ENDOGENOUS AND EXOGENOUS REGULATION OF GROWTH AND DEVELOPMENT IN *Dendrobium* VAR. SONIA 17 AND SONIA 28

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree of

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Faculty of Agriculture

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Department of Pomology and Floriculture

College of Horticulture

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DECLARATION

I hereby declare that this thesis entitled **"Endogenous and exogenous regulation of growth and development in *Dendrobium* var. Sonia 17 and Sonia 28"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara
21st July 2001

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CERTIFICATE

Certified that this thesis, entitled **"Endogenous and exogenous regulation of growth and development in Dendrobium var. Sonia 17 and Sonia 28"** is a record of research work done independently by **Mr. U. Sanjeev Nair,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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We, the undersigned members of the Advisory Committee of **Mr.U. Sanjeev Nair,** a candidate for the degree of **Master of Science in Horticulture** with major in **Pomology and Floriculture**, agree that the thesis entitled **"Endogenous and exogenous regulation of growth and development in *Dendrobium* var. Sonia 17 and Sonia 28"** may be submitted Mr. U. Sanjeev Nair, in partial fulfilment of the requirements for the degree.

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Dedicated to my

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INTRODUCTION

INTRODUCTION

Orchids are valued for exquisite flowers and long keeping quality, which fetch a high price in the international market. It has conquered the cutflower industry during the past few decades. They are most pampered of the plants and occupy top position among all flowering plants, valued for cut flower production and as potted plants.

Taxonomically orchids belong to family orchidaceae and they represent the most highly evolved family among monocotyledons with 600-800 genera and 25,000-35,000 species. Tropical orchids are primarily grown in countries like Thailand, Malaysia and Singapore where the economy depends upon the export of orchids to Japan, Europe and USA.

Japan is the largest importer of orchids. The worldwide retail trade of orchids is worth over $ 25 billion. In India orchids form 9 per cent of our flora and has around 1300 species with 140 genera. Orchid cultivation is however a fairly new venture in India and its position in export market is insignificant.

Kerala is said to be a rare location all over the world, where tropical orchids come up well without the use of much sophisticated conditions. Commercial cultivation of orchids has started only in the late 90's (Chadha, 1992). There are many commercial growers in Kerala engaged in orchid cultivation and trade especially with *Dendrobium, Arachnis* and *Vanda* which have a good market

potential (Rajeevan *et al.,* 1993). The scenario has significantly improved during the last few years, resulting in significant expansion of the area. According to the Federation of Indian Floriculturists Association (1997) about 14 lakh orchids are cultivated in Kerala providing 84 lakh spikes of which only 50 per cent is marketed.

Dendrobium is considered as the second largest genus in orchids. About 1340 species are reported in the genus (Baker and Baker, 1996). In Kerala, dendrobiums occupy more than 90 per cent of cultivated orchids. Some of the commonly cultivated hybrids are Sonia 17, Sonia 28, Renappa, Kasem white, Emma white etc. Lack of information regarding the proper management practices has resulted in low yield and poor quality spikes in the state.

More than 30 hybrids of *Dendrobium* are under commercial cultivation in Kerala. These hybrids differ widely not only with respect to the morphological features of plants and flower spikes but also in their response to various external factors. Production of new shoots, keikis and spikes as well as disorders like water shoot, mixed spike, sepal wilt etc. are some of the salient areas where drastic differences are seen. An understanding of the mechanism controlling these would enrich the area of knowledge about the crop, thus enabling us to take up appropriate remedial measures to counteract the problems.

In this context a study was undertaken in *Dendrobium* var. Sonia 17 and Sonia 28 with the use of nutrients including organic, inorganic and hormones in

order to study the factors responsible for changes in the growth and development of *Dendrobium* varieties Sonia 17 and Sonia 28 with a view to solve field problems and to enhance production.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Floriculture in Kerala assumed a commercial status only in the early nineties with the introduction of orchids and anthuriums as potential crops. Kerala is considered as agro-ecologically congenial for the cultivation of orchids but the commercial production has not reached appreciable levels to meet with international market. *Dendrobium* the most common genus of which Sonia-17 and Sonia-28 are most popular. Efforts have been made in this chapter to review the available information on the effect of other various reasons attributed to the poor performance nutritional aspects in relation to physiology are considered to be more crucial on the growth and development in *Dendrobium* var. Sonia 17 and Sonia 28.

