EFFECT OF DIFFERENT GROWING MEDIA AND pH ON GROWTH AND DEVELOPMENT OF *Anthurium andreanum* LIND.

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EFFECT OF DIFFERENT GROWING MEDIA AND pH ON GROWTH AND DEVELOPMENT OF *Anthurium andreanum* LIND.

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CERTIFICATE

This is to certify that the thesis entitled "EFFECT OF DIFFERENT GROWING MEDIA AND pH ON GROWTH AND DEVELOPMENT OF *Anthurium andreanum* Lind", submitted in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE [AGRICULTURE] in HORTICULTURE to the University of Agricultural Sciences, Bangalore, is a record of research work carried out by Miss SMITHA. R., under my guidance and supervision, and that no part of the thesis has been submitted for the award of any other degree, diploma, associateship, fellowship or other similar titles.

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INTRODUCTION

Anthurium, known world wide for its beauty, elegance and variety of colours is an important tropical flower crop. It belongs to the family 'Araceae' and is a native of tropical zones of the Central and South America. Of the 500-600 species reported so far *Anthurium andreanum* Lind. is the most popular and economically important species, which is grown for its attractive and long lasting inflorescence (Bailey, 1963).

The global anthurium trade is valued at 50 million U.S dollars, and is next only to orchids among the tropical cut flowers. The Netherlands, Mauritius and Hawaii are the major producers of anthurium whereas Germany, Italy, Japan, France and the United States of America are the major consumers. Anthurium production in traditional producing countries has declined by 25 per cent since 1986, due to bacterial blight (Laws and Galinsky, 1996). The new production centres in other geographical locations are now contributing markebly by increasing the production of anthurium cut flowers considerably. So, there is a great potential to grow anthurium in India commercially. Though anthuriums were grown by individuals as a hobby, commercial cultivation of this crop has recently come into economic prominence in India. It can be successfully cultivated in coastal belt of South India, Western and Eastern Ghats and North Eastern Regions. If cultivated scientifically, this crop can earn valuable foreign exchange to our country. Hence, scientific information regarding its cultivation has become very relevant today.

Anthurium plants require a growing medium in good physical and chemical conditions for their proper growth and development. Highly organic, well aerated medium with good water retention capacity is suitable for anthurium cultivation. Various organic waste materials like sugarcane bagasse, tree bark, saw dust, wood shavings, coffee parchment etc., have been tried to grow anthuriums commercially. (Bhatt and Desai, 1989). In addition to these materials, decomposed coir pith, a waste product of coir industry can be used as a growing medium because of its excellent physico-chemical properties.

India has a rich wealth of coconut plantations throughout South India, generating about 7.5 million tonnes of coir pith annually, improper disposal of which is considered to create environmental problems (Savithri and Hameed Khan, 1994). Usefulness of coir pith as an organic manure and mulch has been realised after the standardization of decomposition technology using *Pleurotus* sp. (Nagarajan *et al.*, 1985). But so far no work has been done on the utilization of coir pith as a growing media for ornamental crops like *Anthurium andreanum*. A well decomposed coir pith has high water holding capacity (600-800per cent), good porosity (95per cent), nutrient retention capacity, excellent drainage and light weight. It is a source of major nutrients like potassium and micronutrients such as Fe, Mn, Zn and Cu. All these qualities favoured it as a potential growing medium.

Plant growth and development are greatly influenced by the pH in the root environment. (Arnon and Johnson, 1992), The most important factor that affects the uptake of nutrients is the pH of the growing medium. Too high and too low pH are not favourable for plant growth. Very high pH of the medium may result in unavailability of micronutrients. On the other hand, certain ions such as manganese, aluminium and iron may become toxic to plants at low pH conditions with high concentration of hydrogen ions. Most of the ornamental crops prefer low pH for better growth and quality. It is advantageous to use coir pith as growing medium because the pH of coir pith is slightly acidic (5-5.5) which is favourable for growth of ornamental plants. Due to the high buffering capacity of soil, considerable effort is needed to change the pH of the soil where as it can be easily manipulated in coir pith medium.

Keeping all these aspects in view, an attempt was made in the present investigation to generate information by setting the following objectives.

1. To identify the suitability of different growing media for the growth and development of *Anthurium andreanum*
2. To standardise the suitable pH range for the growth and development of *Anthurium andreanum* in the above media.
3. To find out the effects of media and pH on the nutrient uptake by *Anthurium andreanum*.

REVIEW OF LITERATURE

Chapter - II
REVIEW OF LITERATURE

2.1 Effects of growing media on growth and development of Horticultural crops

Greenhouse grown plants and container grown plants require growing media with good physical and chemical properties for their proper growth and yield. The current trend is towards the use of locally available organic waste materials as growing medium components. Recent research investigations on the effects of different growing media components on the physical and chemical properties of growing media and their effects on crop growth and development are reviewed in this chapter.

2.1.1 Effects of substrate components on physical properties of the growing medium

Plants grown in containers have their root system confined to a limited volume of medium. For optimal plant growth a substrate must contain enough available water and air, which is mainly dependent on the physical properties of the medium. Most of the lightweight, soilless media are combinations of two or more components formulated to achieve desirable physical and chemical properties. Many workers have attempted to modify the substrate components to provide favourable physical environment for greenhouse plants. (Bunt, 1971., Kaukovirta, 1972., Mass and Anderson, 1975).

2.1.1.1 Bulk Density

Bulk density is one of the most commonly used indices for the evaluation of soil physical conditions. This has influence on the other physical and chemical properties of a medium. (Swartz and Kardes, 1963). Optimum range of bulk density for better plant growth was reported by several workers for different plants. The range was as low as 0.35 to 0.5g cc^{-1} (Conover, 1967) to as high as 1.3g cc^{-1} (Furuta, 1969).

By inclusion of various substrate components, the bulk density of the growing medium was effectively modified. De Boodt and Verdonck (1972) reported a bulk density of 0.2 g cc^{-1} for a black peat based medium. A bulk density of 0.34g cc^{-1} has been reported for sludge by Verdonck *et al*, (1983). Brown and Pokorny (1975) stated that mixing of pine bark in proportions of 25,50 and 75 per cent with sand resulted in a curvilinear increase in bulk density of the media. The sand-coarse bark media containing 50 or 75per cent sand had a greater bulk density than comparable media containing sand-fine bark. Bilderback *et al.* (1982) reported that inclusion of peanut hulls to a potting medium decreased bulk density. By incorporating coir pith to the soil, as an amendment, the bulk density was found to be reduced (Mayalagu *et al.*, 1983). Because of large final volume and high noncapillary porosity, the bulk density of the medium which consisted of 70 per cent Kenaf + 30 per cent peat moss was less (0.096g cc^{-1}) than that of 100 per cent Kenaf. (0.114 g cc^{-1}) as reported by Yin-Tung-Wang (1994).

Evans *et al.* (1996) stated that density ranged from 0.04 to 0.008g cc^{-1} among five Philippine produced coconut coir dust sources. By the inclusion of coir pith in the potting medium the bulk density was reduced from 1.21g cc^{-1} (100per cent soil) to 0.59gcc-1 (75per cent coir pith + 25per cent soil) as reported by Baskar and Saravanan (1997). Song Cheon Young *et al.* (1996) reported that the bulk density of the growing media decreased as the content of rice hulls increased.

2.1.1.2 Pore space

One of the most important criteria for any substrate is the percentage pore space and the proportion and amount of water and air that is present in the pore space, because it decides the rate of gaseous exchange with atmosphere. Total pore space is the sum of micro and macro pore spaces. The macro pores allow the ready movement of air and percolating water. In contrast, the micro pores are mostly filled with water in moist conditions and do not permit much air movement. (Brady,1990) Since diffusion and gaseous exchange are linear functions of porosity, the porosity, pore size and rigidity of the porous medium influence root growth. (Kar and Ghildyal, 1975) Verdonck *et al.* (1983) suggested that for optimal growth conditions, it is necessary that in a substrate there is at the same time 20 per cent volume of air and 20-30 per cent volume of easily available water. They reported the total pore space of peat and bark as 93 per cent and 90 per cent respectively. De Boodt and Verdonck (1972) concluded that an ideal substrate should have a total pore space of 85 per cent air capacity.

Goh and Hayens (1977) noticed an increase in aeration by the addition of saw dust to soil media. Peanut hulls increased the particle size, total porosity and air space of the media containing peat moss and thereby increased the growth of azalea (Bilderback *et al.,* 1982). Bugbee and Frink (1986) found that the non capillary porosity of media amended with kenaf was within the range for optimum plant growth.

Peat wool blends have shown potential as potting media as it has large pore space (Lee *et al.,* 1987). Incorporation of sand with pine bark reduced the total porosity and air space to an optimum level as compared with pine bark alone. (Fonteno and Biderback, 1993).

Air filled pore space, water filled pore space and total pore space ranged from 9.5 to 12.6per cent, 73 to 80 per cent and 85.5 to 89.5 per cent (v/v) ,respectively ,for five Philippine produced coconut coir dust sources. (Evans *et al.,* 1996). A decrease in porosity was noticed when a standard peat based medium was amended with composted waste (Jaruis *et al.,* 1996) Baskar and Saravanan (1997) reported that the total pore space was improved by the addition of coir pith in the potting medium and the total pore space of coir pith was found to be 80 per cent.

2.1.1.3 Water Holding capacity

For healthy growth of a plant, it needs a medium which provides an adequate and balanced water and nutrients and abundant oxygen supply. Organic wastes addition to potting mixture is aimed to enhance the water holding capacity. Poole and Waters (1972) stated that the satisfactory level of water holding capacity of the medium must be 30 to 60 per cent by volume.

Brain (1975) observed that water holding capacity of the soil was increased by 40 per cent due to the addition of coir pith. Brown and Pokorny (1975) reported that percolation rate declined as the percentage of sand was increased in the potting media containing pine bark. Peanut hulls showed very low water holding capacity (at pressures> 10cm) due to large number of macro pores. The addition of peat moss to the peanut hull media generally caused the greatest increase in water holding capacity (Bilderback *et al.*, 1982).

Improved water holding capacity of the soils due to the incorporation of coir pith had been reported by many workers (Durai and Rajagoal, 1983, Mayalagu *et al.*, 1983; Ramaswamy and Sree Ramulu, 1983) Peat wool blends had high water holding capacity and excellent rewetting characteristics (Fonteno and Nelson,1990) A medium consisting of 50 per cent kenaf 40 per cent peat moss and 10 per cent vermiculite also had high water holding capacity (Yin-Tung-Wang,1994), Jaruis *et al.* (1996) reported that media amended with composed waste exhibited decreased water holding capacity compared with the standard peat-based medium. With increase in the proportion of composted rice hull in the growing medium, an increase in water holding capacity was reported by Song Cheon Young *et al.* (1996).

Evans *et al.* (1996) reported that the water holding capacity of five Philippine produced coconut coir dust sources ranged from 750 to 1100 per cent on dry weight basis. Saravanan and Baskar (1997) stated that the inclusion of coir pith in potting media increased water holding capacity. They found that the water holding capacity of pure coir pith was 863 per cent on dry weight basis.

2.1.2 Effects of substrate components on the chemical properties of the growing media

Several workers have proposed favourable range of chemical standards like pH, electrical conductivity, cation exchange capacity, C:N ratio etc., for optimum plant growth.

2.1.2.1 Soil reaction (pH)

Hydrogen ion concentration is of major importance to plant growth, because of its effect on the availability of nutrients, particularly minor elements. The pH range at which the availability of minor nutrients is optimal in one medium can be different from that in another medium. (Waller and Wilson, 1983). A satisfactory pH of the medium ranged from 5.5 to 6.5 (Waters *et al.*, 1970; Conover and Poole, 1974). Bunt (1976) concluded that media made from peat and mineral soils were better buffered against pH change than those containing large quantities of sand, perlite etc.

Brown and Pokorny (1975) reported an increase in pH of pine bark from 4.1 to 5.4 with the addition of sand. Goh and Haynes (1977) reported that the medium containing peat had low level of pH (4 to 5) which could be overcome by adding lime ($CaCO_3$) at the time of media preparation. Poole *et al.* (1981) stated that media amended with70 per cent or more kenaf stem core contained pH of the optimum range.

Reduction in Soil pH was noticed with the addition of raw coir pith in saline alkali soils and rice soils (Ramaswamy, *et al.*, 1983; Ramaswamy and Kothandaraman 1985).

Lemaire and Dartigues (1985) reported that inclusion spent mushroom compost with the pine bark and peat medium increased the pH as spent mushroom compost had a high pH . A marginal decline in pH due to coir pith incorporation at the early stages in incubation was observed by Ganapathi (1991).

Williams and Nelson (1992) reported that organic sources released primarily ammoniacal N, which raised the pH of the medium as much as one unit, requiring only less amount of lime stone in the medium formulation. The medium containing 100 per cent kenaf stem core had the highest initial pH of 7.17 which declined with time and increasing proportion of peatmoss (Yin-Tong-Wang, 1994). Meerow (1994) reported that there was no difference in pH between the sedge and coir based media used for growing of ornamentals.

The pH range for five Philippine-produced coconut coir dust sources was reported as 5.6-6.9 by Evans *et al.* (1996).

Jaruis *et al.* (1996) reported that there was an increase in pH when peat was replaced with composted waste or rubber tyre chips and the increase in pH was proportional to the amount of peat replaced. Song Cheon Young *et al.* (1996) stated that the pH of the medium decreased as the content of composted rice hulls increased in the medium. Baskar and Saravanan (1997) reported that the pH of the potting medium was significantly reduced by the addition of coir pith as a component of potting medium.

2.1.2.2 Soluble salt concentration (EC)

The measurement of electrical conductivity gives a meaningful estimate of the soluble salts content of a growing medium. It is important because plants vary in their tolerance to salinity levels and specific soluble salts present in it.

Goh and Haynes (1977) studied different organic wastes as components in pot mixture and found that saw dust medium had the lowest soluble salt concentration.

Coir pith addition had pronounced effect on EC. Addition of coir pith had brought down the EC from 3.2 to 0.7d Sm^{-1} in saline alkali soil (Clarson *et al.*, 1983) and from 1.37 to 0.49 d Sm^{-1}, in rice soil (Ramaswamy *et al.*, 1983) whereas an increase in EC was reported by Ganapathi (1991) in rice soils. Ravichandran (1988) reported an EC value of 15 dSm^{-1} for coir pith.

The major problem of spent mushroom compost that limits its use as a component of potting medium is its high soluble salt concentration (Lemaire *et al.*, 1985) EC of the Kenaf stem core containing media was consistently less than many commercial media as reported by Yin-Tung-Wang, (1994).

Savithri and Hameed Khan (1994) reported that the soluble salts content of coir pith observed from fully mature and older nuts was lesser than that from young nuts. Meerow (1994) stated an EC value of 1.6, 1.7 and 1.4 d Sm^{-1} for coir, sedge peat and sphagnum peat respectively. Evans *et al.* (1996) reported a range of EC values from 0.3 to 2.9 dS m^{-1} for coir pith collected from different areas. The salt content of coir pith depended mainly on the quality of water used for retting of coconut husk and hence coir pith obtained from coastal tracts showed problems of salinity (Savithri *et al.*, 1997).

2.1.2.3 Cation exchange capacity

The CEC of a substrate affects the extent to which a medium can retain, an exchangeable form of cations such as Ca^{2+}, Mg^{2+}, K^{+}, NH_4^{+} Na^{+} and most trace elements. Therefore the management and feeding of plants, will be safer and less demanding if the medium has high CEC. Poole and Waters (1972) reported a CEC of around 30 me $100g^{-1}$ as a satisfactory optimum for most of the plants.

CEC is an important chemical property which influences cation movements in soils. It acts as a nutrient reserve and buffers the medium from sudden changes in nutrient concentration and pH. (Bunt, 1988). Use of media with high CEC has been recommended under conditions of heavy leaching as a result of frequent irrigation by Conover and Poole (1983).

A study conducted by Brown and Pokorny (1975) revealed that sand had very little CEC compared to pine bark which had high CEC (52 me $100g^{-1}$), they reported that CEC declined as the percentage of sand was increased in the pine bark + sand potting medium. Puustjarvi and Robertson (1975) reported that medium containing peat moss had high CEC because of organic acids that were formed from the degradation of lignins in the plant cell wall.

Goh and Haynes (1977) reported that the medium containing sand and sawdust had low CEC value since they contained little clay or humic compounds. Conover and Poole (1983) observed higher CEC in medium containing sedge peat and pine bark when the proportion of sledge peat was more in the medium.

Clarson *et al.* (1983) and Lavanya (1986) reported that the addition of coirpith significantly improved the CEC of the soil under field investigations. Similar effect was reported under pot culture conditions by Saravanan and Nambisan (1995) and Baskar and Saravanan (1997). CEC of coir pith ranged from 38.9 to 60 me $100g^{-1}$ as reported by Evans *et al.* (1996). Incorporation of composted rice hulls to growing medium improved CEC of the medium (Song Cheon Young, 1996).

