RESPONSE OF *Ascocenda* ORCHID TO GROWTH REGULATOR AND MICRONUTRIENTS

by

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THESIS

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DECLARATION

I, hereby declare that the thesis entitled **"Response of *Ascocenda* orchid to growth regulator and micronutrients"** 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 of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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Certified that the thesis entitled **"Response of *Ascocenda* orchid to growth regulator and micronutrients"** is a record of research work done independently by **Jesabel George (2017-12-035)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to her.

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Introduction

1. INTRODUCTION

Orchids are the most exquisite and extravagant ornamental plants nature has ever blessed us with. They possess alluring charm, intoxicating fragrance, symbolic and historic relevance. Orchids belongs to the family Orchidaceae, the largest family of flowering plants comprising 600-800 genera and 25000-35000 species. Among these, about 1331 species are found in India (De *et al.*, 2014). With their enchanting beauty and high productivity at the right season of bloom, complemented by a fairly extensive shelf life, the orchids have a remarkable importance in the cut flower industry. The fact that orchids flowers can be packed and transported in an effortless manner further adds to their significance. Contributing to around 10% of the international trade, orchids rank 6th among the top ten cut flowers (De *et al.*, 2014).

Orchids account for the highest sales in the Indian cut flower industry (Khuraijam *et al.*, 2017). They are also sought after as potted plants and can be an aesthetic piece to be grown in hanging baskets. The demand for orchids in the Indian market can broadly be classified into two; as cut flowers for decoration purposes, and as potted plants for houses and gardens. This huge demand for orchids is met by import from countries like Netherlands and Thailand (Khuraijam *et al.*, 2017). This import which is worthy of crores further escalates at the time of festivals and special days. In India, the import of orchid cut flowers has increased from Rs 299.09 lakhs in 2008-09 to Rs. 3402.36 lakhs in 2014-15 (NRCO, 2015). India, having all the essential ambience and potential to emerge as a successful orchid growing country, still is being compelled to import from other countries to meet the growing demand for orchids. This can be overcome by providing farmers and cultivators with proper knowledge and awareness on diversity in orchids, production technology, and techniques to grow high quality orchids with good returns.

Based on the growth habit of main stem, there are mainly two types of orchids, sympodials and monopodials. The true stem of sympodials grows

horizontally while that of monopodials grows vertically. The attainability of vast varieties and hybrids including intergeneric hybrids, exhibiting a wide range of variability in floral characters has attributed to the approval and acclaim of monopodial orchids recently. The intervention of bigeneric hybrids has taken the environmental range of orchids to an encyclopedic level with an extensive number of more than one lakh hybrids known and cultivated all over the world. They also have attained an improvement in flower size, colour, pattern and habit of inflorescence when compared to the individual species of parental genera.

A bigeneric cross between two monopodials, *Ascocentrum* and *Vanda* has successfully produced a monopodial epiphyte named *Ascocenda*. Vandas have gained huge acclaim over recent times and are now one of the most widely cultivated orchids. They are either cultivated outdoors or in green houses in the warm regions globally. The salient and prominent feature of *Vanda* that has helped in its popularity is the size of flowers. *Ascocentrum* is a small flowered genus possessing erect inflorescence with more compact and long lasting flowers. *Ascocenda* is a hybrid that blends the large flower size of *Vanda* and colour and compactness of *Ascocentrum*, thus resulting in an evergreen and compact epiphyte consisting of upright narrow and oviform leaves and beautiful flowers. The inflorescence, blooming twice or occasionally thrice annually, is an axillary spike with 6-8 open flowers.

Since *Ascocenda* is mainly grown as pot plants, it is used in indoor gardening and in hanging baskets in verandas. Pot plants are grown in soilless medium consisting of charcoal, bricks, etc. Without nutrients, proper growth and development of any plant become difficult. Apart from the type of nutrients applied, their quantity and frequency of application is also very important. Most of the plants fulfil their need for nutrients by absorbing from soil. External application of nutrients is practiced for most of the cultivated crops when the soil nutrients are not sufficient for their growth. The external application of nutrients becomes a necessity in epiphytes since the substrate in which they are grown does not contain soil. Hence foliar application of nutrients, both macro and micro, and growth

regulators at regular intervals is recommended for most of the orchids which are epiphytic in nature and are grown in soilless media, like *Vanda, Ascocentrum, Ascocenda, Dendrobium,* etc.

Application of micronutrients has been reported to improve the vegetative and floral characters of orchids. Nutrient requirement of each genus may vary and has to be standardised including the micronutrients. Such type of research works are limited in *Ascocenda*. In this context, the present study was undertaken with the following objective.

- To find out the effect of micronutrients and growth regulator on growth and performance of Ascocenda orchid.

Review of literature

2. REVIEW OF LITERATURE

Orchids exert a mysterious fascination for many people around the world due to their unique characteristics. They are regarded as the most alluring plants owing to their diversity and distinctiveness in structure, size, shape, colour, and fragrance. According to the growth habit of stem, there are two types of orchids; monopodials with vertical growth and sympodials with horizontal growth habit. *Ascocenda* is an epiphytic monopodial orchid with aerial roots and single non-branching upward growing stem. It is mainly grown as pot plant in hanging baskets using charcoal, bricks, coconut husk *etc*. as growing media. Since the availability of nutrients from growing media is limited, the nutrients required for growth and flowering have to be supplied artificially. Regular application of nutrients including both macro and micronutrients and growth regulators are needed for proper growth and flowering of orchids. Literature regarding the effect of major nutrients, micronutrients (Zn, Mn, B, Fe, Mo), and growth regulators especially benzyl adenine on the growth and flowering of orchids and other ornamentals are briefed hereunder.

2.1. EFFECT OF MICRONUTRIENTS ON GROWTH AND FLOWERING OF ORNAMENTALS

2.1.1. Effect of Zinc on growth and flowering of ornamental plants

Zinc has an important role in the growth of plants. Zinc is essential as a part of enzymes for protein synthesis and energy manufacturing and keeps the structural integrity of bio-membranes (Ganesh and Kannan, 2013). Zinc is needed for the metabolism of carbohydrates, proteins, and the plant hormone auxin, IAA, formation of pollen grains, and for internodal elongation in plants (Shukla *et al*., 2009).

Zinc deficiency disturbs the Calvin cycle and oxidative pentose phosphate pathway of C_3 plants by altering the functions of enzymes, Cu-Zn superoxide

dismutase and D-ribulose-5-phosphate 3-epimerase and thereby reduces net photosynthesis in plants (Jelakovic *et al*., 2003).

A drastic decrease in internodal length and size of leaf that results in rosetting of stem and little leaf respectively are the most common symptoms of zinc deficiency in dicotyledonous plants (Marschner, 1991).

Saud *et al*. (2016), conducted a study to find out the response of orchid to foliar application of micronutrients. Different concentrations of micronutrients *viz*., zinc, manganese and boron were applied to the orchid *Dendrobium* cv. 'Sonia'. The treatment with zinc @1000 ppm was found to be the best with respect to improvement of growth parameters like pseudo bulb height, number of leaves per plant, leaf area, inter nodal length, cane girth, spike length, number of florets per spike, flower spike yield, duration of flowering, shelf life, vase life, total soluble sugar, soluble protein, net assimilation rate and total chlorophyll content. Application with zinc 750 ppm recorded least number of days for flower bud emergence and harvest of spike.

According to Novais *et al.* (2016), there existed a negative correlation between phosphorus and zinc on *Phalaenopsis* orchids. i.e., when the rate of phosphorus application was increased, level of zinc in roots and shoots was reduced. Zinc was applied at three concentrations of 0.0, 0.5, and 0.1 g/L in the form of $ZnSO_4$ at weekly intervals and phosphorus was applied at concentrations of 0.0, 0.35 and 0.7 g/L at weekly intervals in the form of triple super phosphate. They also observed that in the absence of phosphorus application, shoot production increased with increase in zinc application and this effect of zinc was nil in the presence of elevated phosphorus levels.

Increased plant height, number of spikes per plant, and number of florets per spike were observed in *Dendrobium* var. Sonia 17 when sprayed with $ZnSO_4$ @ 1000 ppm at fortnightly intervals (AICRP on Floriculture, 2010-2011). Another study conducted on *Dendrobium densiflorum* revealed that application of 1000 ppm $ZnSO_4$ @ 1000 ppm resulted in maximum plant height, number of pseudobulbs per

plant, number of roots, number of spikes per plant, number of florets per spikes, spike length, flower size and longevity of flower (AICRP on Floriculture, 2010-2011). Highest plant height was reported in *Cymbidium elegans* on application of 1000 ppm $ZnSO_4$ at fortnightly intervals (AICRP on Floriculture, 2007-2008).

According to Sharma *et al.* (2013), application of $ZnSO_4$ @ 0.75% resulted in highest plant height, number of leaves, spike yield, and length of floret in *Gladiolus* cv. Aldebran. Katiyar *et al.* (2012), observed that vegetative growth and spike size of gladiolus was high when it was sprayed with 0.5% $ZnSO_4$ at fortnightly intervals. According to Patidar (2011), flower bud initiation and completion of 50% flowering could be achieved earlier in pot mum cultivars of chrysanthemum on application of 0.4% $ZnSO_4$. According to Chopde *et al.* (2015), plant height and leaf area were maximum in gladiolus var. American Beauty when treated with 0.4% and 0.6% zinc in the form of zinc sulphate on 20th and 30th days after planting. They also reported that early flowering and maximum number of spikes per plant were recorded with the application of 0.4% spray of $ZnSO_4$.

Foliar application of $ZnSO_4$ at different concentrations was carried out in China aster at 30, 45, 60 days after transplanting. Amidst different sprays, $ZnSO_4$ at 0.5% was found best with regard to vegetative characters like plant height, plant spread, number of branches, and floral characters like flower yield, number of flowers, weight of flowers, diameter of flower, stalk length of flower, and vase life of flower (Kakade *et al.*, 2009).

Plant height, flower yield and flower size in chrysanthemum were maximum when sprayed with 0.8% $ZnSO_4$ (AICRP on Floriculture, 2009-2010). Application of $ZnSO_4$ @ 0.4% on 30th and 45th days after planting in *Lilium* cv. Tresor produced higher chlorophyll content in leaves (Singh *et al.*, 2015).

Application of 0.6% and 0.8% $ZnSO_4$ had significant influence on vegetative growth as well as flowering in gerbera (AICRP on Floriculture, 2010-2011). Greatest plant height in gerbera cv. Rosaline was recorded when sprayed with 0.8% $ZnS0_4$ (AICRP on Floriculture, 2010-2011).

2.1.2. Effect of manganese on growth and flowering of ornamental plants

Manganese plays a crucial role in photosynthesis since it activates some specific enzymes which are responsible for the synthesis of chlorophyll (Lidon *et al.*, 2004). Millaleo *et al.* (2010), opined that apart from chlorophyll synthesis, manganese also plays a major role in photosynthesis as an essential component for the water photolysis reaction of photosystem II. Interveinal chlorosis was observed in the leaves of plants which were deficient in manganese (Ganesh and Kannan, 2013).

Manganese present in the protein molecules of plant cells function either as enzyme activators or as catalytically active metal. Examples for enzymes which are activated by manganese include RNA polymerase and enzymes responsible for the biosynthesis of gibberellic acid, fatty acids and metabolism of nitrogen (Hansch and Mendel, 2009).

Maximum flower diameter was recorded in *Dendrobium* var. Sonia 17 with the application of 250 ppm manganese sulphate at fortnightly intervals (AICRP on Floriculture, 2007-2008). Application of 500 ppm $MnSO_4$ had significant effect in *Cymbidium elegance* with respect to number of pseudobulbs, number of roots and length of roots (AICRP on Floriculture, 2007-2008). Maximum number of pseudobulbs in *Dendrobium* var. Sonia 17 was recorded with the application of 500 ppm manganese in the form of manganese sulphate at fortnightly intervals (AICRP on Floriculture, 2009-2010).

Patidar (2011) observed maximum plant height in pot mum cultivars of chrysanthemum by spraying $MnSO_4$ @ 0.4%, which also gave highest yield and maximum number of flowers per plant. Foliar application of manganese in the form of $MnSO_4$ @ 0.4% produced maximum number of flowers per spray in spray chrysanthemum cultivar Reagan White (AICRP on Floriculture, 2009-2010).

Maximum number of suckers and highest flower yield in Gerbera was recorded with the application of 0.8% manganese sulphate whereas, flower stalk length was maximum with application of 0.6% $MnSO_4$ and flower duration was

maximum with the application of 0.4% $MnSO_4$ (AICRP on Floriculture, 2010-2011). Spraying with 0.4% $MnSO_4$ resulted in maximum number of flowers with highest flower stalk length, flower diameter and vase life in Gerbera cv. Rosaline (AICRP on Floriculture, 2010-2011).

2.1.3. Effect of Boron on growth and development of ornamental plants

Boron is an important constituent in the cell wall of higher plants. About 90% of cellular boron is present in the cell wall (Loomis, 1992). Boron deficiency alters the cell wall structure and organization of middle lamella (Hu and Brown, 1996). In the cell wall, boron reacts with the hydroxyl group of glycoproteins or carbohydrates and forms borate esters, which has been attributed as the reason for cross linking of polymers in the cell wall (Loomis, 1992).

Boron has been found to be a prerequisite for reproductive growth like flowering, pollen germination, pollen tube growth, and fruit formation (Loomis, 1992). Ganesh and Kannan (2013) reported that boron was involved in the processes like carbohydrate metabolism, sugar and starch translocation, protein synthesis, meristematic cell division *etc.*

Highest internodal length in *Dendrobium densiflorum* was observed when sprayed with 200 ppm boron in the form of boric acid at fortnightly intervals (AICRP on Floriculture, 2010-2011).

Halder *et al.* (2007), reported that in gladiolus, plant height and number of leaves were highest with the application of boron @ 2kg/ha when compared to a higher dose of 3kg boron/ ha. In case of floral characters, integrated application of zinc and boron (2 and 3 kg/ha respectively) was more effective compared to their single applications in gladiolus. Sharma *et al.* (2013), reported that application of boron @ 0.20% as borax had resulted in greatest plant height and number of leaves in gladiolus cv. Aldebran. They also observed earlier flowering and maximum length of floret when treated with 0.20% borax.

Ahmad *et al.* (2010), had conducted a study to find out the effect of boron, zinc and iron on growth and yield of three cultivars of *Rosa hybrida.* Foliar

application of boron in the form of boric acid @ 0.5% alone or application of the same along with 1.5% zinc sulphate resulted in the production of taller plants with maximum number of leaves. They also opined that floral characters like diameter of flower bud, fresh weight of flower and dry weight of flower were high on application with 0.5% boron as boric acid.

Maximum flower weight in African marigold was recorded in monsoon season when it was sprayed with 0.2% boric acid. But flower yield was maximum when 0.2% boric acid was sprayed along with 0.5% zinc sulphate (Balakrishnan *et al.*, 2007). Rajput *et al.* (2003), reported that plant height in *Tagetes minuta* increased with the application of boron either individually or in combination with zinc and sulphur.

According to AICRP on Floriculture (2010-2011), earlier flowering in gerbera could be achieved by the application of 0.6% boric acid. Foliar application of borax @ 0.2% resulted maximum plant height in pot mum cultivars of chrysanthemum (Patidar, 2011). In tuberose, plant height, number of leaves, and spike yield were maximum when sprayed with 100 ppm boron at fortnightly intervals (Nath and Biswas, 2002).

2.1.4. Effect of iron on growth and flowering of ornamental plants

Iron plays an inevitable role in photosynthesis, as 80% of cellular iron is present in the chlorophyll of plants. Iron, being a redox active metal has been involved in the biosynthesis of chlorophyll, proteins, and plant hormones like ethylene, gibberellic acid and jasmonic acid (Ganesh and Kannan, 2013). It has been found to be involved in processes like scavenging of reactive oxygen species, photosynthesis, mitochondrial respiration, nitrogen assimilation and osmo protection (Hansch and Mendel, 2009).

Interveinal chlorosis on young leaf is the most visible symptom of iron deficiency in plants. Perur *et al.* (1961), reported that iron deficiency in the leaves of maize plants resulted in the decrease of 25% proteins and 82% chloroplasts.

According to Ganga *et al.* (2009), out of different micronutrient solutions, application of iron at 1000 ppm in the form of ferrous ammonium sulphate at fortnightly intervals was found superior in terms of vegetative parameters like plant height, number of leaves per plant, number of pseudo bulbs per plant and number of roots per plant as well as flowering parameters *viz.*, number of spikes per plant, number of florets per spike, spike length, flower pedicel length and vase life in orchid *Dendrobium* var. Sonia 17.

Among different micronutrient treatments, application of 1000 ppm $FeSO_4$ recorded significant effect on vegetative as well as floral characters of *Dendrobium* var. Sonia 17 (AICRP on Floriculture, 2009-2010). Tallest plants with maximum intermodal length was observed in *Dendrobium* var. Sonia 17 when treated with 500 ppm iron in the form of iron sulphate at fortnightly intervals (AICRP on Floriculture, 2009-2010).

Maximum plant spread in N-S direction was recorded in *Cymbidium elegance* on application with 1000 ppm iron in the form of iron sulphate (AICRP on Floriculture, 2007-2008).

Patidar (2011) had conducted a study to assess the effect of different micronutrients on pot mum cultivars of chrysanthemum, and observed that period of flowering was higher when it was sprayed with 0.8% ferrous sulphate. Other floral characters like flower stalk length, flower diameter, and average weight of flowers were also maximum on spraying with 0.8% ferrous sulphate.