2.1 Growth and development

2.1.1 Effect of inorganic nutrients

The macronutrients nitrogen, phosphorous and potassium are required by orchids in varied amounts. Nitrogen has a positive response on vegetative growth. Phosphorous is related with root growth and early maturity of the crop. Potassium is involved in enzyme activation, translocation of assimilates, protein synthesis and N uptake (Tisdale *et al.,* 1995).

Various scientists have reported the effect of inorganic fertilizers in improving growth and flowering in orchids. Effect of different levels of nitrogen, viz., 0, 50 and 100 lbs per acre on growth of *Phalaenopsis* and *Cattleya* seedlings was studied by Sheehan (1960), and reported increased leaf growth with increase

in nitrogen application. In *Phalaenopsis* 'Pink Chiffon', with an increment of nitrogen from 50 to 1000 ppm, showed positive results on vegetative aspects, especially on the number of leaves and leaf area, was seen (Sheehan, 1966).

Excess use of nitrogen led to rotting whereas deficient use led to yellowing and wilting of leaves of *Cattleya.* Deficiency of potassium led to dwarfness, with the edges of leaves scorched and dead (Penningsfield and Fast, 1962).

Northen (1970) reported that excess nitrogen lead to increased vegetative growth and delayed flowering. Bhattacharjee (1977) observed that spraying N, P_2O_5 and K_2O 100 ppm, each, at fortnightly intervals was beneficial in *Bulbophyllum.* In a study conducted by Poole and Seeley,(1978) in *Cymbidium,* and *Phalaenopsis* N, P_2O_5 and K_2O @ 100:50:25 ppm gave better results.

In *Aranda* 'Noorah Alsagoff' growth parameters was enhanced with a spray of nutrients viz. 20.9 mg N, 50 mg P and 21.8 mg K applied at weekly intervals along 3.4 mg calcium (Khaw and Chew, 1980).

Bhattacharjee (1981) reported that effect of different levels of N, P, K (0, 500 and 1000 ppm) on growth of *Dendrobium moschatum* grown in chunks of hardwood charcoal had marked improvement in vegetative growth. With an increment in N with 500 ppm N spray flower and bud appearance was recorded. When applied at 500 ppm 'P' and 'K' had beneficial effects.

Johnson (1984) recommended nutrient solution of N, P and K having 100:20:75 ppm, respectively, for improving growth in *Cymbidium* and *Cattleya*. Spraying 1000 ppm, each, of N, P and K enhanced length and number of leaves in *Aerides multiflorum* whereas plants deficient in nitrogen showed stunted growth and early maturity (Yadav and Bose, 1986). Sakai *et al.* (1985) reported that higher nitrogen dose of 48 mg l^{-1} was beneficial for outdoor cultivation of *Dendrobium*, which gave longer pseudobulbs.

Schum and Fischer (1985) obtained higher number of leaves and fresh weight with N and K applied in the ratio 1:1. Stewart (1988) recommended a combination of 3:1:1 NPK for better vegetative growth and 1:1:1 for sustained growth, respectively.

In a study conducted by Uesato *et al.* (1987) in *Dendrobium* 'Lim Hepa' reported that by increasing N dose from 50 to 300 ppm and K dose from 25 to 150 ppm gave positive results with respect to vegetative growth. Nitrogen at 300 ppm delayed flowering and enhanced stem length. In *Cattleya* and *Phalaenopsis,* with an increase of N, P, K dose from 77:15.5:39.1 ppm to 308:62:156.40 ppm produced early flowering, increased fresh weight and increased N and K content in leaves (Tanaka *et al.* 1981, 1988a, 1988b and 1989).

In a comparison study in *Dendrobium phalaenopsis* one year old seedlings, when fed with MS nutrient solution in ratio of 2:1:1 grew better than two year old seedlings. (Koval'skaya and Zeinenko, 1991).

A trial conducted to study the uptake of nitrate and ammonium by *Cymbidium* sp, *Bombeadia* sp and *Dendrobium* cv. White Fairy resulted in a higher uptake rate for ammonium (Hew *et al.*, 1993). Plants sprayed with NPK 17:17:17 complex at weekly intervals @ 10 g l^{-1} could increase the number of clumps and leaves in *Cymbidium traceanum* (Sobhana and Rajeevan, 1995).