2.1.2.4 C/N ratio

Any organic material having wider C:N ratio offer stiff resistance, to microbial degradation which results in set back in the growth of crops temporarily (Smith and Elliot, 1990). Composting has been found to be the most useful method for narrowing down the C:N ratio (Thumbirajah and Kuthubutheen, 1989). Goh and Haynes (1977) reported that the C:N ratio of saw dust was extremely high (6138:1) and the resultant pot mixture also had high C:N ratio. The high ratio leads to immobilisation of native and added fertilizer nitrogen by microorganisms.

The C:N ratio of the spent mushroom compost containing media depended on the nature of the blended material. This was high in the case of bark and low in the case of french brown peat.

C:N ratio of fresh coir pith has been reported as 60.2:1 by Ravichandran, (1988). Nagarajan *et al.* (1985) proposed a successful method for composting coir pith using *Pleurotus* fungus and urea, which resulted in narrowing down of C:N ratio.

2.1.3 Effect of substrates on nutrient availability.

2.1.3.1 Macronutrients

A number of organic materials which are used as components in growing media are rich in nutrients. The favourable effects of organic matter addition including the priming effect have been reported in many investigations (Puranik *et al.*, 1978; Dormaar *et al.*, 1988).

The favourable influence of coir pith addition both in the form of raw and compost, on soil available N was documented by many workers (Loganathan and Lakshminarasimahan, 1979., Ramaswamy *et al.*, 1983; Lavanya, 1986., Loganathan, 1990., Ganapathi, 1991). According to Ramaswamy (1984) incorporation of coir pith improves the total N and N balance in the soil. Improvement in total nitrogen in sodic soil by the addition of coirpith was also reported by Ramaswamy and Kotharadaraman (1985) under field conditions. The total N,P and K content of coir pith was found to be 0.68, 0.026 and 0.36 per cent respectively. (Ravichandran, 1988). Baskar and Saravanan (1997) reported that increasing proportions of coir pith addition to soil in the preparation of potting mixtures increased the N content of the media.

A study conducted by Lemaire and Dartigues (1985) revealed that increasing proportion of spent mushroom compost in peat medium increased the nitrogen content of the medium. Ramacharan and Gerber (1982) suggested the use of crushed fruit shells of West Indian mahogany as a potting media ingredient. Chemical analysis showed that the fruit shells contained a reasonably high concentration of most nutrients except N. Carnations grown on sawdust alone had the lowest total and soluble N content of leaves compared to those grown in different combinations of peat and saw dust. (Starck *et al.*, 1991) Comparisons of substrates based on bark with conventional peat-based substrates used for ornamental plants showed that bark based substrates are low in available nitrogen, due to immobilisation of this element. To overcome this, it is recommended that fresh bark should be given a urea supplement before use or composted for several months under aerobic conditions. Bark contained substantial reserves of available K. (Meinken and Scharpf, 1988). Foster *et al.* (1983) reported that pine bark adsorbed 1.5mg of N/g of bark when NH_4 solutions were leached through the bark. They recommended the incorporation of NH_4 into a pine bark medium prior to planting to avoid low N levels from occurring due to binding of NH_4 when plants are first planted and fertilized.

Smith (1995) reported that the level of Mg in coir was similar to that in peat, while Ca, Na and K were higher with K being many times higher. Savithri *et al.* (1993) indicated that since coir pith contain an appreciable amount of potassium, attempts could be made to use coir pith as K source for crops. In this attempt, K fertilizer savings to the tune of about 50 per cent were obtained in field crops as reported by Savithri and Hameed Khan (1994).

Robins *et al.* (1986) reported under pot culture conditions, mushroom compost addition as pot mixture component enhanced the available K status even after three years. Ground tree fern, a growing media component used in New Zealand had lower levels of most plant nutrients except for K and Ca, and it fixed more N than peat over a short period, but then gradually released it (Prasad and Fietje, 1989).

2.1.3.2 Micronutrients

Coirpith is a good source of micronutrients like Fe, Mn, Zn and Cu. The addition of coirpith to soil increased the availability of these micronutrients under field conditions (Krishnan, 1986; Mulhulakshmi, 1988; Ganapati, 1991). Coirpith samples contained Fe, Mn, Zn, B and Cu and 0.01 -0.07mg/l as reported by Evans *et al.* (1996).

In experiments with chrysanthemums, the high Mn content of tree bark medium led to Fe deficiency chlorosis (Meinken and Scharpf, 1988). Calvin Chang *et al.* (1991) found that the leaf nutrient contents (Fe, Mn and Zn) of potted ornamentals like dogwood and forsythia were increasing with the addition of spent mushroom compost in media containing pine bark.

2.1.4 Effects of substrates on growth and yield of ornamental crops

2.1.4.1 Anthurium

Anthuriums require a highly organic, well aerated medium with good water retention capacity. An ideal medium should have good water holding capacity, high porosity and good aeration. Various natural derivatives like sugarcane bagasse, sawdust, tree bark wood shavings etc were tried to grow anthurium commercially (Prasad *et al.*, 1997).

Kamemoto and Nakasone (1953) found that coffee parchment and composted sugarcane bagasse gave best growth and production of anthurium among nine materials tested. Nakasone and Kamemoto (1957) tested further three materials individually at various combinations. They reported that a 1:1 mixture of wood shavings and soil, a 5:1 mixture of wood shavings and cow manure and a shredded tree fern fibre gave best results in flower production, flower stem length and flower size.

Higaki and Poole (1978) suggested that sugarcane bagasse was the best media for production, stem length and size of flower followed by wood shavings and black cinder. Nikolova and Zafirova (1980) reported that a medium containing peat, pine bark and perlite in the ratio 2:1:1 was the most suitable medium producing 98.8 per cent top grade flowers and 18 per cent higher yields than medium containing peat.

Pot trials conducted by Turski *et al.* (1983) using different substrates comprising of high peat, low peat, perlite, loam, sand, crushed brick and / or sphagnum moss in different combinations and proportions showed that the best substrates for anthuriums were generally those in which the basic component was high peat. The tallest plants with the highest number of leaves were found on a 2:1:1 mixture of high peat, perlite and sphagnum moss.

Higaki and Imamara (1985) studied the performance of wood products as media for culture of anthurium. For flower production, flower stem length and flower size effectiveness decreased in the order of wood bark > wood chips > baggasse = red wood bark. Anthurium plants performed better in ground tree fern (*Dicksonia sqarrosa*) which had the advantage of high level of aeration and resistance to breakdown during cropping. (Prasad and Fietje 1989).

Holcroft and Laing (1995) reported that among the different grades of pine bark available in South Africa, anthurims grown in coarse potting mix performed best.

2.1.4.2 Other ornamental crops

High quality sedge or sphagnum peat moss, pine bark and sand in several combinations had provided good plant growth at economic cost (Joiner and Conover, 1967; Poole and Water, 1972; Brown and Pokorny, 1975).

Kaukovirta (1980) reported that the development of carnation was faster on peat substrate than on mineral wool. Bilderback *et al.* (1982) reported that shoot dry weight, root dry weight and per cent growth of azalea were greater in pea nut hull containing media and the addition of peat moss to the container media tended to produce less growth. Rathier (1982) recommended 33 per cent of decomposed mushroom compost in media for increased greenhouse production of chrysanthemum and bedding plants.

Pasini *et al.* (1984) reported that the best growth of *Codiaeum variegatum* in terms of plants height, leaf members and root and shoot dry weight were obtained with medium containing 25 per cent by of 2-3mm particle diameter + 45 per cent peat + 30 per cent beach leaves. For *Syngonium podophyllum* the best media contained 50 per cent clay of 3-8mm particle diameter + 30 per cent peat + 20 per cent beach leaves.

In pot trials with *Begonia semperflorens*, *Pelargonium hortorum* and *Tagetes patula*, shoot fresh weight and plant height were maximum in substrates composed of 60 per cent poorly structured peat + 40 per cent undecomposed sphagnum peat or 60 per cent well structured peat + 40 per cent undecomposed sphagnum peat (Abad *et al.*, 1989). A 1:1 mixture of peat, poplar bark and rose compost gave the best results with *Dieffenbackia* cultivar Carina (Pasini *et al.*, 1989).

Laiche and Nash (1990) reported that the best growth of rhododendron hybrid was obtained with composted rice hulls as a primary organic component of growing medium. Backers and Kampf (1991) reported that the best growth and development of *Pilea cadierei* were observed in a medium containing town refuse compost and peat in the ratios 50:50 or 33:67. Saravanan and Nambisan (1995) reported that coir pith could be effectively utilized as a potting medium component to raise the semiepiphytes like Begonia and Neoregelia.

Tripepi *et al.* (1996) evaluated composted pulp and paper sludge as a substitute for peat moss in container media used for growing *Syringa valgaris* and *Acer tataricum* subsp. *ginnata*. They reported that all plants in compost amended media grew as well as or better than those in peat amended media regardless of species. Song Cheon Young *et al*, (1996) reported that the number of leaves, plant height, plant diameter, leaf area and fresh weight of petunias grown in media amended with 30-60per cent composted rice hulls were higher than those grown in media amended with 0, 15, or 75per cent composted rice hulls.

Stamps and Evans (1997) observed that the plant quality, fresh mass and overall mass were higher when *Dieffenbachia maculata* Camille was grown in coir dust containing media when compared to sphagnum peat containing media.

2.2 Effect of pH on growth, yield and nutrient availability

Plant growth and development are greatly influenced by alterations of pH in the root environment. (Arnon and Johnson, 1942; Islam *et al.*, 1980). For many crops optimal pH ranges have been established. Peterson (1980) reported that for inert and organic soil less media, optimum pH values are about one unit lower than the optimum pH characterised for mineral soils. Leaf chlorosis, reduced root growth and decay, stunted shoot growth, poor flower development and other symptoms associated with uptake, transport and function of mineral ions, frequently appear at inappropriate pH conditions in the rhizosphere (Arnon. and Johnson, 1942) this is due to the influence of pH on the solubility and exchangeability of mineral nutrient ions.

2.2.1 Effect of pH on growth, yield, and quality of ornamental crops

The pH in the root environment is an important factor that affects growth and yield or ornamental crops. Willumsen (1986) reported that the fastest rooting and subsequent growth of *Hedera helix* grown in peat substrate was observed when pH in the root zone was between 4 to 6. He reported that in the case of *Exacum affine* the highest fresh and dry matter yields and earliest flowering were obtained in a pH range of 5 to 6.

Beel and Schelstreate (1987) reported that growth of *Dieffenabachia* sp. cv. Camilla and *Ficus benjamina* grown on peat substrate was best at pH level between 4.5 to 6. They noticed that plants tended to be shortest at lowest level of pH ie. 3.5 to 4.5.

2.2.2 Effect of pH on nutrient availability

The availability of nutrients to the plants greatly depend on the pH of the growing medium. Too high and too low pH is not favourable for the uptake of nutrients. Under high pH conditions, the availability of micronutrients like Fe, Mn, Cu, Zn etc become hampered. On the other hand, certain ions such as manganese, aluminium and iron will become excess and even toxic to plants at low pH conditions (Foy *et al.*, 1978). High concentration of hydrogenous ions may, also have a direct affect on root function by affecting negatively the permeability of root cell membranes and impose leakage of various ions from the roots (Moore, 1974; Yan *et al.*, 1992). A rapidly developed decay of the root system has been observed when rose plants were transferred for 48 hrs from low (6) to high (7.5) pH conditions (Zieslin and Snir, 1989).

Cox and Bartley (1988) reported that the combination of low pH and no molybdenum supplement in the nutrient solution resulted in Mo deficiency symptons such as intervenal chlorosis or marginal necrosis on poinsettia leaves. Leaf contert of Mo was at or below the standard value (0.5 ppm) with the combination of low pH and no added Mo.

Daniels and Wright (1988) reported that cation exchange capacity of pine bark increased regularly from 38 to 98 me/100g between pH 4 and 7 and the increase was greater for divalent exchange than for monovalent cations. They concluded that Ammonium/K CEC was higher than K/NH_4 , due to enhanced NH_4 adsorption by carboxyl groups in the CEC complex. High levels of alkalinily altered both nutrient availability in the growing medium and the plant tissue nutrient content in the case of chrysanthemum grown in a 10:7:3 sphagnum peat + perlite + sand medium as reported by Kramer and Peterson (1990).

Harbaugh and Woltz (1991) observed that leaf chlorosis, intervenal chlorosis, tip and leaf edge necrosis and stunted growth of *Eustoma grandiflorum* seedlings were associated with a growing medium pH of 5 to 5.4. They further noticed that leaf tissue Zn concentration was extremely high (1050 mg/kg) at a growing medium pH of 5, but other macro and micronutrients in leaves were at normal levels.

Harbaugh (1995) reported that the accumulation of foliar Fe was reduced to levels ranging from 59 to 196 ppm and prevented Fe toxicity symptoms when *Pentas lanceolata* was grown in a medium with pH range of 6.4 to 6.7. Plants with toxicity symptoms showed extremely high levels of foliar Fe (649 to 1124 ppm) in leaves, when pH was 6.4 to 6.7 in the media.

Voogt (1995) suggested that the positive yield effect of carnation grown in rock wool, at lower pH levels could be caused by increased uptake of micronutrients except molybdenum.

MATERIAL AND METHODS

Chapter III

MATERIALS AND METHODS

The present investigations were carried out to find out the most suitable preparation of coir pith in the growing media and the most appropriate pH level for the growth and development of *Anthurium andreanum* Lind. The plants were maintained in the humidity controlled greenhouse in the Orchid Laboratory of the Indian Institute of Horticulture Research, Hessaraghatta, Bangalore. The experimental site is located at an elevation of 890 m above mean sea level and is at a latitude of 13^0N and a longitude of $77^0$31'E. The materials used, technology adopted and observations noted during the course of this study are presented in this chapter.

3.1 Experimental details

3.1.1 Experimental material

The variety of *Anthurium andreanum* used in this experiment is 'Liver Red'. Three months old, tissue cultured plants are obtained from Ramco Biotech and planted in 9 inch pots on 18^{th} August 1998 and maintained in greenhouse under 80-90 per cent shade, 60 per cent relative humidity and 25-30^0C temperature.

3.1.2 Details of Experimental design

Experimental design	:	Factorial completely randomized design
Number of factors	:	Two (5 types of growing media with coir pith as base and 3 levels of pH).
Treatment combinations	:	15
Replications	:	3

3.1.2.1 Growing media

Well decomposed coir pith, after washing thoroughly with good quality water, to remove the soluble salts was obtained from Varsha Agro Ltd. Different proportions of coir pith, along with normal potting medium (containing soil, sand and FYM in the ratio 2 : 1 : 1 v/v) were used to prepare different growing media. The growing media treatments are given below.

T_1 - 100 per cent coir pith

T_2 - 75 per cent coir pith + 25 per cent normal potting medium (v/v)

T_3 - 50 per cent coir pith + 50 per cent normal potting medium

T_4 - 25 per cent coir pith + 75 per cent normal potting medium

T_5 - 100 per cent normal potting medium

3.1.2.2 pH levels

The pH levels maintained in the media are as follows :

P_1 - 4.5 – 5.5

P_2 - 5.5 – 6.5

P_3 - 6.5 – 7.5

In each growing medium treatment, three pH levels were maintained. There are 15 treatment combinations and in each treatment combination, 9 plants were maintained.

Details of treatment combinations are given below :

T_1P_1 - 100 per cent coir pith and pH of 4.5 –5.5

T_1P_2 - 100 per cent coir pith and pH of 5.5 –6.5

T_1P_3 - 100 per cent coir pith and pH of 6.5 –7.5

T_2P_1 - 75 per cent coir pith + 25 per cent normal potting medium and pH of 4.5 –5.5

T_2P_2 - 75 per cent coir pith + 25 per cent normal potting medium and pH of 5.5 –6.5

T_2P_3 - 75 per cent coir pith + 25 per cent normal potting medium and pH of 6.5 –7.5

T_3P_1 - 50 per cent coir pith + 50 per cent normal potting medium and pH of 4.5 –5.5

T_3P_2 - 50 per cent coir pith + 50 per cent normal potting medium and pH of 5.5 –6.5

T_3P_3 - 50 per cent coir pith + 50 per cent normal potting medium and pH of 6.5 –7.5

T_4P_1 - 25 per cent coir pith + 75 per cent normal potting medium and pH of 4.5 –5.5

T_4P_2 - 25 per cent coir pith + 75 per cent normal potting medium and pH of 5.5 –6.5

T_4P_3 - 25 per cent coir pith + 75 per cent normal potting medium and pH of 6.5 –7.5

T_5P_1 - 100 per cent normal potting medium and pH of 4.5 –5.5

T_5P_2 - 100 per cent normal potting medium and pH of 5.5 – 6.5

T_5P_3 - 100 per cent normal potting medium and pH of 6.5 –7.5

3.1.3 Maintenance of pH

The three pH levels (P_1 – 4.5-5.5 ; P_2 – 5.5-6.5 ; P_3 – 6.5-7.5) in each growing medium were maintained using acidifying material like nitric acid and basic material like calcium carbonate (ground lime stone). Since the initial pH of T_5 (100 % normal potting medium) was very high (8.2), Ammonium sulphate was added to all the pots containing T_5 medium at the rate of 75 g /pot. Addition of Ammonium Sulphate considerably reduced the pH of the medium.