Foliar application of iron in the form of iron sulphate @ 0.8% could result in earlier flowering, highest flower yield and longest duration of flowering in chrysanthemum (AICRP on Floriculture, 2009-2010). Maximum flower size in chrysanthemum could be attained with the application of 0.2% iron in the form of iron sulphate (AICRP on Floriculture, 2009-2010). Highest plant height was observed in gerbera when sprayed with 0.4% iron sulphate (AICRP on Floriculture, 2010-2011).

Kakade *et al.* (2009), reported that earlier flower emergence in China aster could be achieved by foliar application of $FeSO_4$ @ 0.4% after 30, 45, and 60 days of transplanting. A significant increase in plant height was observed in *Lilium* cv. Tresor when treated with 0.4% $FeSO_4$ after 30 and 45 days of planting (Singh *et al.*, 2015).

Foliar application of iron @ 0.4% in the form of $FeSO_4$ was found effective in *Gladiolus* var. American Beauty when applied 20 and 30 days after planting. Significant improvement in vegetative characters like plant height, leaf area and reproductive characters like least days for 50% flowering, early flowering, and number of spikes per plant (Chopde *et al.*, 2015) was observed.

Application of $FeSO_4$ 0.5% along with 0.5% $ZnS0_4$ in African marigold resulted in early flowering and maximum number of flowers with highest flower diameter. Chlorophyll content in the leaf was also high with application of the same in monsoon season, while in winter season highest chlorophyll content was observed with application of 0.5% $FeSO_4$ along with 0.5% $ZnSO_4$ (Balakrishnan *et al.*, 2007).

2.1.5. Effect of molybdenum on growth and flowering of ornamental plants

Molybdenum is required only in minute quantities by plants. It is present in the enzymes nitrate reductase, aldehyde oxidase, and sulphite oxidase which are involved in the processes such as nitrogen assimilation, abscisic acid synthesis, and sulphur metabolism respectively (Schwarz and Mendel, 2006).

Molybdenum deficiency symptoms in plants include pale green coloured leaves with marginal necrosis and upward cupping and stunted growth with dwarfed appearance (Hewitt and Bolle-Jones, 1952). Hecht-Buchhloz (1973) reported that under molybdenum toxicity, complexes of molybdocatechols are formed in the vacuoles of plant cell which led to leaf malformation and shoot discolouration.

Application of molybdenum in the form of molybdic acid at fortnightly interval had an effect on vegetative growth of orchid *Cymbidium elegans*. Maximum number of leaves was recorded with the application of 100 ppm

molybdic acid whereas maximum plant spread in E-W direction was recorded with the application of 200 ppm molybdic acid (AICRP on Floriculture, 2007-2008).

2.2. EFFECT OF BENZYL ADENINE ON GROWTH AND FLOWERING OF ORNAMENTAL PLANTS

Effect of BA depends on cultivar and concentration of solution sprayed. A study was conducted by Wu and Chang (2009) in *Phalaenopsis* orchid to find out the effect of BA. All the treatments were carried out on one year old plants after they were moved in to green house where temperature was regulated as 26^0 C in day and 18^0 C in night. Number of flowering spikes in *Phalaenopsis* Luchia Pink '244' increased by foliar spraying of 70 ppm BA, applied on 1st and 14th day after cool treatment. The foliar application of 150 ppm BA on first day of cool treatment in another cultivar of *Phalaenopsis* named Tai Lin Redangel 'Queen' resulted in increased number of flowers per spike, while its effect was non-significant for characters like number of flowering spikes, diameter of flower, and length of flower. At the same time, application of 150 ppm BA increased the number of flowering spikes in *Phalaenopsis* Sogo Yukidian 'V3'.

Application of benzyl adenine can only partially regulate flowering in *Phalaenopsis* and *Doritaenopsis* orchids, because they require low temperature for flower initiation. So spraying with BA becomes effective only after lowering the temperature of green house. Blanchard and Runkle (2008) observed that application of 200 ppm or 400 ppm BA on *Phalaenopsis* and *Doritaenopsis* orchids three times at weekly intervals after lowering the temperature to 23^0 C induced early flowering and also increased the number of inflorescence as well as number of flowers per inflorescence.

Production of vegetative shoots in two hybrids of *Miltoniopsis* orchids named 'Eileen' and 'Akatsuka' improved with the application of 25 mM and 50 mM benzyladenine. But these plants failed to produce inflorescence on treatment with BA, which indicated that application of BA on *Miltoniopsis* orchids have an inhibitory effect on flowering (Matsumoto, 2006).

Application of BA at 200 ppm or 400 ppm at monthly intervals promoted induction of vegetative shoots and no inflorescence in *Zygopetalum* Redvale 'Fire Kiss'. It may be beacause the assimilates that were required for reproductive growth might have been utilized for vegetative growth (Blanchard and Runkle, 2010).

Goh and Yang (1978) conducted a study in *Dendrobium* 'Lady Hochoy' to assess the effect of growth regulators on flowering. They found that after eight days of injection of BA $10^{-3}M$ in the internodal region of mature pseudobulbs, new flower buds were produced. New vegetative shoots were induced in young *Miltoniopsis* orchids when they were treated with BA @ 4000 ppm five times in two weeks (Newton and Runkle, 2015).

Shilpa (2017) found that application of 100 ppm BA coupled with NPK and *Azospirillum* could result in greatest plant height and plant spread in *Dendrobium* orchids. However for other characters like spike length, stalk length, number of flowers per spike, intermodal length, flower size, longevity of spike, fresh weight of flower, and vase life of flower, application of 150 ppm BA along with NPK and AMF was found to be effective.

2.3. EFFECT OF NPK ON GROWTH AND FLOWERING OF ORNAMENTALS

Wang and Gregg (1994) reported that some characters like number of flowers, diameter of the flower stalk, length of flower stalk, and number of leaves increased in *Phalaenopsis* orchid when the concentration of NPK mixture (20:8.6:16.6) was increased from 250 ppm to 1000 ppm.

The application of NPK had significant effect on plant height. From a study conducted on *Dendrobium* Nobile, height of pseudobulb was maximum when N was applied at 100 and 200 ppm. All doses of phosphorus resulted in an increase of plant height with more number of nodes. Gradual increase in plant height was observed when concentration of potassium was increased from 0 to 100 ppm, but no further increase in height was observed at doses higher than 100 ppm (Bichsel, 2006).

Swapna (2000) reported that greatest plant height in *Dendrobium* var. 'Sonia 17' was observed when NPK mixture 30: 10: 10 was applied @ 0.2 % twice a week along with GA_3 20 ppm. She also reported that application of NPK 30:10:10 @ 0.2 % twice a week along with BA 200 ppm was effective with respect to the characters number of shoots, leaf production, total leaf area, number of roots, biomass production (dry weight), and early flowering, while for floral characters like number of spikes per year and number of florets per spike, a combination of NPK 10:20:10 at 0.2 per cent + BA 100 ppm applied weekly twice was most effective.

Foliar application of NPK mixture 20:10:10 @ 0.2% in an interval of seven days had significant effect on growth and flowering characters of *Dendrobium* orchid cv. Sonia 17 (Patnaik *et al.*, 2013). Requirement of nutrients varies among different genera of orchids. According to Poole and Seeley (1978) *Phalaenopsis* and *Cymbidium* orchids grow best with the application of 100 ppm N, 50-100 ppm K, and 25 ppm Mg, while the requirement of N, K and Mg for *Cattleya* orchid was 50 ppm each.

Kabir *et al.* (2012), conducted a study to find out the effect of NPK sprays on growth and development of *Dendrobium* orchid. He reported that foliar application of NPK mixture 10:25:30 at weekly intervals was best for improving vegetative characters *viz.*, number of leaves, length and width of leaves, and leaf area index, while characters like stem diameter and plant height were improved when the concentration of nitrogen was increased and that of potassium and phosphorus was decreased.

Rodrigues *et al.* (2010), evaluated the effect of organic and mineral fertilizers on growth of an orchid (*Laelia purpurata* 'Werkhanserii' x *L. lobata* 'Jeni'). Commercial organic manures as well as mineral nutrients were applied to the orchids. Commercial organic manures including castor meal, bone meal and wood ash in the proportion of 2:1:1 were applied once in two months to the base of plant. Mineral fertilizers used were calcium nitrate and a formulation termed 'Peters' (NPK 20-20-20+ micronutrients) which applied @ 1g/L by spraying. Treatments were given to 18 month old plants and it was observed that shoot dry

matter was higher in the combined application of organic manure and 'Peters' whereas root dry matter was higher when calcium nitrate was applied along with organic manure. They concluded that plant response to the utilization of mineral fertilizer along with organic manure was superior to the individual use of the manures.

Number of flowers in *Vanda* Miss Joaquim increased with the combined application of P @ 200 kg/ha/year and K @ 275 kg/ha/year in combination with N either @ 150 kg/ha/year or @ 300 kg/ha/year. It was also observed that diameter of stem was higher with lower dose of N @ 150 kg/ha/year and higher dose K @ 275 kg/ha/year, while higher plant height was obtained when N @ 300 kg/ha/year was applied (Higaki and Imamura, 1987).

The effect of different NPK formulations on growth of two cultivars of *Mokara* orchid were studied by Ali *et al.*, (2014). The spray formulations used were NPK 2:1:1, 3:2:1 and 4:3:2. Among these three formulations, certain characters like plant height, leaf area index, leaf width, and diameter of root were higher at 4:3:2 application. However number of roots, number of leaves, length of leaves and length of roots were higher on application of 3:2:1 formulation and highest stem diameter was obtained by applying 2:1:1 spray formulation.

Application of very high phosphorus and potassium with low quantity of nitrogen can reduce the number of flowers in *Phalaenopsis* orchids. It was found that number of flowers in *Phalaenopsis* TAM Butterfly Blume was decreased when N, P, and K were applied at 30, 398, and 506 ppm respectively (Wang, 2000).

Ochsenbauer (1997) evaluated the performance of *Phalaenopsis* pot orchids *viz.*, 'Nopsya', 'Abylos', and 'Sylba' under different NPK levels. NPK was applied @ 150, 275, 400, 525, and 600 mg/plant by using a water soluble fertilizer 16:4:18 (NPK). He reported that number of flowers and buds per plant, and branching of inflorescence was increased at higher concentrations of NPK.

Materials and methods

3. MATERIALS AND METHODS

The present study entitled 'Response of *Ascocenda* orchid to growth regulator and micronutrients' was carried out in the Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara, Thrissur from May 2018 to May 2019. The materials used and methodology adopted for the study are described in this chapter.

3.1. LOCATION

Vellanikkara is situated 22.25 m above MSL at a latitude of $10^0$31'N and longitude of $76^0$13'E.

3.2. CLIMATE

The region enjoys a warm humid tropical climate with maximum temperature varying from 29.2^{0}C to 36.7^0 C and minimum temperature varying from 20.4^{0}C to 25.5^{0}C during the period of observation. The mean relative humidity was in the range of 55 per cent to 89 per cent. The total rainfall recorded during the period of investigation was 3548.6 mm. Weather data during the period of study are given in the Appendix 1.

3.3. MATERIALS

3.3.1. Planting material

Three month old hardened tissue culture plants of *Ascocenda* variety 'Big Suksamran' were used for the study (Plate 1).

3.3.2. Container and potting media

Plastic pots of 8.0 cm height, 6.5 cm bottom diameter and 9.5 cm top diameter were used for growing the plants. Pots were filled with media consisting of charcoal pieces and coconut husk pieces.

3.3.3. Growing structure

The experiment was conducted in top ventilated poly house of the Department of Floriculture and Landscaping, with 25% shade, which is the usual practice for getting best performance of monopodials in the location (Plate 2).

3.4. TREATMENTS

Design of experiment : CRD
No. of treatments : 11
No. of replications : 3
No. of plants per replication : 5

T_1 – PoP + BA 150ppm + Zn @ 0.01%
T_2 – PoP + BA 150ppm + Zn @ 0.025%
T_3 – PoP + BA 150ppm + Mn @ 0.01%
T_4 – PoP + BA 150ppm + Mn @ 0.025%
T_5 – PoP + BA 150ppm + B @ 0.01%
T_6 – PoP + BA 150ppm + B @ 0.025%
T_7 – PoP + BA 150ppm + Fe @ 0.01%
T_8 – PoP + BA 150ppm + Fe @ 0.025%
T_9 – PoP + BA 150ppm + Mo @ 0.01%
T_{10} – PoP + BA 150ppm + Mo @ 0.025%
T_{11} - Control- PoP + BA 150ppm

Foliar application of NPK (3:1:1) weekly twice @ 0.2% and cow dung slurry (1:5) at monthly intervals was given to all treatments (KAU, 2016).

Foliar application of micronutrients and benzyl adenine was done at fortnightly and monthly intervals respectively, upto 12 months after planting.

Plate 1. Three month old TC plants of *Ascocenda* var. Big Suksamran

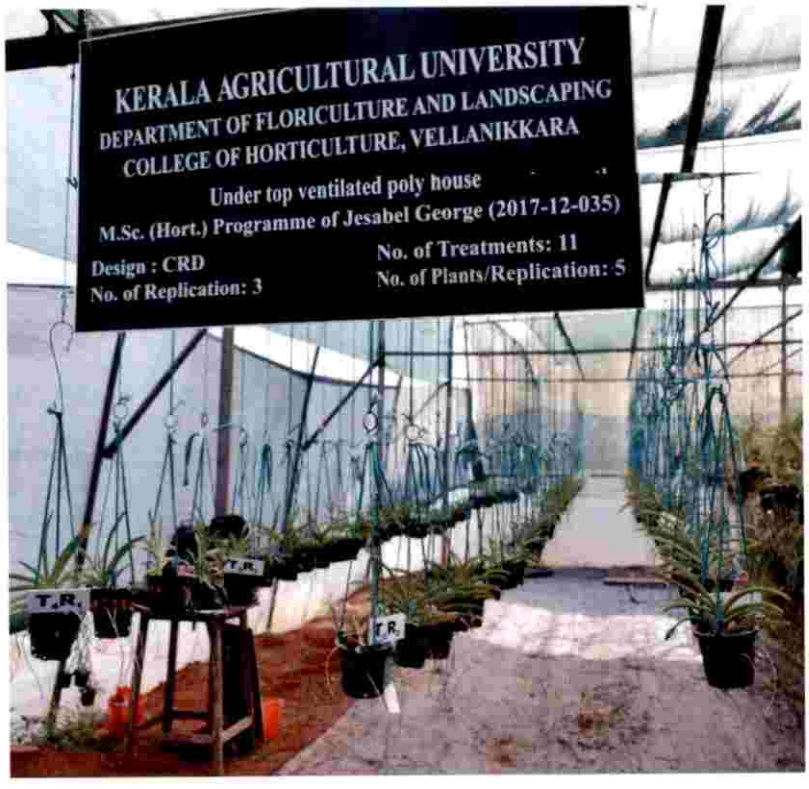


Plate 2. General view of the experimental field

The sources of micronutrients used are given in Table 1.

Table.1. Micronutrients and their sources

Sl. No.	Micronutrient	Source
1	Zinc	Zinc sulphate
2	Manganese	Manganese sulphate
3	Boron	Boric acid
4	Iron	Ferrous ammonium sulphate
5	Molybdenum	Molybdic acid

3.5. OBSERVATIONS

Observations were recorded at monthly intervals.

3.5.1. Vegetative characters

3.5.1.1. Plant height

Height of the plant was taken from base of the plant to growing tip and expressed in centimetres.

3.5.1.2. Shoot diameter

Diameter of the shoot was recorded using Vernier caliper and expressed in millimetres.

3.5.1.3. Number of leaves per plant

Total number of leaves per plant was counted and recorded.

3.5.1.4. Leaf length

Length from base to tip of the leaf was measured and expressed in centimetres.

3.5.1.5. Leaf breadth

Breadth of the expanded leaf was measured at the middle point and expressed in centimetres.

3.5.1.6. Leaf area

Leaf area was calculated using the formula 0.9145 x length x breadth where, 0.9145 is a constant. The constant was derived using Levenberg-Marquardt non-linear regression estimation method.

3.5.1.7. Interval of leaf production

Number of days taken for the production of each leaf after planting was recorded.

3.5.1.8. Number of aerial roots per plant

Number of aerial roots produced from the main shoot was counted and recorded.

3.5.1.9. Length of longest aerial root

Length of the longest and healthiest aerial root was measured and expressed in centimetres.

3.5.1.10. Diameter of the thickest aerial root

Diameter of the thickest root was measured using Vernier caliper and expressed in millimetres.

3.5.2. Floral characters and post harvest studies

During the period of study, flowering was not observed in any of the treatments. Hence the data regarding floral characters could not be recorded. Also, post harvest studies could not be carried out.

3.6. Statistical analysis

The software WASP (Web Agri Stat Package) was used for statistical analysis of the data recorded.

Results

4. RESULTS

An experiment entitled 'Response of *Ascocenda* orchid to growth regulator and micronutrients' was carried out in the top ventilated polyhouse of Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara, Thrissur, to find out the effect of different micronutrients on growth characters of *Ascocenda* orchid var. Big Suksamran. Observations on plant and root parameters were recorded, analysed and are presented below.

4.1. VEGETATIVE CHARACTERS

Data pertaining to the effect of treatments on vegetative characters of *Ascocenda* var. Big Suksamran are presented in Tables 2 to 11.