In *Arachnis* Maggie Oei 'Red Ribbon' under trench culture, a nutrient dosage of 300 ppm N, 400 ppm P and 300 ppm K from the time of planting to nine months after planting and thereafter a dosage of 400 to 500 ppm N, 400 ppm P and 500 ppm K was recommended by Thekkayam (1996). According to her, the beneficial doses in *Dendrobium* 'Sonia 16' was 400 to 500 ppm of N, P and K. Taejung *et al.* (1998) reported that healthy compact plants were produced in *Cymbidium* with NPK combination having high content of K. Leaf analysis showed high N content when 30:10:10 NPK was applied and least when 6:40:6 NPK was given. Nutrient recommendation of 2.0 mg, each NPK from three to six months, 6:2:2 NPK from six to nine months and 6:2:6 NPK from nine to 12 months was made by Umamaheshwari (1999). For more than one year old plants 6:6:2 NPK was the best for maximum vegetative growth.

2.1.2 Effect of organic nutrients

According to Wu *et al.* (1994) application of organic fertilizer @ 10-40 per cent promoted growth significantly in *Phalaenopsis.*

Another study in spinach showed that growth was increased by the application of organic fertilizers (Sorin and Tanaka, 1991). The application of organic supplements had a positive effect on the growth parameters especially in *Brinjal* (Prasanna, K.P. 1998)..

2.1.3 Effect of cytokinins

According to Kunisaki (1975) in *Ascocenda* and *Paphiopedilum* lateral shoot growth was promoted in intact stems of orchids using cytokinins.

Cytokinins when applied on *Dendrobium* cv. Youppadeevan at various doses ranging from 0.15 to 0.40 per cent, the treatment with 0.20 per cent concentration gave best results with increased leaf length, leaf width plant height and fresh weight (Widiastoety and Soebijanto, 1987).

Keithly *et al.* (1991) reported the growth enhancing properties of dichloro phenoxy triethyl amine (DCPTA) in *Dendrobium* 'Hickam Deb'. Shoot growth root: shoot ratio and survival of DCPTA treated plants were increased significantly. In another study Piluek *et al.* (1992) found that application of BA @ 1000 mg l^{-1} significantly reduced leaf shedding during transit.

2.2 Effect on spike characters

Effect of macronutrients, viz., N, P and K on flowering is similar to that of other crops. Increased nitrogen supply in P*halaenopsis* upto 1000 ppm produced longer flower spikes and spikes with increased girth. With an increase in the NPK

dose of 3:3:2 to 5:5:2 improvement in flowering of *Dendrobium* Madame Pompadour was observed (Vachorotayan and Keethapirom, 1975).

In another trial the effect of three levels of nitrogen, viz., 250, 500 and 1000 ppm, was studied in combination with 250 and 500 ppm, each, of P_2O_5 and K_2O in *Rhynchostylis gigantea*. It was observed that when 500 ppm of N was used with a combination of 500 ppm of P_2O_5 and K_2O, flowering and flower parameters were enhanced (Bhattacharjee, 1982).

Based on a trial conducted by Longman (1989) recommended foliar feeding of mature flowering plants of orchids using NPK at 18:18:18. However, NPK at 10:30:30 produced more number of spikes per year.

Wang and Gregg (1994) reported that increasing the fertilizer application from 0.25 to 1.00 g l^{-1}, increased the flower number, stalk diameter and length in *Phalaenopsis*. Wang (1996) reported that fertilizer application using 20.0 N, 8.6 P and 16.6 K @ 1 g l^{-1} in *Dendrobium* Rinappa resulted in more number inflorescences and flowers.

In *Dendrobium* 'Sonia 16' nitrogen at 500 ppm increased the length of inflorescence, number of florets per inflorescence and span area of flowers. The number of inflorescence produced was also greater in the plants receiving 400 and 500 ppm N, 500 ppm, each, of P and K, respectively (Thekkayam, 1996).

2.3 Effect on postharvest characters

Orchid flowers are sensitive to ethylene (Beyer, 1976; Davidson, 1949). Premature fading of *Cymbidium* flower was observed when exposed to ethylene at 0.0002 ppm for 24 hours (Davidson, 1949).

In *Dendrobium* cv. 'Pompadour' Nair and Tung, (1987) reported that after anthesis ethylene evolved and became prominent with increase in the levels of 1-aminocyclopropane-1-carboxylic acid (ACC) whereas exogenous application of ACC resulted in accelerated senescence in fully mature flowers.