The pH of the media are checked at fortnightly intervals using pH meter with glass calomel combined electrode (Elico, Model LI-120). Based on the pH value obtained pH of the growing medium was adjusted to the targeted pH levels. Concentrated nitric acid (HNO_3) added at the rate of 2 ml and 1 ml per litre of water was used in the case of P_1 (4.5-5.5) and P_2 (5.5-6.5) treatments respectively, to bring down the pH to desired levels. Three hundred ml of this acid water solution was added to each pot whenever necessary. To maintain pH levels in P_3 range (6.5-7.5) ground calcium carbonate was used at the rate of 25 g per pot for T_1 P_3(100 % coir pith) and 12.5 g /pot for T_1P_2 (100 % coir pith + pH of 5.5-6.5) as the pH of coir pith was found to be low. For P_3 range in T_2(75 % coir pith + 25 % normal potting medium), T_3 (50 % coir pith + 50 % normal potting medium) and T_4 (25 % coir pith + 75 % normal potting medium) 5g of calcium carbonate per pot was added to maintain the pH in the range of 6.5-7.5.

Electrical conductivity of the media was checked at monthly intervals using conductivity bridge (Elico type CM82T).

The average pH and EC values maintained in the media during the experiment is given in the table.

pH and EC maintained in the media

Treatments	Targeted pH level	Average pH	Average EC
T_1P_1	4.5-5.5	4.85	0.51
T_1P_2	5.5-6.5	6.13	0.55
T_1P_3	6.5-7.5	6.94	0.71
T_2P_1	4.5-5.5	5.19	0.46
T_2P_2	5.5-6.5	5.65	0.45
T_2P_3	6.5-7.5	6.73	0.43
T_3P_1	4.5-5.5	5.67	0.39
T_3P_2	5.5-6.5	6.20	0.40
T_3P_3	6.5-7.5	6.70	0.45
T_4P_1	4.5-5.5	6.10	0.28
T_4P_2	5.5-6.5	6.62	0.28
T_4P_3	6.5-7.5	7.00	0.31
T_5P_1	4.5-5.5	5.24	0.30
T_5P_2	5.5-6.5	5.80	0.33
T_5P_3	6.5-7.5	6.50	0.51

3.1.4 Application of nutrient solution

For proper growth of the plants, nutrients are applied in balanced amounts through irrigation water. Composition of nutrient solution applied to the plants is give below.

Composition of nutrient solution (for 100 litres of water)

Macro nutrients

Ammonium nitrate	-	33 g
Diammonium phosphate	-	33 g
Potassium sulphate	-	33 g
Calcium nitrate	-	120 g
Magnesium sulphate	-	80 g

Micro nutrients

Iron sulphate	-	1 g	
Manganese sulphate	-	0.8 g	
Borax	-	0.25 g	
Zinc sulphate	-	1.25 g	
Copper sulphate	-	0.2 g	
Ammonium molybdate	-	0. 05 g	(George *et al.*, 1987)

100 ml of nutrient solution containing major and secondary nutrients was applied to each plant in alternate days. Micro-nutrients solution was applied once in a week.

3.2 Plant growth and development analysis

Growth parameters like number of leaves, petiole length, petiole thickness, leaf area, number of suckers, number of leaves per sucker, number of roots, fresh weight and dry weight of roots and shoots etc. were recorded from plants of each treatment. The observations were recorded at 2, 4, 6 and 8 months after planting. Since anthurium has long juvenile period, detailed observations on flower characters were not taken.

3.2.1 Number of leaves

Total number of well developed and fully grown leaves in each plant was recorded at 2, 4, 6 and 8 months after planting. Unfolded leaves, young developing leaves and old drying leaves were not counted.

3.2.2 Petiole length

Length was measured from the base of the petiole to the tip from two petioles in each plant and average of these two was worked out and expressed in centimeters.

3.2.3 Petiole thickness

Diameter of the petiole was measured at just below the leaf lamina with the help of vernier calipers and expressed in centimeters.

3.2.4 Total leaf area

Leaf area was estimated through linear parameters like length and breadth of leaf using the equation leaf area = L X B X 0.85 where L is the length and B is the breadth of the leaf. The factor 0.85 was derived by dividing the actual leaf area measured accurately from the graph paper by the leaf area computed from length and breadth leaf (Lila *et al.*, 1996).

Leaf areas of two youngest fully matured leaves were calculated from each plant and average was worked out. Total leaf area was determined by multiplying the average leaf area with total number of leaves. Leaf area was expressed in centimeter square (cm^2).

3.2.5 Number of suckers

Suckering was noticed 5th months after planting. Hence, number of suckers from each plant was recorded at 6th and 8th month after planting.

3.2.6 Number of leaves / sucker

Number of fully unflolded leaves from each sucker was recorded at 6th and 8th month after planting.

3.2.7 Number of roots

The plants were uprooted at the end of the experiment (8 months after planting). Number of primary roots and secondary roots were recorded by visual counting.

3.2.8 Fresh weight and dry weight

Plants were uprooted from each treatment, 8th month of planting and fresh weight was recorded in grams. These plants were dried in hot air oven at 60^0C and the dry weight was recorded after complete drying.

3.2.9 Leaf development stages

Leaf development, was classified into four stages such as appearance of bud, emergence of bud from the leaf sheath, complete unfolding of leaf, development of green colour and full size of leaf. Number of days required for completing each stage was recorded.

3.2.10 Water potential of leaves

Water potential of the youngest mature leaf from each treatment was determined using Dew point micro-voltmeter (Model No. HR 33T, Wescor, USA) at 4 and 8 months after planting and was expressed in bars. The same leaves were used for nutrient analysis.

3.2.11 Nutrient uptake studies

The uptake of phosphorus, potassium, calcium, magnesium, sulphur, iron, manganese, copper, zinc and sodium were calculated by multiplying the nutrient contents with the dry weight of plants and expressed as g per kg of dry weight.

3.3 GROWING MEDIA ANALYSIS

3.3.1 Collection of samples

Growing media were prepared and initial composite samples were collected from each media before the commencement of the experiment and stored in polythene bags to study the physical and chemical properties.

For checking pH and EC media samples were taken from root zone depth (5-8 cm) at fortnightly intervals.

3.3.2 Analysis of growing media samples

Analytical methods adopted are furnished here under :

Sl. No.	Parameters	Method	Author
1.	Physical properties (particle density, bulk density, total pore space and maximum water holding capacity	Keen-Raczkowski brass cup method	Piper (1966)
2.	PH	Potentiometry (Media : water, 1 : 2)	Jackson (1973)
3.	Electrical conductivity	Conductometry (media : water, 1 : 2)	Jackson (1973)
4.	Cation exchange capacity	Using neutral normal ammonium acetate	Schollenbeger and Dreibelbis (1930)
5.	Available nitrogen	Alkaline permanganate method	Subbiah and Asija (1956)
6.	Available phosphorus	Bray's l method	Jackson (1973)
7.	Available potassium	Neutral normal ammonium acetate	Stanford and English (1949)
8.	Exchangeable Ca	Versenate titration	Jackson (1973)
9.	Exchangeable Mg	Versenate titration	Jackson (1973)

10.	Exchangeable K	Flame photometry	Toth and Prince (1949)
11.	Exchangeable Na	Flame photometry	Toth and Prince (1949)
12.	DTPA extractable micronutrients (Fe, Mn, Zn, Cu)	0.005 M DTPA extraction. Atomic absorption spectrophotometer	Lindsay and Norvell (1978)

3.4 Leaf analysis

For leaf analysis, index leaf i.e., youngest mature leaf was collected at four months after planting. The samples were oven dried at 70^{0}C and ground using mortar and pestle. These samples were analysed for nutrients like phosphorus, potassium, calcium, magnesium, sulphur and micro nutrients like Fe, Mn, Zn and Cu. The analytical methods followed for the processed plants samples are presented below.

Sl. No.	Parameters	Method	Author
1.	Phosphorus	Vanado molybdate	Jackson (1973)
2.	Potassium	Flame photometry	Jackson (1973)
3.	Calcium	Flame photometry	Jackson (1973)
4.	Magnesium	Flame photometry	Jackson (1973)
5.	Sulphur	Turbidometry	Jackson (1973)
6.	Micronutrients (Fe, Mn, Zn, Cu)	Atomic absorption spectrophotometer	Lindsay and Norvell (1978)

3.5 Statistical Analysis

The analytical data observed in the study were subjected to statistical analysis to determine the effects due to treatments. Fisher's (1963) method of analysis of variance was adopted for the analysis and interpretation of data as outlined by Panse and Sukhatme (1967). Correlation studies were conducted to determine the correlation between leaf nutrient content and vegetative characters.

EXPERIMENTAL RESULTS

Chapter -IV

EXPERIMENTAL RESULTS

Results of the experiments carried out to find out the effect of different growing media and different levels of pH on growth and development of *Anthurium andreanum* are presented in this chapter.

4.1 Physico-chemical properties of growing media

The physico-chemical properties of the growing media are presented in Table – 1. The coir pith which was used as one of the major components in the preparation of different growing media had a bulk density of 0.1 g cc^{-1} with 96 per cent pore space and had a maximum water holding capacity of 600 per cent. The pH of the coir pith was slightly acidic (5.5) and it had 0.16 dSm^{-1} EC (Electrical Conductivity) and 69.02 C mol kg^{-1} CEC(Cation Exchange Capacity). The available N, P, K were 891, 56 and 170 μg/g, respectively. The DTPA (Diethylene triamine tetra acetic acid) extractable micronutrients like Fe, Cu, Zn, Mn were 360, 6.7, 84 and 94 μg g^{-1}, respectively. It also contained 13.9 Cm kg^{-1} of exchangeable Ca, 4.1 Cm $kg^{-1}$of exchangeable Mg, 5.3 Cm kg^{-1} of exchangeable K and 3.4 Cm kg^{-1} of exchangeable Na.

The normal potting medium containing soil, sand and FYM in the ratio 2 : 1 : 1 had bulk density of 1.1 g cc^{-1}, pore space of 40 per cent and CEC of 11.33 c mol kg^{-1}. The available N content was 130 μg/g while P and K were 175 and 570.63 μg/g, respectively. The micronutrient contents were 18, 2.3,

Table 1 : Physico-chemical properties of potting media

Sl. No	Properties	Unit	T_1	T_2	T_3	T_4	T_5
1.	Bulk density	g cc^{-1}	0.1	0.5	0.7	0.9	1.1
2.	Particle density	g cc^{-1}	1.3	1.5	2.6	2.6	2.6
3.	Water holding capacity	%	600	176	100	66	51
4.	Pore space	%	96	90	75	65	40
5.	Volume of expansion	%	97.7	91.4	43.5	33.5	18.2
6.	Soil reaction	pH	5.5	6.0	6.6	7.0	7.4
7.	Electrical conductivity	dSm^{-1}	0.16	0.14	0.17	0.14	0.14
8.	CEC	Cm kg^{-1}	69.02	21.93	15.98	12.32	11.33
9.	Available N	µg g^{-1}	891	335	211	169	130
10.	Available P	µg g^{-1}	56	127	186	235	175
11.	Available K	µg g^{-1}	1570	674	672	709	570
12.	Exchangeable Ca	Cm kg^{-1}	13.9	4.8	4.7	4.6	4.6
13.	Exchangeable Mg	Cm kg^{-1}	4.1	1.3	1.2	1.2	1.2
14.	Exchangeable K	Cm kg^{-1}	5.3	2.3	1.8	1.7	1.5
15.	Exchangeable Na	Cm kg^{-1}	3.4	1.2	0.60	0.5	0.4
16.	DTPA – Fe	µg g^{-1}	360	80	35	25	18
17.	DTPA – Mn	µg g^{-1}	94	59	45	30	23
18.	DTPA – Zn	µg g^{-1}	84	20	15	15	14
19.	DTPA – Cu	µg g^{-1}	6.7	2.2	1.9	2.0	2.3

T_1 = 100 % coir pith

T_2 = 75 % coir pith + 25 % normal potting medium

T_3 = 50 % coir pith + 50 % normal potting medium

T_4 = 25 % coir pith + 75 % normal potting medium

T_5 = 100 normal potting medium

14 and 23 μg/g respectively for DTPA extractable Fe, Cu, Zn and Mn. The exchangeable Ca, Mg, K and Na contents were 4.6, 1.2, 1.5 and 0.4 Cm kg^{-1}, respectively.

The changes of different parameters due to the addition of coirpith in varying proportions with the normal potting medium are given in the Table. Due to the addition of increasing proportions of coir pith in the media, bulk density, particle density and pH were decreased. Water holding capacity, pore space, CEC, available N, K exchangeable Ca, Mg, K, Na and DTPA extractable micronutrients were found to be increasing with increase in the proportion of coir pith in the mdium.

4.2 Effect of growing media and pH on growth parameters

The effect of growing media and pH on vegetative parametes like total leaf area, leaf number, petiole length, petiole thickness, number of suckers per plant, number of leaves per sucker, number of roots, fresh weight and dry weight of roots and shoots etc were studied (Tables 2a to 13 ; Plates 1 to 4).

4.2.1 Total Leaf Area

The data on total leaf area at different growth stages as influenced by growing media and pH are presented in the Tables 2a,2b and2c.

The different growing media significantly influenced the leaf area at different growth stages i.e., 2, 4, 6, and 8 months after planting. Plants grown in 100 per cent coir pith medium (T_1) showed maximum leaf area at all the

Table 2 a : Effect of growing media and pH on total leaf area (cm^2) at different growth stages in anthurium.

Treatments	Months after planting			
	2	4	6	8
Growing media				
T_1	198.89[a]	478.88[a]	753.72[a]	837.83[a]
T_2	205.67[a]	469.33[a]	624.16[b]	645.56[b]
T_3	159.97[b]	302.09[b]	440.83[c]	421.56[c]
T_4	144.12[b]	274.94[c]	365.64[d]	319.31[d]
T_5	102.46[c]	160.81[d]	217.13[e]	222.67[e]
SEm ±	7.58	7.162	8.08	8.74
CD at 5 %	21.89	20.68	23.32	25.23
pH levels				
P_1	165.57	367.29[a]	530.66[a]	524.25[a]
P_2	166.17	352.22[a]	501.95[b]	531.71[a]
P_3	154.92	292.11[b]	408.28[c]	412.20[b]
SEm ±	5.872	5.55	6.25	6.77
CD at 5 %	NS	16.02	18.061	19.55

T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium
P_1 = pH 4.5-5.5
P_2 pH 5.5-6.5
P_3 = pH 6.5-7.5
NS = Non significant

Treatments means with different superscripts are significantly different at P = 0.05

Table 2b : Interaction effect of growing media x pH on total leaf area (cm^2) at 2 and 4 months after planting in anthurium

