	35.79	38.17	40.46	42.32	44.83*	47.02*
	2 x 1	29.46	31.91	34.91	37.02	38.95	41.27	43.18	45.24	47.14	49.08	51.10*	53.44*
	2 x 2	29.19	32.00	34.33	37.04	39.18	41.22	43.13	44.13	47.49	49.64	51.76*	53.98*
CD		2.50	2.37	2.41	2.47	2.45	2.53	2.67	3.33	2.73	2.75	2.80	2.77
D x E	1 x 1	26.08	28.15	30.95	33.01	34.82	37.14	39.12	41.19	42.88	44.58	46.54	48.63
	1 x 2	25.48	28.32	30.51	32.96	34.90	37.24	39.04	41.29	43.71	45.68	48.04	50.03
	2 x 1	24.97	27.54	30.05	31.84	33.56	35.50	37.23	39.14	41.14	42.49	44.68	46.74
	2 x 2	25.08	27.89	30.62	33.49	35.87	37.62	39.88	41.00	44.23	46.28	48.55	50.98
CD		2.50	2.37	2.41	2.47	2.45	2.53	2.67	3.33	2.73	2.75	2.80	2.77
C V %		17.39	15.01	14.00	13.33	12.47	12.14	12.19	14.48	11.25	10.84	10.56	9.99

Factor A Growing structure/ Environment (1. Top ventilated rain-shelter; 2. Fan and pad system);

Factor B Methods of Growing (1. On bench; 2. Hanging);

Factor C Types of *Phalaenopsis* (1. Pot plant; 2. Cut flower);

Factor D Types of pots (1. White – transparent plastic pots (translucent); 2. Opaque (Black) plastic pots);

Factor E Media (1. Brick + charcoal medium; 2. Brick + coconut husk bits medium);

** Significant at 1 % level * Significant at 5 % level

method x type of plant, growing structure and type of pot, growing method x type of pot, type of plant x type of pot, growing structure and media, growing method x media and type of pot x media were also not statistically different.

4.1.7 Pattern of root growth

Visual observation on pattern of root growth indicated that in general growth of roots outside the pot was higher in black pot, when compared to that in white pot (Plate 7).

In general, vegetative characters are expressed by number of leaves, plant height, length, breadth and area of leaves, were higher in top ventilated rain shelter among the structure, in pot plant type than cut flower type and in brick + coconut husk bits medium.

4.2 Flowering characters

4.2.1 Mean flowering percentage

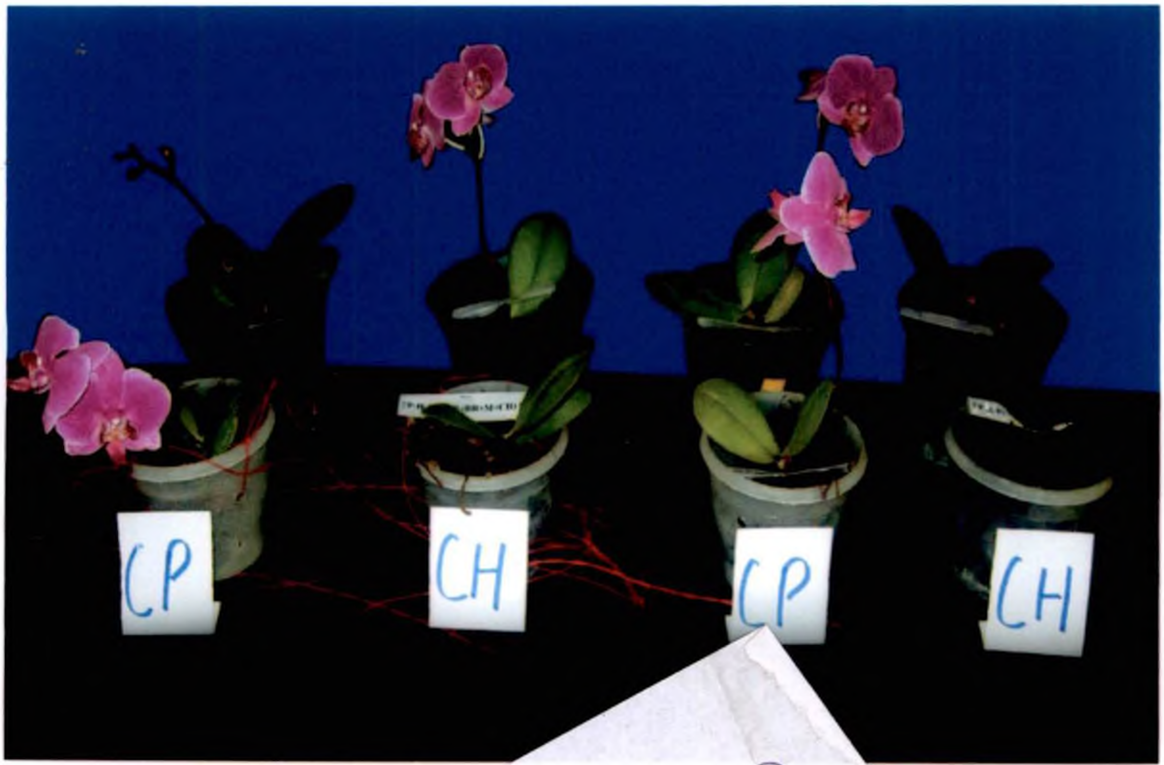
Data on mean flowering percentage during the period of study (May 2011 to April 2012) are presented in Table 7.

Flowering of plants statistically differed with respect to growing structure, type of plant and growing media but, it was not significant with respect to methods of growing and types of pot.

In case of growing structure, fan and pad showed the higher flowering (32.29 %) and rain shelter showed lower flowering percentage (17.70 %).

With respects to plant type, pot plant type recorded higher flowering percentage (32.81%) as compared to cut flower type (17.18 %) (Plate 5).

Considering the effect of media, brick + coconut husk bits recorded more flowering percentage (31.77 %) as compared to brick + charcoal (18.22 %) (Plate 5).



a) Pot pl

b) Cut flower (Taisuco Confidence) during flowering

Plate 5. *Phalaenopsis* during flowering

I

II

III

IV

V

VI

Plate 7. Pattern of root growth in different types of pot

Table 7. Influence of different factors on flowering percentage of *Phalaenopsis*

Factors		Flowering (%)
A	1	17.70**
	2	32.29**
CD		0.86
B	1	25.00
	2	25.00
CD		0.86
A x B	1 x 1	19.79
	1 x 2	15.62
	2 x 1	30.20
	2 x 2	34.37
CD		1.22
C	1	32.81**
	2	17.18**
CD		0.86
A x C	1 x 1	26.04
	1 x 2	9.37
	2 x 1	39.58
	2 x 2	25.00
CD		1.22
B x C	1 x 1	33.33
	1 x 2	16.66
	2 x 1	32.92
	2 x 2	17.70
CD		1.22
D	1	22.91
	2	27.08
CD		0.86
A x D	1 x 1	10.41**
	1 x 2	25.00**
	2 x 1	35.41**
	2 x 2	29.16**
CD		1.22
B x D	1 x 1	18.75*
	1 x 2	31.25*
	2 x 1	27.08*
	2 x 2	22.91*
CD		1.22
C x D	1 x 1	31.25
	1 x 2	34.37
	2 x 1	14.58
	2 x 2	19.79
CD		1.22
E	1	18.22**

	2	31.77**
CD		0.86
A x E	1 x 1	8.33
	1 x 2	27.08
	2 x 1	28.12
	2 x 2	36.45
CD		1.22
B x E	1 x 1	17.70
	1 x 2	32.29
	2 x 1	18.75
	2 x 2	31.25
CD		1.22
C x E	1 x 1	20.83**
	1 x 2	44.79**
	2 x 1	15.62**
	2 x 2	18.75**
CD		1.22
D x E	1 x 1	18.75
	1 x 2	27.08
	2 x 1	17.70
	2 x 2	36.45
CD		1.22
C V %		51.81

Factor A Growing structure/ Environment (1. Top ventilated rain-shelter; 2. Fan and pad system);

Factor B Methods of Growing (1. On bench; 2. Hanging);

Factor C Types of *Phalaenopsis* (1. Pot plant; 2. Cut flower);

Factor D Types of pots (1. White – transparent plastic pots (translucent); 2. Opaque (Black) plastic pots);

Factor E Media (1. Brick + charcoal medium; 2. Brick + coconut husk bits medium);

** Significant at 1 % level * Significant at 5 % level

Similarly, interaction effects of growing structures and types of pot, growing methods and type of pots and plant type and media have recorded significant difference with respect to flowering of plants.

Interaction between growing structure and types of pot, fan and pad x white pot showed the highest flowering percentage (35.41%) and rain shelter x white pot showed the lowest flowering percentage (10.41%). In case of interaction between methods of growing and types of pot, on bench x black pot showed the highest flowering percentage (31.25%) and on bench x white pot showed the lowest flowering percentage (18.75 %). Considering the interaction between types of plant and media, pot plant x brick + coconut husk bits showed the highest flowering percentage (44.79 %) and cut flower x brick + charcoal showed the lowest flowering percentage (15.62 %).

Influence of all other interactions, *i.e.* growing structure x growing method, growing structure x type of plant, growing method x type of plant, type of plant x type of pot, growing structure x media, growing method x media, type of pot and x media had no significant influence on flowering of plants.

4.2.2 Time of emergence of spike

Data on time taken for emergence of spike in plant during the period of study (May 2011 to April 2012) are furnished in Table 8.

Time of emergence of spike exhibited statically significant difference with respect to growing structures and growing methods, but it was statically on par with respect to plant types, type of pots and media. Days of emergence of spike showed a wide variation, this ranged from 79 to 263 days.

Considering the overall mean, plants grown in the rain shelter took fewer days for emergence of spike (51.04 days) and that in fan and pad took more duration for emergence of spike (125.14 days). In case of growing methods on bench took less days for emergence of spike (83.47 days) and hanging took more days for emergence of spike (92.70 days).

Influence of interaction between growing structure and type of pot, growing method and type of pot, type of pot and media also showed statistically difference, while all other interactions were statistically at par with each other.

Plants grown under rain shelter x white pot took the minimum days (33.62 days) and those in fan and pad x white pot took maximum days for emergence of spike (153.33 days). In case of interaction between growing methods and type of pot, hanging x black pot took the minimum days (67.00 days) and those in hanging x white pot took maximum days for emergence of spike (118.41days). Interaction between type of pot and media, black pot x brick + charcoal took the minimum days (57.41 days) and those in black pot x brick + coconut husk bits took maximum days for emergence of spike (108.00 days).

4.2.3 Spike length

Data on spike length during the period of study (May 2011 to April 2012) are furnished in Table 8.

Length of spike recorded significant difference with respect to growing structures, but it was non significant with respect to growing methods, type of plant, type of pots and media. Range of spike length varies from 9.2 to 33.4 cm.

In general, plants grown under fan and pad system shown a high mean spike length (16.56 cm) where as those grown in rain shelter system has a lower spike length (7.62 cm).

Among the interactions, growing structures and type of pot and growing methods and types of pot exhibited significant difference while all other interactions were statistically non significant.

Interactions between growing structure and type of pot, fan pad x white pot recorded the maximum spike length (17.92 cm) and that in rain shelter x white pot recorded minimum spike length (4.52 cm). In case of interaction between growing method and type of pot, plants grown on bench x white pot recorded the maximum (15.77 cm) and on bench x white pot recorded minimum spike length (8.72 cm).

4.2.4 Time of first bud opening

Data on time of first bud opening during the period of study (May 2011 to April 2012) are furnished in Table 8.