4.1.1. Plant height

The plant height data recorded monthly with respect to different micronutrient treatments are presented in Table 2. From the table it is evident that the effect of different micronutrient treatments on plant height was non-significant for the first two months after planting. Three months after planting, maximum plant height of 4.25 cm was observed in treatments T_5 (0.01% B + PoP + 150 ppm BA) followed by T_3 (Mn 0.01% + PoP + 150 ppm BA) with a height of 4.19 cm, which were statistically on par with each other. At four months after planting greatest plant height of 5.08 cm was recorded in T_3 (Mn 0.01% + PoP + 150 ppm BA) followed by T_4 (Mn 0.025%+ POP + 150 ppm BA), and T_5 (0.01% B + PoP + 150 ppm BA) and they were statistically on par with one another. Same trend was followed till 5MAP.

Highest plant height of 7.48 cm was observed in T_4 at 6MAP followed by T_3 with a height of 7.38 cm and they were statistically on par with each other. This was followed by T_5 with a plant height of 7.06 cm. The same trend was observed till 12 MAP. Throughout the period of observation, least plant height was observed in T_{10} (Mo 250 ppm +PoP+ 150 ppm BA) and it was 4.72 cm at 12 MAP (Plate 3). Highest plant height of 8.86 cm, 8.81cm, and 8.63 cm were recorded at 12 months

Table 2. Effect of micronutrients on plant height (cm) in different months in *Ascocenda* orchid var. Big Suksamran

Treatments	May(at planting)	June (1MAP)	July (2MAP)	Aug (3MAP)	Sep (4MAP)	Oct (5MAP)	Nov (6MAP)	Dec (7MAP)	Jan (8MAP)	Feb (9MAP)	Mar (10MAP)	April (11MAP)	May (12MAP)
T_1	2.62	3.14	3.38	4.06	4.45	5.93	6.16	6.63	6.72	6.86	7.09	7.28	7.33
T_2	2.72	3.22	3.30	3.85	4.21	5.63	6.00	6.43	6.55	6.72	6.89	7.08	7.15
T_3	2.73	3.18	3.58	4.19	5.08	7.04	7.38	7.64	8.05	8.20	8.35	8.54	8.63
T_4	2.83	3.07	3.34	3.95	4.99	7.04	7.48	7.73	8.13	8.47	8.68	8.77	8.86
T_5	2.65	3.03	3.62	4.25	4.64	6.80	7.06	7.34	7.82	8.25	8.43	8.77	8.81
T_6	2.63	2.96	3.32	3.98	4.40	5.62	6.03	6.20	6.38	6.53	6.78	6.97	7.06
T_7	2.68	2.94	3.06	3.75	4.28	5.83	6.25	6.45	6.80	7.15	7.31	7.41	7.48
T_8	2.63	2.93	3.05	3.64	3.98	5.11	5.43	5.83	6.01	6.38	6.59	6.70	6.73
T_9	2.83	3.18	3.30	3.68	4.21	5.32	5.58	5.92	6.25	6.34	6.59	6.70	6.76
T_{10}	2.50	2.93	3.19	3.73	3.68	4.18	4.24	4.41	4.48	4.52	4.68	4.72	4.72
T_{11}	2.65	3.04	3.54	4.04	4.60	6.31	6.49	6.76	7.39	7.49	7.69	7.81	7.82
CD(0.05)	**NS**	**NS**	**NS**	**0.30**	**0.46**	**0.50**	**0.58**	**0.49**	**0.44**	**0.45**	**0.50**	**0.50**	**0.51**
CV	**6.77**	**7.70**	**8.69**	**4.57**	**6.11**	**5.04**	**5.50**	**4.42**	**3.80**	**3.83**	**4.09**	**4.05**	**4.11**

T_1 -PoP + BA 150ppm + Zn @ 0.01%
T_2 - PoP + BA 150ppm + Zn @ 0.025%
T_3 - PoP + BA 150ppm + Mn @ 0.01%
T_4 - PoP + BA 150ppm + Mn @ 0.025%
T_5 - PoP + BA 150ppm + B @ 0.01%
T_6- PoP + BA 150ppm + B @ 0.025%
T_7- PoP + BA 150ppm + Fe @ 0.01%
T_8- PoP + BA 150ppm + Fe @ 0.025%
T_9- PoP + BA 150ppm + Mo @ 0.01%
T_{10} -PoP + BA 150ppm + Mo @ 0.025%
T_{11}- Control - POP + BA 150ppm

after planting in treatments T_4, T_5 and T_3 respectively, which were statistically on par. From this period of observation, it could be inferred that foliar application of 0.01% Mn or 0.025% Mn, or 0.01% B along with 150 ppm BA and recommended dose of NPK are equally good for increasing plant height.

4.1.2. Shoot diameter

The data pertaining to shoot diameter at different months are presented in Table 3. There was significant difference among treatments throughout the period of observation. At 2 MAP highest shoot diameter of 7.12 mm was recorded in T_5 (B 0.01% + PoP + 150 ppm BA) followed by T_1 (Zn 0.01% + PoP + 150 ppm BA), T_3 (Mn 0.01% + PoP + 150 ppm BA) and T_2 (Zn 0.025% + PoP + 150 ppm BA) which were statistically on par with one another. Least shoot diameter was observed in T_{10} with a value of 6.22 mm. Three months after planting, T_5 (B 100 ppm+ PoP+ 150ppm BA) had the highest value for shoot diameter (7.61 mm) followed by T_1, T_3, and T_4 (7.42 mm, 7.34 mm, 7.30 mm respectively) which were statistically on par with one another. The same trend was followed till 6 MAP.

A declining trend in the shoot diameter was noticed in plants of T_{10} (Mo 0.025% + PoP + 150 ppm BA) up to 12 MAP. Seven months after planting, highest shoot diameters of 9.00 mm and 8.86 mm were observed in T_5 and T_4 respectively followed by T_3 with a value of 8.63 mm. The same trend was noticed till 12 MAP. Maximum shoot diameter of 10.20 mm was recorded in T_5 at 12 MAP followed by T_4 and T_3 (9.96 mm and 9.84 mm respectively) which were statistically on par with one another. So in general it could be concluded that treatments T_5, T_4 and T_3 were superior in terms of shoot diameter.

4.1.3. Number of leaves

Data on the number of leaves recorded at monthly intervals in different treatments are depicted in Table 4. The influence of different micronutrient treatments on number of leaves per plant was non-significant for the first three months after planting. At 4 MAP significant difference among treatments was observed with highest number of leaves per plant in T_5 and T_4 (14.28 and 14.22

Table 3. Effect of micronutrients on shoot diameter (mm) in different months in *Ascocenda* orchid var. Big Suksamran

Treatments	May(at planting	June (1MAP)	July (2MAP)	Aug (3MAP)	Sep (4MAP)	Oct (5MAP)	Nov (6MAP)	Dec (7MAP)	Jan (8MAP)	Feb (9MAP)	Mar (10MAP)	April (11MAP)	May (12MAP)
T_1	6.21	6.57	6.97	7.42	7.84	8.05	8.15	8.29	8.53	8.71	8.82	9.12	9.37
T_2	6.03	6.31	6.92	7.21	7.56	7.86	8.00	8.09	8.24	8.53	8.74	8.96	9.01
T_3	6.00	6.41	6.95	7.34	7.73	8.04	8.45	8.65	8.72	8.92	9.36	9.62	9.84
T_4	6.05	6.33	6.77	7.30	7.62	8.05	8.48	8.86	9.02	9.34	9.48	9.70	9.96
T_5	6.09	6.67	7.12	7.61	8.10	8.42	8.72	9.00	9.20	9.42	9.64	10.01	10.20
T_6	5.92	6.43	6.67	6.88	7.17	7.46	7.78	8.04	8.34	8.65	9.13	9.21	9.25
T_7	5.96	6.25	6.55	6.90	7.21	7.49	7.79	8.04	8.21	8.31	8.55	8.75	8.92
T_8	5.96	6.17	6.41	6.68	6.87	7.14	7.33	7.53	7.74	7.93	8.23	8.39	8.51
T_9	6.02	6.18	6.31	6.50	6.65	6.70	6.91	7.28	7.51	7.82	7.91	8.01	8.21
T_{10}	5.91	5.98	6.22	6.36	6.32	6.26	6.17	6.13	6.08	6.00	5.96	5.82	5.78
T_{11}	6.19	6.37	6.66	6.86	7.14	7.55	7.92	8.17	8.37	8.59	8.71	8.92	9.11
CD(0.05)	**NS**	**0.33**	**0.36**	**0.39**	**0.36**	**0.37**	**0.34**	**0.31**	**0.35**	**0.39**	**0.44**	**0.50**	**0.43**
CV	**3.02**	**3.08**	**3.15**	**3.27**	**2.91**	**2.93**	**2.55**	**2.27**	**2.53**	**2.75**	**3.05**	**3.35**	**2.86**

T_1 -PoP + BA 150ppm + Zn @ 0.01%
T_2 - PoP + BA 150ppm + Zn @ 0.025%
T_3 - PoP + BA 150ppm + Mn @ 0.01%
T_4 - PoP + BA 150ppm + Mn @ 0.025%
T_5 - PoP + BA 150ppm + B @ 0.01%
T_6 - PoP + BA 150ppm + B @ 0.025%
T_7 - PoP + BA 150ppm + Fe @ 0.01%
T_8 - PoP + BA 150ppm + Fe @ 0.025%
T_9 - PoP + BA 150ppm + Mo @ 0.01%
T_{10} -PoP + BA 150ppm + Mo @ 0.025%
T_{11} - Control - POP + BA 150ppm

Table 4. Effect of micronutrients on number of leaves in different months in *Ascocenda* orchid var. Big Suksamran

Treatments	May(at planting)	June (1MAP)	July (2MAP)	Aug (3MAP)	Sep (4MAP)	Oct (5MAP)	Nov (6MAP)	Dec (7MAP)	Jan (8MAP)	Feb (9MAP)	Mar (10MAP)	April (11MAP)	May (12MAP)
T_1	11.08	13.42	13.17	13.50	12.67	14.33	14.00	14.17	12.05	11.92	12.08	12.25	12.69
T_2	11.67	12.83	14.00	13.58	13.75	14.83	13.94	14.25	11.83	12.03	12.39	12.94	13.25
T_3	12.33	14.00	14.17	13.25	12.92	14.08	14.42	13.25	12.22	12.25	12.14	12.92	13.50
T_4	10.92	12.92	12.89	13.64	14.22	15.55	14.30	14.50	12.36	11.97	12.00	12.67	12.28
T_5	11.50	14.25	14.42	14.05	14.28	15.58	15.11	16.50	12.77	12.25	12.80	13.14	13.69
T_6	10.92	13.00	13.00	12.94	13.58	14.28	14.44	14.05	11.17	11.17	11.14	11.67	11.00
T_7	11.25	13.50	13.83	13.92	13.75	15.00	14.83	13.50	12.69	12.28	12.00	12.92	13.00
T_8	11.50	13.58	12.17	12.61	12.55	13.94	13.72	13.50	11.33	10.80	11.08	12.16	12.25
T_9	11.50	13.33	12.83	12.17	12.08	12.42	12.83	12.83	10.78	10.28	9.83	10.50	11.17
T_{10}	10.50	13.17	11.44	11.77	11.66	11.88	12.44	11.78	7.11	7.33	8.11	8.67	8.11
T_{11}	11.00	12.17	12.89	13.39	13.67	14.17	13.42	13.19	11.17	10.83	11.50	12.58	12.58
CD(0.05)	**NS**	**NS**	**NS**	**NS**	**1.62**	**1.71**	**NS**	**1.68**	**1.77**	**1.58**	**1.64**	**1.90**	**1.80**
CV	**8.25**	**5.74**	**7.94**	**6.57**	**7.24**	**7.12**	**8.58**	**7.19**	**9.17**	**8.35**	**8.49**	**9.34**	**8.73**

T_1 . PoP + BA 150ppm + Zn @ 0.01%
T_2 . PoP + BA 150ppm + Zn @ 0.025%
T_3 . PoP + BA 150ppm + Mn @ 0.01%
T_4 - PoP + BA 150ppm + Mn @ 0.025%
T_5 - PoP + BA 150ppm + B @ 0.01%
T_6 - PoP + BA 150ppm + B @ 0.025%

T_7 - PoP + BA 150ppm + Fe @ 0.01%
T_8 - PoP + BA 150ppm + Fe @ 0.025%
T_9 - PoP + BA 150ppm + Mo @ 0.01%
T_{10} -PoP + BA 150ppm + Mo @ 0.025%
T_{11} - Control - PoP + BA 150ppm

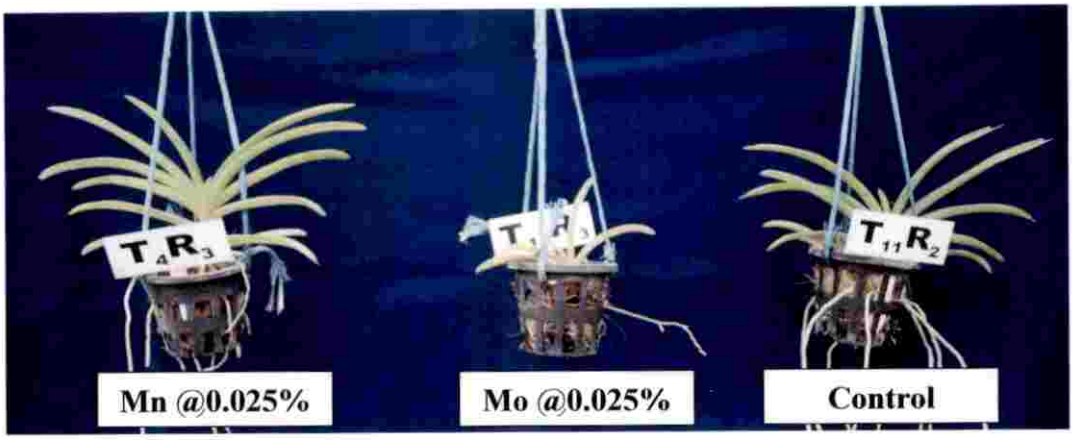


Plate 3. Treatment effect on plant height

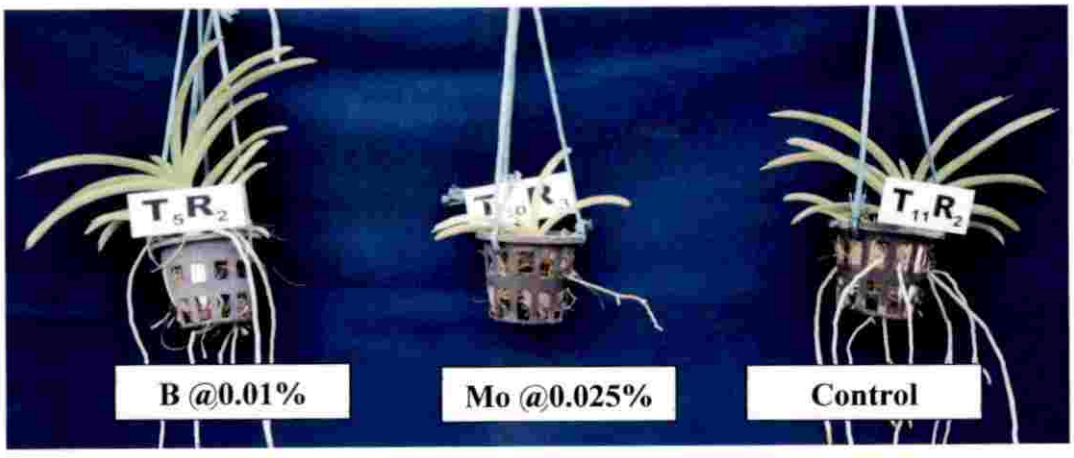


Plate 4. Treatment effect on number of leaves

respectively) followed by T_2 (13.75) and T_7 (13.75) which were statistically on par. The lowest number of leaves per plant with a reading of 11.66 was observed in T_{10} (Mo 0.025% + PoP + 150 ppm BA). Five months after planting, greater number of leaves of 15.58 was recorded in T_5 followed by treatments T_4, T_7, T_2, T_1, T_6 and T_{11} (15.55, 15.00, 14.83, 14.33, 14.28, and 14.17 respectively) which were performing on par with one another. At 6th month of planting the data recorded on number of leaves were found non-significant. However significant differences could be noticed from 7th to 12th months. The greatest number of leaves per plant of 16.5 was recorded in T_5 followed by T_4, T_2, T_1, T_6, T_7, and T_8 in 7th month of planting. After 8 months of planting highest number of leaves per plant was observed in T_5 (12.77) followed by T_7 (12.69). At 9 MAP treatments T_7, T_5, T_3, T_2, T_4, and T_1 were found on par with one another with highest number of leaves of 12.28, 12.25, 12.25, 12.03, 11.97, and 11.91 respectively. The lowest number of leaves per plant (7.33) was observed in T_{10}.

After 10 months of planting highest number of leaves (12.80) was found in T_5 followed by T_2, T_3, T_1, T_7, T_4 and T_{11} which were statistically on par with one another. At 11 MAP maximum number of leaves was observed in T_5 (13.14), followed by T_2, T_7, T_5, T_4, and T_{11} which were statistically on par and the lowest number was noticed in T_{10} (8.67). After 12 months of planting, higher number of leaves was observed in treatments T_5 (13.69), T_3 (13.5), T_2 (13.25), and T_7 (13.00) which were on par with one another and the lowest number of leaves per plant (8.11) was recorded in T_{10}. From these results obtained, it could be inferred that regarding number of leaves per plant the best treatment was T_5 and T_{10} (Mo 0.025% + PoP + 150 ppm BA) remained the lowest, throughout the period of study (Plate 4).