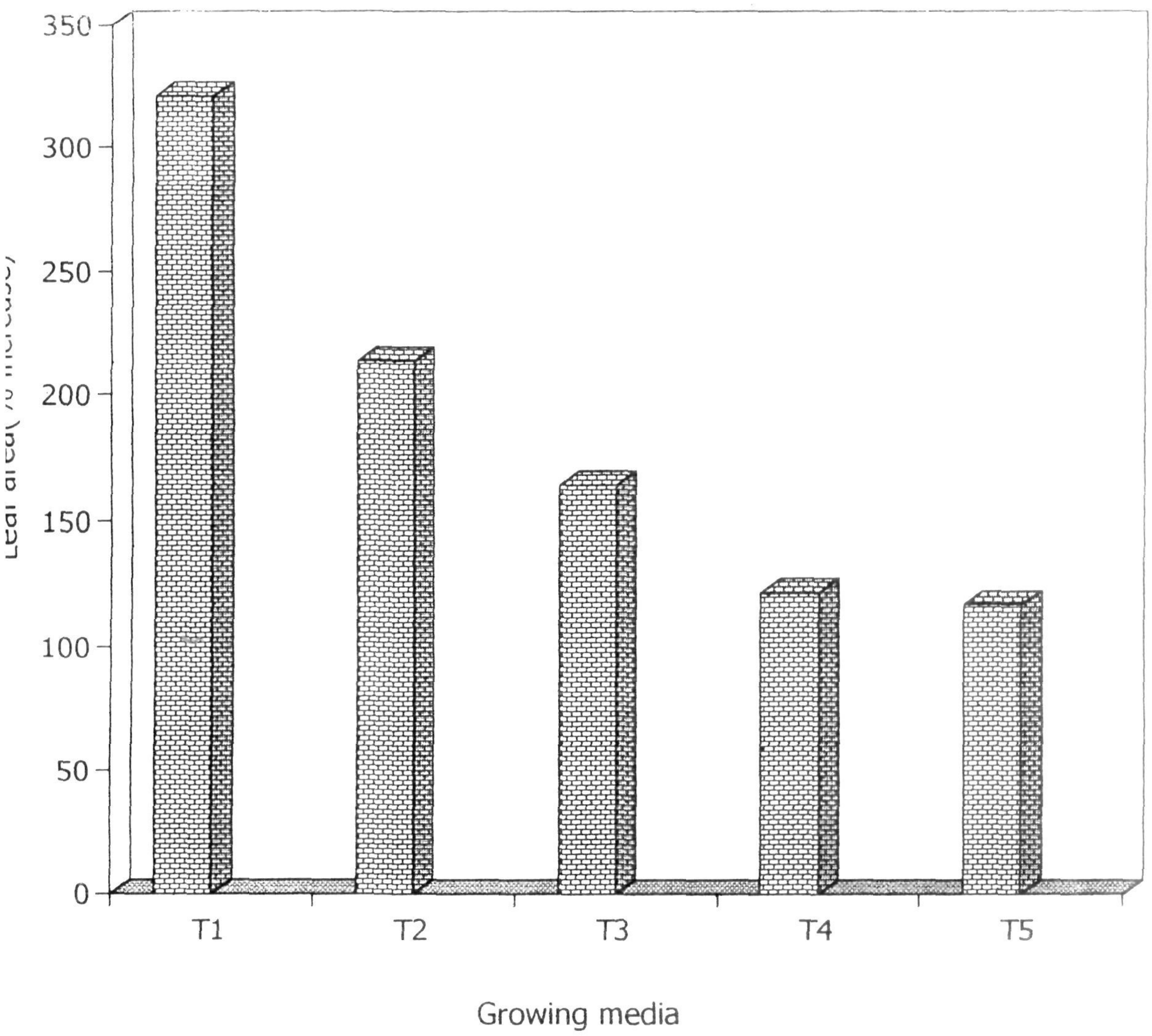
Treatments	**2 months after planting**			**4 months after planting**		
	P_1	P_2	P_3	P_1	P_2	P_3
T_1	180.56	208.30	207.80	477.8^{c}	504.63^{bc}	454.20^{c}
T_2	203.33	212.27	201.41	478.77^{c}	547.48^{a}	381.73^{d}
T_3	164.26	160.18	155.47	344.4^{e}	294.73^{f}	267.13^{f}
T_4	145.80	150.83	135.73	272.47^{f}	275.30^{d}	277.07^{f}
T_5	133.90	99.27	74.20	263.03^{d}	138.97^{g}	80.43^{h}
SEm $\pm$	13.131			12.41		
CD at 5 %	NS			35.82		

NS = Non significant
Treatments means with different superscripts are significantly different at $P = 0.05$

Table 2c : Interaction effect of growing media x pH on total leaf area (cm^2) at 6 and 8 months after planting in anthurium

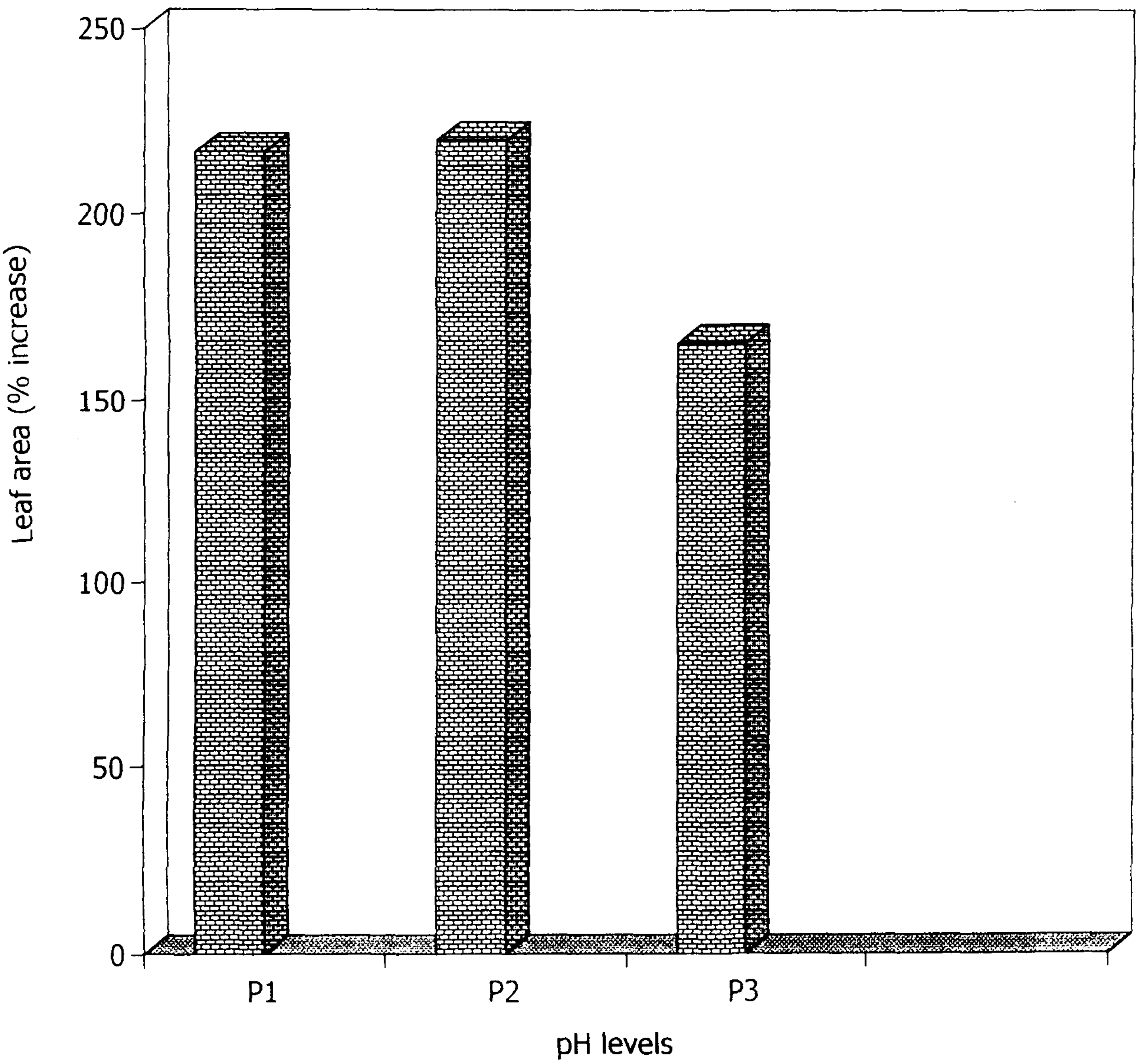
Treatments	**6 months after planting**			**8 months after planting**		
	P_1	P_2	P_3	P_1	P_2	P_3
T_1	724.53^{b}	873.10^{a}	663.53^{c}	816.17^{b}	1024.0^{a}	673.33^{d}
T_2	714.67^{b}	651.63^{c}	506.17^{d}	722.13^{c}	682.53^{d}	532.00^{e}
T_3	463.87^{e}	450.03^{e}	408.60^{f}	398.67^{f}	490.00^{e}	376.00^{f}
T_4	386.80^{g}	365.83^{gh}	344.30^{j}	329.27^{g}	305.33^{g}	323.33^{g}
T_5	363.43^{gh}	169.17^{i}	118.80^{j}	355.00^{fg}	156.67^{h}	156.33^{h}
SEm $\pm$	13.99			15.14		
CD at 5 %	40.38			43.71		

Treatments means with different superscripts are significantly different at $P = 0.05$



T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium

Fig. 1 : Percentage increase in total leaf area over a period of 6 months (2 MAP to 8 MAP) in different growing media



P_1 = pH 4.5-5.5
P_2 = pH 5.5-6.5
P_3 = pH 6.5-7.5

Fig. 2: Percentage increase in total leaf area over a period of 6 months in different pH levels

growth stages. At 2 and 4 months after planting, leaf area of plants grown in 100 per cent coir pith (T_1) and 75 % coir pith + 25 % normal potting medium (T_2) were at par and were significantly different from other treatments. Leaf area of plants grown in 100 per cent coir pith was significantly superior to other treatments at 6 and 8 months after planting (753.72 and 837.83 cm^2, respectively). The difference between growing media were more obvious with respect to leaf area, at later stages of growth. Percentage increase in total leaf area over a period of six months was highest in T_1 medium (321%) which was followed by T_2, T_3, T_4 and T_5 medium (Fig 1).A decrease in leaf area was noticed in T_5 medium over a period of six months, due to faster drying of older leaves and slow development of new leaves in this medium. The new leaves produced from plants grown in T_5 media were smaller in size.

The different levels of pH (P_1 – 4.5-5.5 ; P_2 –5.5-6.5 and P_3-6.5-7.5) did not show significant influence on the leaf area at initial stage (2 months after planting). However, with the progress of growth, there was a marked influence of these treatments on leaf area. Maximum leaf area was observed for P_1 (4.5-5.5) at 4 months and 6 months after planting and P_2 (5.5-6.5) at 8 months after planting. Throughout the growth period lowest leaf area was observed for P3 (6.5-7.5). Percentage increase in leaf area from 2 months to 6 months after planting was maximum in P_2. The interaction effect of growing media and pH on leaf area was observed to be non-significant at 2 months after planting (Table 2b). At 4, 6 and 8 months after planting, the interaction effects were significant (Table 2c). Maximum leaf area was recorded for 100 per cent coir pith (T_1) with pH of 5.5-6.5 (P_2) at 6 months after planting (873.1 cm^2) and 8 months after planting (1024 cm^2).

4.2.2 Number of leaves

The data in Table 3a presents the influence of growing media and pH on the number of leaves.

Significant differences were recorded with respect to number of leaves in different growing media at all the stages of plant growth. During the initial stages of plant growth i.e., 2 and 4 MAP, maximum number of leaves was observed in T_2 medium (75 % coir pith + 25 % normal potting medium). However, at later stages of growth (6 and 8 MAP) highest number of leaves was noticed in T_1 medium (100 % coir pith). A steep increase in the number of leaves was recorded in the case of T_1 medium (100 % coir pith). The number of leaves in T_3,$T_4$and T_5 showed a decrease over a period of six months. This was due to faster drying of older leaves and slow development of new leaves in these media.

The number of leaves differed significantly with respect to pH levels also. Highest number of leaves were observed for P_1 (4.5-5.5) during the entire growth period.

The interaction effects of different growing media and pH levels on leaf number were significant at all growth stages (Tables 3b and 3c). Initially (2 and 4 MAP) plants grown in T_2 media (75 % coir pith + 25 % normal potting medium) with pH of 5.5-6.5 (P_2) produced maximum number of leaves ; while

Table 3a : Effect of growing media and pH on number of leaves at different growth stages in anthurium

Treatments	Months after planting			
	2	4	6	8
Growing media				
T_1	6.1[c]	6.9[b]	7.4[a]	8.0[a]
T_2	6.8[a]	7.6[a]	7.1[b]	7.2[b]
T_3	6.2[c]	6.8[c]	6.7[c]	6.1[c]
T_4	6.4[b]	6.7[d]	6.2[d]	5.2[d]
T_5	6.1[c]	5.3[e]	5.2[e]	4.4[e]
SEM	0.067	0.03	0.07	0.066
CD at 5 %	0.192	0.09	0.211	0.19
pH levels				
P_1	6.4[a]	7.0[a]	6.9[a]	6.5[a]
P_2	6.4[a]	6.7[b]	6.6[b]	6.3[b]
P_3	6.1[b]	6.3[c]	6.1[c]	5.8[c]
SEm ±	0.052	0.023	0.057	0.051
CD at 5 %	0.15	0.067	0.163	0.147

T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium
P_1 = pH 4.5-5.5
P_2 = pH 5.5-6.5
P_3 = pH 6.5-7.5

Treatments means with different superscripts are significantly different at P = 0.05

Table 3b : Interaction effect of growing media x pH on number of leaves at 2 and 4 months after planting in anthurium

Treatments	2 months after planting			4 months after planting		
	P_1	P_2	P_3	P_1	P_2	P_3
T_1	6.1^{cd}	6.4^{bc}	5.7^{d}	7.1^{c}	7.2^{bc}	6.3^{f}
T_2	6.7^{b}	7.0^{a}	6.6^{b}	7.8^{a}	7.8^{a}	7.3^{b}
T_3	6.2^{c}	6.0^{c}	6.4^{bc}	7.2^{b}	6.6^{e}	6.4^{f}
T_4	6.5^{bc}	6.5^{bc}	6.2^{c}	6.6^{e}	6.7^{e}	6.9^{d}
T_5	6.7^{b}	6.2^{c}	5.4^{d}	6.4^{f}	5.1^{g}	4.5^{h}
SEm ±	0.115			0.052		
CD at 5 %	0.33			0.15		

Treatments means with different superscripts are significantly different at P = 0.05

Table 3c : Interaction effect of growing media x pH on number of leaves at 6 and 8 months after planting in anthurium

Treatments	6 months after planting			8 months after planting		
	P_1	P_2	P_3	P_1	P_2	P_3
T_1	7.1^{b}	8.0^{a}	7.0^{c}	8.1^{b}	8.7^{a}	7.2^{c}
T_2	7.4^{b}	7.3^{bc}	6.6^{d}	7.5^{c}	7.5^{c}	6.8^{d}
T_3	7.0^{c}	6.5^{d}	6.7^{c}	6.2^{e}	6.3^{e}	5.7^{d}
T_4	6.6^{d}	6.3^{d}	5.9^{e}	5.5^{d}	5.0^{g}	5.0^{g}
T_5	6.3^{d}	4.9^{f}	4.4^{g}	5.2^{g}	3.8^{i}	4.3^{h}
SEm ±	0.13			0.114		
CD at 5 %	0.37			0.33		

Treatments means with different superscripts are significantly different at P = 0.05

at later stages (6 + 8 MAP) T_1 medium (100 % coir pith) with pH level of 5.5-6.5 (P_2) produced highest number of leaves.

4.2.3 Petiole length

The data on effect of growing media and pH on length at different growth stages are given in Table 4a.

At all growth stages, the petiole length was significantly, influenced by growing media treatments. Highest petiole length was observed in the case of plants grown in 100 per cent coir pith (T_1). Percentage increase in petiole length over a period of 6 months was also highest in the medium(Fig 3) Least petiole length was noticed in T_5 medium (100 % normal potting medium).

The effect of pH on petiole length did not vary significantly at 2 months after planting. However, at later stages of growth (4, 6 and 8 MAP), petiole length showed significant difference , where P_1 (4.5-5.5) showed best results. Percentage increase in petiole length (39%) was also more in the pH range over a period of 6 months(Fig 4).

There were no significant differences among the interactions of growing media and pH with respect to petiole length at initial growth stages (Table 4b). During later stages (6 & 8 MAP) significant interactions were noticed(Table 4c), where T_1P_1 (100 % coir pith + 4.5-5.5 pH) gave highest petiole length at 6 MAP and T_1P_2 (100 % coir pith + 5.5-6.5 pH) gave highest petiole length (20.7 cm) at 8 MAP which is on par with T_1P_1 (100 % coir pith + 4.5-5.5 pH).