Time of first bud opening showed statistically significant difference with respect to growing structures, types of plant and types of media but it was statically non significant with respect to growing methods, types of pot and media. Time taken for bud opening ranged from 25 to 63 days.

In general, plants grown under rain shelter took less time for opening of first bud (15.95 days) and fan and pad took more time for opening of first bud (37.20 days) where as in case of type of plant, cut flower took less days for opening of first bud (20.41 days) and pot plant took more days for opening of first bud (32.75 days) similarly, brick + charcoal medium took less days for opening of first bud (22.52 days) and brick + coconut husk bits took more days for opening of first bud (30.64 days).

Among interaction between growing structures and types of pot, growing methods and types of pot, types of plant and media and types of pot and media shown statistically significant difference while, interaction between growing structures and growing methods, growing structures and types of plant, growing methods and types of plant, types of plant and types of pot, growing structures and media, types of plant and media were statistically non significant.

Interaction between growing structures and types of pot, rain shelter x white pot took the minimum days for opening of first bud (9.54 days) and fan and pad x white pot took maximum days for first bud opening (40.29 days). In case of interaction between growing methods and types of pot, on bench x white pot took minimum days for opening of first bud (20.25 days) and hanging x black pot took maximum days for opening of first bud (32.00 days). Interaction between types of plant and media, cut flower x brick + charcoal took the minimum days for opening of first bud (19.87 days) and pot plant x brick + coconut husk bits took maximum days for opening of first bud (40.33 days) and interaction between type of pot and media, black pot x brick + charcoal took the minimum days for opening of first bud (20.50 days) and black pot x brick + coconut husk bit took the maximum days for opening of first bud (36.00 days).

4.2.5 Number of florets per spike

Data on number of florets per spike during the period of study (May 2011 to April 2012) are furnished in Table 8.

Number of florets per spike showed statically significant difference with respect to growing structure, types of plant and type of media but it was statically non significant with respect to growing methods, types of pot. Number of florets per spike ranged from 2 to 5.

In case growing structure, fan and pad recorded more number of florets per spike (2.04) and rain shelter recorded less number of florets per spike (1.06) where as in case of type of plant, pot plant and cut flower type, pot plant recorded more number of florets per spike (1.93) and cut flower recorded less number of florets per spike (1.16). Similarly, number of florets per spike was higher in brick + coconut husk bits medium (1.83) and minimum in brick + charcoal medium (1.27).

Among the interactions, those between growing methods and types of pot shown statistically significant difference while interaction between growing structures and growing methods, growing structures and types of plant, growing methods and types of plant, growing structures and types of pot, growing methods and types of pot, types of plant and types of pot, growing structures and media, growing methods and media, types of plant and media, types of pot and types of media were statistically non significant.

Plants grown on bench x black pot recorded the maximum number of florets per spike (2.00) and on bench x white pot recorded minimum number of florets per spike (1.25).

4.2.6 Flower size

Data on flower size during the period of study (May 2011 to April 2012) are furnished in Table 8.

Size of flower (vertical length x horizontal length) had shown statistically significant difference with respect to growing structure and type of plant but it was statically non significant with respect to growing method, type of pot and type of media. Range of flower size varied from (5.0 to 8.6) and (5.9 to 9.6) vertical and horizontal length respectively.

In case of growing structure, fan and pad recorded lager flower size (5.77 x 6.57 cm) and rain shelter recorded small flower size (2.66 x 3.04 cm) and where as in case of type of plant, pot plant recorded lager flower size (5.06 x 5.09 cm) and cut flower recorded small flower size (3.38 x 3.82 cm).

Among other interactions no statistical significant difference was recorded with respect to flower size.

4.2.7 Flowering duration

Data on flowering duration in spike of plants observed during the period of study (May 2011 to April 2012) are presented in Table 8.

Flowering duration (days taken for first to last flower opening in the spike) of plant shown significant difference with respect to growing structure, type of plant and media but it is statically non significant with respect to growing method and type of pot. Range of flowering duration varies from (6 to 19).

In general, rain shelter recorded less time for complete flowering (4.18 days) and fan and pad recorded more days for flowering (7.56 days). In case of type of plant, cut flower recorded less time for complete flowering (4.29 days) and pot plant recorded more days for flowering (7.45 days). While brick + charcoal medium recorded less time (4.85 days) and brick + coconut husk bits medium recorded more time for flowering (6.89 days).

Interaction between types of plant and media showed statistically significant difference while interaction between growing structures and growing methods, growing structures and types of plant, growing methods and types of plant, growing structures and types of pot, growing methods and types of pot, types of plant and types of pot, growing structures and media, growing methods and media, types of pot and types of media were statistically non significant.

Interaction between type of plant and media cut flower x brick + coconut husk bits recorded minimum flowering duration (4.12 days) and pot plant x brick + coconut husk bits recorded maximum flowering duration (9.66 days).

4.2.8 Longevity of spike on plant

Data on longevity of spike on plant during the period of study (May 2011 to April 2012) are furnished in Table 8.

Longevity of spike on plant showed significant difference with respect to growing structures, types of plant and media but it is non significant with respect to growing methods and types of pot. Range of longevity of spike on plants varied from (31 to 82 days).

In case growing structure, fan and pad recorded the maximum longevity of spike on plant (38.04 days) and rain shelter recorded minimum longevity of spike on plant (21.58 days). In case of type of plant, pot plant recorded the maximum longevity of spike on plant (38.22 days) and cut flower recorded minimum longevity of spike on plant (21.39 days). While brick + coconut husk bits medium recorded the maximum longevity of spike on plant (35.56 days) and brick + charcoal medium recorded minimum longevity of spike on plant (24.06 days).

Among interactions, those between types of plant and media showed statistically significant difference while interaction between growing structures and growing methods, growing structures and types of plant, growing methods and types of plant, growing structures and types of pot, growing methods and types of pot, types of plant and types of pot, growing structures and media, growing

Table 8. Influence of different factors on flowering characters of *Phalaenopsis*

Flowering character → Factor ↓		Time for emergence of spike (days)	Spike length (cm)	Time for 1st opening of bud (days)	Number of florets per spike	Flower size (vertically) (cm)	Flower size (across) (cm)	Flowering duration (days)	Longevity of spike on plant (days)
A	1	51.04** (4.87)	7.62** (2.17)	15.95** (2.93)	1.06** (1.12)	2.66** (1.49)	3.04** (1.58)	4.18** (1.72)	21.58** (3.35)
	2	125.14** (10.13)	16.54** (3.83)	37.20** (5.70)	2.04** (1.54)	5.77** (2.38)	6.57** (2.52)	7.56** (2.65)	38.04** (5.75)
CD		1.81	0.64	0.89	0.17	0.32	0.34	0.42	1.01
B	1	83.47* (7.39)	12.25 (3.03)	26.12 (4.31)	1.62 (1.35)	4.23 (1.94)	4.82 (2.05)	6.18 (2.24)	31.00 (4.66)
	2	92.70* (7.61)	11.91 (2.96)	27.04 (4.32)	1.47 (1.31)	4.20 (1.92)	4.78 (2.03)	5.56 (2.13)	28.62 (4.44)
CD		1.81	0.64	0.89	0.17	0.32	0.34	0.42	1.01
A x B	1 x 1	61.25 (5.39)	8.27 (2.27)	15.54 (2.96)	1.25 (1.18)	2.79 (1.52)	3.16 (1.59)	4.66 (1.81)	22.70 (3.49)
	1 x 2	40.83 (4.34)	6.97 (2.07)	16.37 (2.91)	0.87 (1.07)	2.53 (1.45)	2.91 (1.51)	3.70 (1.64)	20.45 (3.21)
	2 x 1	105.70 (9.38)	16.23 (3.80)	36.70 (5.66)	2.00 (1.53)	5.68 (2.37)	6.48 (2.51)	7.70 (2.68)	39.29 (5.84)
	2 x 2	144.58 (10.88)	16.85 (3.85)	37.70 (5.73)	2.03 (1.55)	5.87 (2.40)	6.65 (2.54)	7.41 (2.62)	36.79 (5.66)
CD		2.56	0.90	1.26	0.24	0.45	0.49	0.59	1.43
C	1	97.83	12.52	32.75**	1.93**	5.06*	5.79**	7.45**	38.22**

		(8.83)	(3.33)	(5.24)	(1.49)	(2.22)	(2.35)	(2.59)	(5.65)
	2	78.35 (6.17)	11.64 (2.66)	20.41** (3.39)	1.16** (1.17)	3.38* (1.65)	3.82** (1.72)	4.29** (1.78)	21.39** (3.45)
CD		1.81	0.64	0.89	0.17	0.32	0.34	0.42	1.01
A x C	1 x 1	66.20 (6.50)	9.51 (2.68)	23.33 (3.97)	1.54 (1.32)	3.70 (1.81)	4.24 (1.92)	6.25 (2.22)	31.41 (4.58)
	1 x 2	35.87 (3.23)	5.72 (1.66)	8.58 (1.90)	0.58 (0.93)	1.62 (1.16)	1.83 (1.19)	2.12 (1.23)	11.75 (2.11)
	2 x 1	129.45 (11.15)	15.53 (3.98)	42.16 (6.51)	2.33 (1.67)	6.42 (2.62)	7.33 (2.79)	8.66 (2.96)	45.04 (6.72)
	2 x 2	120.83 (9.11)	17.55 (3.67)	32.25 (4.88)	1.75 (1.40)	5.13 (2.14)	5.18 (2.25)	6.45 (2.34)	31.04 (4.79)
CD		2.56	0.90	1.26	0.24	0.45	0.49	0.59	1.43
B x C	1 x 1	89.12 (8.49)	12.35 (3.31)	31.00 (5.11)	1.95 (1.50)	5.05 (2.22)	5.77 (2.35)	7.62 (2.62)	39.75 (5.76)
	1 x 2	77.83 (6.28)	12.15 (2.75)	21.25 (3.51)	1.29 (1.21)	3.41 (1.67)	3.87 (1.75)	4.75 (1.87)	22.25 (3.57)
	2 x 1	106.54 (9.16)	12.70 (3.35)	34.50 (5.37)	1.91 (1.49)	5.06 (2.24)	5.80 (2.36)	7.29 (2.57)	36.70 (5.54)
	2 x 2	78.87 (6.07)	11.12 (2.57)	19.58 (3.27)	1.04 (1.13)	3.35 (1.63)	3.77 (1.70)	3.83 (1.69)	20.54 (3.33)
CD		2.56	0.90	1.26	0.24	0.45	0.49	0.59	1.43
D	1	93.47 (7.55)	11.22 (2.85)	24.91 (4.10)	1.41 (1.28)	3.98* (1.87)	4.52 (1.96)	5.41 (2.09)	26.91 (4.26)
	2	82.70 (7.45	12.94 (3.15)	28.25 (4.53)	1.68 (1.38)	4.45* (2.00)	5.09 (2.11)	6.33 (2.28)	32.70 (4.84)
CD		1.81	0.64	0.89	0.17	0.32	0.34	0.42	1.01
A x D	1 x 1	33.62**	4.52*	9.54**	0.70	1.91	2.18	2.83	14.75