4.1.4. Leaf length

The data pertaining to leaf length in different treatments are presented in Table 5. Regarding the parameter leaf length, there was no significant difference among treatments for the first two months of planting. Three months after planting highest leaf length was observed in T_3 (11.51 cm) followed by T_1 (11.12 cm), and

Table 5. Effect of micronutrients on leaf length (cm) in different months in *Ascocenda* orchid var. Big Suksamran

Treatments	May (at planting)	June (1MAP)	July (2MAP)	Aug (3MAP)	Sep (4MAP)	Oct (5MAP)	Nov (6MAP)	Dec (7MAP)	Jan (8MAP)	Feb (9MAP)	Mar (10MAP)	April (11MAP)	May (12MAP)
T_1	9.70	10.13	10.38	11.12	11.41	12.00	12.53	13.17	13.60	13.77	13.85	14.08	14.73
T_2	9.45	9.87	10.30	10.72	11.34	11.52	12.04	12.87	13.36	13.74	14.02	14.32	14.53
T_3	10.29	10.50	10.84	11.51	11.78	12.53	13.47	14.06	14.96	15.43	15.66	16.03	16.48
T_4	9.76	10.08	10.29	10.75	11.02	11.76	13.04	13.89	14.19	14.48	14.65	14.91	15.13
T_5	9.88	10.11	10.56	10.98	11.21	11.70	12.60	13.60	14.98	15.84	16.26	16.45	16.70
T_6	9.54	9.79	10.02	10.24	10.47	10.68	11.22	11.93	12.40	13.04	13.72	13.81	14.40
T_7	9.51	9.83	9.92	10.28	10.71	11.14	12.82	13.53	14.01	14.32	14.46	14.64	14.78
T_8	9.93	10.03	10.19	10.49	10.61	10.67	11.25	12.08	12.17	12.83	13.16	13.28	13.83
T_9	9.94	10.09	10.24	10.48	10.85	11.22	11.82	12.25	12.48	12.69	13.00	13.12	13.30
T_{10}	9.43	9.56	9.89	10.13	10.44	10.79	11.11	11.20	11.26	11.52	11.54	11.82	11.59
T_{11}	9.43	9.73	10.06	10.45	10.71	10.91	12.13	13.23	13.74	13.99	14.29	14.73	14.95
CD(0.05)	**NS**	**NS**	**NS**	**0.71**	**NS**	**NS**	**1.26**	**1.39**	**1.19**	**1.06**	**1.07**	**0.92**	**1.12**
CV	**3.70**	**3.45**	**3.40**	**3.94**	**5.74**	**6.75**	**6.11**	**6.37**	**5.24**	**4.54**	**4.47**	**3.80**	**4.54**

T_1 -PoP + BA 150ppm + Zn @ 0.01%
T_2 - PoP + BA 150ppm + Zn @ 0.025%
T_3 - PoP + BA 150ppm + Mn @ 0.01%
T_4 - PoP + BA 150ppm + Mn @ 0.025%
T_5 - PoP + BA 150ppm + B @ 0.01%
T_6- PoP + BA 150ppm + B @ 0.025%

T_7 - PoP + BA 150ppm + Fe @ 0.01%
T_8 - PoP + BA 150ppm + Fe @ 0.025%
T_9 - PoP + BA 150ppm + Mo @ 0.01%
T_{10} - PoP + BA 150ppm + Mo @ 0.025%
T_{11}- Control - PoP + BA 150ppm

the lowest leaf length of 10.13cm was noticed in T_{10}. At 4th and 5th month of planting no significant difference among treatments was observed. A maximum leaf length of 13.47 cm was recorded in T_3 (Mn 0.01% + PoP + 150 ppm BA) at 6 MAP, followed by T_4, T_7, T_5 and T_1 which were statistically on par with one another. T_3 recorded maximum leaf length of 14.06 cm at 7 MAP which was on par with T_4 (13.89 cm). It was closely followed by T_5 (13.60 cm) and T_7 (13.53cm) which were statistically on par with each other.

After 8 months of planting, T_5 had recorded maximum leaf length (14.98 cm) followed by T_3 (14.96 cm), T_4 (14.19 cm) and T_7 (14.01 cm). At 9 MAP a highest leaf length of 15.84 cm was observed in T_5 followed by T_3 and T_4 with values of 15.43 cm and 14.48 cm respectively. The same trend was followed till 12 MAP. The maximum leaf length recorded after 12 months of planting was 16.70 cm in treatment T_5 which was on par with T_3 (16.48 cm). The lowest leaf length was observed in treatment T_{10} throughout the period of observation. So it could be inferred that leaf length was maximum when plants were treated with T_5 (B 0.01% + PoP + 150 ppm BA) or T_3 (Mn 0.01% + PoP + 150 ppm BA), while it was minimum when treated with T_{10} (Mo 0.025% + PoP + 150 ppm BA).

4.1.5. Leaf breadth

The data recorded on leaf breadth with respect to different micronutrient treatments are presented in Table 6. From the table it was evident that the effect of different micronutrient treatments on leaf breadth was found non-significant for the first two months of planting. However, significant difference among treatments were observed from 3 MAP to 12 MAP with regard to leaf breadth. After three months of planting maximum leaf breadth of 1.28 cm was observed in T_5 followed by T_6 (1.26 cm), T_{11} (1.26 cm), and T_4 (1.26 cm) which were statistically on par with one another. The lowest leaf breadth was observed in T_{10} (1.19 cm). At 4 MAP, maximum leaf breadth of 1.3 cm was recorded for treatments T_5 and T_3. This was followed by T_4, T_{11}, T_6, T_1 and T_8 (1.28 cm, 1.28 cm, 1.26 cm, 1.26 cm and 1.26 cm respectively) which were statistically on par with one another.

Table 6. Effect of micronutrients on leaf breadth (cm) in different months in *Ascocenda* orchid var. Big Suksamran

Treatments	May(at planting)	June (1MAP)	July (2MAP)	Aug (3MAP)	Sep (4MAP)	Oct (5MAP)	Nov (6MAP)	Dec (7MAP)	Jan (8MAP)	Feb (9MAP)	Mar (10MAP)	April (11MAP)	May (12MAP)
T_1	1.16	1.17	1.20	1.23	1.26	1.28	1.30	1.31	1.33	1.38	1.38	1.38	1.41
T_2	1.20	1.21	1.21	1.22	1.25	1.28	1.29	1.30	1.31	1.33	1.34	1.38	1.42
T_3	1.19	1.22	1.24	1.26	1.30	1.32	1.37	1.38	1.39	1.44	1.47	1.50	1.51
T_4	1.19	1.20	1.20	1.26	1.28	1.31	1.37	1.38	1.40	1.46	1.48	1.48	1.51
T_5	1.20	1.21	1.23	1.28	1.30	1.35	1.38	1.38	1.43	1.44	1.48	1.48	1.52
T_6	1.24	1.24	1.25	1.26	1.26	1.28	1.31	1.33	1.35	1.36	1.36	1.37	1.38
T_7	1.12	1.19	1.19	1.23	1.26	1.27	1.31	1.32	1.33	1.34	1.36	1.38	1.40
T_8	1.18	1.20	1.22	1.24	1.26	1.29	1.30	1.31	1.32	1.34	1.34	1.34	1.36
T_9	1.20	1.20	1.22	1.22	1.22	1.23	1.26	1.27	1.29	1.33	1.34	1.35	1.36
T_{10}	1.17	1.17	1.18	1.19	1.20	1.20	1.24	1.26	1.28	1.30	1.30	1.31	1.31
T_{11}	1.17	1.18	1.22	1.26	1.28	1.29	1.31	1.31	1.33	1.39	1.42	1.43	1.44
CD(0.05)	**NS**	**NS**	**NS**	**0.04**	**0.04**	**0.04**	**0.04**	**0.03**	**0.04**	**0.06**	**0.06**	**0.06**	**0.06**
CV	**4.15**	**3.04**	**2.25**	**2.03**	**1.85**	**1.99**	**1.89**	**1.41**	**1.89**	**2.45**	**2.55**	**2.66**	**2.68**

T_1 -PoP + BA 150ppm + Zn @ 0.01%
T_2 - PoP + BA 150ppm + Zn @ 0.025%
T_3 - PoP + BA 150ppm + Mn @ 0.01%
T_4 - PoP + BA 150ppm + Mn @ 0.025%
T_5 - PoP + BA 150ppm + B @ 0.01%
T_6- PoP + BA 150ppm + B @ 0.025%
T_7 - PoP + BA 150ppm + Fe @ 0.01%
T_8 - PoP + BA 150ppm + Fe @ 0.025%
T_9 - PoP + BA 150ppm + Mo @ 0.01%
T_{10} - PoP + BA 150ppm + Mo @ 0.025%
T_{11}- Control - PoP + BA 150ppm

After 5 months of planting highest leaf breadth of 1.35 cm was observed in T_5 followed by T_3 (1.32 cm). At 6MAP, T_5, T_3 and T_4 had higher leaf breadth of 1.38 cm, 1.37 cm, and 1.37 cm respectively. The same trend was followed during 7th and 8th months of planting also.

A maximum leaf breadth of 1.46 cm was recorded in T_4 at 9 MAP. This was followed by T_3 (1.44 cm) and T_5 (1.44 cm) which were statistically on par. The same trend was noticed in the 10th month of planting. At 11 months after planting maximum leaf breadth of 1.5 cm was observed in T_3 followed by T_4 and T_5 with reading of 1.48 cm. During 12th month T_5 had the highest leaf breadth of 1.52cm which was closely followed by T_3 and T_4, each of which recorded the leaf breadth of 1.51cm and were on par with T_5. The lowest value for leaf breadth was recorded in the treatment T_{10} throughout the period of observation. So from this period of observation it could be concluded that treatments T_3, T_4 and T_5 were superior in terms of leaf breadth.

4.1.6. Leaf area

Leaf area as influenced by different micronutrient treatments are presented in Table 7. Leaf area was found non-significant for the first two months of planting. Three months after planting leaf area was found highest in T_3 (13.24 cm^2) followed by T_5 with a leaf area of 12.86 cm^2. The lowest leaf area of 11.00 cm^2 was recorded in treatment T_{10}. During fourth month of planting no significant difference among treatments was observed with regard to leaf area. A highest leaf area of 15.09 cm^2 was noticed in T_3 at 5 MAP. This was followed by treatments T_5, T_4, and T_1 with leaf area of 14.43 cm^2, 14.07 cm^2, and 14.00 cm^2 respectively. The lowest leaf area was recorded in T_{10} and it was 11.85cm^2.

After 6 months of planting, maximum leaf area was recorded in T_3 (16.83 cm^2) followed by T_4 (16.63 cm^2) and T_5 (15.87 cm^2). The same trend was noticed at 7 MAP. During 8th month of planting T_5 and T_3 were performing better and T_5 had the highest leaf area of 19.56 cm^2 which was on par with T_3 (19.04 cm^2). This was followed by T_4 with leaf area of 18.16 cm^2. The same trend was observed during

Table 7. Effect of micronutrients on leaf area (cm^2) in different months in *Ascocenda* orchid var. Big Suksamran

Treatments	May(at planting)	June (1MAP)	July (2MAP)	Aug (3MAP)	Sep (4MAP)	Oct (5MAP)	Nov (6MAP)	Dec (7MAP)	Jan (8MAP)	Feb (9MAP)	Mar (10MAP)	April (11MAP)	May (12MAP)
T_1	10.32	10.83	11.43	12.45	13.13	14.00	14.91	15.76	16.49	17.43	17.53	17.81	19.00
T_2	10.37	10.90	11.41	11.93	12.96	13.42	14.20	15.30	15.98	16.75	17.20	18.11	18.82
T_3	11.22	11.68	12.33	13.24	14.02	15.09	16.83	17.68	19.04	20.33	20.99	21.99	22.73
T_4	10.63	11.05	11.30	12.39	12.90	14.07	16.30	17.58	18.16	19.31	19.88	20.23	20.87
T_5	10.85	11.19	11.90	12.86	13.35	14.43	15.87	17.22	19.56	20.91	21.94	22.32	23.17
T_6	10.84	11.12	11.45	11.84	12.10	12.47	13.43	14.45	15.31	16.20	17.04	17.26	18.18
T_7	9.73	10.73	10.83	11.61	12.33	12.91	15.34	16.28	17.09	17.58	17.96	18.41	18.93
T_8	10.70	11.04	11.34	11.92	12.24	12.60	13.38	14.45	14.65	15.74	16.14	16.31	17.22
T_9	10.87	11.12	11.40	11.67	12.09	12.59	13.61	14.19	14.75	15.37	15.94	16.19	16.51
T_{10}	10.06	10.20	10.66	11.00	11.46	11.85	12.59	12.90	13.23	13.69	13.72	14.16	13.89
T_{11}	10.10	10.52	11.19	12.05	12.55	12.89	14.51	15.83	16.75	17.82	18.55	19.24	19.74
CD(0.05)	**NS**	**NS**	**NS**	**0.98**	**NS**	**1.82**	**1.82**	**1.87**	**1.82**	**1.74**	**1.80**	**1.66**	**2.014**
CV	**6.58**	**5.32**	**4.70**	**4.79**	**6.73**	**8.06**	**7.35**	**7.06**	**6.52**	**5.90**	**5.94**	**5.33**	**6.257**

T_1 - PoP + BA 150ppm + Zn @ 0.01%
T_2 - PoP + BA 150ppm + Zn @ 0.025%
T_3 - PoP + BA 150ppm + Mn @ 0.01%
T_4 - PoP + BA 150ppm + Mn @ 0.025%
T_5 - PoP + BA 150ppm + B @ 0.01%
T_6- PoP + BA 150ppm + B @ 0.025%

T_7 - PoP + BA 150ppm + Fe @ 0.01%
T_8 - PoP + BA 150ppm + Fe @ 0.025%
T_9 - PoP + BA 150ppm + Mo @ 0.01%
T_{10} - PoP + BA 150ppm + Mo @ 0.025%
T_{11}- Control - PoP + BA 150ppm

subsequent months also. In general, the treatments T_5, T_3 and T_4 were superior while T_{10} had the least value of leaf area throughout the period of observation.

4.1.7. Interval of leaf production

The data pertaining to interval of leaf production as influenced by different micronutrients are given in Table 8. Regarding the interval of leaf production the data recorded was not subjected to statistical analysis. At the time of planting there was 5 – 6 leaves in the plants. After planting, the treatment T_{11} took the least number of days (40.33 days) for the production of a new leaf, followed by T_4 (42.33 days) and T_6 (42.89 days). However, to produce a new leaf, T_{10} took 65.55 days. Only 73.33 days were needed for T_4 to produce the second leaf. It was followed by T_{11}, T_5 and T_1 (74.66 days, 77.27 days and 77.50 days respectively). The highest number of days was taken by T_{10} (124.66 days) for the production of second leaf. For the production of 3rd leaf only 98.36 days were needed for T_4 followed by T_{11} (100.10 days). The maximum of 221.49 days was taken by T_{10} for the production of 3rd leaf. The lowest number of days taken for the production of 4th leaf was T_4 (126.89 days) followed by T_{11} and T_5 (140.90 days and 147.66 days respectively). While T_9 took the highest number of days (280.15 days) to produce the 4th leaf. After emergence of 4th leaf T_4 took only 34.28 more days and T_{11} took only 42.83 more days to produce the 5th leaf, while T_{10} took a maximum of 105.85 more days to produce the same and no further leaves were produced by T_{10}. The lowest number of days taken for the production of 6th leaf was in T_4 (210.42 days), followed by T_{11} (244.56 days). It was observed that treatments T_2, T_6 and T_9 were also didn't produce any further leaves during the period of observation. The least number of days taken for the production of 7th leaf was 281.78 days (T_2) followed by T_3 with 310.61 days. Only the treatments T_3, T_4, T_5, and T_{11} were able to produce the 8th leaf. Among these T_4 took the shortest period of 337.45 days to produce the 8th leaf.

4.1.8. Number of roots

The data on number of roots as influenced by different micronutrients treatments are presented in Table 9. Number of roots was found significant throughout the period of observation.

Table 8. Effect of micronutrients on interval of leaf production (days) in different months in *Ascocenda* orchid var. Big Suksamran

Treatments	1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf	6th leaf	7th leaf	8th leaf
T_1	44.58	77.50	115.00	160.92	218.22	289.89	352.39	
T_2	56.33	90.08	126.66	177.66	260.05	325.16		
T_3	48.33	81.66	113.91	148.24	194.16	250.83	315.25	364.00
T_4	42.33	73.33	98.36	126.89	161.17	210.42	281.78	337.45
T_5	46.97	77.27	109.80	147.66	192.69	256.80	323.91	384.91
T_6	42.89	78.44	117.88	172.96	242.21	316.29		
T_7	45.00	79.08	114.50	153.25	202.44	269.47	341.72	
T_8	46.75	80.69	116.22	160.14	222.03	292.92	365.75	
T_9	52.83	93.58	136.00	210.58	275.79	352.29		
T_{10}	65.55	124.66	221.49	280.15	386.00			
T_{11}	40.33	74.66	100.10	140.90	183.73	244.56	310.61	380.61

T_1 - PoP + BA 150ppm + Zn @ 0.01%
T_2 -PoP + BA 150ppm + Zn @ 0.025%
T_3 - PoP + BA 150ppm + Mn @ 0.01%
T_4 - PoP + BA 150ppm + Mn @ 0.025%
T_5 - PoP + BA 150ppm + B @ 0.01%
T_6- PoP + BA 150ppm + B @ 0.025%
T_7 - PoP + BA 150ppm + Fe @ 0.01%
T_8 - PoP + BA 150ppm + Fe @ 0.025%
T_9 - PoP + BA 150ppm + Mo @ 0.01%
T_{10} -PoP + BA 150ppm + Mo @ 0.025%
T_{11} - Control - PoP + BA 150ppm

First month after planting a highest of 9.00 roots were observed in T_5 followed by T_2 (8.25), T_1 (8.17), T_3 (8.17), and T_{11} (8.17). Lowest value was observed in T_8 with 3.83 number of roots. During second month of planting highest number of roots was observed in T_3 with 9.25 roots followed by T_2 with 7.92 roots. The lowest number was recorded in T_8 with 3.83 roots. A maximum of 8.17 roots was observed in T_4 at 3 MAP. This was followed by T_5 with eight roots and lowest of 4.67 roots was observed in T_8. Four months after planting, treatments T_4 and T_3 had the highest number of roots (7.42), however T_4 and T_3 were statistically on par with T_2 with a number of roots of 7.00. A lowest of only 4.33 roots was observed in T_8. During 5th month of planting a highest of 8.67 roots was observed in T_3 followed by T_1, T_5, T_4, T_{11}, and T_2 (8.25, 8.17, 7.92, 7.83, and 7.83 respectively). The number of roots was minimum in treatments T_{10} and T_8 with values 5.92 and 5.58 respectively.