Table 4a : Effect of growing media and pH on petiole length (cm) at different growth stages in anthurium

Treatments	Months after planting			
	2	4	6	8
Growing media				
T_1	13.71[a]	15.79[a]	19.31[a]	20.63[a]
T_2	11.61[b]	12.70[b]	15.72[b]	16.88[b]
T_3	11.16[c]	11.58[c]	13.72[c]	14.42[c]
T_4	11.34[bc]	10.26[d]	12.5[d]	12.7[d]
T_5	10.40[d]	8.54[a]	8.89[e]	10.18[e]
SEM	0.127	0.105	0.099	0.076
CD at 5 %	0.37	0.30	0.29	0.22
pH levels				
P_1	11.46	12.07[a]	15.37[a]	15.93[a]
P_2	11.78	12.01[a]	13.60[b]	15.01[b]
P_3	11.69	11.24[b]	13.13[c]	13.97[c]
SEm $\pm$	0.098	0.082	0.077	0.059
CD at 5 %	NS	0.24	0.221	0.17

T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium
P_1 = pH 4.5-5.5
P_2 = pH 5.5-6.5
P_3 = pH 6.5-7.5

Treatments means with different superscripts are significantly different at P = 0.05

Table 4b : Interaction effect of growing media x pH on petiole length (cm) at 2 and 4 months after planting in anthurium

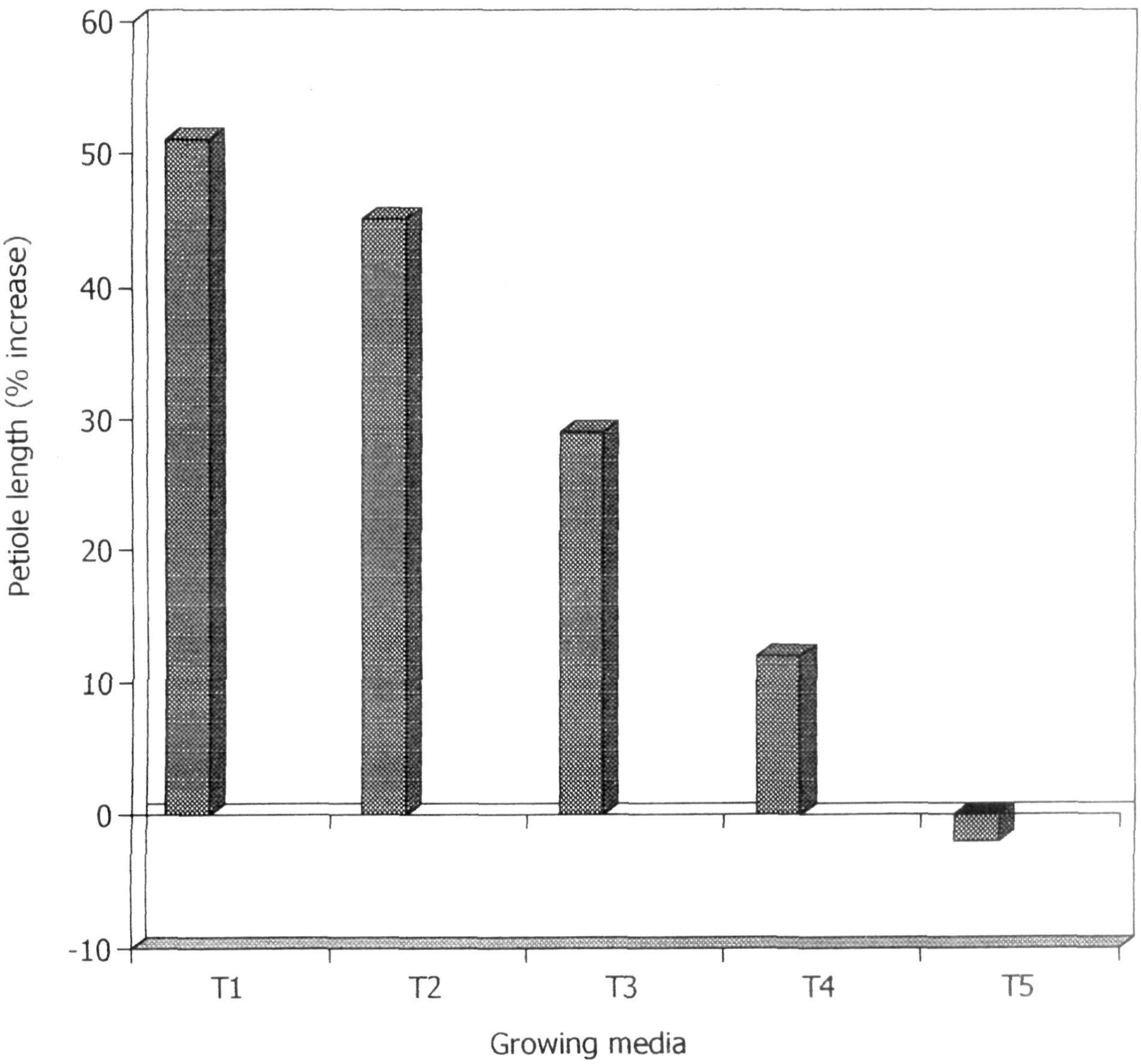
Treatments	2 months after planting			4 months after planting		
	P_1	P_2	P_3	P_1	P_2	P_3
T_1	13.37	13.53	14.23	15.83	16.33	15.2
T_2	11.53	11.67	11.63	12.77	13.00	12.33
T_3	11.30	11.27	10.90	12.17	11.63	10.93
T_4	10.87	11.72	11.43	10.31	10.60	9.87
T_5	10.24	10.73	10.20	9.27	8.5	7.87
SEm $\pm$	0.22			0.182		
CD at 5 %	NS			NS		

NS = Non significant

Table 4c : Interaction effect of growing media x pH on petiole length (cm) at 6 and 8 months after planting in anthurium

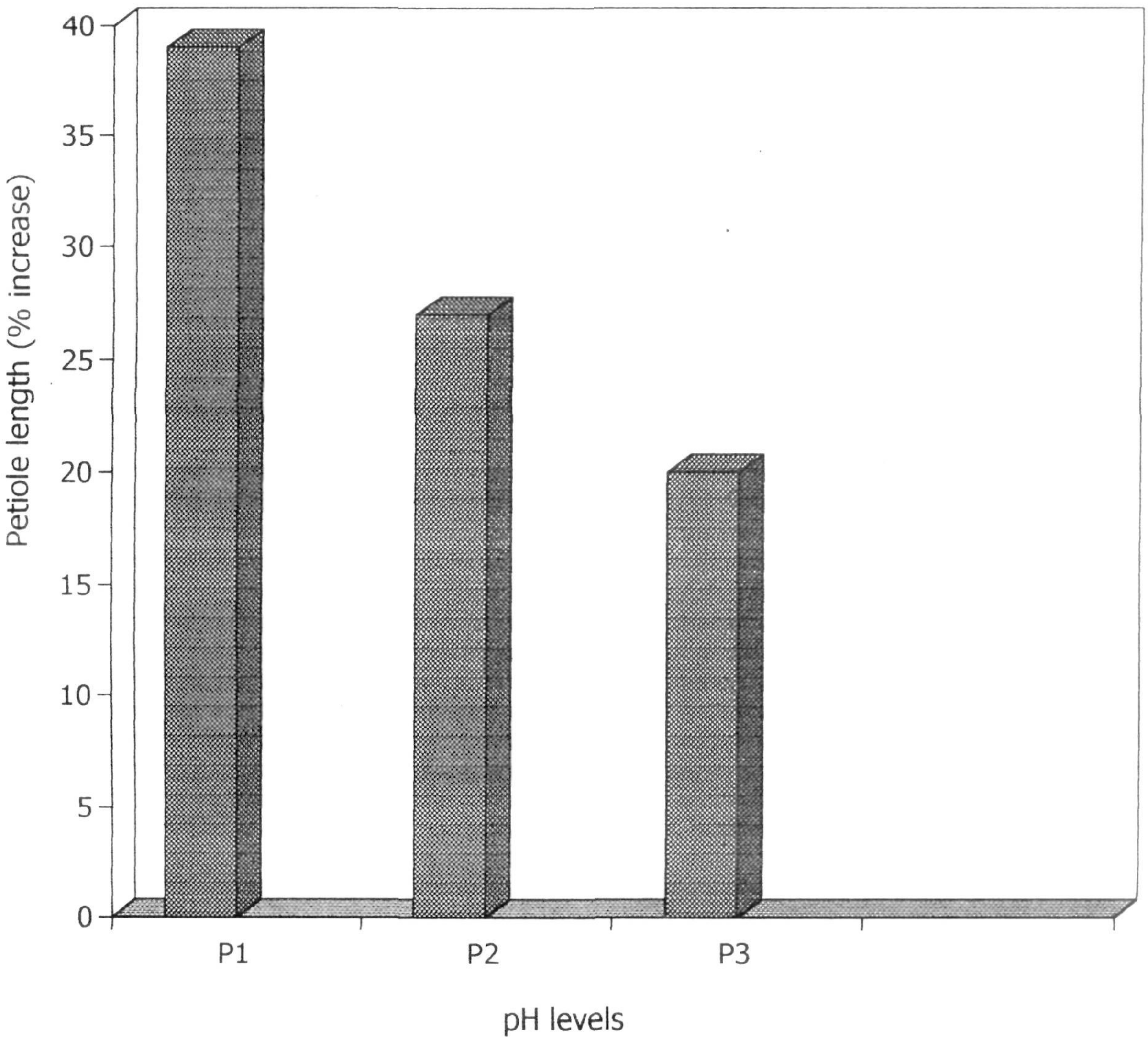
Treatments	6 months after planting			8 months after planting		
	P_1	P_2	P_3	P_1	P_2	P_3
T_1	20.30^{a}	19.40^{b}	18.23^{c}	21.57^{a}	21.70^{a}	18.63^{b}
T_2	16.97^{d}	14.90^{ed}	15.30^{e}	17.3^{c}	17.37	15.97^{d}
T_3	13.67^{g}	14.6^{f}	12.90^{h}	13.53^{g}	15.23^{c}	14.50^{d}
T_4	13.60^{g}	11.40^{j}	12.50^{hi}	13.77^{g}	12.10^{h}	12.33^{h}
T_5	12.30^{i}	7.70^{k}	6.70^{d}	13.50^{g}	8.63^{i}	8.40^{l}
SEm $\pm$	0.171			0.132		
CD at 5 %	0.49			0.38		

Treatments means with different superscripts are significantly different at $P = 0.05$



T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium

Fig. 3 : Percentage increase in petiole length over a period of 6 months (2 MAP to 8 MAP) in different growing media



P_1 = pH 4.5-5.5
P_2 = pH 5.5-6.5
P_3 = pH 6.5-7.5

Fig. 4 : Percentage increase in petiole length over a period of 6 months in different pH levels

4.2.4 Petiole thickness

The data on Table 5a represent the effect of growing media and pH on petiole thickness at different growth stages. Petiole thickness differed significantly with respect to growing media and highest petiole thickness was recorded in the case of T_1 (100 % coir pith) at all growth stages. Percentage increase in petiole thickness over a period of 6 months was maximum (60 %) in T_1 (100 % coir pith) medium while it was least for T_5 The effect of pH levels had a significant influence on petiole thickness during the entire growth period and pH level of 4.5-5.5 was found to be better with respect to petiole thickness. The highest percentage increase in petiole thickness (55 %) was observed in pH level of 5.5-6.5 which was followed by 4.5-5.5 (48 %) and 6.5-7.5 (44 %).

Interaction effect of growing media and pH on petiole thickness was found to be significant at all growth stages Tables (5b& 5c). T_1 media (100 % coir pith) with pH of 4.5 –5.5 showed better results at 2 and 4 months after planting while T_1 media with pH of 5.5-6.5 was better at 6 and 8 MAP.

4.2.5 Number of suckers

The data on the number of suckers as influenced by growing media and pH are presented in Table 6a. The different growing media treatments had a significant influence on the number of suckers per plant at 6 and 8 months after planting. Growing medium with 75 % coir pith + 25 % normal potting medium

Table 5a : Effect of growing media and pH on petiole thickness (cm) at different growth stages in anthurium

	Months after planting			
Treatments	**2**	**4**	**6**	**8**
Growing media				
T_1	0.197^a	0.227^a	0.299^a	0.316^a
T_2	0.192^b	0.215^b	0.285^b	0.300^b
T_3	0.178^c	0.195^c	0.263^c	0.277^c
T_4	0.179^c	0.190^d	0.232^d	0.246^d
T_5	0.159^d	0.155^e	0.182^e	0.205^e
SEM	0.0094	0.0013	0.0013	0.00209
CD at 5 %	0.0027	0.0036	0.0038	0.0061
pH levels				
P_1	0.188^a	0.207^a	0.257^a	0.278^a
P_2	0.178^b	0.194^b	0.257^a	0.275^a
P_3	0.177^b	0.188^c	0.243^b	0.254^b
SEm $\pm$	0.00073	0.00097	0.00101	0.00162
CD at 5 %	0.0021	0.0028	0.0029	0.0047

T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium
P_1 = pH 4.5-5.5
P_2 = pH 5.5-6.5
P_3 = pH 6.5-7.5

Treatments means with different superscripts are significantly different at P = 0.05

Table 5b : Interaction effect of growing media x pH on petiole thickness at 2 and 4 months after planting in anthurium

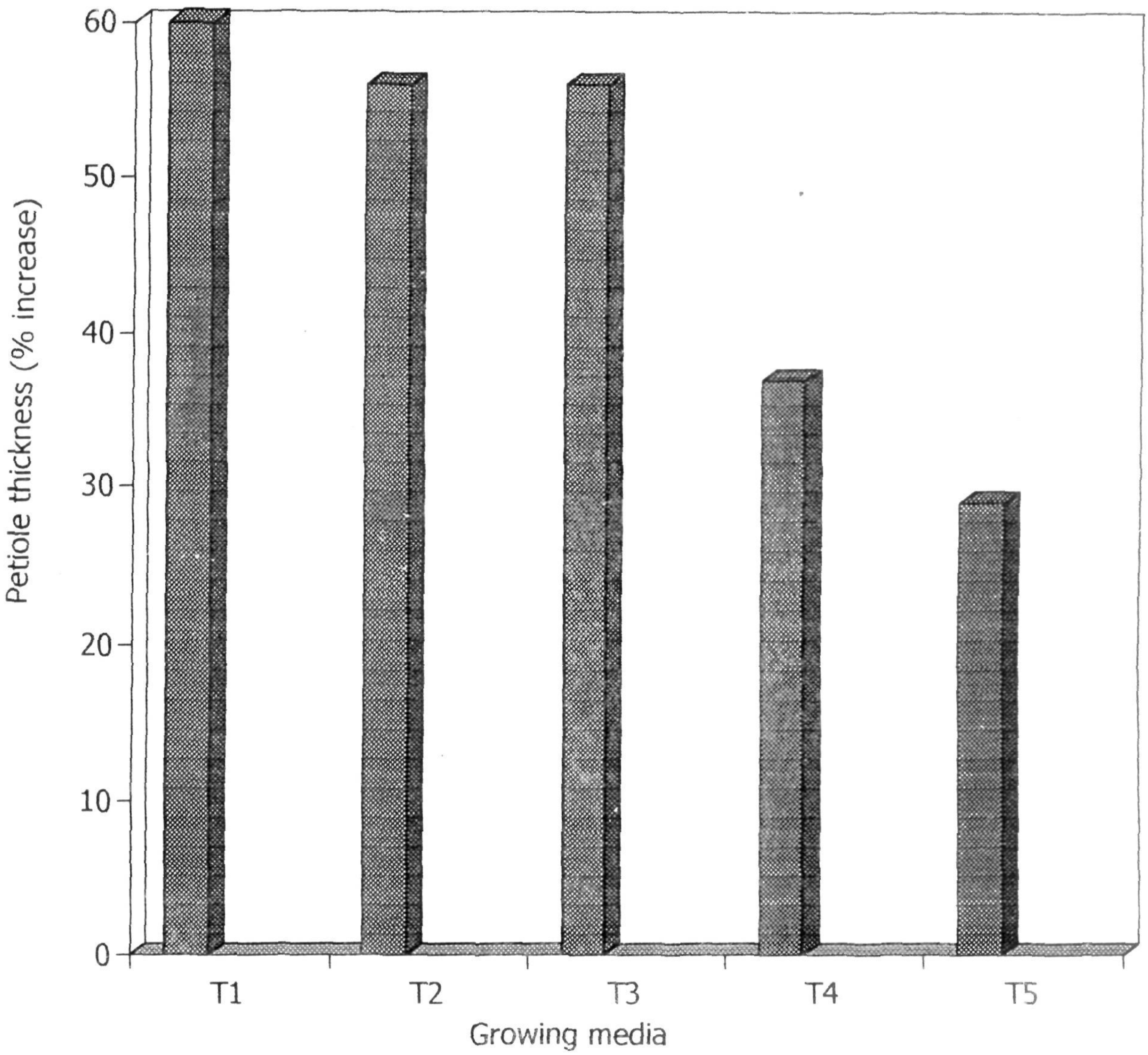
Treatments	2 months after planting			4 months after planting		
	P_1	**P_2**	**P_3**	**P_1**	**P_2**	**P_3**
T_1	0.205^{a}	0.185^{dc}	0.200^{b}	0.233^{a}	0.232^{a}	0.214^{b}
T_2	0.193^{c}	0.193^{c}	0.189^{d}	0.231^{a}	0.217^{b}	0.196^{d}
T_3	0.192^{c}	0.174^{g}	0.169^{h}	0.202^{cd}	0.181^{g}	0.203^{c}
T_4	0.179^{f}	0.181^{e}	0.178^{f}	0.191^{e}	0.191^{e}	0.188^{f}
T_5	0.173^{g}	0.156^{i}	0.151^{j}	0.176^{h}	0.150^{i}	0.140^{j}
SEm $\pm$	0.0016			0.0022		
CD at 5 %	0.0047			0.0063		