		(3.63)	(1.66)	(2.17)	(0.99)	(1.27)	(1.32)	(1.42)	(2.57)
	1 x 2	68.45** (6.10)	10.71* (2.67)	22.37** (3.69)	1.41 (1.26)	3.41 (1.70)	3.90 (1.79)	5.54 (2.03)	28.41 (4.12)
	2 x 1	153.33** (11.46)	17.92* (4.03)	40.29** (6.04)	2.12 (1.57)	6.06 (2.46)	6.86 (2.61)	8.00 (2.76)	39.08 (5.94)
	2 x 2	96.95** (8.80)	15.16* (3.62)	34.12** (5.36)	1.95 (1.50)	5.49 (2.30)	6.27 (2.44)	7.12 (2.54)	37.00 (5.57)
CD		2.56	0.90	1.26	0.24	0.45	0.49	0.59	1.43
B x D	1 x 1	68.54** (6.12)	8.72** (2.45)	20.25* (3.53)	1.25* (1.21)	3.28 (1.68)	3.73 (1.76)	5.04 (1.95)	24.62 (3.85)
	1 x 2	98.41** (8.65)	15.77** (3.62)	32.00* (5.09)	2.00* (1.50)	5.18 (2.21)	5.92 (2.34)	7.33 (2.54)	37.37 (5.47)
	2 x 1	118.41** (8.98)	13.72** (3.25)	29.58* (4.68)	1.58* (1.36)	4.68 (2.06)	5.31 (2.17)	5.79 (2.23)	29.20 (4.66)
	2 x 2	67.00** (6.25)	10.10** (2.67)	24.50* (3.96)	1.37* (1.26)	3.72 (1.79)	4.25 (1.88)	5.33 (2.03)	28.04 (4.21)
CD		2.56	0.90	1.26	0.24	0.45	0.49	0.59	1.43
C x D	1 x 1	108.87 (9.29)	11.93 (3.26)	31.16 (5.12)	1.87 (1.47)	5.00 (2.21)	5.72 (2.34)	7.20 (2.56)	36.20 (5.50)
	1 x 2	86.79 (8.36)	13.12 (3.40)	34.33 (5.36)	2.00 (1.51)	5.12 (2.23)	5.85 (2.37)	7.70 (2.63)	40.25 (5.80)
	2 x 1	78.08 (5.81)	10.52 (2.44)	18.66 (3.09)	0.95 (1.09)	2.95 (1.53)	3.32 (1.59)	3.62 (1.62)	17.62 (3.01)
	2 x 2	78.62 (6.54)	12.75 (2.89)	22.16 (3.69)	1.37 (1.24)	3.79 (1.77)	4.32 (1.86)	4.95 (1.94)	25.16 (3.89)
CD		2.56	0.90	1.26	0.24	0.45	0.49	0.59	1.43
E	1	80.75 (6.72)	10.42 (2.67)	22.52* (3.77)	1.27* (1.22)	2.68 (1.76)	4.17 (1.85)	4.85* (1.94)	24.06** (3.87)

	2	95.43 (8.28)	13.74 (3.33)	30.64* (4.86)	1.83* (1.44)	4.76 (2.10)	5.44 (2.23)	6.89* (2.44)	35.56** (5.23)
CD		1.81	0.64	0.89	0.17	0.32	0.34	0.42	1.01
A x E	1 x 1	30.83 (3.30)	5.35 (1.68)	9.54 (2.07)	0.66 (0.97)	1.86 (1.23)	2.10 (1.27)	2.54 (1.33)	13.79 (2.38)
	1 x 2	71.25 (6.44)	9.89 (2.65)	22.37 (3.79)	1.45 (1.28)	3.42 (1.74)	3.98 (1.84)	5.83 (2.12)	29.37 (4.32)
	2 x 1	130.66 (10.14)	15.49 (3.65)	35.50 (5.46)	1.87 (1.48)	5.50 (2.30)	6.24 (2.43)	7.16 (2.54)	34.33 (5.73)
	2 x 2	199.62 (10.13)	17.60 (4.01)	38.91 (5.94)	2.20 (1.60)	6.05 (2.47)	6.90 (2.62)	7.95 (2.76)	41.75 (6.14)
CD		2.56	0.90	1.26	0.24	0.45	0.49	0.59	1.43
B x E	1 x 1	77.16 (6.71)	10.80 (2.74)	22.95 (3.85)	1.33 (1.25)	3.72 (1.79)	4.21 (1.88)	5.12 (2.00)	24.54 (3.97)
	1 x 2	89.79 (8.06)	13.70 (3.33)	29.29 (4.77)	1.91 (1.46)	4.75 (2.10)	5.43 (2.23)	7.25 (2.49)	37.45 (5.36)
	2 x 1	84.33 (6.72)	10.03 (2.59)	22.08 (3.68)	1.20 (1.20)	3.64 (1.74)	4.12 (1.83)	4.58 (1.88)	23.58 (3.78)
	2 x 2	101.08 (8.50)	13.79 (3.33)	32.00 (4.96)	1.75 (1.42)	4.76 (2.10)	5.44 (2.23)	6.54 (2.38)	33.66 (5.09)
CD		2.56	0.90	1.26	0.24	0.45	0.49	0.59	1.43
C x E	1 x 1	91.75 (7.70)	9.62 (2.74)	25.16* (4.24)	1.45 (1.31)	3.98 (1.90)	4.53 (2.00)	5.25 (2.09)	27.37* (4.41)
	1 x 2	103.91 (9.95)	15.42 (3.92)	40.33* (6.24)	2.14 (1.68)	6.13 (2.54)	7.04 (2.71)	9.66 (3.10)	49.08* (6.89)
	2 x 1	69.75 (5.73)	11.21 (2.59)	19.87* (3.29)	1.08 (1.14)	3.38 (1.63)	3.80 (1.70)	4.45 (1.79)	20.75* (3.34)
	2 x 2	86.95	12.06	20.95*	1.25	3.38	3.84	4.12	22.04*

		(6.62)	(2.74)	(3.49)	(1.20)	(1.66)	(1.74)	(1.77)	(3.56)
CD		2.56	0.90	1.26	0.24	0.45	0.49	0.59	1.43
D x E	1 x 1	104.08** (7.74)	10.60 (2.72)	24.54* (3.97)	1.29 (1.24)	3.79 (1.80)	4.29 (1.89)	4.79 (1.95)	22.70 (3.84)
	1 x 2	82.87** (7.35)	11.85 (2.98)	25.29* (4.24)	1.54 (1.33)	4.17 (1.93)	4.75 (2.04)	6.04 (2.23)	31.12 (4.68)
	2 x 1	57.41** (5.69)	10.24 (2.61)	20.50* (3.57)	1.25 (1.21)	3.57 (1.73)	4.05 (1.81)	4.91 (1.93)	25.41 (3.91)
	2 x 2	108.00** (9.21)	15.63 (3.68)	36.00* (5.49)	2.12 (1.55)	5.34 (2.27)	6.12 (2.41)	7.75 (2.64)	40.00 (5.78)
CD		2.56	0.90	1.26	0.24	0.45	0.49	0.59	1.43
Range		79 - 263	9.2 - 33.4	25 - 63	2 - 5	5.0 -8.6	5.9 -9.6	6 - 19	31 - 82
C V %		60.50	53.44	51.73	32.14	41.51	42.50	47.99	55.62

Factor A Growing structure/ Environment (1. Top ventilated rain-shelter; 2. Fan and pad system)

Factor B Methods of Growing (1. On bench; 2. Hanging)

Factor C Types of *Phalaenopsis* (1. Pot plant; 2. Cut flower)

Factor D Types of pots (1. White – transparent plastic pots (translucent); 2. Opaque (Black) plastic pots)

Factor E Media (1. Brick + charcoal medium; 2. Brick + coconut husk bit medium)

** Significant at 1 % level, * Significant at 5 % level

Parenthesis values (square root transformation) methods and media, types of pot and types of media were statistically non significant.

Interaction between types of plant and media, pot plant x brick + coconut husk bits recorded maximum longevity of spike on plant (49.08 days) and cut flower x brick + charcoal recorded minimum longevity of spike on plant (20.75 days).

Conclusion, general inference with respect to flowering character fan and pad was better with respect to percentage flowering, spike length, number of florets per spike, flower size, flowering duration and longevity of spike on plants while rain shelter was better for early flowering and less time taken for first bud opening. Pot plant type and brick + coconut husk bits medium was better for flowering percentage, spike length, number of florets per spike, flower size, flowering duration and longevity of spike.

4.3 Inference of weather parameter

Mean of weather parameters *viz.* maximum and minimum temperature (°C), relative humidity (%), light intensity recorded in rain shelter and fan and pad structures were recorded. Vegetative characters and flowering characters observed were correlated to mean monthly weather parameters like maximum and minimum temperature (°C), morning and afternoon relative humidity (%) and light intensity (lux) inside the protected structure. Mean monthly weather parameters and results of correlation obtained are furnished in Table 9.

It was seen that only minimum temperature in rain shelter and minimum temperature and light intensity in fan and pad had significant correlation with leaf area. Correlations of other parameters with plant characters were not statistically significant. It was observed that minimum temperature in rain shelter and fan and pad system had a positive correlation with growth of leaves *i.e.*, 0.70 and 0.71 respectively. Light intensity had negative correlation with increase in leaf area in fan and pad system. Considering the overall effect by pooled analysis, only minimum temperature had a significant influence on leaf area increase. Based on this, multiple regression equations developed and are given below.

Inside the rain shelter and fan and pad system the increase in rate of leaf area production is determined only by the minimum temperature during the period. Light intensity also affected (negative correlation) with the leaf area in fan and pad system. While considering two growing situation together (pooled analysis) increase in leaf area is mainly determined by minimum temperature.

Separate multiple regression equations were made for rain shelter, fan and pad and combined equation for the two above situations.

The regression equations are reproduced below:

a) Rain shelter

Increase in Leaf Area = -16.035 +1.054 T_{min} ($R^2 = 0.49$)

b) Fan and pad system

Increase in Leaf area = -5.552 + 0.910T_{min} – 0.002 LI ($R^2 = 0.8$)

c) Combination equation

Increase in Leaf area = -15.099 + 0.988 T_{min} ($R^2 = 0.5$)

Where, T_{min} = Mean monthly minimum temperature in °C

LI = Light intensity in lux

R^2 = Regression coefficient

From this, it is clearly understood that the growth rate of leaf enlargement is mainly determined by minimum temperature (50 per cent). So increasing the minimum temperature inside the protected structure to an optimum level with enhances the growth of *Phalaenopsis* under protected condition. So minimum temperature inside the structure has to be considered as most important weather parameter while growing *Phalaenopsis* under protected condition.

Table 9. Mean monthly weathers parameters and correlation of leaf area with weather parameters

a) Weathers parameters at monthly interval of growing system

Month → Weather parameters ↓		May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April
Temperature °C (Maximum)	Rain shelter	39.51	34.60	34.26	34.52	35.27	39.33	36.31	35.88	35.38	39.47	39.59	40.21
	Fan and pad	38.24	34.15	34.22	34.94	35.84	37.87	35.78	34.31	36.49	38.48	38.37	38.77
	Open	33.0	29.30	29.10	29.40	30.0	32.0	31.40	31.90	32.80	35.10	35.20	34.80
Temperature °C (Minimum)	Rain shelter	24.68	23.99	23.82	23.92	23.36	23.39	23.04	22.40	20.76	21.7	23.68	23.52
	Fan and pad	24.82	23.63	23.33	23.19	22.81	23.27	22.13	21.37	20.74	21.05	23.30	24.05
	Open	24.90	23.60	22.90	22.90	23.10	23.50	22.90	22.60	21.30	22.10	24.20	24.80
Relative humidity % (average)	Rain shelter	71.14	79.90	79.45	78.70	75.05	68.52	52.18	58.53	57.38	53.23	56.86	64.65
	Fan and pad	81.30	95.07	94.93	95.36	92.60	89.50	85.29	82.70	81.03	75.95	84.48	89.80
	Open	76.83	88.99	87.83	87.04	84.41	77.87	68.10	62.01	57.54	54.0	67.87	71.76
Light intensity (lux)	Rain shelter	6300	6825	6337	5458	6523	10898	10837	9494	10888	10968	6308	6815
	Fan and pad	4717	3789	4256	4688	5532	5354	4367	4132	5129	4690	5580	7231

b) Correlation coefficients between leaf area and weather parameters

	Temperature (Maximum) °C	Temperature (Minimum) °C	RH (I) %	RH (II) %	Light intensity (lux)
Rain shelter	-0.144	0.697*	0.660	0.605	-0.504
Fan and pad	-0.223	0.707*	0.393	0.401	-0.440*
Combined	-0.102	0.704*	0.533	-0.099	-0.002

* significant

Discussion

5. Discussion

Standardisation of agrotechniques and identification of the appropriate plant types in *Phalaenopsis* orchids suited to different growing environments are essentially required for any commercial venture in the crop in Kerala State. The present set of experiments was taken up in this background with the object of finding out the suitable plant type and environment for commercial growing and for standardizing the appropriate agrotechniques such as method of growing, type of pots and media for better growth and quality spikes. The results generated are discussed below.