At 6 MAP, maximum number of roots was recorded in T_4 (8.92) closely followed by T_5 (8.83) and the lowest was noticed in T_8 (5.42). After seven months of planting a highest of 9.12 roots was observed in T_5 followed by T_4 (8.58). The least number of roots was recorded in T_8 with 5.83 roots. At 8MAP, a highest of 8.75 roots was observed in T_4 followed by T_7 with 7.58 roots. The least number was noticed in T_8 (5.58) which was statistically on par with T_{10} (5.7). At 9th month after planting a maximum of 9.33 roots was observed in T_4 followed by T_3, T_5 and T_{11} (7.5, 7.5, and 7.42 respectively). The least number of roots was recorded in T_{10} with a value of 4.60. The treatment T_4 was performing best with 9.25 roots at 10th month of planting while treatment T_{10} had the lowest number of roots (4.00).

At 11 MAP, highest number of roots was observed in T_4 with 9.12 roots followed by T_3 (8.61) and T_5 (8.17). At 12MAP also, the maximum number of roots was recorded in T_4 (10.28). This was followed by treatments T_5 and T_3 with 9.41 and 8.94 number of roots respectively. During the last two months of observation the lowest number of roots was observed in T_{10} (Plate 5). Even though the best treatments with respect to number of roots varied from month to month, in general the treatments T_4, T_5 and T_3 were superior compared to others.

Table 9. Effect of micronutrients on number of roots in different months in *Ascocenda* orchid var. Big Suksamran

Treatments	May(at planting)	June (1MAP)	July (2MAP)	Aug (3MAP)	Sep (4MAP)	Oct (5MAP)	Nov (6MAP)	Dec (7MAP)	Jan (8MAP)	Feb (9MAP)	Mar (10MAP)	April (11MAP)	May (12MAP)
T_1	7.50	8.17	7.75	7.42	5.92	8.25	7.58	7.00	6.75	6.67	7.00	7.50	7.61
T_2	9.42	8.25	7.92	7.42	7.00	7.83	6.67	6.42	6.75	6.42	7.17	7.92	8.19
T_3	8.50	8.17	9.25	7.83	7.42	8.67	7.58	7.58	7.25	7.50	7.33	8.61	8.94
T_4	6.17	6.92	6.75	8.17	7.42	7.92	8.92	8.58	8.75	9.33	9.25	9.42	10.28
T_5	7.58	9.00	7.33	8.00	6.50	8.17	8.83	9.17	7.17	7.50	8.17	8.17	9.41
T_6	6.58	7.67	6.58	6.08	6.08	7.42	7.42	6.50	6.75	5.75	5.75	6.53	6.64
T_7	7.00	6.00	6.50	6.17	6.33	7.42	8.00	7.67	7.58	6.67	6.67	6.67	7.33
T_8	8.33	3.83	3.83	4.67	4.33	5.58	5.42	5.83	5.58	5.50	5.67	5.91	6.25
T_9	6.83	6.33	6.92	7.08	4.83	6.58	6.08	6.08	6.17	5.92	5.00	5.28	5.80
T_{10}	8.08	7.92	7.25	6.33	5.33	5.92	5.92	6.75	5.70	4.60	4.00	3.78	3.44
T_{11}	7.00	8.17	7.25	7.42	6.33	7.83	7.33	7.58	7.17	7.42	7.00	7.11	8.00
CD(0.05)	**NS**	**1.92**	**1.41**	**1.86**	**1.62**	**1.76**	**1.71**	**1.58**	**1.33**	**1.50**	**1.22**	**1.31**	**1.73**
CV	**16.90**	**15.52**	**11.83**	**15.74**	**15.54**	**14.02**	**13.96**	**12.94**	**11.44**	**13.26**	**10.82**	**11.07**	**13.68**

T_1 - PoP + BA 150ppm + Zn @ 0.01%
T_2 - PoP + BA 150ppm + Zn @ 0.025%
T_3 - PoP + BA 150ppm + Mn @ 0.01%
T_4 - PoP + BA 150ppm + Mn @ 0.025%
T_5 - PoP + BA 150ppm + B @ 0.01%
T_6 - PoP + BA 150ppm + B @ 0.025%
T_7 - PoP + BA 150ppm + Fe @ 0.01%
T_8 - PoP + BA 150ppm + Fe @ 0.025%
T_9 - PoP + BA 150ppm + Mo @ 0.01%
T_{10} - PoP + BA 150ppm + Mo @ 0.025%
T_{11} - Control - PoP + BA 150ppm

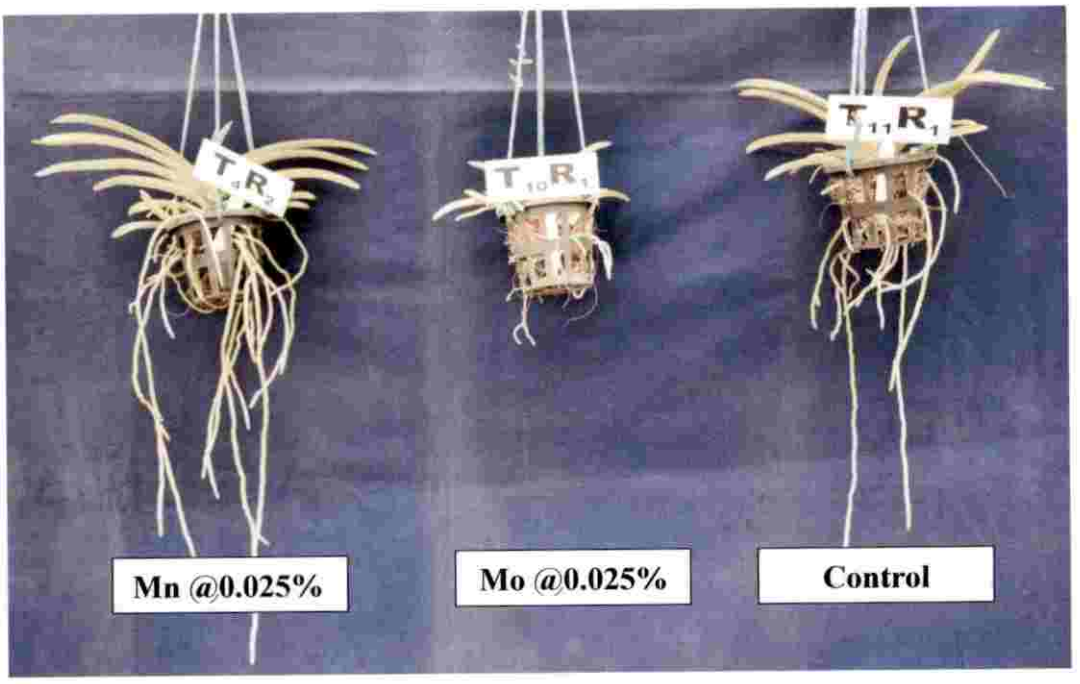


Plate 5. Treatment effect on number of roots

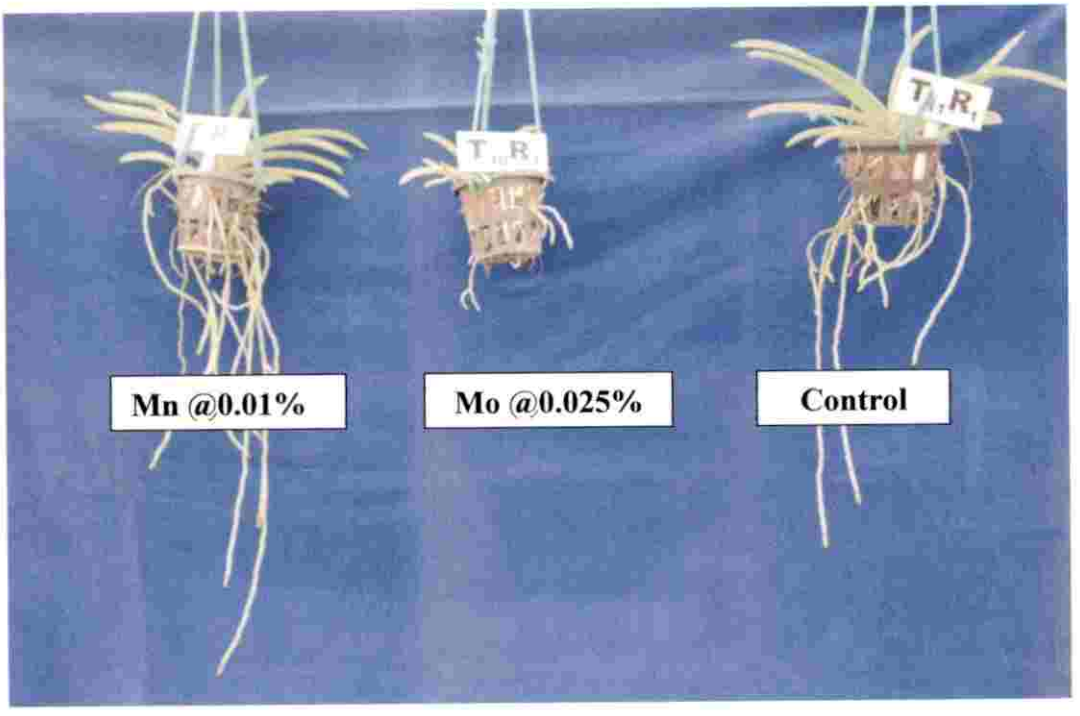


Plate 6. Treatment effect on root length

4.1.9. Length of the longest aerial root

Twelve month data on length of the longest aerial root was recorded and are presented in Table 10. From the table, it is clear that from the first month of planting itself there was significant difference among different micronutrient treatments. T_3 had recorded highest root length with 13.19 cm followed by T_{11}, T_1, T_{10}, T_5, and T_4 which were statistically on par with one another (11.22 cm, 10.73 cm, 10.38 cm, 10.24 cm and 10.18 cm respectively). The lowest root length of 5.01 cm was observed in T_8. During second month of planting maximum length of root noticed was in T_3 (13.72 cm) followed by T_{11} (12.69 cm). Treatment T_6 had the least root length (7.47 cm), however T_8 and T_7 were statistically on par with T_6 which had the values 7.58 cm and 7.50 cm respectively. The same trend was observed for the subsequent two months also.

At 5th month after planting a highest of 14.57 cm was observed in T_3 followed by T_1 (14.12 cm). This was followed by T_{11} with 14.05 cm length in root. The least root length of 8.34 cm was observed in T_6. The same trend was noticed for the subsequent month and during 7th month of planting, highest root length was observed in T_1 (16.43 cm) followed by T_3 (16.03 cm). The lowest root length was recorded in T_6 with 9.89 cm. Significant difference among treatments could not be noticed for the next three months of observation. At 11th and 12th months of planting, highest root length was recorded in T_3 (22.73 cm and 26.59 cm) which was on par with T1 (20.68 cm, 23.40 cm), T8 (20.01 cm, 23.36 cm) and T2 (19.58 cm, 22.74 cm) and lowest was recorded in T_{10} (7.54 cm and 7.86 cm). From this period of observation it could be inferred that T_3 was superior in terms of root length (Plate 6).

4.1.10. Diameter of the thickest aerial root

The diameter of the thickest aerial root recorded in different treatments are presented in Table 11. From the table, it is evident that there was no significant difference among treatments for the first three months of planting.

Table 10. Effect of micronutrients on root length (cm) in different months in *Ascocenda* orchid var. Big Suksamran

Treatments	May(at planting)	June (1MAP)	July (2MAP)	Aug (3MAP)	Sep (4MAP)	Oct (5MAP)	Nov (6MAP)	Dec (7MAP)	Jan (8MAP)	Feb (9MAP)	Mar (10MAP)	April (11MAP)	May (12MAP)
T_1	10.46	10.73	10.88	12.10	12.54	14.12	15.14	16.43	12.97	13.36	15.52	20.68	23.40
T_2	12.21	9.09	10.63	11.03	11.85	11.23	12.82	12.90	13.30	13.93	14.36	19.58	22.74
T_3	10.96	13.19	13.72	13.89	15.36	14.57	15.67	16.03	16.36	14.78	16.87	22.73	26.59
T_4	9.58	10.18	11.45	12.47	12.64	13.03	13.28	13.46	13.92	13.28	15.39	17.98	20.94
T_5	10.72	10.24	11.47	10.30	12.27	12.50	12.93	13.78	12.13	12.54	13.75	18.06	22.13
T_6	9.08	7.68	7.47	7.18	8.20	8.34	9.02	9.89	9.17	8.43	9.14	12.79	15.31
T_7	9.65	5.87	7.50	7.93	9.01	8.87	11.71	13.26	11.19	11.85	13.43	18.38	20.69
T_8	10.89	5.01	7.58	7.04	9.39	9.88	11.45	12.90	13.95	14.77	17.14	20.01	22.36
T_9	11.44	9.22	9.80	11.48	12.11	13.02	13.14	12.44	12.39	13.28	12.84	15.53	17.62
T_{10}	10.78	10.38	10.45	10.33	10.85	10.93	11.60	12.25	12.08	9.59	9.01	7.54	7.86
T_{11}	11.11	11.22	12.69	14.01	13.71	14.05	13.88	14.28	13.44	13.82	15.88	19.34	21.62
CD(0.05)	**NS**	**4.01**	**2.57**	**2.70**	**2.72**	**2.87**	**3.02**	**3.44**	**NS**	**NS**	**NS**	**6.27**	**6.94**
CV	**17.13**	**25.35**	**14.66**	**14.87**	**13.80**	**14.29**	**13.96**	**15.15**	**21.50**	**20.41**	**22.99**	**21.13**	**20.37**

T_1 - PoP + BA 150ppm + Zn @ 0.01%
T_2 -PoP + BA 150ppm + Zn @ 0.025%
T_3 - PoP + BA 150ppm + Mn @ 0.01%
T_4 - PoP + BA 150ppm + Mn @ 0.025%
T_5 - PoP + BA 150ppm + B @ 0.01%
T_6- PoP + BA 150ppm + B @ 0.025%
T_7 - PoP + BA 150ppm + Fe @ 0.01%
T_8 - PoP + BA 150ppm + Fe @ 0.025%
T_9 - PoP + BA 150ppm + Mo @ 0.01%
T_{10} -PoP + BA 150ppm + Mo @ 0.025%
T_{11} - Control - PoP + BA 150ppm

Significant difference between treatments was observed during 4th month of planting with maximum root diameter in treatments T_3, T_5 and T_4 (2.29 mm each). The lowest root diameter of 1.91 mm was observed in T_{10}. The same trend was observed for the subsequent two months of observation. At 7 MAP highest root diameter was recorded in T_3 (2.53 mm) followed by T_5 (2.48 mm) and T_4 (2.46 mm) and the least was observed in T_{10} with value of 1.76 mm. Highest root diameter of 2.59 mm was observed in T_3 at 8 MAP, which was closely followed by T_8 (2.56 mm) and they were statistically on par. This was followed by T_4 and T_5 with value 2.54 mm each. The lowest root diameter of 1.68 mm was observed in T_{10}.

At 9 MAP highest root diameter of 2.66 mm was observed in T_4, closely followed by T_8 and T_3 which were statistically on par (2.65 mm and 2.65 mm respectively). The least root diameter of 1.63 mm was recorded in T_{10}. During 10th month of planting, T_4 had the highest root diameter (2.78 mm), followed by T_8 (2.73 mm) and T_3 (2.70 mm). At 10th month also T_{10} had the thinnest root with a diameter of 1.56 mm. The same trend was noticed for the subsequent months also. In general it could be inferred that treatments T_4, T_3, and T_8 were superior in terms of root diameter.

4.2. FLORAL CHARACTERS

Since none of the plants in the various treatments flowered during the experimental period, data on floral characters could not be recorded.

4.3. POST HARVEST STUDIES

Post harvest studies could not be carried out since flowering was not obtained.