Treatments means with different superscripts are significantly different at P = 0.05

Table 5c : Interaction effect of growing media x pH on petiole thickness (cm) at 6 and 8 months after planting in anthurium

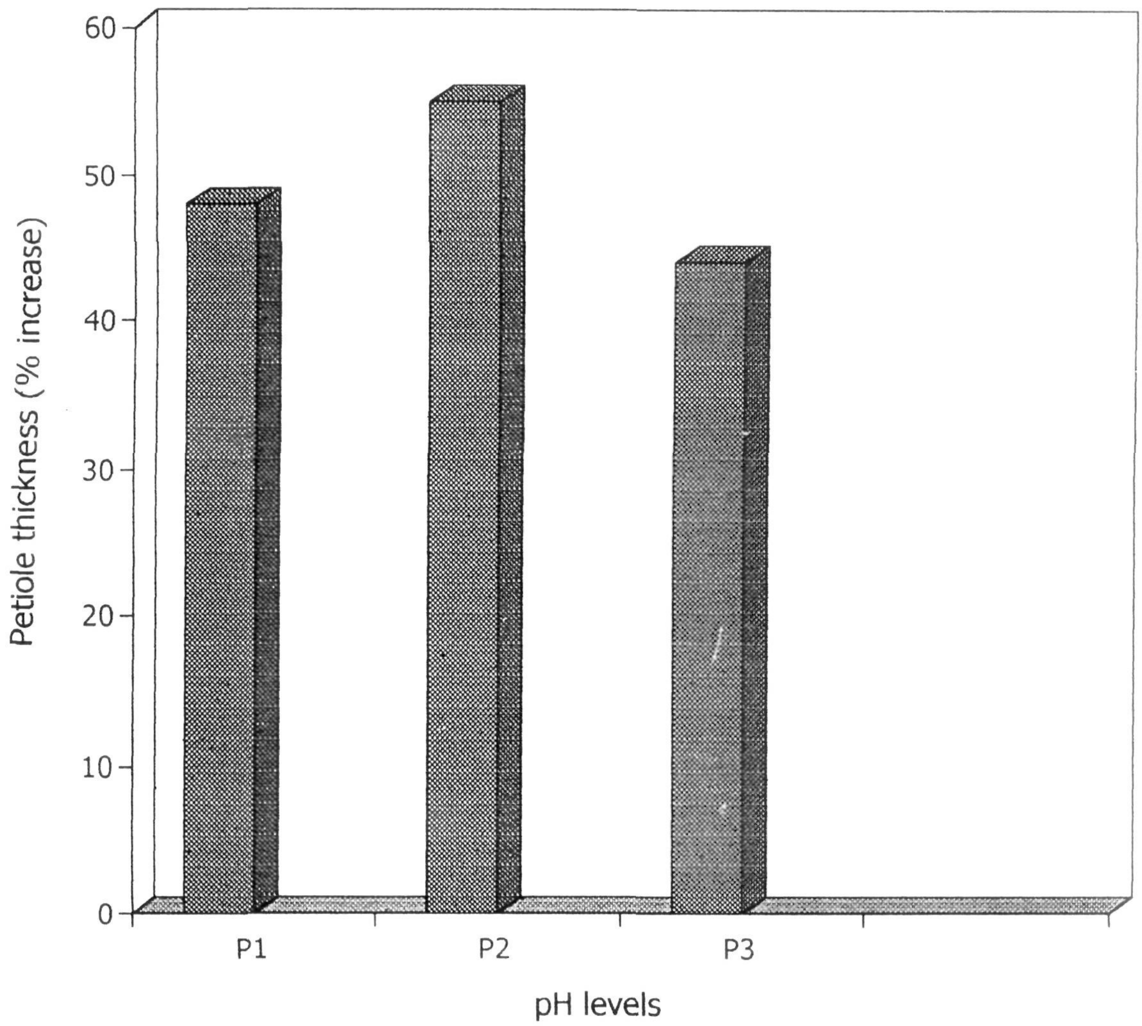
Treatments	6 months after planting			8 months after planting		
	P_1	**P_2**	**P_3**	**P_1**	**P_2**	**P_3**
T_1	0.302^{a}	0.306^{a}	0.290^{b}	0.327^{a}	0.328^{a}	0.292^{c}
T_2	0.266^{a}	0.300^{a}	0.290^{b}	0.303^{bc}	0.305^{b}	0.293^{c}
T_3	0.268^{c}	0.288^{b}	0.235^{d}	0.273^{d}	0.298^{b}	0.261^{e}
T_4	0.228^{e}	0.227^{e}	0.242^{d}	0.238^{g}	0.250^{f}	0.249^{f}
T_5	0.222^{f}	0.166^{g}	0.158^{h}	0.248^{f}	0.196^{h}	0.173^{I}
SEm $\pm$	0.0023			0.0036		
CD at 5 %	0.007			0.010		

Treatments means with different superscripts are significantly different at P = 0.05



T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium

Fig. 5 : Percentage increase in petiole thickness over a period of 6 months (2 MAP to 8 MAP) in different growing media



P_1 = pH 4.5-5.5
P_2 = pH 5.5-6.5
P_3 = pH 6.5-7.5

Fig. 6 : Percentage increase in petiole thickness over a period of 6 months in different pH levels

Table 6a : Effect of growing media and pH on number of suckers at different growth stages in anthurium

Treatments	Months after planting	
	6	8
Growing media		
T_1	2.3[a]	2.9[a]
T_2	2.4[a]	3.1[a]
T_3	1.9[ab]	2.0[b]
T_4	1.5[b]	1.5[c]
T_5	1.1[b]	1.2[c]
SEM	0.247	0.227
CD at 5 %	0.714	0.654
pH levels		
P_1	2.4	2.5
P_2	1.6	1.9
P_3	1.6	2.0
SEm $\pm$	0.191	0.176
CD at 5 %	NS	NS

T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium
P_1 = pH 4.5-5.5
P_2 = pH 5.5-6.5
P_3 = pH 6.5-7.5

Table 6b : Interaction effect of growing media x pH on number of suckers at 6 and 8 months after planting in anthurium

Treatments	6 months after planting			8 months after planting		
	P_1	**P_2**	**P_3**	**P_1**	**P_2**	**P_3**
T_1	2.8	2.0	2.2	3.0	2.8	2.8
T_2	3.3	1.6	2.2	4.1	2.1	3.0
T_3	1.9	2.0	1.8	1.9	2.3	1.9
T_4	1.4	1.8	1.3	1.2	1.4	2.0
T_5	2.3	0.6	0.4	2.4	0.8	0.4
SEm ±	0.43			0.39		
CD at 5 %	NS			NS		

NS = Non significant

Table 7a : Effect of growing media and pH on number of leaves per sucker at 6 and 8 months after planting in anthurium

Treatments	Months after planting	
	6	8
Growing media		
T_1	2.2[a]	3.6[a]
T_2	2.4[a]	3.4[a]
T_3	2.0[a]	3.3[a]
T_4	2.1[a]	3.1[a]
T_5	1.5[b]	2.5[b]
SEM	0.161	0.226
CD at 5 %	0.464	0.651
pH levels		
P_1	2.1	3.5
P_2	2.2	3.0
P_3	1.8	3.0
SEm $\pm$	0.125	0.175
CD at 5 %	NS	NS

T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium
P_1 = pH 4.5-5.5
P_2 = pH 5.5-6.5
P_3 = pH 6.5-7.5

produced maximum number of suckers which was on par with T_1 (100 % coir pith).

The number of suckers per plant did not differ significantly with different pH levels. The interaction effect of growing media and pH levels were also non-significant during the entire growing period (Table 6b).

4.2.6 Number of leaves per sucker

The data on the effect of growing media and pH on the number of leaves per sucker at different growth stages are given in the Table 7a.

The growing media treatments had significant effect on number of leaves per sucker at 6 and 8 months after planting. Least number of leaves per sucker was produced from plants grown in T_5 medium (100 % normal potting medium). All other media differed significantly from T_5 and these were on par with each other with respect to number of leaves per sucker.

Different pH levels had no significant effect on number of leaves per sucker. The interaction effect of growing media and pH was also found to be non-significant (Table 7b)

4.2.7 Number of roots

The data on the effect of growing media and pH on the number of primary and secondary roots are presented in Table 8a (Plate 4).

There was a significant difference among growing media treatments with respect to number of primary and secondary roots. The highest number of

Table 7b : Interaction effect of growing media x pH on number of leaves per sucker at 6 and 8 months after planting in anthurium

Treatments	6 months after planting			8 months after planting		
	P_1	P_2	P_3	P_1	P_2	P_3
T_1	2.4	2.3	1.8	4.0	3.7	3.2
T_2	2.3	2.5	2.4	3.7	3.5	3.0
T_3	1.8	2.1	2.2	3.0	3.3	3.6
T_4	2.1	2.2	2.1	3.7	2.3	3.2
T_5	1.9	2.0	1.0	3.1	2.4	2.0
SEm ±	0.28			0.39		
CD at 5 %	NS			NS		

Table 8a : Effect of growing media and pH on number of roots at 8 months after planting in anthurium

Treatments	Primary roots	Secondary root
Growing media		
T_1	15.5^{a}	39.2^{a}
T_2	13.7^{b}	40.7^{a}
T_3	8.0^{c}	20.3^{b}
T_4	9.0^{c}	18.8^{b}
T_5	6.2^{d}	14.5^{c}
SEm $\pm$	0.54	1.143
CD at 5 %	1.62	3.443
pH levels		
P_1	10.70^{b}	26.6
P_2	12.0^{a}	28.9
P_3	8.70^{c}	24.6
SEm $\pm$	0.416	0.89
CD at 5 %	1.25	NS

T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium
P_1 = pH 4.5-5.5
P_2 = pH 5.5-6.5
P_3 = pH 6.5-7.5

Treatments means with different superscripts are significantly different at

P = 0.05

Table 8b : Interaction effect of growing media x pH on number of primary and secondary roots at 8 months after planting in anthurium

Treatments	Primary roots			Secondary roots		
	P_1	P_2	P_3	P_1	P_2	P_3
T_1	15.0^{b}	17.5^{ab}	14.0^{b}	38.5	38.5	40.5
T_2	14.0^{b}	18.5^{a}	8.50^{cd}	40.50	47.0	34.5
T_3	7.0^{d}	10.5^{c}	6.5^{d}	17.5	24.5	17.0
T_4	11.0^{c}	7.0^{d}	9.0^{cd}	18.5	17.5	20.5
T_5	6.5^{d}	6.5^{d}	5.5^{d}	16.0	17.0	10.5
SEm $\pm$	0.931			1.98		
CD at 5 %	2.81			NS		

NS = Non significant

Treatments means with different superscripts are significantly different at $P = 0.05$

primary roots (15.5) was noticed in the case of T_1 medium (100 % coir pith) which was significantly higher than other growing media treatments ; while the maximum number of secondary roots was recorded for T_2 medium (75 % coir pith + 25 % normal potting medium) which was found to be on par with T_1 (100 % coir pith).

Number of primary roots differed significantly with respect to different pH treatments, where the maximum number of primary roots were obtained at a pH of 4.5-5.5 (12.00). The effect of pH levels on number of secondary roots was not significant. The interaction effect of growing media and pH was significant in the case of primary roots while interaction was not significant for secondary roots (Table 8b). The media containing 75 % coir pith + 25 % normal potting media (T_2) with a pH of 5.5-6.5 (P_2) produced maximum number of primary roots (18.5).

4.2.8 Fresh weight and dry weight

The data on the effect of growing media and pH on fresh weight and dry weight of roots and shoots are presented in Tables 9a and 9b.

The fresh weight and dry weight of roots were significantly influenced by growing media treatments. The maximum fresh weight of roots was recorded from T_1 medium (100 % coir pith) which was on par with T_2 (75 % coir pith + 25 % normal potting medium) and significantly different from other treatments. The highest dry weight of roots was recorded from T_2 medium (75 % coir pith + 25 % normal potting medium). Fresh weight and dry weight of

Table 9a : Effect of growing media on fresh weight and dry weight of roots and shoots (g) in anthurium

Treatments	Root		Shoot	
	Fresh weight	Dry weight	Fresh weight	Dry weight
T_1	51.3^{a}	4.1^{ab}	38.1^{a}	5.0^{ab}
T_2	44.0^{a}	4.3^{a}	37.6^{b}	5.7^{a}
T_3	14.4^{b}	1.9^{ab}	18.1^{b}	2.8^{b}
T_4	11.6^{b}	1.6^{b}	17.5^{b}	2.9^{b}
T_5	7.1^{b}	0.8^{b}	10.5^{b}	1.8^{b}
SEm $\pm$	8.35	0.794	5.8	0.714
CD at 5 %	27.23	2.59	18.96	2.33

T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium
Treatments means with different superscripts are significantly different at P = 0.05

Table 9b : Effect of pH on fresh weight and dry weight of roots and shoots (g)

Treatments	Root		Shoot	
	Fresh weight	Dry weight	Fresh weight	Dry weight
P_1	26.4	2.5	24.0	3.6
P_2	34.8	3.4	29.5	4.3
P_3	15.7	1.7	19.5	3.0
SEm $\pm$	10.14	0.83	6.7	0.86
CD at 5 %	NS	NS	NS	NS

P_1 = pH 4.5-5.5 P_2 = pH 5.5-6.5
P_3 = pH 6.5-7.5 NS = Non significant

Plate 1 : Photograph showing plants grown in different growing Media

0 : 100 - 100 % normal potting medium
25 : 75 - 25 % coir pith + 75 % Normal potting medium (v/v)
50 : 50 - 50 % coir pith + 50 % Normal potting medium (v/v)
75 : 25 - 75 % coir pith + 25 % Normal potting medium (v/v)
100 : 0 – 100 % coir pith

Plate 2 : Photograph showing plants grown in different pH levels

P_1 – pH 4.5-5.5
P_2 – pH 5.5-6.5
P_3 – pH 6.5-7.5


0:100
25:75
50:50
75:25
100:0


P1
P2
P3

Plate 3 : Photograph showing a plant grown in 100 % coir pith medium

Plate 4 : Photograph showing root system of plants grown in different growing media

0 : 100 - 100 % normal potting medium
25 : 75 - 25 % coir pith + 75 % Normal potting medium (v/v)
50 : 50 - 50 % coir pith + 50 % Normal potting medium (v/v)
75 : 25 - 75 % coir pith + 25 % Normal potting medium (v/v)
100 : 0 – 100 % coir pith


100:0


75:25
0:100
50:50
25:75

shoots also followed similar trend as that of roots. Effect of pH levels on fresh weight and dry weight of shoots and roots were found to be non-significant.

4.3 Effect of growing media and pH on water potential

The data furnished in Table 10a present the effect of growing media and pH on water potential at different growth stages.

The influence of growing media on water potential was significant at both growth stages (4 and 8 months after planting). T_1 medium containing 100 % coir pith showed maximum water potential at 4 and 8 months after planting.

The different pH levels had no significant effect on water potential at all stages of growth. None of the interactions had significant effect on water potential (Table 10b).

4.4 Leaf Nutrient Content

The data on nutrient content of leaf as influenced by growing media and pH are given in Tables 11a and 11b.