5.1 Vegetative characters as influenced by different treatment combinations

5.1.1 Number of leaves

Yield and flowering performance of crop depend on the optimum vegetative growth expressed by the plants prior to flowering. Vegetative growth is influenced by atmospheric and soil conditions and the nutrient supply. As far as orchids are concerned, the weather parameters in the growing structure, type of media *etc.* influence the vegetative growth.

Present studies have shown no significant difference with respect to the number of leaves for the first five months of growing period (May to September) under the two growing conditions *viz.* rain shelter and fan and pad where as it was significant during the subsequent sixth to tenth months (October to February) (Fig. 1). The results hence indicates no conspicuous effect of growing condition on number of leaves produced by the plant during the initial growth stage but showing a positive influence during the latter phase. It was noted that the retention of leaves was much affected by high incidence of diseases under fan and pad system resulting in negative effect on the overall growth of the plant. On the contrary, under rain shelter condition the disease incidence was less and provided much optimal condition for plant growth. Rittershausen (1979) has reported that in *Phalaenopsis* the old leaves shed at the rate of one or two per year often or just after flowering which is subsequently replaced by younger ones and on an average the plant will retain three to six leaves at a time. Results from the present studies are in general conforming to the previous reports on this aspect.

Comparison of the plant types with respect to number of leaves produced per plant showed significant variation during the first five months (May to September). Cut flower type recorded more number of leaves than the pot plant during May to September (Fig. 2). Such a variation in leaf number can be attributed to production of new leaves and the severe disease and pest (snails) incidence on plants in fan and pad system, which resulted in premature leaf fall and retention of less number of leaves per plant. Incidence for bacterial diseases was much higher on plants grown in fan and pad system due to higher relative humidity prevailing most of the time, nevertheless it finds support from Kaveriamma (2007), who concluded that the plant type did not exert any significant influence on the number of leaves produced during the growing period in short stemmed epiphytes like *Phalaenopsis*.

Other factor which affected the leaf number per plant was the interval between emergences of subsequent leaves *i.e.* phylacron. Time required for the emergence of first leaf shown significant difference in plants grown under rain shelter and fan and pad structure. Interval of leaf production is an indication of growth rate. Under rain shelter, time taken for emergence of first leaf was less while fan and pad took more time for emergence of first leaf (Fig. 3). This resulted in more number of leaves per plant in rain shelter because it took less time for emergence of first leaf and there was no significance difference in time taken for production of second leaf. The time taken for emergence of third leaf differed significantly for the growing structures; fan and pad took minimum and rain shelter took maximum for production of third leaf. Initial growth or leaf production took more time and once plants are well established in pots further leaf production and growth was at a faster rate. Plants under rain shelter produced almost three leaves per plant while under fan and pad produced two leaves only.

Fig. 1 Number of leaves of *Phalaenopsis* as influenced by growing structure at monthly interval

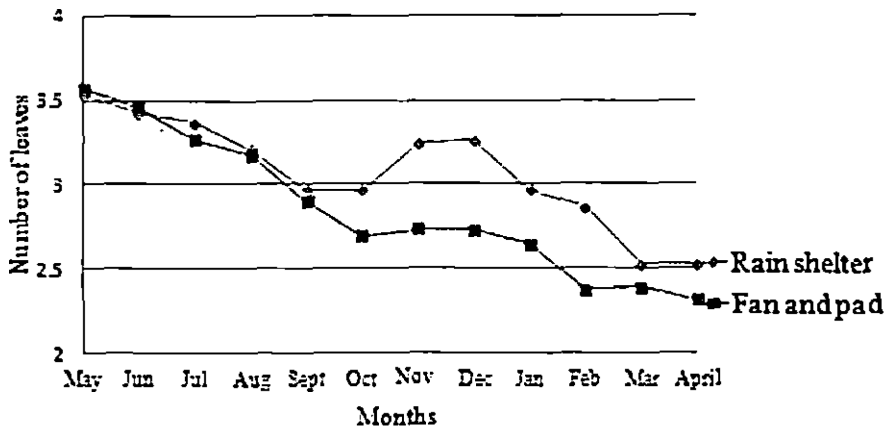


Fig. 2 Number of leaves influenced by *Phalaenopsis* types at monthly interval

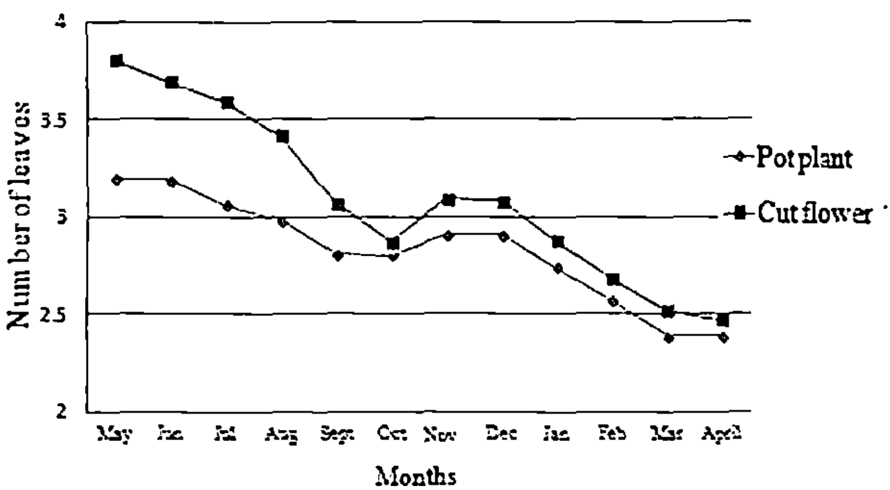
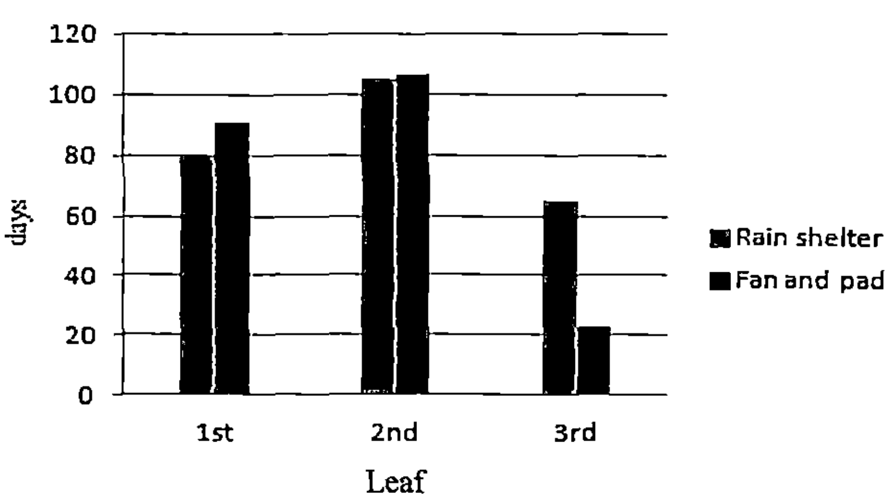


Fig. 3 Interval of leaf production of *Phalaenopsis* as influenced by growing structures



5.1.2 Plant height

Height is an inherent genetic character of plant which can be influenced by growing conditions. The height differences are largely due to difference in internodal length. Plant height did not show conspicuous difference among two methods of growing for the first five months (May to September) but it was significantly different during the last seven months (October to April). In general, higher plant height was noted in bench method of growing than the hanging method during October to April (Fig. 4).

Plant height had shown significant difference with respect to plant types (pot plant and cut flower) and type of pots (white pot and black pot) during the entire period of the study. During the first month·(May), cut flower type recorded higher value for height than the pot plant (Fig. 5). Similarly height of plants grown in black pot was higher and than in white pot (Fig. 6). *Phalaenopsis* are short stemmed monopodial orchids exhibiting indeterminate nature of growth without lateral branching. Due to this indeterminate growth habit increase in terms of plant height was very less and internodes are not visible as leaves are compactly arranged at the base. When progressive rate of increase was calculated it shows that growth in terms of plant height was very less and no significant difference was observed with respect to factors and their interactions except with respect to type of plant (pot plant and cut flower). Pot plant shown high progressive growth (47.12 %) and cut flower showed less progressive growth (38.96 %) in one year duration (Table 10). Similar reports made by Kaveriamma (2007) also showed short stemmed epiphytes manifesting slow rate of growth throughout. It is also conforming to observations of Zotz (1998) that in slow growing epiphytic orchid *Dimerandra emarginata* the growth was highly seasonal with little variation between the years.

5.1.3 Leaf length

Leaf length of the plant varied significantly in plants grown under rain shelter and fan and pad system for first eight months (May to December) but it was not significant during the remaining four months. During first month (May), plants

Fig. 4 Plant height (cm) of *Phalaenopsis* as influenced by growing method at monthly interval