In a study by Porat *et al.* (1993, 1994) it was found that methyl-jasmonate (JA-Me) enhances senescence of flowers in *Petunia* and *Dendrobium* via promotion of ACC and ethylene production. In *Dendrobium* cv. Jacquelyn Thomas, flowers had longevity up to three weeks but after pollination rapid acceleration of wilting with the production of ethylene and sensitivity to ethylene increased.

Ketsa *et al.* (1995) reported that in *Dendrobium* open florets on the spike enhanced the bud opening of flowers. Porat *et al.* (1995) based on the studies in *Dendrobium* reported that exogenous application of methyl-jasmonate (JA-Me) enhances ethylene production and senescence of flowers. Lipoxygenase activity (LOX) and jasmonates are probably not involved in the endogenous regulation of this process.

It was reported that rapid ethylene production in pollinated flowers was reduced by prior application of aminoxy acetic acid (AOA), an inhibitor of ACC synthase (Ketsa and Luangsuwalai, 1996). In *Dendrobium* cv. 'Pompadour', Ketsa and Rugkong (1999) showed premature petal and sepal senescence in flowers following pollination.

2.4 Stomatal studies

It is reported that (Withner *et al.,* 1975) in orchids stomata are generally with a greater extent found on the lower surface than in the upper surface of the leaf depending upon species.

It was reported that in different species of *Dendrobium* the stomatal frequency on abaxial leaf surfaces varied from 57.3 to 111.0 per mm^2 (Yukawa *et al.,* 1992). Paek and Jun (1995) studied the size and frequency of stomata in 33 orchid leaves and revealed that the number of stomata increased with age and ranged from 516 per cm^2 in *Blettilla* sp. to 2711 per cm^2 in *Paphiopedilum* and 26,988 per cm^2 in *Cymbidium* sp. The size tended to decrease with age. Stomatal frequency was studied in five species of the genus Paphiopedilum where stomata occurred only on the lower epidermis and all the species were characterized by low stomatal frequency, ranging from 13.7 to 46.8 stomata/mm^2. Stomatal frequency had a significant negative correlation with stomatal size (Handique and Handique, 1996).

Comparison of leaf anatomy, stomatal size, stomatal count and chlorophyll content was made between the leaf tissues of *in vitro* cultured and greenhouse grown plants of a *Dendrobium* hybrid 'Sonia-17' indicated a reduction in size of the guard cells, chlorophyll content of tissue cultured plants than in plants grown in greenhouse (Anitha *et al.*, 2000).

2.5 Growth analysis

In groundnut significant increase was observed in the relative growth rate and leaf area index with increasing levels of nitrogen (Reddy *et al.,* 1984, Selamet and Gardnea, 1985). A study on growth parameters of late maturing *Pigeonpea* genotypes showed considerable variability for physiological parameters such as LAI and SLW (Mehra *et al.,* 1987). Application of organic manure in groundnut resulted in increased drymatter production (Loganathan, 1990).

Growth analysis on castor cultivars showed significant difference for plant height, LAI, drymatter production etc. (Reddy *et al.*, 1997). Field investigation of 41 genotypes of soybean showed significant variation for total drymatter per plant and other morphological characters (Mehetre *et al.*, 1998).

2.6 Physiological characters

2.6.1 Chlorophyll content

Sanford (1975) reported that the amount of chlorophyll content present in leaves was adequate for photosynthesis. Kirichenko *et al.* (1989) found that the

pigment system of flowers had low chlorophyll a:b ratio compared to that of leaves in *Dendrobium* and several other orchid species.

Chae-Soochen *et al.* (1998) expressed that the ratio of chlorophyll a to b was in the ratio of 2:1 in several *Dendrobium nobile* cultivars.

Based on a study in *Dendrobium*, Khoo and Hew (1999) reported that the chlorophyll a:b ratio was same in the case of flowers and leaves whereas the total chlorophyll content in flowers declined as they matured.

2.6.2 Phenols

Chromatography has revealed the presence of many phenolic compounds (Sanford *et al.*, 1965, Withner and Stevenson, 1968). He examined chemical fractions extracted from bark of number of West African trees selected for heaviness and paucity of epiphyte load showed the presence of phenolic compounds. Arditti (1969) has also detected the presence of phenols in the flowers of some orchid species. Paul (2000) has reported the presence of phenols in Kalmegh.