Among the different nutrients analysed, only calcium, iron and zinc were found to vary significantly with respect to the growing media treatments. Calcium content of leaf was maximum (2.35 %) in plants grown in T_1 medium (100 % coir pith), while it was least (1.5 %) in T_5 medium ((100 % normal potting medium). Iron content of leaf was highest (595 ppm) in T_2 (75 % coir pith) and T_1 (100% coir pith + 25 % normal potting medium). The maximum content of zinc (48.89 ppm) was observed in plants grown in T_1 medium (100

Table 10a : Effect of growing media and pH on water potential (bars) at different growth stages in anthurium

Treatments	Months after planting	
	4	8
Growing media		
T_1	-10.00[a]	-12.11[a]
T_2	-11.44[ab]	-12.78[a]
T_3	-11.79[b]	-12.89[a]
T_4	-12.22[b]	-14.78[b]
T_5	-14.22[c]	-19.67[c]
SEM	0.58	0.77
CD at 5 %	1.74	2.33
pH levels		
P_1	-10.87	-14.5
P_2	-12.34	-14.27
P_3	-12.6	-14.53
SEm ±	0.45	0.599
CD at 5 %	NS	NS

T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium
P_1 = pH 4.5-5.5
P_2 = pH 5.5-6.5
P_3 = pH 6.5-7.5

Table 10b : Interaction effect of growing media x pH on water potential (bars) at 4 and 8 months after planting in anthurium

Treatments	4 months after planting			8 months after planting		
	P_1	P_2	P_3	P_1	P_2	P_3
T_1	-9.34	-10.00	-10.67	-11.00	-13.34	-12.00
T_2	-10.33	-12.34	-11.67	-11.67	-13.00	-13.67
T_3	-10.67	-12.69	-12.00	-13.00	-12.00	-13.67
T_4	-11.34	-12.67	-12.67	-19.34	-12.67	-12.34
T_5	-12.67	-14.00	-16.00	-17.67	-20.34	-21.00
SEm $\pm$	1.001			1.34		
CD at 5 %	NS			NS		

T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium
P_1 = pH 4.5-5.5
P_2 = pH 5.5-6.5
P_3 = pH 6.5-7.5

Table 11a : Effect of growing media on nutrient content of leaf in anthurium

Treatments	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Na (ppm)
T_1	0.35	4.31	2.35^{a}	0.56	0.231	592.69	598.9	48.9^{a}	21.1	533.3
T_2	0.31	4.50	2.08^{ab}	0.45	0.236	595.6^{a}	614.4	46.7^{a}	14.5	588.9
T_3	0.27	4.42	1.96^{ab}	0.44	0.219	570.0^{a}	598.9	46.5^{a}	13.3	566.7
T_4	0.27	4.52	1.81^{ab}	0.38	0.214	528.9^{b}	518.9	40.0^{a}	11.1	544.5
T_5	0.25	4.78	1.5^{b}	0.32	0.216	505.6^{b}	422.22	23.6^{b}	8.8	488.9
SEm $\pm$	0.029	0.139	0.226	0.29	0.059	9.44	131.3	5.14	2.65	43.9
CD at 5 %	NS	NS	0.71	NS	NS	29.75	NS	16.19	NS	NS

T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium
NS = Non significant
Treatments means with different superscripts are significantly different at P = 0.05

Table 11b : Effect of pH on nutrient content of leaf in anthurium

Treatments	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Na (ppm)
P_1	0.317	4.37	1.83	0.37	0.227	571.3	769.3^{a}	43.5	17.3	560
P_2	0.27	4.55	1.98	0.49	0.222	562.0	514.0^{b}	46.0	14.7	580
P_3	0.272	4.59	2.01	0.43	0.221	544.0	368.7^{c}	33.9	9.3	493.3
SEm ±	0.025	0.13	0.328	0.24	0.0059	18.4	55.5	5.3	2.24	30.1
CD at 5 %	NS	NS	NS	NS	NS	NS	170.9	NS	NS	NS

P_1 = pH 4.5-5.5
P_2 = pH 5.5-6.5
P_3 = pH 6.5-7.5
NS = Non significant
Treatments means with different superscripts are significantly different at P = 0.05

% coir pith) which was on par with T_2, T_3 and T_4 medium. Only T_5 medium containing 100 % normal potting medium showed significantly lower zinc content of leaf (23.63).

The different levels of pH significantly influenced the content of Manganese in leaves. It was highest in plants grown in a pH levels of 4.5-5.5. , while it decreased with increase in pH levels. Other nutrients like Ca, Mg, K, Na, Fe, Cu, Zn, S and P did not vary significantly with pH treatments.

4.5 Nutrient Uptake

The data on the effect of growing media and pH on the uptake of nutrients like phosphorus, potassium, calcium, magnesium, sulphur, iron, manganese, copper, zinc and sodium are given in Tables 12a and 2b.

The different growing media treatments had significant influence on the uptake of nutrients like P, K, Ca, Mg, S, Fe, Cu, Zn and Na. Plants grown in T_1 growing medium (100 % coir pith) showed maximum uptake of P, Ca, Mg and Cu. The uptake of nutrients like K, S, Fe, Zn and Na were highest in T_2 medium (75 % coir pith + 25 % normal pitting medium). Both these media (T_1 and T_2) showed significantly higher uptake of all the nutrients, compared to other media. A marginal increase in Mn uptake was found in T_1 and T_2 growing media, but it did not reach the level of significance.

The uptake of all the nutrient analyzed, was found to be vary significantly with different pH levels. The pH leve of 5.5 –6.5 showed the highest uptake of P, K, Ca, Mg, Fe, Cu, Zn and Na while Mn uptake was

Table 12a : Effect of growing media on nutrient uptake (g/kg) in anthurium

Treatments	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Na (ppm)
T_1	32^{a}	392^{b}	214^{a}	51^{a}	21^{b}	5.4^{b}	5.5	0.19^{a}	0.45^{a}	4.9^{a}
T_2	31^{a}	455^{a}	210^{a}	46^{a}	24^{a}	6.0^{a}	6.2	0.15^{a}	0.47^{a}	6.0^{a}
T_3	13^{b}	207^{c}	92^{b}	21^{b}	10^{c}	2.6^{c}	2.8	0.06^{b}	0.2^{b}	2.7^{b}
T_4	13^{b}	204^{c}	82^{b}	17^{b}	9.7^{b}	2.4^{b}	2.4	0.05^{b}	0.18^{c}	2.5^{b}
T_5	6^{c}	123^{d}	39^{c}	8^{b}	5.6^{e}	1.3^{e}	1.1	0.05^{b}	0.06^{d}	1.3^{c}
SEm $\pm$	2.6	5.77	8.67	6.34	0.37	0.05	1.12	0.022	0.05	0.33
CD at 5 %	8.4	18.81	28.23	20.67	1.2	0.17	NS	0.07	0.16	1.1

T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium
NS = Non significant
Treatments means with different superscripts are significantly different at P = 0.05

Table 12b : Effect of pH on nutrient uptake (g/kg) in anthurium

Treatments	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Na (ppm)
P_1	19.3^{a}	266^{b}	111.6^{b}	22.6^{b}	13.8^{b}	3.5^{b}	4.7^{a}	0.105^{ab}	0.26^{ab}	3.4^{b}
P_2	20.8^{a}	351^{a}	153.3^{a}	38.1^{a}	17.1^{a}	4.3^{a}	4.0^{a}	0.113^{a}	0.36^{a}	4.5^{a}
P_3	12.9^{b}	218^{c}	95.5^{c}	20.5^{b}	10.5^{c}	2.6^{c}	1.8^{b}	0.05^{b}	0.16^{b}	2.3^{c}
SEm ±	1.6	5.59	10.9	4.51^{c}	0.37	0.12	0.34	0.14	0.035	0.19
CD at 5 %	5.1	18.2	35.69	14.7	1.2	1.39	1.14	0.45	0.11	0.65

Treatments means with different superscripts are significantly different at P = 0.05

P_1 = pH 4.5-5.5
P_2 = pH 5.5-6.5
P_3 = pH 6.5-7.5

maximum in pH range of 4.5-5.5. Under high levels of pH (6.5-7.5), the uptake of all the nutrients were significantly low.

4.6 Correlation studies

Correlation between leaf nutrient content and growth parameters like leaf area, number of leaves and petiole length were studied and data are presented in Table 13.

The contents of calcium and potassium were found to be significantly correlated to petiole length and the correlation was negative. Sodium content showed positive and significant correlation with leaf area. Iron and copper contents were positively and significantly correlated with leaf area, number of leaves and petiole length. Zinc content showed positive and significant correlation with leaf area and number of leaves, while manganese showed positive ad significant correlation with number of leaves and petiole length.

4.7 Leaf Development Stages

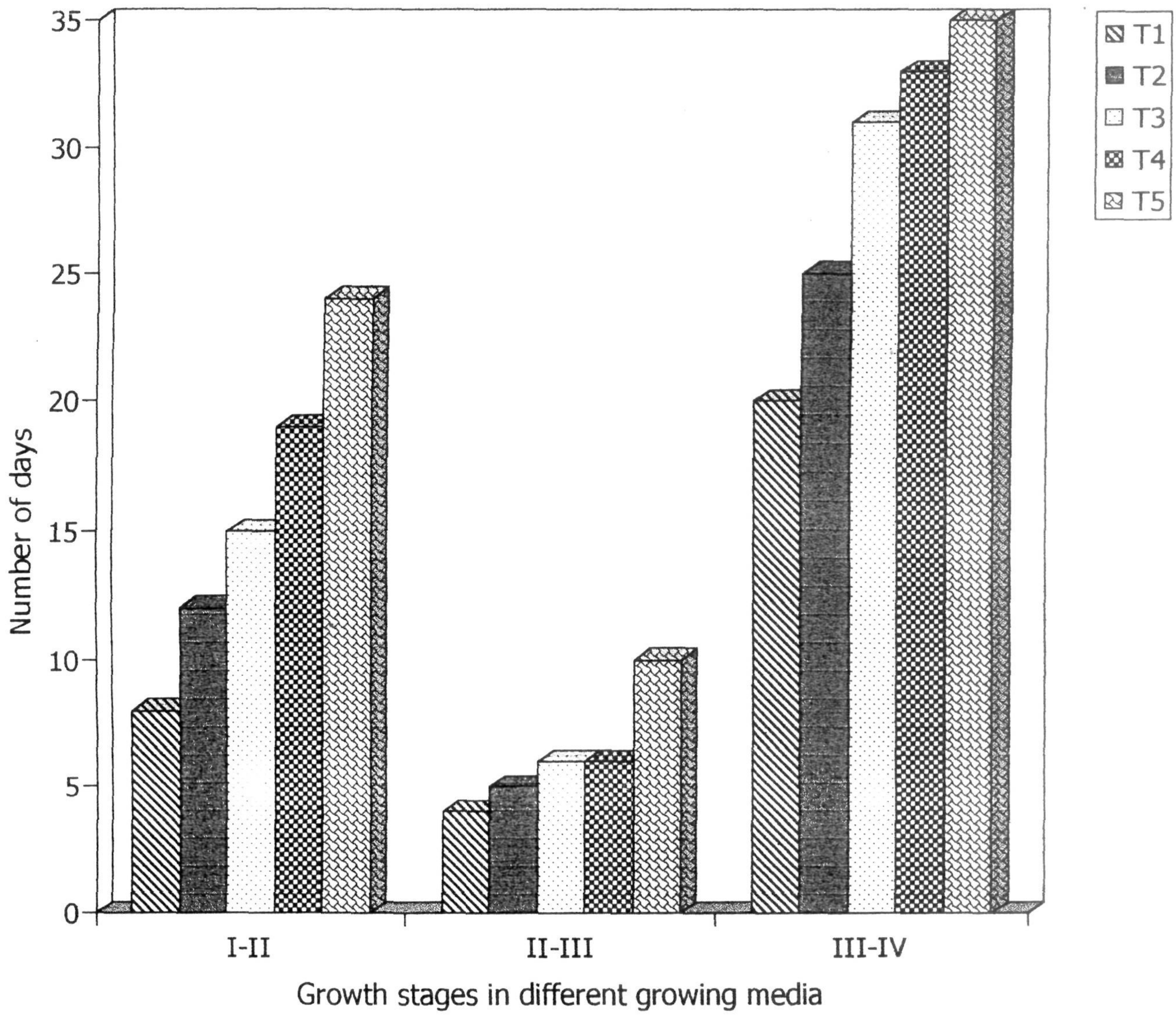
Number of days taken for completing different leaf developmental stages are presented in Fig. 7. From the graph it could be concluded that the number of days taken to complete these stages are least for plants grown in T_1 growing medium (100 % coir pith) and highest for T_5 medium (100 % normal potting medium).

Fig. 8 represents the interval between (number of days taken) for the emergence of two consecutive leaves, in different growing media treatments.

Table 13 : Matrix of simple correlation coefficients between nutrient content, leaf area, number of leaves and petiole length in anthurium

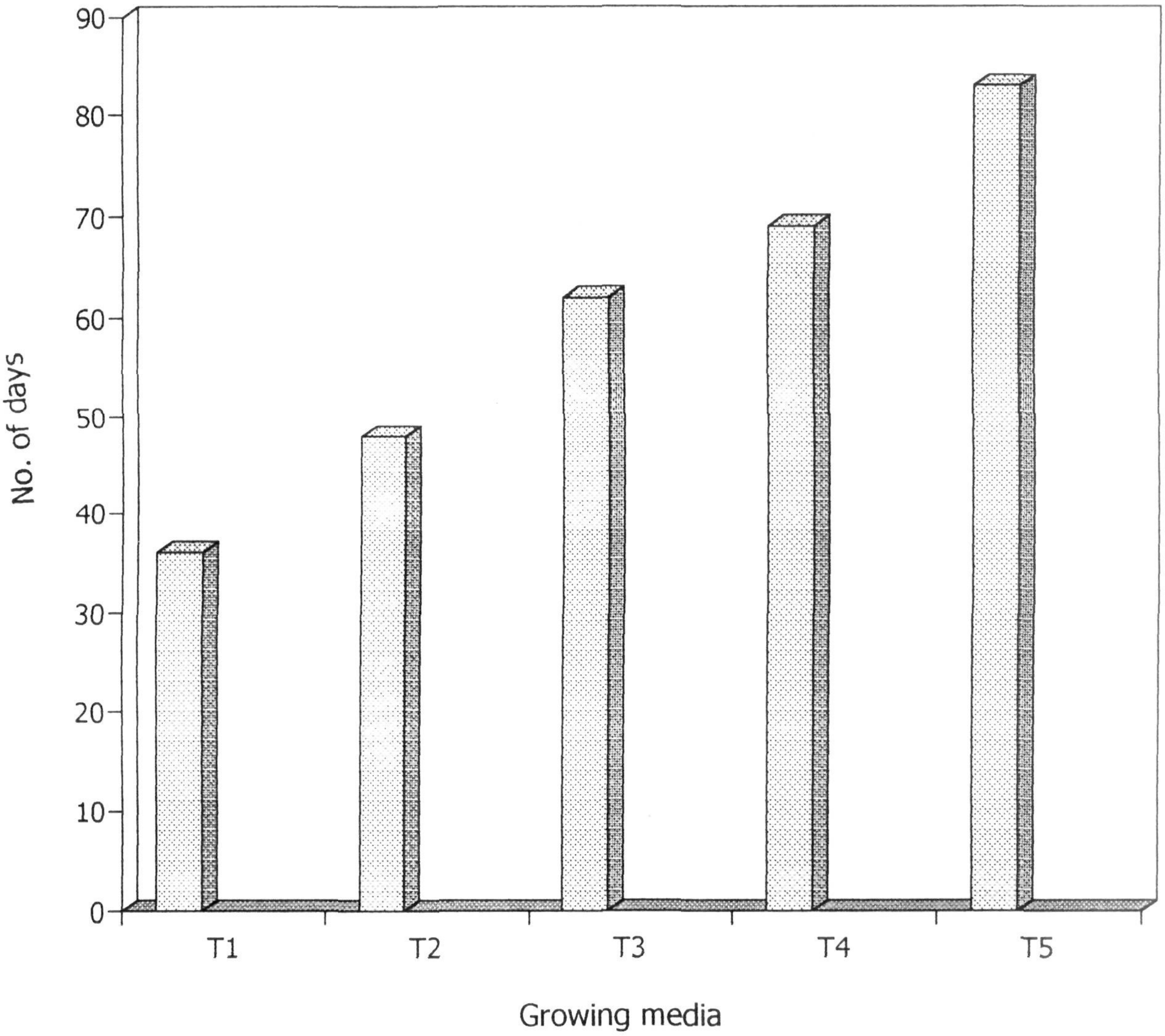
Variable	Leaf area	Number of leaves	Petiole length
Ca	-0.584	-0.82	-0.92*
Mg	0.065	-0.268	-0.461
K	-0.59	0.824	-0.923*
Na	0.986**	0.876	0.758
Fe	0.922*	0.998**	0.989**
Cu	0.916*	0.991**	0.991**
Zn	0.99**	0.889*	0.776
Mn	0.741	0.921*	0.982**
S	0.307	0.604	0.755
P	0.417	0.694	0.827

* significant at 5 % level
** significant at 1 % level



I = Appearance of leaf bud
II = Emergence of bud from leaf sheath
III = Complete unfolding of leaf
IV = Development of green colour and full size of leaf

Fig. 7 : Number of days taken to complete different growth stages during leaf development



T_1 = 100 % coir pith
T_2 = 75 % coir pith + 25 % normal potting medium
T_3 = 50 % coir pith + 50 % normal potting medium
T_4 = 25 % coir pith + 75 % normal potting medium
T_5 = 100 normal potting medium

Fig. 8 : Interval between emergence of two successive leaves

This interval was found to be least for plants grown in T_1 growing medium (100 % normal potting medium).

DISCUSSION

Chapter - V

DISCUSSION

The results of the investigations carried out to study the effect of different growing media and pH on the growth and development of *Anthurium andreanum* are discussed in this chapter.