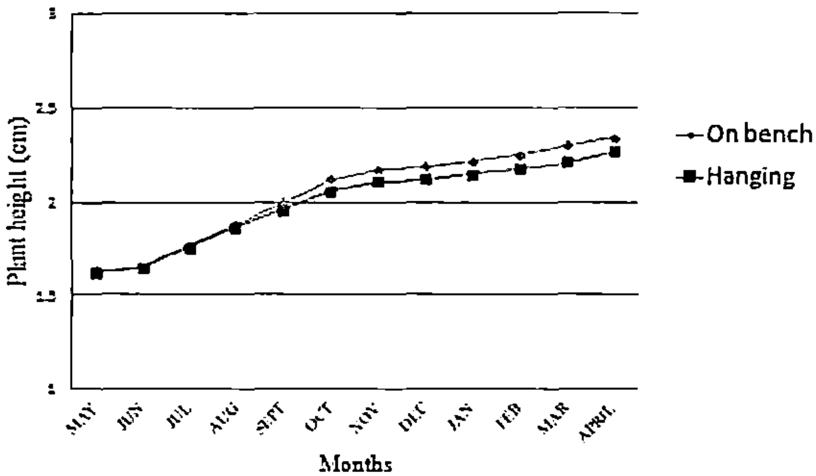


Fig. 5 Height (cm) of *Phalaenopsis* types at monthly interval

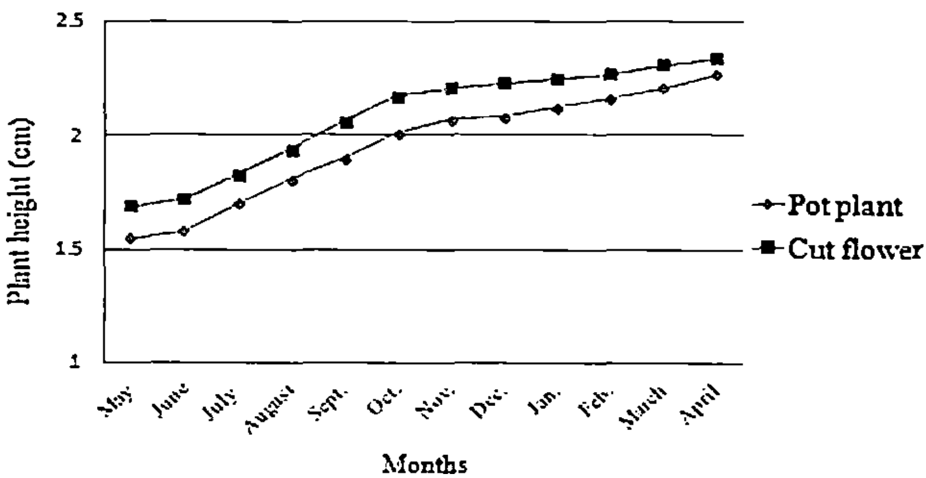
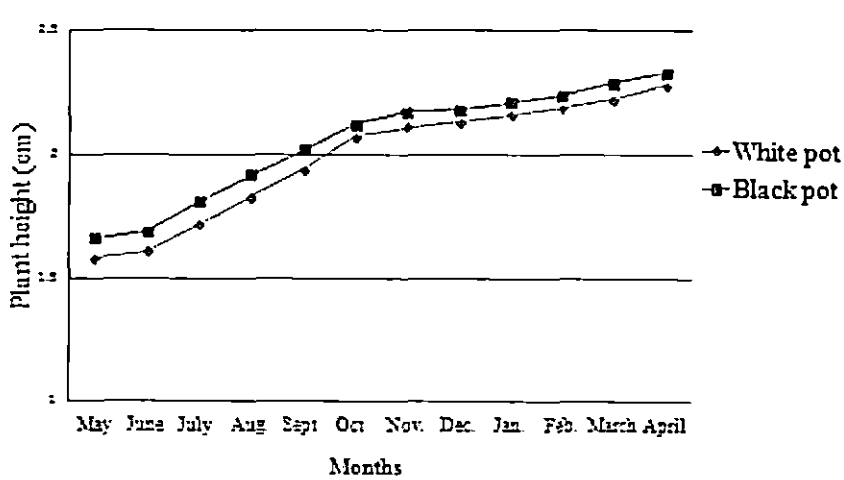


Fig. 6 Plant height (cm) of *Phalaenopsis* as influenced by types of pots at monthly interval



grown under fan and pad system gave the highest growth and rain shelter gave the lowest growth (Fig.7). During the eighth month (December) plants grown under fan and pad system gave the highest growth and rain shelter gave the lowest growth. It doesn't mean that vegetative growth was better in fan and pad system as compared to rain shelter system because when the progressive increase of rate for one year was compared with respect to leaf length, plants in rain shelter showed higher rate increase (52.07 %) and under fan and pad showed lower rate increase (40.72 %) during the study period (Table 9). It indicated that the rain shelter condition favoured leaf growth in terms of length of leaf.

Pot plant and cut flower recorded significant difference with respect to leaf length during entire period of study. In case of pot plant, leaf length was lowest (6.22 cm) in May and increased up to (9.30 cm) during April while that of cut flower type was higher (8.83 cm) in May and increased up to (11.92 cm) in April (Fig. 8). Although leaf length was greater in cut flower type as compared to pot plant, pot plants recorded a high progressive increase rate (47.12 %) and lower rate in cut flower (38.96 %) (Fig.16). These results are in tune with Bhattacharjee *et al.* (2002) who reported similar observations among different cultivars of orchids.

Leaf length of plants did not show any conspicuous difference grown under different media (Brick + charcoal and brick + coconut husk bits) for the first eleven months (May to March) but it was significant in April. Leaf length of plants grown in brick + coconut husk bits was higher and lower in brick + charcoal (Fig. 9). It showed that brick + coconut husk bits was good medium for vegetative growth as compared to brick + charcoal. A progressive rate of increase in leaf length was evident in both the media but brick + coconut husk bits recorded higher rate increase (45.13 %) and brick + charcoal recorded a lower rate increase (40.95 %) (Fig.17). Such a difference in growth can be attributed to the media characteristics in which coconut husk bits can retain moisture and nutrients for a longer duration than charcoal. Jin and Ichihashi (2002) also reported that *Doritaenopsis* (Dtps.) potted with New Zealand sphagnum moss grew better than when potted with New Zealand bark, coconut husk chips or rock wool.

Fig. 7 Influence of growing structures on leaf length (cm) of *Phalaenopsis* at monthly interval

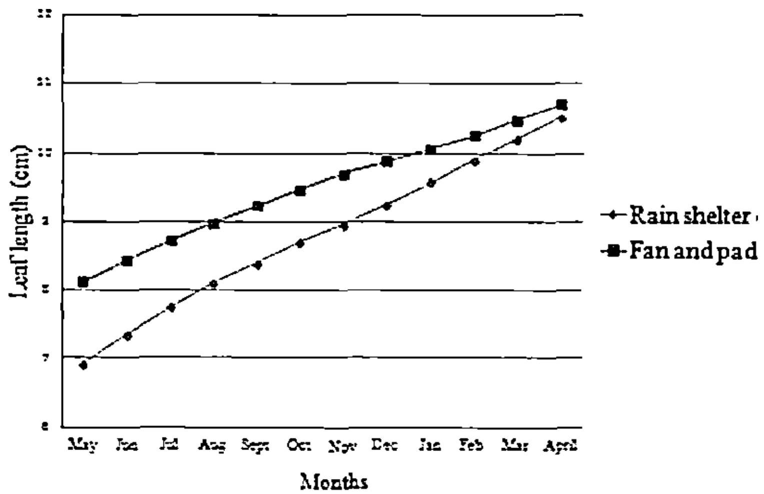


Fig.8 Leaf length (cm) of *Phalaenopsis* types at monthly interval

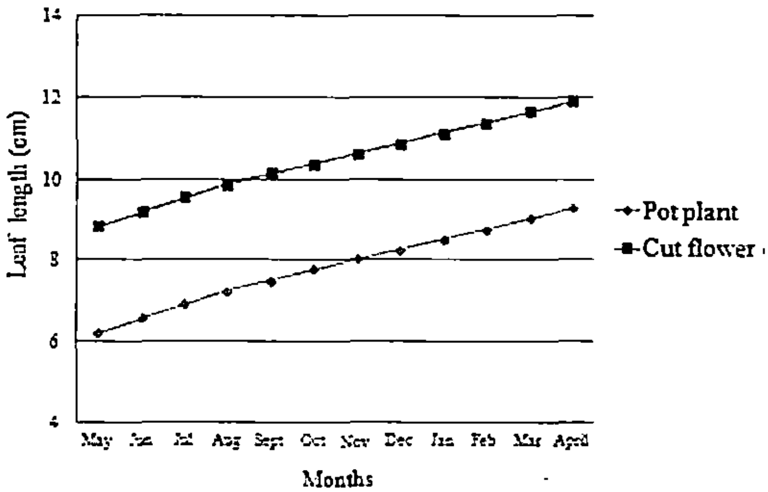
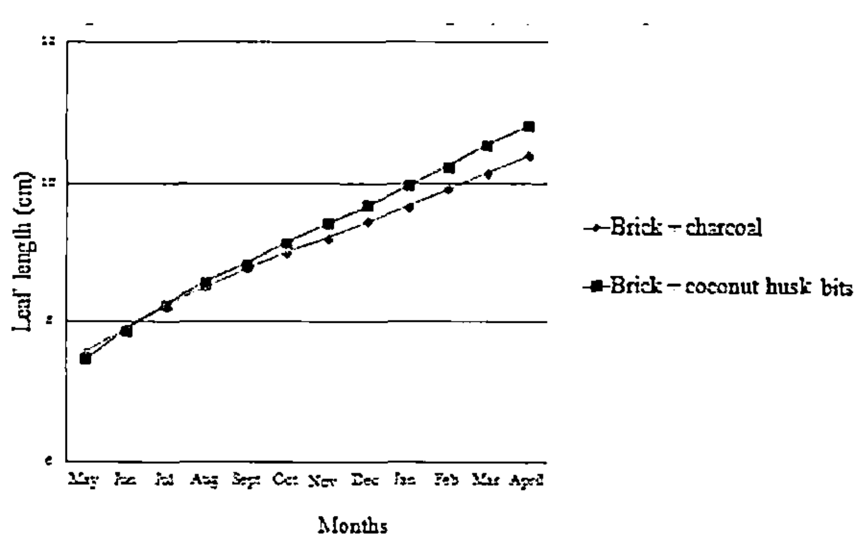


Fig.9 Influence of media on leaf length (cm) of *Phalaenopsis* at monthly interval



Progressive rate of increase in leaf length was highest during entire year in rain shelter x on bench (53.16 %) and lowest in fan and pad x hanging (38.05%) (Table 10). Maximum leaf length was recorded in case of rain shelter x brick + coconut husk bits and minimum in case of rain shelter x brick + charcoal. Interaction between growing structure and media, rain shelter x brick + coconut husk bits recorded highest progressive rate of increase (54.96 %) and fan and pad x brick + charcoal shown lowest rate of increase (38.69 %) during the course of study.

5.1.4 Leaf breadth

Leaf breadth of the plants showed significant difference in plant grown under rain shelter and fan and pad system for the first five months (May to September) and thereafter remained insignificant. In general, plants grown under rain shelter showed low leaf breadth; and that in fan and pad was higher. The value recorded for leaf breadth during the first month was 4.52 cm for plants under fan and pad system where as it was 4.19 under rain shelter system. During fifth month of growth (September) plants grown under fan and pad system recorded growth value of (5.28 cm) whereas rain shelter recorded (5.19 cm) (Fig. 10). These observations indicated that rain shelter system in general promotes higher growth rate than fan and pad system.