Table 11. Effect of micronutrients on root diameter (mm) in different months in *Ascocenda* orchid var. Big Suksamran

Treatments	May(at planting)	June (1MAP)	July (2MAP)	Aug (3MAP)	Sep (4MAP)	Oct (5MAP)	Nov (6MAP)	Dec (7MAP)	Jan (8MAP)	Feb (9MAP)	Mar (10MAP)	April (11MAP)	May (12MAP)
T_1	1.98	2.03	2.07	2.11	2.16	2.22	2.25	2.32	2.41	2.47	2.53	2.57	2.63
T_2	1.89	1.95	2.00	2.06	2.12	2.17	2.21	2.28	2.36	2.44	2.49	2.59	2.67
T_3	2.10	2.29	2.19	2.23	2.29	2.33	2.45	2.53	2.59	2.65	2.70	2.75	2.84
T_4	2.00	2.07	2.15	2.22	2.29	2.36	2.43	2.46	2.54	2.66	2.78	2.85	2.91
T_5	2.04	2.11	2.14	2.21	2.29	2.36	2.42	2.48	2.54	2.58	2.65	2.73	2.82
T_6	1.86	1.91	1.95	2.01	2.05	2.13	2.20	2.29	2.34	2.39	2.43	2.50	2.55
T_7	2.00	1.94	2.03	2.08	2.10	2.18	2.25	2.30	2.33	2.42	2.49	2.52	2.56
T_8	1.90	1.73	1.95	2.08	2.17	2.28	2.34	2.41	2.56	2.65	2.73	2.81	2.86
T_9	2.01	2.02	2.03	2.05	2.06	2.06	2.06	2.07	2.08	2.08	2.11	2.11	2.17
T_{10}	1.89	1.89	1.93	1.93	1.91	1.86	1.77	1.76	1.68	1.63	1.56	1.46	1.39
T_{11}	1.97	2.04	2.06	2.12	2.20	2.26	2.35	2.38	2.43	2.48	2.51	2.53	2.58
CD(0.05)	**NS**	**NS**	**NS**	**NS**	**0.21**	**0.20**	**0.16**	**0.20**	**0.18**	**0.20**	**0.22**	**0.20**	**0.21**
CV	**7.33**	**9.23**	**7.33**	**6.96**	**5.83**	**5.25**	**4.28**	**5.00**	**4.63**	**4.86**	**5.18**	**4.84**	**4.86**

T_1 - PoP + BA 150ppm + Zn @ 0.01%
T_2 -PoP + BA 150ppm + Zn @ 0.025%
T_3 - PoP + BA 150ppm + Mn @ 0.01%
T_4 - PoP + BA 150ppm + Mn @ 0.025%
T_5 - PoP + BA 150ppm + B @ 0.01%
T_6- PoP + BA 150ppm + B @ 0.025%
T_7 - PoP + BA 150ppm + Fe @ 0.01%
T_8 - PoP + BA 150ppm + Fe @ 0.025%
T_9 - PoP + BA 150ppm + Mo @ 0.01%
T_{10} -PoP + BA 150ppm + Mo @ 0.025%
T_{11} - Control - PoP + BA 150ppm

Discussion

5. DISCUSSION

The experiment entitled 'Response of *Ascocenda* orchids to growth regulator and micronutrients' was conducted to find out the effect of micronutrients *viz.*, Zn, Mn, B, Fe and Mo on the performance of *Ascocenda* orchid var. Big Suksamaran. The results obtained are briefly discussed hereunder.

5.1. INFLUENCE OF MICRONUTRIENTS ON VEGETATIVE CHARACTERS

The result obtained in the present study indicated that foliar application 0.025% manganese along with 150 ppm BA and recommended dose of NPK (T_4) was best for getting maximum plant height. The highest plant height obtained at 12 MAP was 8.86 cm. This was followed by T_5 (8.81 cm) and T_3 (8.63 cm) which were statistically on par with T_4 (Fig. 1). The parameter shoot diameter was found higher with the application of 0.01% boron along with 150 ppm BA and recommended dose of NPK. The maximum shoot diameter (10.20 mm) was observed in T_5 at 12 MAP, which was on par with T_4 (9.96 mm) and T_3 (9.84 mm) (Fig. 2).

The treatment with T_3 (Mn 0.01% + PoP + 150ppm BA) had produced the maximum values for leaf characters namely leaf length and leaf area up to 7 MAP. After that highest leaf length and leaf area were observed in T_5 which received boron at 0.01% + PoP + 150ppm BA. However, there was no significance difference between T_3 and T_5 in terms of leaf length and leaf area. At 12 MAP, highest leaf length of 16.70 cm was recorded in T_5 which was on par with T_3 (16.48 cm) (Fig. 4). The highest leaf area recorded at 12 MAP was 23.17 cm^2 in T_5 (B 0.01% + PoP + 150ppm BA) followed by T_3 (Mn 0.01% + PoP + 150ppm BA) with 22.73 cm^2 leaf area and they were statistically on par with each other (Fig. 6). The parameters number of leaves and leaf breadth was found higher with the application of 0.01% boron along with 150 ppm BA and recommended dose of NPK (T_5).

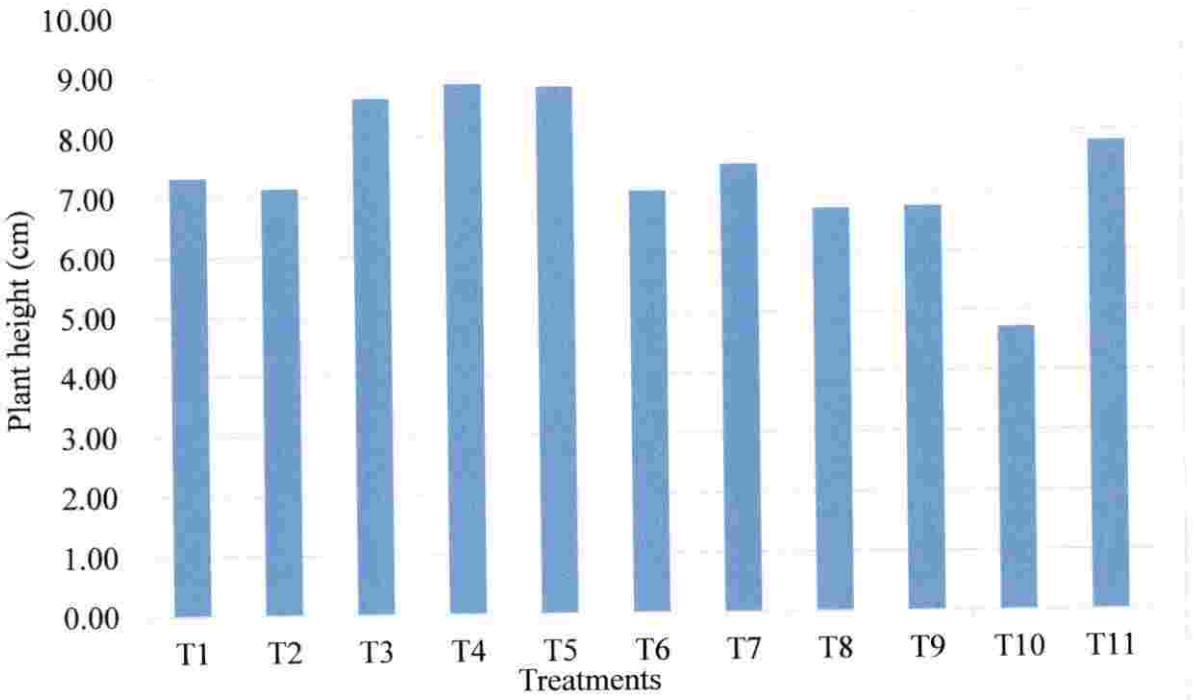


Fig. 1. Effect of micronutrients on plant height (cm)

T_1 - PoP + BA 150ppm + Zn @ 0.01%

T_2 - PoP + BA 150ppm + Zn @ 0.025%

T_3 - PoP + BA 150ppm + Mn @ 0.01%

T_4 - PoP + BA 150ppm + Mn @ 0.025%

T_5 - PoP + BA 150ppm + B @ 0.01%

T_6 - PoP + BA 150ppm + B @ 0.025%

T_7 - PoP + BA 150ppm + Fe @ 0.01%

T_8 - PoP + BA 150ppm + Fe @ 0.025%

T_9 - PoP + BA 150ppm + Mo @ 0.01%

T_{10} - PoP + BA 150ppm + Mo @ 0.025%

T_{11} – Control – PoP + BA 150ppm

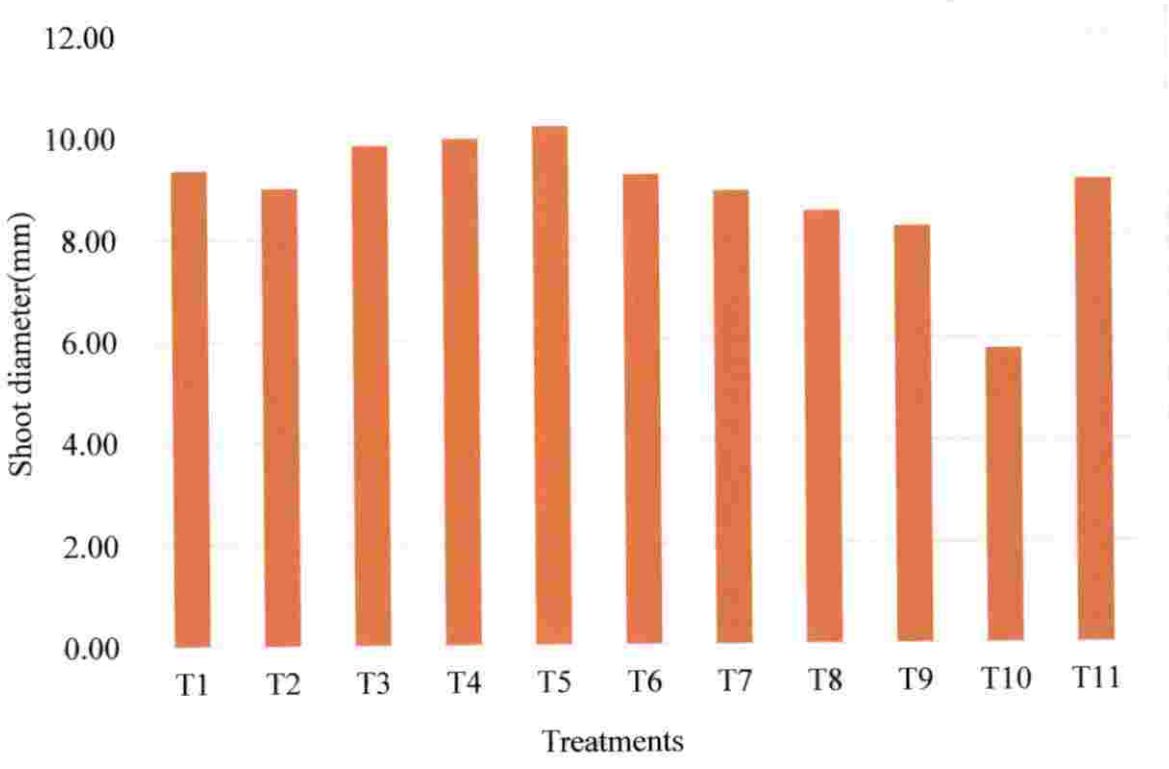


Fig. 2. Effect of micronutrients on shoot diameter (mm)

T_1 - PoP + BA 150ppm + Zn @ 0.01%

T_2 - PoP + BA 150ppm + Zn @ 0.025%

T_3 - PoP + BA 150ppm + Mn @ 0.01%

T_4 - PoP + BA 150ppm + Mn @ 0.025%

T_5 - PoP + BA 150ppm + B @ 0.01%

T_6 - PoP + BA 150ppm + B @ 0.025%

T_7 - PoP + BA 150ppm + Fe @ 0.01%

T_8 - PoP + BA 150ppm + Fe @ 0.025%

T_9 - PoP + BA 150ppm + Mo @ 0.01%

T_{10} - PoP + BA 150ppm + Mo @ 0.025%

T_{11} – Control – PoP + BA 150ppm

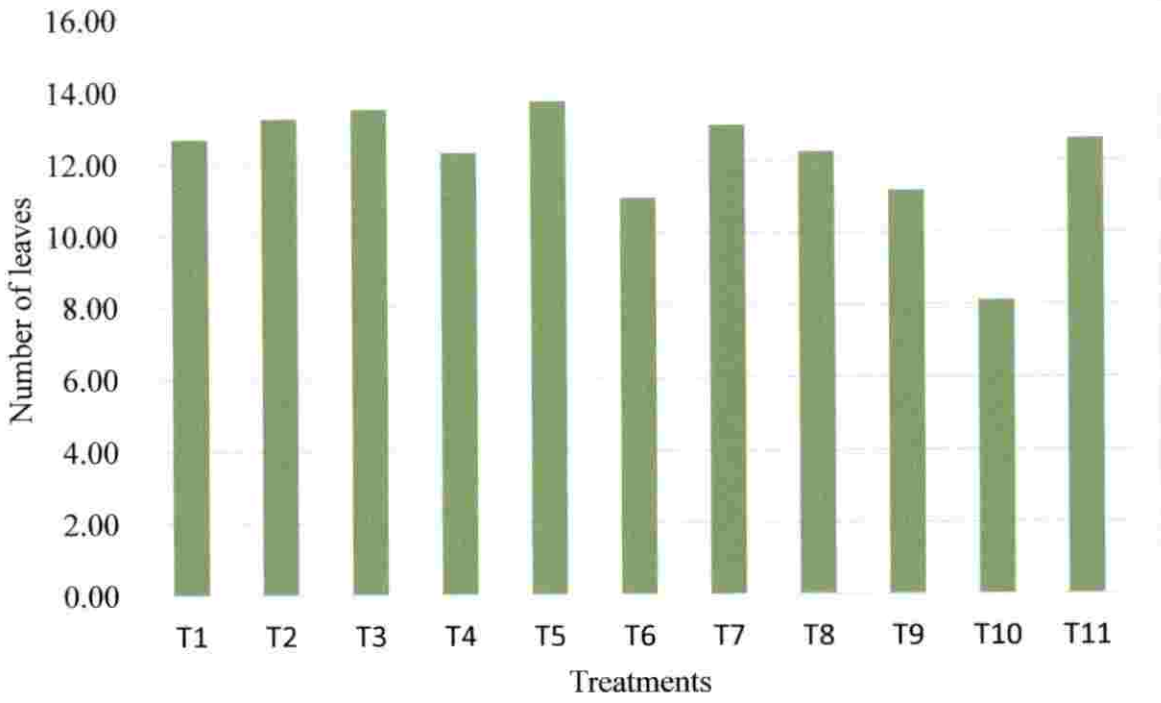


Fig. 3. Effect of micronutrients on number of leaves

T_1 - PoP + BA 150ppm + Zn @ 0.01%

T_2 - PoP + BA 150ppm + Zn @ 0.025%

T_3 - PoP + BA 150ppm + Mn @ 0.01%

T_4 - PoP + BA 150ppm + Mn @ 0.025%

T_5 - PoP + BA 150ppm + B @ 0.01%

T_6 - PoP + BA 150ppm + B @ 0.025%

T_7 - PoP + BA 150ppm + Fe @ 0.01%

T_8 - PoP + BA 150ppm + Fe @ 0.025%

T_9 - PoP + BA 150ppm + Mo @ 0.01%

T_{10} - PoP + BA 150ppm + Mo @ 0.025%

T_{11} – Control – PoP + BA 150ppm

Regarding number of leaves, a highest of 13.69 was observed in T_5 at 12MAP (Fig. 3). The highest leaf breadth observed in T_5 after 12 months of planting was 1.52 cm, which was closely followed by T_3 and T_4 (1.51 cm each), and no significant difference between these three treatments could be noticed (Fig. 5).

The parameter root length was found maximum on application with 0.01% manganese + PoP + 150 ppm BA (T_3) and it was 26.59 cm at 12th month of observation (Fig. 8). The other root parameters namely, number of roots and root diameter were higher on application with T_4 (0.025% Mn + PoP + 150 ppm BA) (Fig. 7). The best treatment with respect to number of roots varied during initial months, even though, from 6 MAP onwards, highest number of roots were observed in T_4 (Mn 0.025% + PoP + 150ppm BA) with a value of 10.28 number of roots at 12 MAP. In case of root diameter, a highest of 2.91 mm was recorded in T_4 at 12 MAP, which was closely followed by T_8 (Fe 0.025% + PoP + 150ppm BA) (2.86 mm) and T_3 (Mn 0.01% + PoP + 150ppm BA) (2.84 mm) (Fig. 9).