5.1 Physico-chemical properties of growing media

To provide good physical and chemical conditions for plant growth, coir pith was incorporated with normal potting media, in different proportions, during the preparation of different growing media. The physico-chemical properties of the media were improved by the increased proportions of coir pith in the media. The lowering of bulk density and particle density in the coir pith amended media was due to the increase in pore space and the lighter weight of coir particles. The improvement in the CEC, maximum water holding capacity and nutrient content, with increased proportions of coir pith in the media were attributed to the high CEC, pore space and nutrient status of pure coir pith (Saravanan and Nambisan, 1995). Coir pith used in this experiment alone had a water holding capacity of 600 per cent. The reduction in pH of the growing media due to the addition of coir pith might be attributed to the acidic nature of coir pith. The available macro and micro nutrients were also found to be enhanced by the increased proportions of coir pith in the growing media due to its higher nutrient retention capacity and high nutrient content of coir pith. Similar results were reported by Saravanan and Baskar (1997).

5.2 Effect of growing media on different growth parameters

The growth parameters like leaf area, number of leaves, petiole length, petiole thickness, number of suckers per plant, number of leaves per sucker, number of roots per plant, fresh weight and dry weight of roots and shoots differed significantly in different growing media over a period of eight months.

Leaf area was more in the media which contained more of coir pith.. The percentage increase in leaf area over a period of six months was also maximum for growing medium containing 100 per cent coir pith. This may be due to the favourable physico-chemical properties and high nutrient content of coir pith media that supported proper growth of the plants. Plants grown in coir pith media produced bigger leaves compared to plants grown in other media. the observation of Saravanan and Baskar (1998) confirms that coir pith amended media improved leaf area in Bromiliads.

The number of leaves also varied significantly with respect to growing media. Media containing 75 per cent coir pith and 25 per cent normal potting medium produced more number of leaves initially, while during later stages of growth 100 per cent coir pith media was found to be better for the production of more leaves. This can be attributed to the fact that in 100 per cent coir pith media, the interval between the production of two successive leaves was shorter. In T5 medium (normal potting medium), the number of leaves retained by the plant showed a steep decrease over a period of six months. This was due to the faster drying and abscission of older leaves in the case of plants grown in T5 media (normal potting media). The beneficial effects of coir pith amended media, with respect to the increase in production of leaves have been reported by Saravanan and Nambisan (1995) in Begonia; Turski *et al.*(1983) reported that the highest number of leaves was obtained when anthuriums were grown on a substrate containing peat as a basic component.

During the entire period of growth, petiole length and petiole thickness were maximum in plants grown in 100 per cent coir pith medium, which showed significant differences from other four media tried in the experiment. After 4 months of planting, the difference between growing media became more obvious with respect to petiole length and petiole thickness, which persisted afterwards.

Plants grown in T_2 medium (75 % coir pith + 25 % normal potting medium) showed early production of suckers and more number of suckers per plant. The growth of the suckers as indicated by number of leaves per sucker was significantly lower in T_5 medium containing normal potting medium alone. The number of suckers per plant was also lower in the case of T_5 medium. This may be attributed to the poor physico-chemical properties of this growing medium.

A significant difference was noticed among growing media treatments with respect to number of primary roots and secondary roots. T_1 medium containing 100 per cent coir pith showed significantly higher number of primary roots while secondary roots were maximum in T_2 medium (75 % coir pith + 25 % normal potting medium). The physical properties of coir pith such as low bulk density and particle density, high water holding capacity and porosity enhanced root growth. Because of the highly porous nature of coir pith, the aeration of the media might have improved which resulted in increased root growth. Lokesha *et al.* (1990) reported root inducing property of coir pith and concluded that this property could be due to the release of phenolic compounds as a result of the action between the lignin content of coir pith and acids produced by the microbial flora of the media.

Fresh weight and dry weight of roots and shoots were higher in the case of T_1 media (100 % coir pith) and T_2 media (75 % coir pith + 25 % coir pith). This may be ascribed to the better physico-chemical properties of these media such as high moisture holding capacity, nutrient retention capacity, porosity etc. which resulted in more growth and development of plants grown in these media. Saravanan and Baskar (1997) reported similar results with tomato and cowpea when grown in coir pith amended media. The dry matter content of Fuchsia was more in coir pith when compared to plants grown in peat substrate (Smith, 1995). Fresh weight of dieffenbachia was also higher in coir pith amended medium, compared to sphagnum peat containing medium as observed by Stamps and Evans (1997).

5.3 Effect of pH on growth parameters

The pH of the media had a significant influence on the growth parameters like leaf area, leaf number, petiole length, petiole thickness and number of primary roots. In the initial stages of growth (2 MAP) leaf area and petiole length did not vary significantly with different pH levels. However, at later stages these parameters showed a significant difference with respect to pH levels. The different pH levels influenced these growth parameters over a longer period of time. The effect of pH levels was not as quick as that of the growing media with respect to leaf area and petiole length.

At the end of the experiment (8 MAP) maximum leaf area was observed in plants grown in a pH range of 5.5 – 6.5 (P_2) which was on par with 4.5 – 5.5 (P_1). During all the growth stages significantly lower leaf area was observed in the highest pH level of 6.5 – 7.5 (P_3). This may be due to the unavailability of micronutrients under high pH conditions. Similar trend was reported by Beel and Schelstraete (1987) in dieffenbachia and ficus grown on peat substrate.

Petiole length varied significantly with respect to pH levels from 4 months after planting. The difference in petiole length as affected by pH levels was more clearly felt after 6 months of planting. The highest petiole length was obtained in the lowest level of pH (4.5-5.5). This can be attributed to the increased availability of micro nutrients under low pH conditions. The micronutrient cations like iron, manganese, zinc and copper are most soluble and available under acidic conditions (Brady, 1990). As the pH is increased, the ionic forms of the micronutrient cations are changed first to the hydroxy ions of the elements and finally to the insoluble hydroxides or oxides. This may be the reason for lower petiole length under high pH conditions of growing media. Malinowska (1991) also had the opinion that lower pH of the medium containing peat and pine bark improved plant growth and higher pH markedly reduced plant growth in the case of *Empetrum nigrum*.

pH levels influenced the number of leaves during all the stages of growth. The differences in number of leaves with respect to each of the pH treatment was clearly observed from 4^{th} month onwards. The maximum number of leaves was obtained from P_1 (4.5-5.5) which was followed by P_2 (5.5-6.5) and P_3 (6.5-7.5). The report of Kramar and Peterson (1990) is also in accordance with this result.

Petiole thickness also varied significantly with respect to different pH levels. Initially (2 and 4 MAP),lowest pH level (4.5-5.5) produced significantly higher petiole thickness, while during later stages (6 and 8 MAP), the petiole thickness was similar in both P_1 and P_2 (4.5-5.5) and (5.5-6.5). However, the highest level of pH (6.5-7.5) was not favourable as far as petiole thickness was concerned.

The different pH levels significantly influenced the number of primary roots. The maximum number of primary roots was obtained when the pH of the root environment was between 5.5-6.5 and it was significantly lower under both higher (6.5-7.5) and lower (4.5-5.5) pH levels. Under low pH levels the root growth was affected by the excess levels of micronutrients especially manganese and subsequent toxicity and also the direct effect of hydrogen ions on root function by affecting the permeability of cell membranes (Moore, 1974 ; Yan *et al.*, 1992). Optimum pH range for root growth was 5.5-6.5 as the availability of all the nutrients was optimum under this pH. The number of secondary roots was not significantly affected by pH levels.

The number of suckers per plant, number of leaves per sucker, fresh weight and dry weight of roots and shoots were not influenced by different pH levels. These are the parameters which were more affected by the physical properties of the growing media than the chemical properties.

5.4 Effect of growing media and pH on water potential of leaves

The different growing media treatments had a significant influence on the water potential of leaves. The lowest water potential was noticed in plants grown in T_5 growing medium (normal potting medium) which was significantly different from other media tried in the experiment. With increasing proportion of coir pith in the media, there was an increase in water potential of leaves. This was due to the high water holding capacity of coir pith (600 %). In coir pith amended media, the availability of water to plants was more and hence water potential was high. The high water holding capacity of coir pith allowed the medium to hold water and nutrients for a longer period so that plants could thrive even if irrigation was withheld for few days. On the other hand water holding capacity of T_5 medium containing normal potting medium was very low (51 %) and more energy was needed for the plants to absorb water. The plants grown in such media experienced water stress more frequently and showed low water potential of leaves. These observations were in accordance with the reports of Henderson *et al.* (1991) who concluded that the leaf water potential was higher in rose when grown on a medium (pine bark : sand, 3 : 1) amended with hydrophilic gel to improve the water holding capacity. The different pH levels did not have any significant effect on the water potential of leaves.

5.5 Effect of growing media on nutrient content of leaves

Leaf contents of Ca, Fe and Zn were significantly affected by the different growing media treatments while other nutrients like P, K, Mg, S, Cu, Mn and Na were not significantly different with respect to growing media treatments. All these nutrients except K showed marginal increase in plants grown in coir pith amended media. The low availability of K in coir pith amended media may be ascribed to the binding of K by coir pith particles due to its high cation exchange capacity (Elgala and Amberger, 1988). The calcium and zinc contents were considerably high in coir pith amended media compared to T5 medium containing normal potting medium because of high cation exchange capacity and high contents of these nutrients in coir pith. Savithri and Hameed Khan (1994) also reported high content of these nutrients in coir pith.

The content of iron was significantly higher in T_1 (100 % coir pith), T_2 and T_3 compared to that of T_4 and T_5. This may be due to the low pH of coir pith that increased the availability of Fe.

The marginally high amount of P in plants grown in coir pith media may be ascribed to the high anion exchange capacity of coir pith. The organic anions and hydroxy acids liberated from the decomposing coir pith increased the anion exchange capacity of coir pith. The report of Baskar and Saravanan (1997) supports this observation.

The sodium content of leaf ranged from 588 to 488 ppm in different growing media which was far below the toxic levels of sodium (> 0.5 %). The considerably high amount of Na in coir pith amended medium compared to normal potting medium may be due to the accumulation of Na in coir pith medium. If coir pith medium is maintained for longer periods, Na may exceed the desired levels. Handreck (1993) also confirmed that coir pith contained high amounts of Na compared to peat.

5.6 Effect of pH on nutrient content of leaves

The reason why plants are sensitive to pH of the media is that the pH affects the concentration of different nutrients ions and also their availability to plants. In the present experiment, the different pH levels had significant effect on the content of Mn in leaves. Under lowest pH condition (P_1 – 4.5-5.5) the content of Mn was maximum (769 ppm) which was followed by P_2 (5.5-6.5) and P_3 (6.5-7.5). Lindsay (1979) reported that for each unit decrease in pH, there was 100 fold increase in Mn availability. The high leaf content of Mn under low pH conditions may be due to the high solubility and availability of Mn under low pH conditions For proper plant growth the ratio of Fe/Mn should be narrow (1 : 1). This ratio was maintained under the pH level of 5.5-6.5 while under higher (6.5-7.5) and lower (4.5-5.5) pH levels, the ratio of Fe and Mn was wider, resulting in reduced availability of these elements.

The leaf contents of other nutrients like P, K, Ca, Mg, Fe, Zn, Cu and Na did not show significant difference with respect of pH levels. However, there was a marginal increase in the leaf contents of Ca and K with increase in pH.

5.7 Effect of growing media on nutrient uptake

Uptake of nutrients like P, Ca, Mg, Cu and Zn was significantly higher in T_1 (100 % coir pith) and T_2 (750 coir pith + 25 % normal potting medium) growing media compared to other growing media treatments. This may be due to the better physico-chemical properties of these media such as high water holding capacity, nutrient retention capacity and porosity , which favoured root growth resulting in enhanced uptake of nutrients. Uptake of K, S and Fe was more from T_2 medium containing 75% coir pith + 25 % normal potting medium. Uptake of P, K, Ca, S, Fe and Zn was significantly lower in T_5 medium containing normal potting medium alone. The increase in P uptake by the chelating and complexing activity of organic anions and hydroxy acids liberated from the decomposing coir pith was reported by Dhakshinamoorthy (1991). Baskar and Saravanan(1997) reported that the increase in available P with the addition of coir pith in the media was due to the release of CO_2 and organic acids during the decomposition of coir pith rendering less soluble P into more soluble P. Uptake of Mn was not affected by different growing media used in the experiment but it was influenced by pH levels.

Elgala and Amberger (1988) were of the opinion that the natural organic chelating agent produced by the action of micro organisms on organic residues improved availability of micronutrients like Fe, Cu and Zn.

5.8 Effect of pH on nutrient uptake

The different levels of pH significantly affected the uptake of all the nutrients analysed. Uptake of K, Ca, Mg, S, Fe and Zn were significantly higher under pH range of 5.5-6.5, as it is the optimum pH level for the availability of most of the nutrients. Manganese showed marginally high uptake under pH of 4.5-5.5 because of its increased solubility under low pH conditions. The availability of Zn is highly pH dependent and decreased 100 folds for each unit increase in pH. At high pH values the level of Zn in solution is so low that very little Zn will be held on the exchange sites (Elgala and Amberger, 1988).

High pH levels adversely affected the uptake of all the nutrients. Similar trends were observed by Kramer and Peterson (1990) in chrysanthemum. The slightly acidic pH of 5.5-6.5 increased the solubility and availability of the nutrient elements, resulting in higher uptake of these nutrients. Root growth was enhanced under slightly acidic conditions (pH 5.5-6.5) which also might have contributed to the higher uptake of nutrients.

5.9 Correlation studies

The negative correlation of Ca and K with petiole length may be due to dilution effect of these nutrients in vegetative parts i.e., if the vegetative growth is more the nutrients get distributed and their contents become less (Devlin and Witham, 1986). Micronutrients like Fe and Cu showed positive correlation with leaf area, number of leaves and petiole length because when the vegetative growth is more, there will be more uptake of micronutrients.

SUMMARY

Chapter – VI

SUMMARY

Anthurium is gaining importance in the global cut-flower trade, because of its attractive and long lasting flowers. Commercial cultivation of this crop started recently in India and hence there is a need to standardize the growing techniques.

Anthurium plants require a growing medium with good physical and chemical properties for their proper growth and development. In the present study coir pith, a waste product of coir industry, was tested in combination with different proportions of normal potting medium (soil, sand and FYM in 2 : 1 : 1 ratio) to find out their suitability as substrate for anthurium. Coir pith and normal potting medium in the ratio of 100 : 0, 75 : 25, 50 : 50, 25 : 75 and 0 : 100 were tried in the experiment. In each growing media three levels of pH (4.5-5.5, 5.5-6.5, 6.5-75) were maintained to determine the optimum range of pH for anthurium. The experiment was designed in a completely randomized factorial design with fifteen treatment combinations. Based on the results obtained from the experiment, the following conclusions were drawn.

Increased proportions of coir pith in the growing media improved the physical properties viz., maximum water holding capacity, porosity and drainage. The bulk density and particle density were lowered with the addition of coir pith due to the increase in pore space and lighter weight of particle. The pH of the growing medium was decreased with increasing proportions of coir pith, whereas CEC was found to be increasing with increasing amounts for coir pith. The available N,P,K status of coir pith contining medium was higher than that of normal potting medium.

The growth parameters like leaf area, number of leaves, petiole length, petiole thickness and number of roots were maximum in 100 per cent coir pith medium. The number of suckers per plant, fresh weight and dry weight were higher in T_2 (75 % coir pith + 25 % normal potting medium) and T_1 (100 % coir pith) growing media when compared to other growing media treatments. Early flowering was also noticed in these two media where plants flowered within a period of eight months. Leaf water potential was improved by increasing amounts of coir pith in the growing media.

Among the different vegetative parameters studied, leaf area and petiole thickness were better in media with pH below 6.5. While petiole length and number of leaves were superior in the lowest pH range of 4.5 – 5.5. The number of roots was maximum in moderately acidic pH range of 5.5-6.5.

Fresh weight and dry weight of plants, number of suckers, number of leaves per sucker, leaf water potential etc, were determined by the physical properties of growing medium rather than the chemical properties like pH.

The leaf contents of Ca, Fe and Zn were significantly higher in coir pith containing media. Manganese content of leaf was significantly higher in the lowest range of pH (4.5-5.5) which was found to be toxic to plants. Calcium and Magnesium contents were marginally higher in the pH range of 5.5-6.5.

The coir pith containing medium recorded higher uptake of all the nutrients analyzed, while uptake of Mn was more influenced by the pH of the growing medium. Uptake of all the nutrients was affected by the pH of levels maintained in the rhizosphere environment. A pH higher than 6.5 adversely affected the nutrient uptake. Most of the nutrients like K, Ca, Mg, S, Fe etc showed highest uptake in slightly acidic conditions (pH 5.5-6.5).

In the light of these results, it can be concluded that for better growth and development of anthurium the most suitable growing medium is the one containing coir pith alone. Among the different pH levels maintained in the media, slightly acidic pH range of 5.5-6.5 was optimum for the growth of anthurium plants.

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Chapter - VII

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* Originals not seen