2.7 Translocation of nutrients

Backbulbs are considered as a source of reserved assimilates for the growing shoots. Usually once the backbulb starts withering the assimilates are transferred to the younger shoots of the plant. But very little work has been done on this aspect.

Leaves on backshoots supplied significantly more 14 C - assimilates to another shoot bearing an inflorescence than to the other plant parts within the backshoot itself. The inflorescence on the current shoot obtained 14 C – assimilates from the leaves of both the current shoot and back shoot. It is concluded that backshoots are an important source of photoassimilates for growth and flower production in *Dendrobium* (Wadasinghe and Hew, 1995).

MATERIALS AND METHODS

MATERIALS AND METHODS

The present study titled endogenous and exogenous regulation of growth and development in dendrobium var. Sonia 17 and Sonia 28 was carried out in the orchidarium of All India Co-ordinated Floriculture Improvement Project, in the Department of Pomology and Floriculture from June 1999 to November 2000. The objectives of the study were to understand the factors responsible for changes in growth and development of *Dendrobium* varieties Sonia 17 and Sonia 28 with a view to solve field problems and to enhance production.

1 Factors responsible for changes in growth

Two commercial varieties of *Dendrobium*, namely Sonia 17 and Sonia 28 were used for the study(Plate 1). The trial consisted of three parts.

1.1. Study of endogenous factors

1.2. Study of exogenous factors

1.3. Study of translocation of nutrients

1.1 Study of endogenous factors

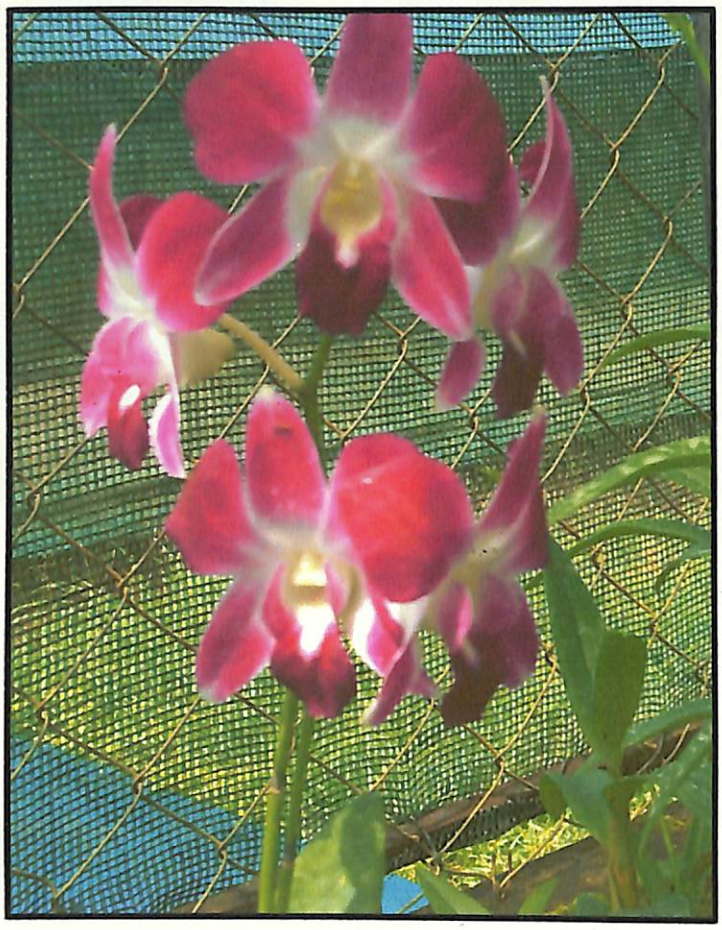
The internal changes during the following developmental stages were observed.

a) Appearance of new shoot (StageI)

b) Development of keiki (StageII)

c) Appearance of inflorescence (StageIII)

d) Wilting / senescence of flower (on the plant and in vase) (StageIV)



Sonia 17

Sonia 28

Plate 1. Dendrobium varieties used for the study

Tissue culture derived plants of size 5-8 cm were used for the study. These plants were planted in pots. Fifty plants were taken under each variety. The plants were sprayed as per the recommendation of the package of practices of Kerala Agricultural University (KAU, 1993).