It is evident that foliar application of manganese at both concentrations (0.01% as well as 0.025%) in the form of manganese sulphate resulted in improved vegetative growth of the plant in terms of plant height, interval of leaf production, number of roots, root length, and root diameter. These results are in conformity with findings of Patidar (2011) in pot mum cultivars of chrysanthemum where greatest plant height was observed when manganese was applied as $MnSO_4$ @ 0.4%. Similarly, application of 500 ppm $MnSO_4$ resulted in maximum vegetative growth with respect to number of pseudobulbs, number of roots and length of roots in *Cymbidium elegance* (AICRP on Floriculture, 2007-2008). Manganese has been found to produce a favorable effect on vegetative growth of the plant. This might be due to the increase in photosynthesis, because manganese plays a crucial role in photosynthesis by activating some specific enzymes which are responsible for the synthesis of chlorophyll (Lidon *et al.*, 2004). Manganese also plays a major role as an essential component for the water photolysis reaction of photosystem II (Millaleo *et al.*, 2010). The enzymes which are activated by manganese include RNA polymerase and are enzymes responsible for the biosynthesis of gibberellic

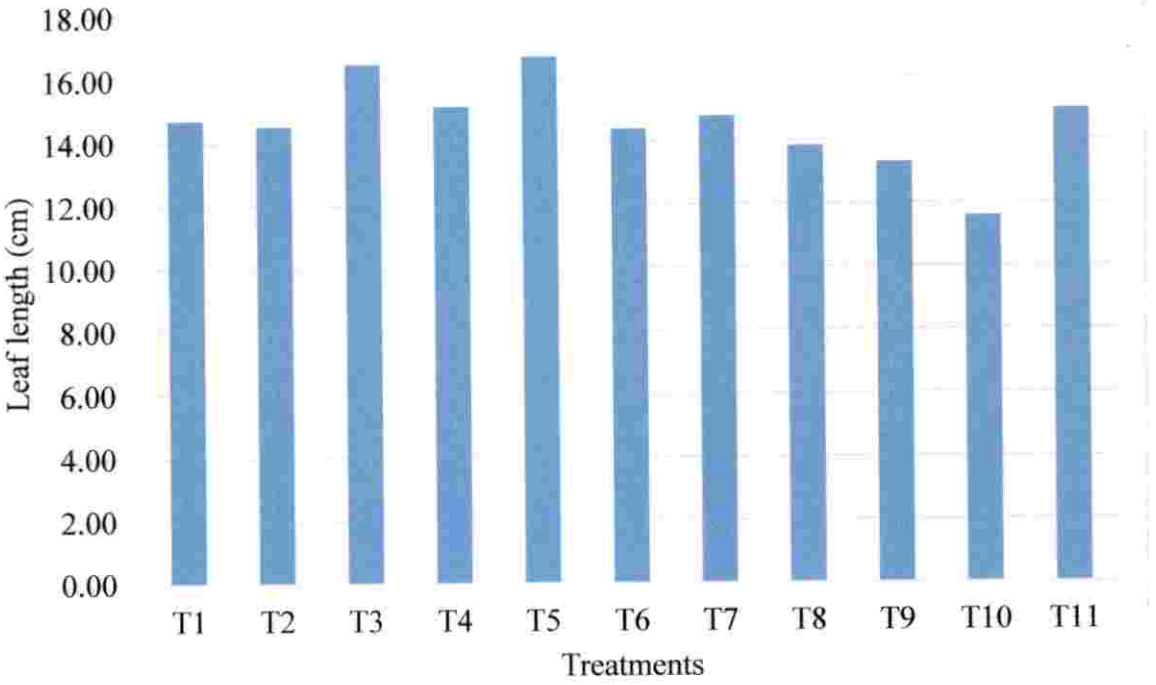


Fig. 4. Effect of micronutrients on leaf length (cm)

T_1 - PoP + BA 150ppm + Zn @ 0.01%

T_2 - PoP + BA 150ppm + Zn @ 0.025%

T_3 - PoP + BA 150ppm + Mn @ 0.01%

T_4 - PoP + BA 150ppm + Mn @ 0.025%

T_5 - PoP + BA 150ppm + B @ 0.01%

T_6 - PoP + BA 150ppm + B @ 0.025%

T_7 - PoP + BA 150ppm + Fe @ 0.01%

T_8 - PoP + BA 150ppm + Fe @ 0.025%

T_9 - PoP + BA 150ppm + Mo @ 0.01%

T_{10} - PoP + BA 150ppm + Mo @ 0.025%

T_{11} – Control – PoP + BA 150ppm

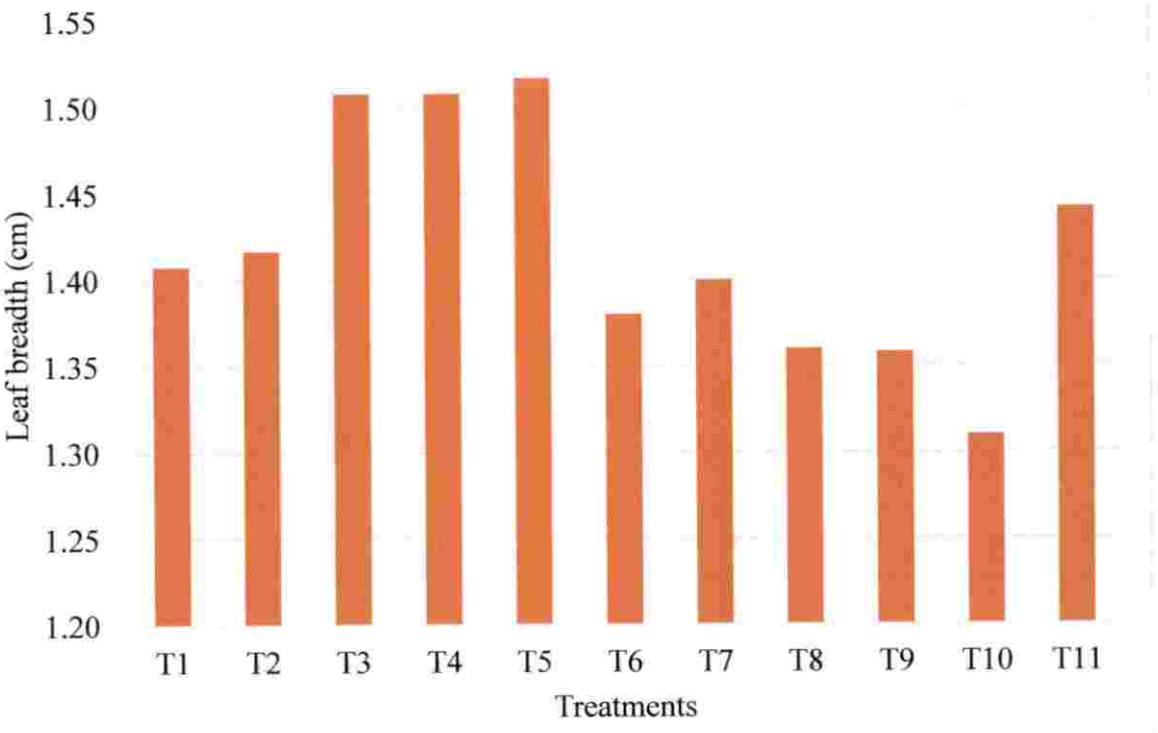


Fig. 5. Effect of micronutrients on leaf breadth (cm)

T_1 - PoP + BA 150ppm + Zn @ 0.01%

T_2 - PoP + BA 150ppm + Zn @ 0.025%

T_3 - PoP + BA 150ppm + Mn @ 0.01%

T_4 - PoP + BA 150ppm + Mn @ 0.025%

T_5 - PoP + BA 150ppm + B @ 0.01%

T_6 - PoP + BA 150ppm + B @ 0.025%

T_7 - PoP + BA 150ppm + Fe @ 0.01%

T_8 - PoP + BA 150ppm + Fe @ 0.025%

T_9 - PoP + BA 150ppm + Mo @ 0.01%

T_{10} - PoP + BA 150ppm + Mo @ 0.025%

T_{11} – Control – PoP + BA 150ppm

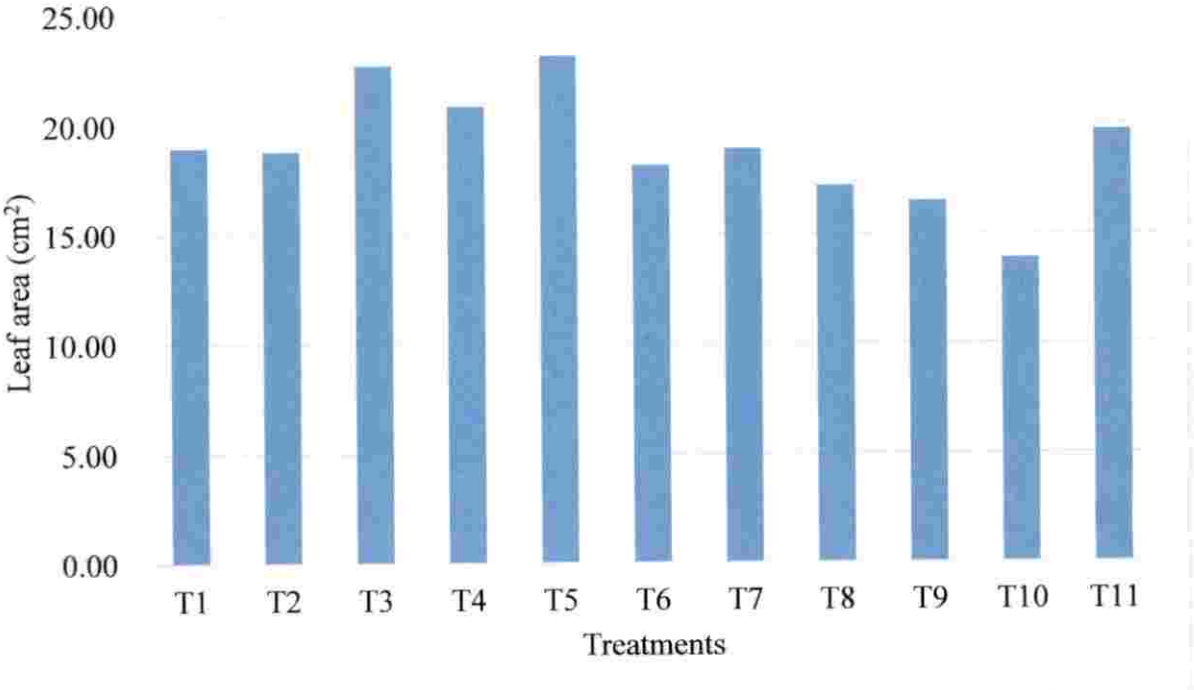


Fig. 6. Effect of micronutrients on leaf area (cm^2)

T_1 - PoP + BA 150ppm + Zn @ 0.01%

T_2 - PoP + BA 150ppm + Zn @ 0.025%

T_3 - PoP + BA 150ppm + Mn @ 0.01%

T_4 - PoP + BA 150ppm + Mn @ 0.025%

T_5 - PoP + BA 150ppm + B @ 0.01%

T_6 - PoP + BA 150ppm + B @ 0.025%

T_7 - PoP + BA 150ppm + Fe @ 0.01%

T_8 - PoP + BA 150ppm + Fe @ 0.025%

T_9 - PoP + BA 150ppm + Mo @ 0.01%

T_{10} - PoP + BA 150ppm + Mo @ 0.025%

T_{11} – Control – PoP + BA 150ppm

acid, fatty acids and metabolism of nitrogen (Hansch and Mendel, 2009). The activation of several enzymes coupled with increased photosynthesis might have assisted for the betterment of plant characters like plant height, days to leaf production, number of roots, root length and root diameter.

Foliar application of 0.01% boron in the form of boric acid along with recommended dose of NPK and 150 ppm BA was found to have profound influence on vegetative characters with production of highest shoot diameter, leaf length, leaf breadth, leaf area, and number of leaves. Ganesh and Kannan (2013), reported that boron is involved in processes like carbohydrate metabolism, sugar and starch translocation, protein synthesis, meristematic cell division, phloem development, and translocation of nitrogen, phosphorus and certain hormones. Boron is also involved in the process of DNA synthesis (Shukla *et al*., 2009).

The findings of this study are in conformity with those of Halder *et al.* (2007) in gladiolus where plant height and number of leaves were highest with the application of boron @ 2kg/ha. Ahmad *et al.* (2010) reported that foliar application of boron in the form of boric acid @ 0.5% could result in the production of taller plants with maximum number of leaves in *Rosa hybrida*. Similar result was reported by Sharma *et al.* (2013) in gladiolus cv. Aldebran where application of boron @ 0.20% as borax resulted in greatest plant height and number of leaves. In tuberose, highest plant height and number of leaves were observed when sprayed with 100 ppm born at fortnightly intervals (Nath and Biswas, 2002). The present findings were in conformity with the findings of Rajput *et al*., (2003) in *Tagetes minuta* and Patidar (2011) in pot mum cultivars of chrysanthemum.

However the higher dose of boron (0.025%) did not produce significant response compared to the lower dose (0.01%). It was found that length of root was less when sprayed with 0.025% boron along with 150 ppm BA and recommended dose of NPK. Similar result was reported by Halder *et al.* (2007) in gladiolus. i.e., application of boron @ 2kg/ha produced plants with maximum plant height and number of leaves while that of 3kg/ha did not produce any significant effect on plants. It indicated that the concentration at which micronutrients were applied was

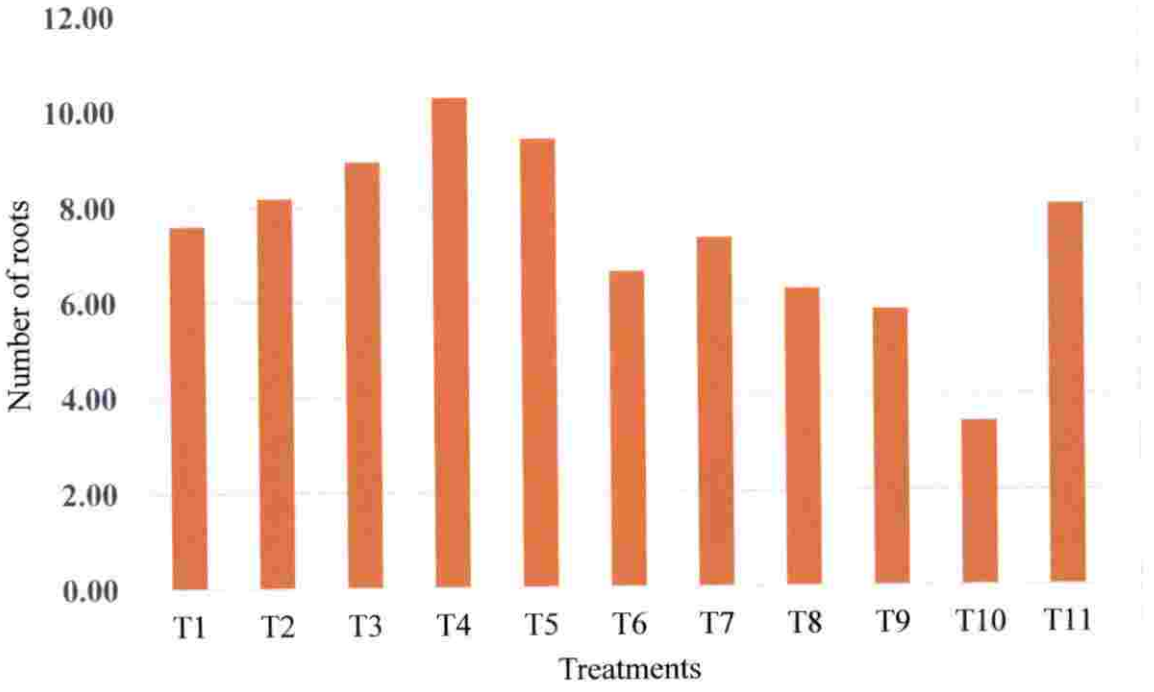


Fig. 7. Effect of micronutrients on number of roots

T_1 - PoP + BA 150ppm + Zn @ 0.01%

T_2 - PoP + BA 150ppm + Zn @ 0.025%

T_3 - PoP + BA 150ppm + Mn @ 0.01%

T_4 - PoP + BA 150ppm + Mn @ 0.025%

T_5 - PoP + BA 150ppm + B @ 0.01%

T_6 - PoP + BA 150ppm + B @ 0.025%

T_7 - PoP + BA 150ppm + Fe @ 0.01%

T_8 - PoP + BA 150ppm + Fe @ 0.025%

T_9 - PoP + BA 150ppm + Mo @ 0.01%

T_{10} - PoP + BA 150ppm + Mo @ 0.025%

T_{11} – Control – PoP + BA 150ppm

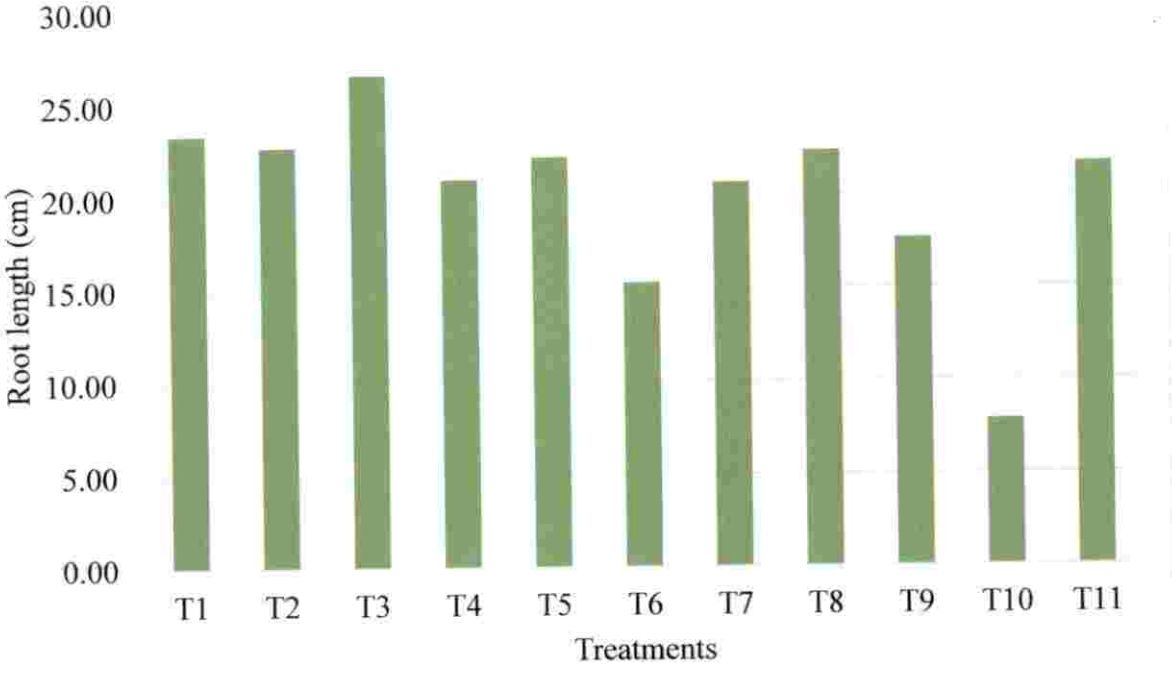


Fig. 8. Effect of micronutrients on root length (cm)