Even though this particular parameter did not show much significant variation during the initial eleven months of growing period, it recorded significant difference during the 12th month (April) among different media treatment combinations. Leaf breadth of plants grown in brick + coconut husk bits was high and brick + charcoal was low in 12th month (Fig. 11). Progressive growth of plants was also higher in brick + coconut husk bits (48.27 %) and lower in brick + charcoal (40.31 %) during the period of study (Table 10). Jin and Ichihashi (2002) reported that *Doritaenopsis* (Dtps.) potted with New Zealand sphagnum moss grew better when potted with New Zealand bark, coconut husk chips or rock wool. The positive effect of growth by media different treatment combinations can be attributed to the characters of the media like moisture holding ability and content

Fig. 10 Influence of growing structures on leaf breadth (cm) of *Phalaenopsis* at monthly interval

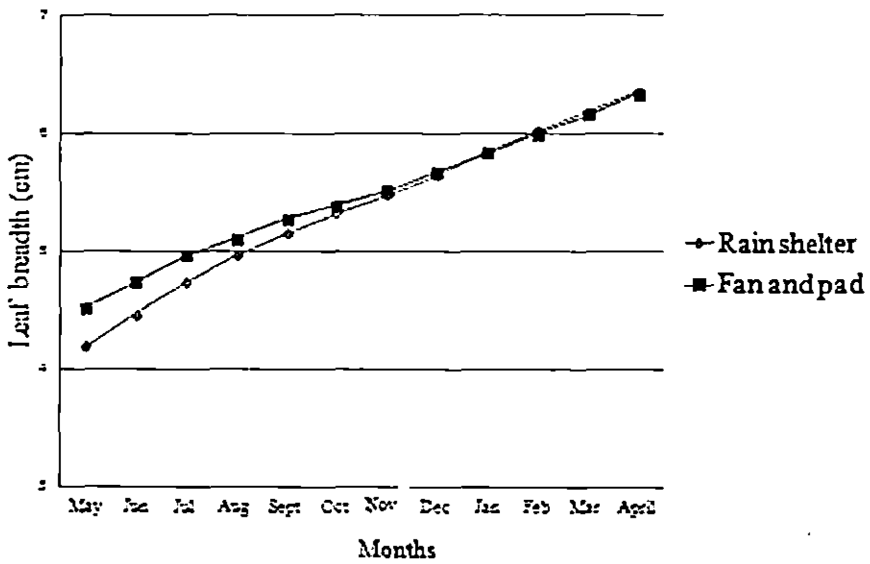
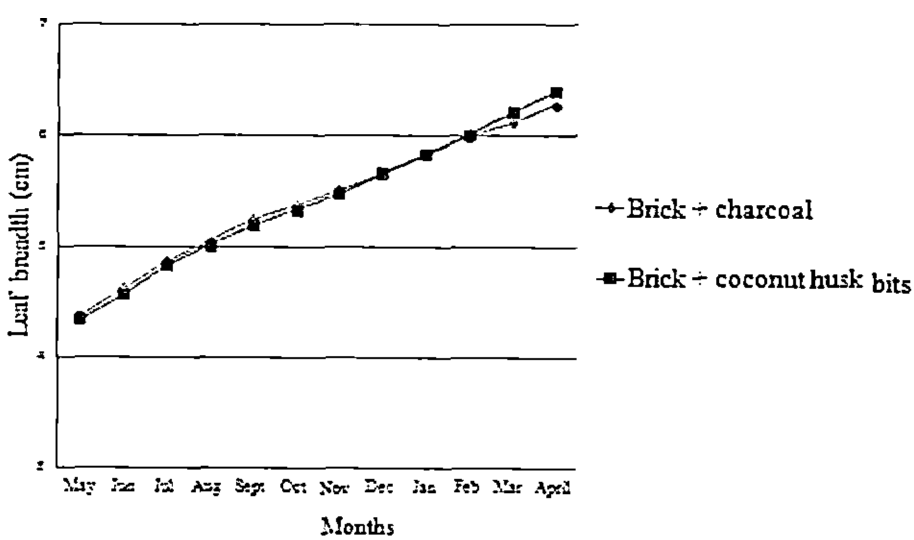


Fig. 11 Influence of media on leaf breadth (cm) of *Phalaenopsis* at monthly interval



and release of minerals from the media. Similarly, interaction effect of growing structure and method of growing was not much conspicuous during the early growth stage but it resulted in significant growth enhancement from the sixth month onwards. Leaf breath value recorded in June in fan and pad x hanging was (4.84 cm) and it was (4.46 cm) rain shelter x hanging. During October, highest leaf breadth was recorded in fan and pad x hanging and lowest in rain shelter x hanging. It gradually increased thereafter and recorded maximum value in March in rain shelter x on bench where as minimum value was recorded in treatment combination of rain shelter x hanging.

Progressive rate of increase in growth was the highest during entire period in rain shelter x hanging (55.86 %) and the lowest in fan and pad x hanging (27.56 %) (Table 10). Maximum leaf breadth was recorded in case of rain shelter x cut flower and minimum in case of rain shelter x pot plant. Interaction between growing structure and type of pot had not shown any significant difference for initial nine months but was significant thereafter. Rain shelter x black pot recorded maximum leaf breadth and fan and pad x black pot recorded minimum leaf breadth during February. It gradually increased thereafter and recorded maximum value in rain shelter x black pot whereas minimum value was recorded in treatment combination of fan and pad x black pot.

5.1.5 Leaf area

Leaf area of the plant varied significantly in plants grown under rain shelter and fan and pad system for first four months (May to August) but it was not significant during the remaining eight months. During first month (May) plants grown under fan and pad system gave the highest growth and rain shelter gave the lowest growth (Fig.12) in terms of leaf area. During the fifth month (September) plants grown under fan and pad system gave the highest growth and rain shelter gave the lowest growth. Increase in leaf area is due to increase in leaf growth as expressed through leaf length and breadth. It doesn't mean that vegetative growth was better in fan and pad system as compared to rain shelter system because when we compare the progressive increase of rate for one year with respect to leaf area,

Fig. 12 Influence of growing structures on leaf area (cm^2) of *Phalaenopsis* at monthly interval

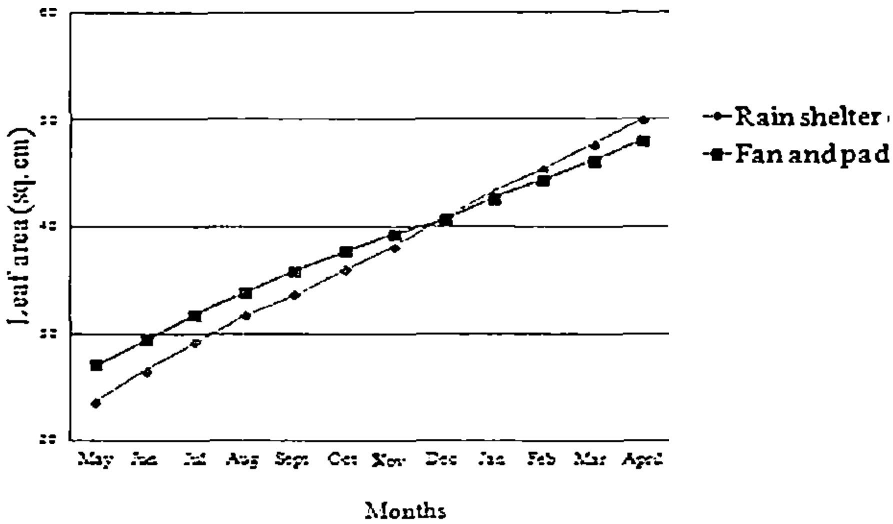


Fig. 13 Leaf area (cm^2) of *Phalaenopsis* types at monthly interval

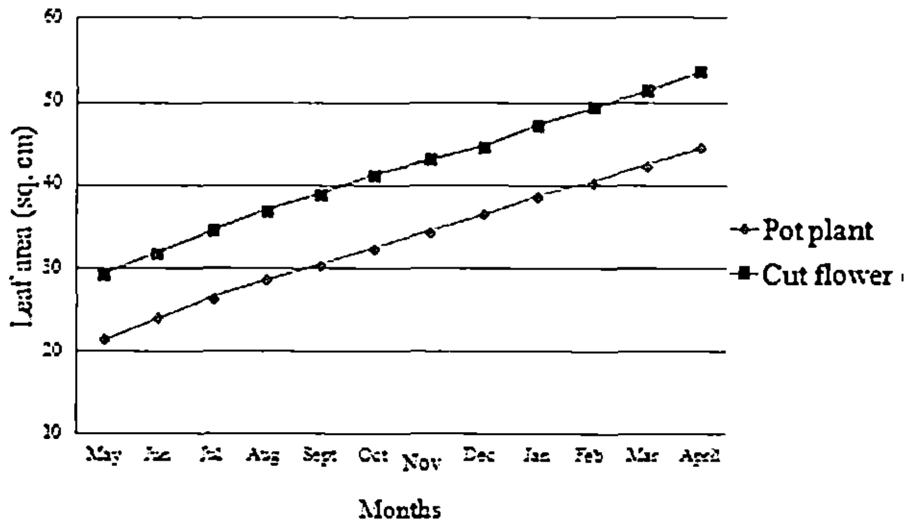
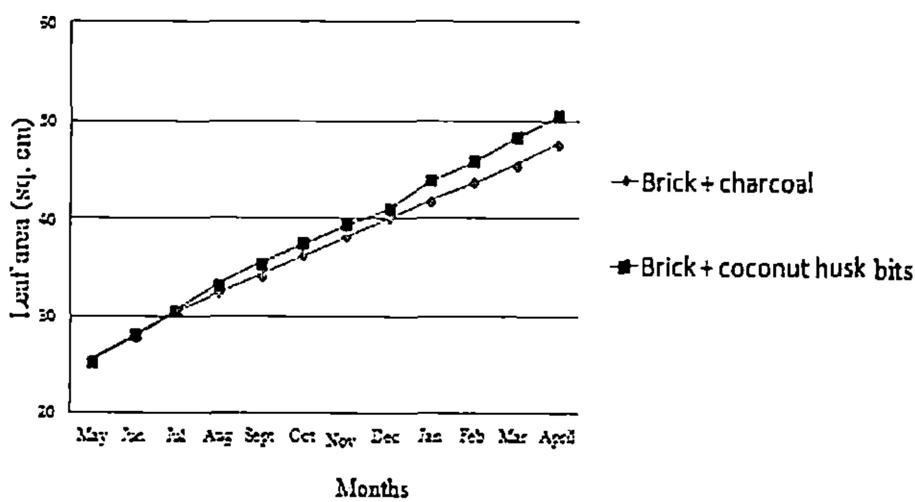


Fig. 14 Influence of growing media on leaf area (cm^2) of *Phalaenopsis* at monthly interval



rain shelter shown a higher rate of increase (117.89 %) and fan and pad shown lower rate increase (82.27 %) during the study period. It indicated that the rain shelter conditions favoured leaf growth in terms of leaf area.

Pot plant and cut flower types recorded significant difference with respect to leaf area during entire period of study. In case of pot plant, leaf area was the lowest (21.48 cm^2) in May and increased up to (44.48 cm^2) during April, while that of cut flower type was higher (29.32 cm^2) in May and increased up to (53.71 cm^2) in April (Fig. 13). Although leaf area was greater in cut flower type as compared to pot plant but progressive increase rate was recorded higher in pot plant (111.80 %) and lower in cut flower (88.36 %) (Fig.16). These results are in tune with Bhattacharjee *et al.* (2002) who reported similar observations among different cultivars of orchids.

Leaf area of plants did not show any conspicuous difference grown under different media (Brick + charcoal and brick + coconut husk bits) for first nine months (May to January) but it was significant thereafter. Leaf area of plants grown in brick + coconut husk bits was higher and lower in brick + charcoal during April (Fig. 14). It showed that brick + coconut husk bits was a good medium for vegetative growth as compared to brick + charcoal. A progressive rate of increase in leaf area was evident in both the media but brick + coconut husk bits recorded higher rate increase (107.23 %) and brick + charcoal recorded a lower rate increase (92.93%) (Fig. 17). Such a difference in growth can be attributed to the media characteristics in which coconut husk bits can retain moisture and nutrients for a longer duration than charcoal. Jin and Ichihashi (2002) also reported a favourable effect of coconut husk chips on growth of *Doritaenopsis* (Dtps.).