1.2 Study of exogenous factors

The effect of external application of various organic and inorganic materials on growth and development were studied in *Dendrobium* varieties Sonia 17 and Sonia 28.

Treatments: 10

1. Groundnut oilcake at 1:10 dilution, weekly
2. Groundnut oilcake at 1:20 dilution, weekly
3. Greencare 13:27:27* at 0.1% twice a week
4. Greencare 13:27:27 at 0.2% twice a week
5. BA at 250 mg l^{-1} once a month
6. BA at 500 mg l^{-1} once a month
7. Combination of 1 and 3 above
8. Combination of 3 and 5 above
9. Combination of 1, 3 and 5 above
10. Control

(Constituents of Greeencare 13:27:27 are given in appendix II)

Replications	:	3
Number of plants per treatment	:	12
Design	:	CRD

1.2.1 Observations

The following observations were recorded

1.2.1.1 Growth parameters

1.2.1.1.1 Plant height

Height of the plant was measured and recorded from the base of the plant to the tip at monthly intervals and was expressed in cm.

1.2.1.1.2 Number of shoots

Number of shoots on each plant was counted and recorded at monthly intervals.

1.2.1.1.3 Number of leaves

Number of leaves on each shoot was counted and recorded at monthly intervals.

1.2.1.1.4 Total leaf area

Leaf area was calculated using the formula (Swapna, 2000)

$$a = 2.78 + 0.688\ lb$$

Where a = leaf area in cm^2

l = length of the leaf in cm

b = breadth of the leaf in cm

1.2.1.2 Spike characters

Spike characters were observed as and when the spikes were produced.

1.2.1.2.1 Number of spikes per plant

Number of spikes per plant was counted and recorded.

1.2.1.2.2 Number of florets per spike

Number of florets per spike was counted and recorded.

1.2.1.2.3 Size of the individual floret

Size of the individual floret was calculated by taking the length and breadth and was expressed in cm.

1.2.1.2.4 Blooming period

Blooming period was recorded from the emergence of the spike till the senescence of all the flowers.

1.2.1.2.5 Internodal length

Internodal length of each spike was calculated in the following way, and was expressed in cm.

$$\frac{\text{Length of the spike in cm}}{\text{Number of florets} + 1}$$

1.2.1.3 Post harvest characters

1.2.1.3.1 Fresh weight of the spike

Immediately after harvest the fresh weight of the spikes was taken and recorded in g.

1.2.1.3.2 Days to wilting of first floret

Time taken from the emergence of inflorescence to the wilting of the first floret was recorded in days.

1.2.1.4 Stomatal studies

The studies were conducted during the initiation of spike.

1.2.1.4.1 Frequency of stomata

A thin layer of Quickfix (adhesive) was applied on the lower surface of the leaves and the epidermal peelings were taken and mounted on a slide. Frequency was calculated as number of stomata per mm^2. Average of 10 fields were taken (Srivastava *et al.*, 1980).

1.2.1.4.2 Stomatal size

Stomatal size was calculated by measuring the length and breadth of stomata using ocular micrometer and expressed in mm.

1.2.2 Growth analysis

1.2.2.1 Relative growth rate (RGR)

Relative growth rate expresses the dry weight increase in a time interval in relation to the initial weight and is expressed as $g\ g^{-1}\ day^{-1}$. RGR was calculated using the formula suggested by Blackman (1919).

$$RGR = \frac{\ln w_2 - \ln w_1}{t_2 - t_1}$$

Where,

ln = logarithm to the base 'e' (Napiers constant)

W_1 and W_2 = total plant dry weight at t_2 and t_1, respectively

1.2.2.2 Leaf area index (LAI)

Leaf area index is the ratio of the total leaf area of plant to the area covered by the plant. LAI was worked out using the formula given by Watson (1952).

$$LAI = \frac{\text{Leaf area per plant}}{\text{Land area per plant}}$$

1.2.2.3 Specific leaf weight (SLW)

Specific leaf weight is the ratio of leaf weight and leaf area and expressed as g m^{-2} (Jackson 1963).

SLW = LW/LA

Where,

LA = Leaf area

LW = Leaf weight

1.2.2.4 Total dry matter production

Total dry matter was found out after uprooting the whole plant and drying it completely at 70°C. The weight was expressed in g.

1.2.3 Nutrient content

The dried plant samples were ground and then chemically analysed for nitrogen, phosphorus and potassium at different stages of growth.