T_1 - PoP + BA 150ppm + Zn @ 0.01%

T_2 - PoP + BA 150ppm + Zn @ 0.025%

T_3 - PoP + BA 150ppm + Mn @ 0.01%

T_4 - PoP + BA 150ppm + Mn @ 0.025%

T_5 - PoP + BA 150ppm + B @ 0.01%

T_6 - PoP + BA 150ppm + B @ 0.025%

T_7 - PoP + BA 150ppm + Fe @ 0.01%

T_8 - PoP + BA 150ppm + Fe @ 0.025%

T_9 - PoP + BA 150ppm + Mo @ 0.01%

T_{10} - PoP + BA 150ppm + Mo @ 0.025%

T_{11} – Control – PoP + BA 150ppm

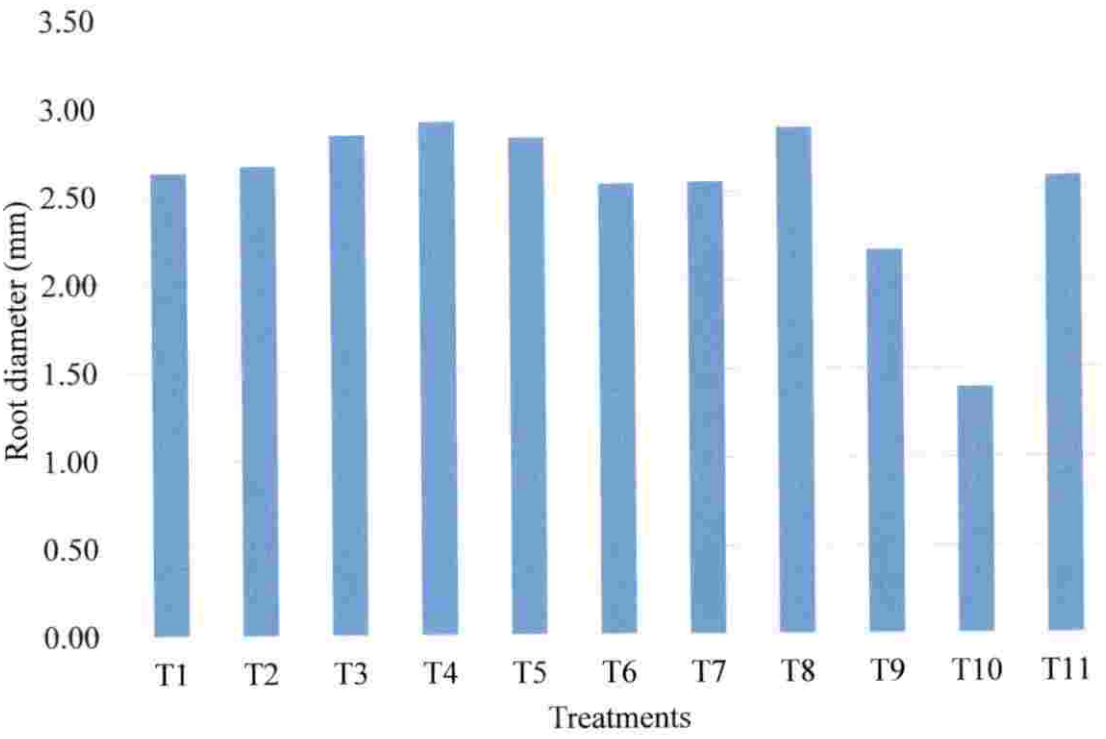


Fig. 9. Effect of micronutrients on root diameter (mm)

T_1 - PoP + BA 150ppm + Zn @ 0.01%

T_2 - PoP + BA 150ppm + Zn @ 0.025%

T_3 - PoP + BA 150ppm + Mn @ 0.01%

T_4 - PoP + BA 150ppm + Mn @ 0.025%

T_5 - PoP + BA 150ppm + B @ 0.01%

T_6 - PoP + BA 150ppm + B @ 0.025%

T_7 - PoP + BA 150ppm + Fe @ 0.01%

T_8 - PoP + BA 150ppm + Fe @ 0.025%

T_9 - PoP + BA 150ppm + Mo @ 0.01%

T_{10} - PoP + BA 150ppm + Mo @ 0.025%

T_{11} – Control – PoP + BA 150ppm

as important as their need by plants (Whitcomb *et al.*, 1975). Toxic levels of boron in plants inhibited cell division in roots and thereby reduced the root growth (Nable *et al.*, 1997).These results are in conformity with the present findings. Reid *et al.* (2004) reported that application of boron at higher concentration (10mM) in wheat inhibited the growth of root when applied to the root tip. Yellowing or chlorosis of mature leaves from tip was also noticed in T_6 (0.025% B+ PoP + 150 ppm BA). Marginal or tip chlorosis and necrosis in older leaves are the main toxic symptoms of boron in leaves (Roessner *et al.* 2006).This may due to the decreased rate of photosynthesis and chlorophyll content in leaves under elevated levels of boron in plants (Nable *et al.*, 1997). In the leaves of barley toxicity symptoms were more prominent at the leaf tip region because excess boron is deposited at the end of transpiration stream (Reid *et al.*, 2004).

Application of BA @ 150 ppm along with treatments at monthly intervals might have enhanced the vegetative growth of plants. This is in conformity with the findings of Shilpa (2017) in *Dendrobium* orchids, and Matsumoto (2006) in *Miltoniopsis* orchids. According to Werner et al., (2001), exogenous application of BA, the synthetic cytokinin, helped in the processes like cell division, organogenesis, cell elongation, translocation of assimilates, *etc.*

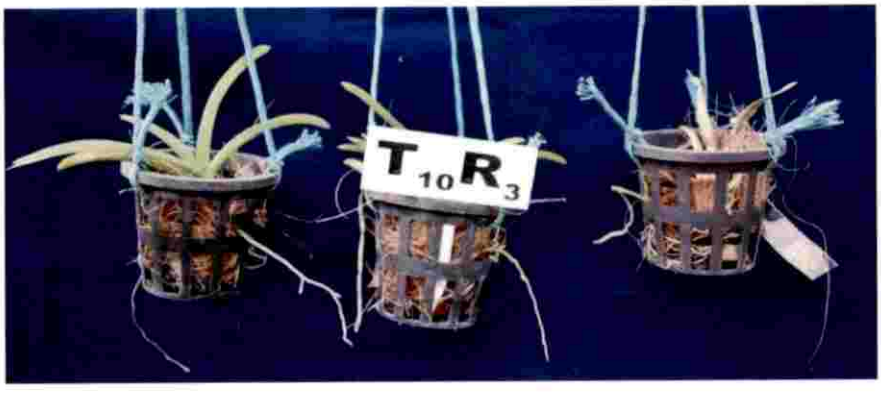
Among the eleven treatments including control, T_{10} (0.025% Mo+ PoP + 150 ppm BA) was found least performing for all the vegetative characters studied (Plate 7). It was observed that continuous application of Mo @ 0.025% at fortnightly intervals was detrimental to the plants. So the treatment T_{10} (0.025% Mo+ PoP + 150 ppm BA) was stopped during 8^{th} month of planting. During the period of observation, T_{10} showed a declining trend in growth for the characters root and shoot diameter. From these results it could be inferred that higher dose of molybdenum was toxic to the plants. This was in conformity with the findings of Arnon and Stout (1939) in tomato seedlings, who reported that application of Mo was found toxic to the seedlings of tomato when the concentration exceeded 10 ppm. Hecht-Buchhloz (1973) reported that under molybdenum toxicity, complexes

of molybdocatechols were formed in the vacuoles of plant cells which led to leaf malformation and shoot discolouration.

It has been reported that there was a significant positive correlation between plant height and number of leaves with number of flowers in dendrobium. It was also reported that length of inflorescence was positively correlated with total number of leaves (Sobhana, 2000). In this context, the results obtained in the present study indicate that beneficial effects of manganese (0.01% and 0.025%) and boron (0.01%) in plant height and number of leaves may reflect in the increased number of flowers and length of inflorescence of *Ascocenda* orchid.

(A)

(B)



(c)

Plate 7. Inhibitory effect of Mo @0.025% on vegetative characters: (A) Replication 1, (B) Replication 2, (C) Replication 3

Summary

6. SUMMARY

The present study entitled 'Response of *Ascocenda* orchid to growth regulator and micronutrients' was conducted during May 2018 to May 2019 in top ventilated poly house of Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara.

The experiment was conducted with eleven treatments, which included five micronutrients *viz.*, zinc, manganese, boron, iron and molybdenum, each at two concentrations 0.01% and 0.025%, applied at fortnightly intervals. Foliar application of benzyl adenine @ 150 ppm was given to all the treatments at monthly intervals. Application of NPK (3:1:1) weekly twice @ 0.2% and cow dung slurry (1:5) at monthly intervals was also given to all the treatments as per PoP recommendation of KAU. Three month old tissue cultured plants of *Ascocenda* var. Big Suksamran were used for the study.

The results obtained are briefly summarised hereunder:

- Foliar application of 0.025% manganese along with 150 ppm BA and recommended dose of NPK (T_4) was best for getting maximum plant height. The highest plant height obtained at 12 MAP was 8.86 cm (T_4) which was on par with T_5 (8.81 cm) and T_3 (8.63 cm).
- Shoot diameter was found higher with the application of 0.01% boron along with 150 ppm BA and recommended dose of NPK. The maximum shoot diameter observed in T_5 was 10.20 mm at 12MAP, which was on par with T_4 (9.96 mm) and T_3 (9.84 mm).
- The treatment with T_3 (Mn 0.01% + PoP + 150ppm BA) had resulted in maximum values for leaf characters namely leaf length and leaf area up to 7 MAP. After that highest leaf length and leaf area were observed in T_5 which received boron at 0.01% + PoP + 150ppm BA, however, there was no significance difference between T_3 and T_5 in terms of leaf length and leaf area. At 12 MAP, highest leaf length of 16.70 cm was recorded in T_5 which

was on par with T_3 (Mn 0.01% + PoP + 150ppm BA) (16.48 cm). The maximum leaf area recorded at 12 MAP was 23.17 cm^2 in T_5 (B 0.01% + PoP + 150ppm BA) followed by T_3 (22.73 cm^2) which were statistically on par with each other.

- Number of leaves per plant was maximum when plants were treated with 0.01% boron + 150 ppm BA + POP. At 12 MAP 13.69 leaves were observed in T_5 (B 0.01% + PoP + 150ppm BA).
- The widest leaf was produced on application with T_5 (0.01% boron + 150 ppm BA + POP). After 12 months of planting, highest leaf breadth observed was 1.52 cm (T_5), which was on par with T_3 and T_4 (1.51 cm each).
- Regarding interval of leaf production, only 4 treatments (T_3, T_4, T_5, and T_{11}) could produce the highest number of eight leaves, within a period of 386 days. Among these, T_4 (Mn 0.025% + PoP + 150ppm BA) took the shortest period of 337.45 days to produce the 8^{th} leaf. T_{10} (Mo 0.025% + PoP + 150ppm BA) produced only five leaves with in a period of 386 days.
- The parameter root length was found maximum on application with 0.01% manganese + PoP + 150 ppm BA (T_3) and it was 26.59 cm at 12^{th} month of observation. The other root parameters like number of roots and root diameter were higher on application with T_4 (0.025% Manganese + PoP + 150 ppm BA). The best treatment with respect to number of roots varied during initial months, even though, from 6 MAP onwards, highest number of roots was observed in T_4 with a value of 10.28 at 12 MAP. In the case of root diameter, a highest of 2.91 mm was recorded in T_4 at 12 MAP, which was statistically on par with T_8 (2.86 mm) and T_3 (2.84 mm).
- Application of Mo @ 0.025% (T_{10}) at fortnightly intervals was inhibitory to the plants in terms of all the vegetative characters studied.
- Flowering could not be noticed in any of the treatments during the period of experiment.

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Appendices

APPENDICES

Appendix I. Meteorological data during the period of observation from May 2018 to May 2019

Months	Temperature (°C)		Mean RH (%)	Rainfall (mm)
	Max	Min		
May 18	33.2	22.6	79	483.6
Jun 18	29.8	23.2	89	730.0
July 18	29.6	22.5	88	793.2
Aug 18	29.2	22.2	87	928.0
Sep 18	32.2	22.5	75	29.0
Oct 18	32.8	22.9	76	393.0
Nov 18	32.7	23.3	68	66.6
Dec 18	33.0	22.5	63	0.0
Jan 19	32.9	20.4	55	0.0
Feb 19	35.3	23.4	59	0.0
Mar 19	36.7	24.8	65	0.0
Apr 19	36.2	25.5	70	76.4
May 19	34.6	24.9	74	48.8

Appendix II. Manurial schedule for orchids as per PoP recommendation of KAU

Sl. No.	Nutrient recommendation	Crop stage	Dosage	Interval of application
1	NPK @ 3:1:1	Vegetative phase	0.2 %	Weekly twice
2	NPK @ 1:2:2	Flowering phase	0.2 %	Weekly twice
3	Cow dung slurry	Both vegetative and flowering phase	1 kg in 5 L water	Monthly once

RESPONSE OF *Ascocenda* ORCHID TO GROWTH REGULATOR AND MICRONUTRIENTS

by

JESABEL GEORGE
(2017-12-035)

ABSTRACT OF THE THESIS

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ABSTRACT

A study entitled 'Response of *Ascocenda* orchid to growth regulator and micronutrients' was carried out at Department of Floriculture and Landscaping, College of Horticulture Vellanikkara, from May 2018 to May 2019. *Ascocenda* is a monopodial, epiphytic, bigeneric hybrid, which is mainly grown as pot plant in hanging baskets using bricks, charcoal, coconut husk pieces *etc.* as growing media. The objective of the study was to evaluate the influence of foliar application of different micronutrient treatments on growth and yield of *Ascocenda* orchid. The experiment was conducted with eleven treatments *viz.*, 0.01% zinc + 150 ppm benzyl adenine + PoP (T_1), 0.025% zinc + 150 ppm benzyl adenine + PoP (T_2), 0.01% manganese + 150 ppm benzyl adenine + PoP (T_3), 0.025% manganese + 150 ppm benzyl adenine + PoP (T_4), 0.01% boron + 150 ppm benzyl adenine + PoP (T_5), 0.025% boron + 150 ppm benzyl adenine + PoP (T_6), 0.01% iron + 150 ppm benzyl adenine + PoP (T_7), 0.025% iron + 150 ppm benzyl adenine + PoP (T_8), 0.01% molybdenum + 150 ppm benzyl adenine + PoP (T_9), 0.025% molybdenum + 150 ppm benzyl adenine + PoP (T_{10}), 150 ppm benzyl adenine + PoP (T_{11} – control). Three month old tissue cultured plants of *Ascocenda* var. Big Suksamran were used for the study.

The micronutrients were applied at fortnightly intervals and benzyl adenine was applied at monthly intervals. Application of NPK (3:1:1) weekly twice @ 0.2% and cow dung slurry (1:5) at monthly intervals was given to all treatments as per PoP recommendation of KAU.

Observations were taken at monthly intervals. The results indicated that foliar application of 0.025% manganese along with 150 ppm BA and recommended dose of NPK (T_4) was best for improving plant height. The maximum plant height obtained at 12MAP was 8.86 cm. This was followed by T_5 (8.81 cm) and T_3 (8.63 cm) which were statistically on par with T_4. The maximum shoot diameter was observed in T_5 (10.20 mm) at 12 MAP which was on par with T_4 and T_3 (9.96 mm and 9.84 mm respectively).

The treatment T_3 was superior in terms of leaf characters like leaf length and leaf area up to 7 MAP and thereafter these parameters were highest in treatment T_5. However, there was no significant difference between T_5 and T_3 in terms of leaf length at 12 MAP (16.70 cm and 16.48 cm respectively). The highest leaf area at 12 MAP was observed in T_5 (23.17 cm^2) followed by T_3 (22.73 cm^2). Number of leaves and leaf breadth were found highest with the

application of 0.01% boron along with 150 ppm BA and recommended dose of NPK. A maximum of 13.69 leaves were observed in T_5 at 12MAP. The maximum leaf breadth observed in T_5 after 12 months of planting was 1.52 cm, which was closely followed by T_3 and T_4 (1.51 cm each), and no significant difference between these three treatments could be noticed. Regarding interval of leaf production, only 4 treatments (T_3, T_4, T_5, and T_{11}) could produce the highest number of eight leaves, within a period of 386 days. Among these, T_4 took the shortest period of 337.45 days to produce the 8th leaf. T_{10} produced only five leaves within a period of 386 days.

Among the root parameters, highest root length was observed in T_3 (0.01% manganese + POP + 150 ppm BA) at 12 MAP (26.59 cm) whereas the treatment T_4 (0.025% Mn + PoP + 150 ppm BA) was superior in terms of number of roots and root diameter. The best treatment with respect to number of roots varied during initial months, even though, from 6 MAP onwards, highest number of roots was observed in T_4 with a value of 10.28 at 12 MAP. In the case of root diameter, a highest of 2.91 mm was recorded in T_4 at 12 MAP, which was on par with T_8 (2.86 mm), T_3 (2.84 mm) and T_5 (2.82 mm).

Among the eleven treatments, T_3 (Mn 0.01% + PoP + 150ppm BA), T_4 (Mn 0.025% + PoP + 150ppm BA), and T_5 (B 0.01% + PoP + 150ppm BA)were found to be best for improving the vegetative characters of *Ascocenda* orchid, while application of Mo @ 0.025% (T_{10}) at fortnightly intervals was inhibitory to the plants in terms of all the vegetative characters studied. The objective of studying the floral and postharvest characters could not be achieved since the plant did not bloom within the period of study.