Progressive rate of increase in growth was the highest during entire period in interactions between rain shelter x hanging (120.19 %) and the lowest in fan and pad x hanging (72.09 %) (Table 10). Constant air movement around orchid is essential to keep the plants in good health which leads to good vegetative growth of plant with more aerial roots when exposed to current of fresh air (Bose *et al.*, 1999). They do the best when grown in baskets kept hanging from the beams of the

Fig. 15 Rate of increase (%) in vegetative characters of *Phalaenopsis* as influenced by growing structures from May 2011 to April 2012

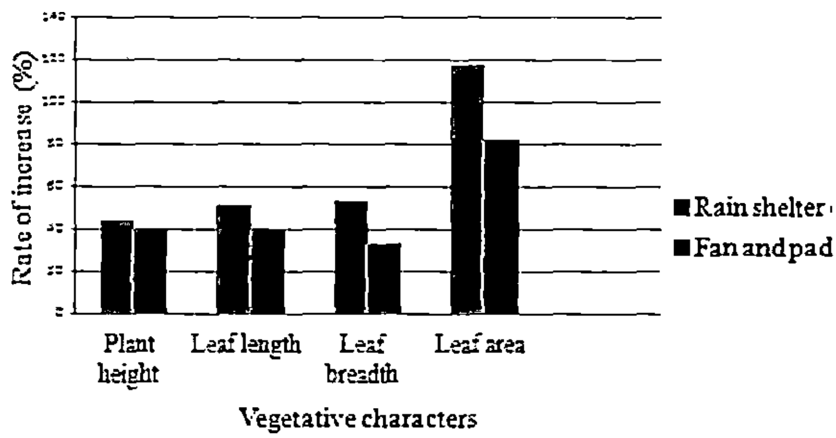


Fig. 16 Difference in rate of increase (%) of *Phalaenopsis* types from May 2011 to April 2012

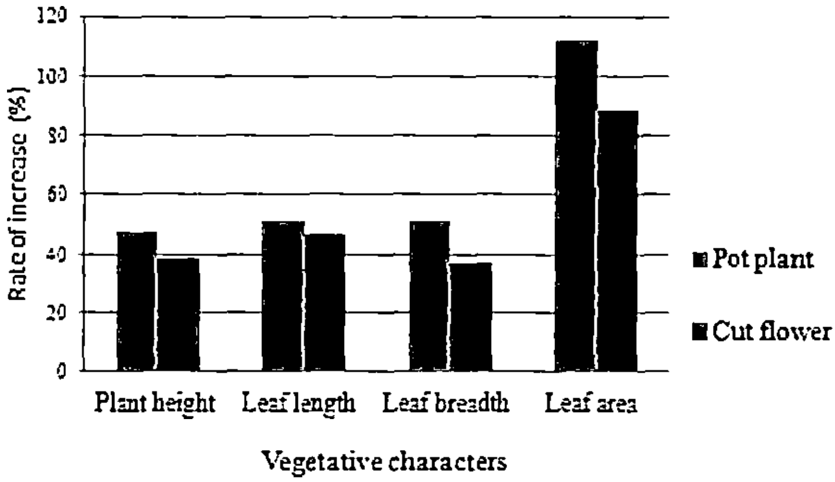


Fig.17 Influence of media on rate of increase (%) in vegetative characters of *Phalaenopsis* from May 2011 to April 2012

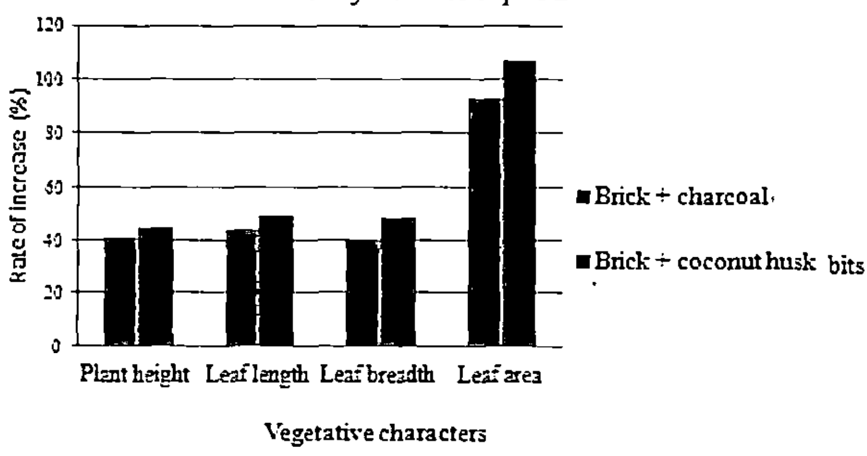


Table 10. Rate of increase (%) in vegetative characters of *Phalaenopsis* as influenced by different factors during May 2011 to April 2012

Vegetative characters → Factors		Plant height	Leaf length	Leaf breadth	Leaf area
A	1	45.10	52.07	54.28	117.89
	2	40.98	40.72	34.30	82.27
CD		NS	3.66	4.46	9.01
B	1	44.63	48.28	46.87	104.01
	2	41.45	44.51	41.71	96.14
CD		NS	3.66	4.46	NS
A x B	1 x 1	46.20	53.16	52.69	115.58
	1 x 2	44.01	50.98	55.86	120.19
	2 x 1	43.05	43.39	41.05	92.44
	2 x 2	38.90	38.05	27.56	72.09
CD		NS	NS	6.32	12.05
C	1	47.12	46.33	51.24	111.80
	2	38.96	46.46	37.34	88.36
CD		5.36	NS	4.42	9.01
A x C	1 x 1	48.01	51.14	60.86	129.08
	1 x 2	42.19	53.00	47.69	106.70
	2 x 1	46.23	41.52	41.62	94.52
	2 x 2	35.72	39.93	26.99	70.01
CD		NS	NS	NS	NS
B x C	1 x 1	48.34	49.77	59.37	122.81
	1 x 2	40.91	46.78	34.38	85.21
	2 x 1	45.90	42.89	43.12	100.79
	2 x 2	37.00	46.14	40.30	91.50
CD		NS	NS	6.32	12.75
D	1	44.74	45.74	44.60	99.60
	2	41.33	47.06	43.98	100.56
CD		NS	NS	NS	NS
A x D	1 x 1	45.69	50.93	55.43	116.62
	1 x 2	44.52	53.21	53.12	119.15
	2 x 1	43.80	40.55	33.78	82.57
	2 x 2	38.15	40.90	34.83	81.97
CD		NS	NS	NS	NS
B x D	1 x 1	48.29	50.01	47.26	107.34
	1 x 2	40.96	46.54	46.49	100.68
	2 x 1	41.20	41.46	41.95	91.85
	2 x 2	41.71	47.57	41.47	100.44
CD		NS	NA	NS	NS
C x D	1 x 1	48.52	45.32	53.34	115.85
	1 x 2	45.73	47.34	49.14	107.75

	2 x 1	40.97	46.16	35.86	83.34
	2 x 2	36.94	46.77	38.81	93.37
CD		NA	NS	NS	NS
E	1	40.95	43.94	40.31	92.93
	2	45.13	48.85	48.27	107.23
CD		NS	3.66	4.46	9.01
A x E	1 x 1	39.34	49.18	49.02	109.78
	1 x 2	50.86	54.96	59.53	125.99
	2 x 1	42.56	38.69	31.60	76.07
	2 x 2	39.39	42.75	37.01	88.46
CD		7.59	5.18	NS	NS
B x E	1 x 1	41.23	45.86	43.21	98.03
	1 x 2	48.02	50.70	50.53	109.99
	2 x 1	40.67	42.02	37.42	87.82
	2 x 2	42.24	47.01	46.00	104.47
CD		NS	NS	NS	NS
C x E	1 x 1	42.62	43.58	46.99	99.92
	1 x 2	51.62	49.08	55.49	123.68
	2 x 1	39.27	44.30	33.64	85.93
	2 x 2	38.64	48.63	41.04	90.78
CD		NS	NS	NS	12.75
D x E	1 x 1	40.67	42.58	41.37	93.09
	1 x 2	48.82	48.89	47.84	105.20
	2 x 1	41.23	45.30	39.25	91.86
	2 x 2	41.44	48.41	48.70	109.26
CD		NS	NS	NS	NS
C V %		31.17	19.76	25.22	22.52

Factor A Growing structure/ Environment (1. Top ventilated rain-shelter; 2. Fan and pad system);

Factor B Methods of Growing (1. On bench; 2. Hanging);

Factor C Types of *Phalaenopsis* (1. Pot plant; 2. Cut flower);

Factor D Types of pots (1. White – transparent plastic pots (translucent); 2. Opaque (Black) plastic pots);

Factor E Media (1. Brick + charcoal medium; 2. Brick + coconut husk bits medium);

NS – Not significant

greenhouse or lath house (Mukherjee, 2002). These findings support the results of the present study on better performance of plants under hanging system.

5.16 Pattern of root growth

Nature of root growth was observed under the different treatment combinations during the course of study. Difference was observed on the pattern root growth with respect to types of pot (white pot and black pot). Number of roots outside the pot was more in case of black pot as compared to that in white pot (Plate 7). Blanchard and Runkle (2008a) reported that plants in opaque pots had formed >7 roots outside of each container, whereas it was <2 roots per pot in case of the translucent containers. This is attributed to the photosynthetically active nature of the *Phalaenopsis* roots and in the case of black pots, the roots comes out either from side holes or from upper side of pot due to phototropism. It was seen that the roots were more clinging or adhering to the surface of the black pots and in case of white pots roots were of less clinging nature. The practical implication is that while repotting it is more arduous to repot plants of black pots due to the clinging nature of roots as compared to that of white pots.

An overall assessment of the effect of different treatment combinations during the course of study indicated that the most of combinations had significant influence on the vegetative growth of the plants. But further confirmatory studies are required to arrive at final conclusions and recommendations on this aspect. Abraham and Vatsala (1981) while studying orchids in Kerala condition observed that growth, development and productivity are much dependant on the interaction between environmental factors and genetic constitution of plant. Since orchid is one such crop which expresses a high magnitude of diversity and responds very well to the environment, results from the present investigations are to be used as an indicator for future studies.

5.2 Influence of weather parameters

5.2.1 Effect of weather parameter on leaf area

Leaf area is considered as one of most important biometric parameters which determine the photosynthetic efficiency and final yield. The increase in leaf area throughout the growing period were correlated with weather parameter like maximum and minimum temperatures (°C), morning and afternoon relative humidity (%) and light intensity (lux) inside the protected structure.

Results indicated that minimum temperature in rain shelter and fan and pad system had a positive correlation with growth of leaves. Light intensity had negative correlation with increase in leaf area in fan and pad system. Considering the overall effect by pooled analysis, only minimum temperature had a significant positive influence on leaf area increase.

From this, it is clearly understood that the leaf area is mainly determined by minimum temperature (50%). So maintaining the minimum temperature inside the protected structure to an optimum level enhances the growth of *Phalaenopsis* under protected condition. So minimum temperature inside the structure has to be considered as most important weather parameter while growing *Phalaenopsis* under protected condition. But the vegetative characters were higher in rain shelter, which is having a higher temperature throughout the growing season. This means, a higher temperature is ideal for vegetative growth and optimum temperature for vegetative growth is ranges from 28 to 32 °C. Blanchard and Runkle (2008b) categorised production of *Phalaenopsis* orchids into three phases on the basic of temperature requirement *i.e.* vegetative, spike initiation and finishing phase which required the temperature range of (28 to 32 °C), (17 to 25 °C) and (17 to 26 °C) respectively. The optimal temperature for vegetative growth and flowering are to be standardised under Kerala conditions.

5.3 Flowering characters

Early reports show that spiking of *Phalaenopsis* is induced by exposure to a temperature below 25 °C for several weeks (Sakanishi *et al.*, 1980). Wang (1995) reported that combinations effect the low-temperature and exposure to high-intensity light is necessary to induce the spiking process. In the present studies plants in fan and pad showed high flowering percentage (32.29 %) than rain shelter plants (17.70 %) and in fan and pad it was possible to maintain temperature at somewhat optimal range (< 25 °C) which in turn ought to have increased flowering. These results are in conformity with the above findings.

Yong and Hew (2004) stated that juvenility, vernalisation and photoperiodism are three important factors deciding the time of flowering with respect to ontogeny and season. Plant often responds to change in photoperiod and temperature so that they naturally flower when environment condition become favourable for a reproductive phase (Lopez and Runkle, 2004). Flowering as such shows variation among plants with in the species also. In the present studies there was a clear difference on flowering with respect to the plant type used. Pot plant group recorded more flowering (32.81%) as compared to cut flower type (17.18 %).

With respect to media, the combination of brick + coconut husk bits recorded more flowering (31.77 %) as compared to brick + charcoal combination (18.22 %). Good vegetative growth is an essential pre requisite for better flower production and the brick + coconut husk bits combination produced good vegetative growth, and hence flowering was also better in this medium. Interactions between growing structure and type of pot; and fan and pad x white pot recorded higher flowering (35.41%) than rain shelter x white pot (10.41%). Interaction effects of method of growing and type of pot, rain shelter x black pot showed the high flowering (31.25%) than rain shelter x white pot (10.41 %). Similarly interaction effect of type of plant and media, pot plant x brick + coconut husk bits showed higher flowering (44.79 %) than cut flower x brick + charcoal (15.62 %). The results as such indicated a varying influence of different combination on flowering in *Phalaenopsis*.

Plants in rain shelter took less days for emergence of spike than fan and pad. But bench method of growing recorded less days for emergence of spike than hanging method. It is possibly due to the good vegetative growth of the plants and early attainment of flowering stage in rain shelter and on bench method of growing. This in turn influenced the spike emergence also. Interaction effect between growing structure and type of pot showed rain shelter x white pot recorded minimum days for emergence of spike and fan and pad x white pot taking maximum days for emergence of spike.

Length of spike had shown significant difference with respect to the growing structure. The overall spike length was higher in case of fan and pad method in comparison with rain shelter system. It is probably due to the shy flowering nature noted in rain shelter than the fan and pad system. Robinson (2002) opined that temperature has little or no effect on spike length. Interaction effects between growing structure and type of pot showed fan pad x white pot recording maximum spike length and rain shelter x white pot recording minimum spike length. In case of interaction between growing method and type of pot, on bench x white pot recorded maximum spike length and on bench x white pot recorded minimum spike length.

Rain shelter took less time for opening of first bud than plants in fan and pad system where as in case of type of plant, cut flower took less days for opening of first bud than pot plant, similarly brick + charcoal medium took less days for opening of first bud than brick + coconut husk bits medium. It was generally observed that vegetative growth was higher and faster in rain shelter conditions and thus, plant under rain shelters would have reached physiological maturity of flowering earlier. Lee and Lin (1984) opined that flower bud initiation occurred after the reproductive stem (spike) has reached certain length under required environmental condition. Lopez and Runkle (2005) stated that once flower bud has initiated flower development time is dependent on genotype and temperature.

Plants in fan and pad system recorded more number of florets per spike and rain shelter recorded less number where as in case of type of plant pot plant and cut flower type, pot plant recorded more number of florets per spike and cut flower had less number of florets per spike. Similarly number of florets per spike was higher in brick + coconut husk bits medium and minimum in brick + charcoal medium. In case of flower size fan and pad recorded lager flower size and rain shelter recorded small flower size and where as in case of type of plant, pot plant recorded lager flower size and cut flower recorded small flower size. These differences can only be attributed to the variation in flowering process among plants in different treatment combinations possibly.

Plants in rain shelter recorded less time for completion of flowering whereas fan and pad plants recorded more days. In case of type of plant, cut flower recorded less time for complete flowering and pot plant recorded more days for flowering. While brick + charcoal medium recorded less time and brick + coconut husk bits medium recorded more time for flowering.

Most *Phalaenopsis* flowers are long lasting and can stay in bloom for 2 – 4 months under favourable conditions. It depends on environment conditions, genetic factors and incidence of pest and diseases. In case growing structure, fan and pad has recorded maximum longevity of spike on plant and rain shelter has recorded minimum longevity of spike on plant. The low temperature conditions prevailed during flowering phase in fan and pad system would have helped to increase longevity when compared to rain shelter system. The environment conditions in fan and pad may help to maintain the carbohydrates reserve in spike, osmotic concentration and pressure potential of petals cells favouring longevity of spikes. Spikes from pot plant recorded maximum longevity and cut flower recorded minimum longevity. While brick + coconut husk bits medium recorded maximum longevity of spike and brick + charcoal medium recorded minimum longevity. Optimum growing conditions and moisture and nutrient availability provided by coconut husk bits medium would have helped in extending the flowering longevity. Interaction between type of plant and media, pot plant x brick + coconut husk bits has recorded maximum longevity of spike on plant and cut flower x brick + charcoal medium recorded minimum longevity of spike. Kaveriamma (2007) reported that in short stemmed epiphytes the spike lasted for 2-8 months under normal condition in the plants and it is an important factor deciding the suitability of *Phalaenopsis* as a pot plant.

In general, the studies indicated that rain shelter conditions and prevailing high temperature favour better vegetative growth and fan and pad system having low temperature conditions favour flowering characters in *Phalaenopsis.* The optimum weather parameters for vegetative and reproductive phase suited to Kerala conditions are to be worked out in future studies. This will also help to design the appropriate growing structure, or to make seasonal alterations in the structure provided optimum conditions for commercial cultivation of *Phalaenopsis*. The vegetative and flowering characters varied between the plant types. In general white pots and combination of brick + coconut husk bits was better.

Among the different treatment combinations for vegetative growth, both pot plants and cut flower types performed better in rain shelter x brick + coconut husk bits medium and flowering was found higher in fan and pad x brick + coconut husk bits medium.

Standardisation of nutrient management and effective plant protection strategies are the potential aspects for the future studies in the crop.

Summary

6. SUMMARY

Studies on "Standardisation of agrotechniques in *Phalaenopsis* orchids" were carried out at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara from May 2011 to April 2012. The studies were conducted to find out the best plant type and environment suited for commercial cultivation of *Phalaenopsis* and to standardise the agrotechniques like type of pot, growing media, growing method and structure for better growth and quality spikes. The results of the study are summarized below.

- Number of leaves per plant was higher under rain shelter structure and pot plant type whereas it was low under fan and pad and cut flower type.
- Plants kept under rain shelter took lesser time for emergence of first leaf as compare to fan and pad system.
- Plants kept under rain shelter produced almost three leaves per plant while under fan and pad produced only two leaves during the period of study.
- Height of plant was higher in bench method of growing as compared to hanging method.
- Height of plant was higher in pot plant type as compared to cut flower type.
- Among interactions between growing structure and method of growing, rain shelter x on bench method recorded the maximum plant height whereas rain shelter x hanging recorded the minimum plant height.
- Increase in leaf length in one year of study was higher in rain shelter, on bench method and brick + coconut husk bits medium as compared to fan and pad, hanging method and brick + charcoal medium.
- Among interactions between growing structure and media, increase in leaf length was recorded the highest in case of plants grown under rain shelter condition with brick + coconut husk bits medium and the minimum in fan and pad with brick + charcoal medium.

- Increase in leaf breadth in one year of study was higher in rain shelter, on bench method, pot plant type and brick + coconut husk bits medium as compared to fan and pad, hanging method, cut flower and brick + charcoal medium.
- Among interactions between growing structure and method of growing, increase in leaf breadth was recorded the highest in rain shelter x hanging and the lowest in fan and pad x hanging.
- Increase in leaf area in one year of study was recorded higher in rain shelter, on bench method, pot plant type and brick + coconut husk bits medium, as compared to fan and pad, hanging method, cut flower and brick + charcoal medium.
- Among interactions between growing structure and method of growing, increase in leaf area recorded was the highest in rain shelter x hanging and the lowest in fan and pad x hanging.
- Pot types (white pot and black pot) did not record any significant difference with respect to vegetative growth, but pattern of root growth was different for both the pots where more number of roots were outside in black pot as compared to white pot wherein the roots were confined within the pots.
- Method of growing (on bench and hanging) and types of pot types (white pot and black pot) did not record any significant difference with respect to vegetative growth and percentage of flowering.
- Percentage of flowering was higher in fan and pad system, pot plant types and brick + coconut husk bits medium as compared to rain shelter, cut flower and brick + charcoal medium.
- Among interactions between growing structures and types of pot, fan and pad x white pot showed the highest flowering percentage and rain shelter x white pot showed the lowest.
- Interaction between methods of growing and types of pot, on bench x black pot showed the highest flowering percentage and on bench x white pot showed the lowest flowering percentage.

- Interaction between types of plant and media, pot plant x brick + coconut husk bits showed the highest flowering percentage and cut flower x brick + charcoal showed the lowest flowering percentage.
- Plants grown in the rain shelter and on bench method took fewer days for emergence of spike as compared to fan and pad system and hanging method.
- Plants grown under fan and pad system recorded longer spikes as compared to rain shelter system.
- Plants grown under rain shelter, cut flower type and brick + charcoal medium took less time for opening of the first bud as compared to fan and pad, pot plant type and brick + coconut husk bits medium.
- Number of florets per spike was higher in fan and pad system, pot plant type and brick + coconut husk bits medium as compared to rain shelter, cut flower type and brick + charcoal medium.
- Plants grown under fan and pad system produced larger flowers than those under the rain shelter system.
- Rain shelter, cut flower type and brick + charcoal medium recorded less time for complete flowering as compared to fan and pad, pot plant type and brick + coconut husk bits medium.
- Fan and pad, pot plant type and brick + coconut husk bits medium recorded the longest spike longevity on the plant as compared to rain shelter, cut flower type and brick + charcoal medium.
- Minimum temperature in rain shelter and fan and pad system had a positive correlation with growth of leaves whereas light intensity had negative correlation with increase in leaf area in fan and pad system. Considering the overall effect, as indicated by pooled analysis, only minimum temperature had a significant influence on leaf area.

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Abstract

STANDARDISATION OF AGROTECHNIQUES IN *PHALAENOPSIS* ORCHIDS

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ABSTRACT OF THE THESIS
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ABSTRACT

The present study entitled "Standardisation of agrotechniques in *Phalaenopsis* orchids" was carried out at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara from May 2011 to April 2012. The studies were conducted to find out the best plant type and environment suited for commercial cultivation of *Phalaenopsis* and to standardise the agrotechniques like type of pot, growing media and growing method for better plant growth and quality spikes.

The study involved comparison of 32 treatment combinations involving two plant types, two types of pots, two types of potting media, two growing conditions and two methods of growing. The experiment was laid out in CRD with three replications. Various vegetative and floral characters were recorded, analysed and correlated with weather parameters.

Results indicated that of the two growing structures used in the study *i.e.*, fan and pad and rain shelter, the latter promoted vegetative growth manifested by enhanced leaf length, leaf breadth and leaf area. Plant height was not influenced in both the situation.

The plant types *viz.*, pot plant and cut flower, differed in their growth rate. Pot plant type recorded higher growth rate in terms of length, breadth and area of leaf but *per se* length, breadth and area of leaf was higher in cut flower type.

Regarding the media, brick + coconut husk bits was found better for vegetative growth as compared to brick + charcoal. The other two factors, method of growing and type of pots did not affect the vegetative growth. But root growth outside the pot was recorded more in black pot compared to that on white pot.

Percentage of flowering was also influenced by growing structure, type of plant and media. Plants grown under fan and pad, pot plant type and brick + coconut husk bits medium recorded higher flowering percentage than those under rain shelter, cut flower and brick + charcoal medium.

Correlation values with weather parameters indicated positive correlation between increase in leaf area and minimum temperature under rain shelter and fan and pad system whereas negative correlation with light intensity was seen under fan and pad system. Considering the overall effect by pooled analysis, only minimum temperature had a significant influence on increase in leaf area.