1.2.3.1 Nitrogen

One gram dried sample was digested using concentrated sulphuric acid and was estimated using nitrogen using the Microkjeldahl method (Jackson, 1958).

1.2.3.2 Phosphorus

Diacid mixtures of nitric acid and perchloric acid, taken in the ratio of 9:4 (Johnson and Ulrich, 1959), was poured into the conical flask containing 0.5 g plant sample and digested. This was than made upto 100 ml. Aliquot were taken for reading. Phosphorus was estimated using Vanadomolybdophosphoric yellow colour method (Jackson, 1958). The intensity of yellow colour was read in Spectronic-20 at 470 nm.

1.2.3.2 Potassium

From the digested sample, as mentioned above, potassium was estimated using a flame photometer (EEL)

1.2.3.2 Nutrient uptake

Nutrient content was computed from the values of concentration of the nutrients and dry weight of the parts sampled and was expressed in g.

1.2.4 Physiological characters

1.2.4.1 Chlorophyll

Chlorophyll content (a, b, total) was estimated using DMSO (Dimethyl Sulphoxide) method during different stages of plant growth. Chlorophyll a, b and

total were calculated using the formula by Hiscox and Israelstam (1979) was expressed in mg g^{-1}.

Chlorophyll 'a' = 12.7 A_{663} - 2.99 A_{645} x V/1000 x W

Chlorophyll 'b' = 22.9 A_{645} - 4.68 A_{663} x V/1000 x W

Total chlorophyll = 20.2 A_{645}+8.02 A_{663} x V/1000 x W

Where

A_{645} and A_{663} = Absorbance at wavelength 645 and 663 nm respectively

W = Fresh weight of the sample

V = Volume of extract (ml)

Chlorophyll was estimated using Spectronic - 20 spectrophotometer.

1.2.4.2 Total phenol content

Total phenol content was estimated using folinciocalteau method (Sadasivam and Manickam, 1996). Finely powdered plant sample (0.5g) was ground in a pestle and mortar with 10 times volume of water and made up to 50 ml. The made up solution was further diluted to 500 ml. One ml of diluted solution was taken in a test tube and made up to 3 ml with water, followed by addition of 2 ml of sodium carbonate and 0.5 ml of folinciocalteau reagent. It was then kept in a boiling water bath for one minute and cooled down to room temperature. The intensity of blue colour developed was read at 650 nm in a spectrophotometer. Total phenol content was calculated from a standard curve of catechol and was expressed as 'mg' of phenol per 'g' of plant sample.

$$\text{Total phenol content} = \text{Factor} \times \text{Absorbance} \times \frac{\text{Dilution}}{\text{Vol.made}} \times \frac{1000}{\text{Weight of the sample}}$$

1.3 Translocation of nutrients

Dendrobium variety Sonia-28 was taken and 15 plants of uniform age size and health were chosen. Backbulb of the plant was injected with 10.0 µci of ^{32}P solution(Plate 2). Samples were taken on 2^{nd}, 4^{th}, 6^{th}, 8^{th} and 10^{th} day, respectively. Translocation of radioactivity was studied from the backbulb to the immature shoots. The samples were cut and dried and digested using diacid mixture of nitric acid and perchloric acid in the ratio of 9:4. The digested samples were made upto 20 ml. and transferred to vials. These vials were read in a liquid scintillation counter using Cerenkov method.

1.4 Statistical analysis

Statistical analysis was done using analysis of variance technique (Panse and Sukhatme, 1985). MSTATC and MS - Excel softwares were used for computation and analysis.

Dispensing ^{32}P solution

A close up view

Plate 2. Inoculation of ^{32}P into the back bulb

RESULTS

RESULTS

Results of the experiment titled "Endogenous and exogenous regulation of growth and development in Dendrobium var. Sonia 17 and Sonia 28" are presented in this chapter. The weather data for the period June1999 to November 2000 is given in appendix I.

4.1 Effect of endogenous factors

The morpho-physiological parameters of *Dendrobium* varieties Sonia 17 and Sonia 28 are given in Tables 1 to 3.

4.1.1 Growth parameters

Data pertaining to growth parameters are given in Table 1 (Fig.1).

When plant height was considered the var. Sonia-17 and Sonia-28 varied insignificantly with each other. It was also evident that Sonia-17 had expressed more vigour by producing more number of leaves (10.1) than in Sonia 28 (8.4). The number of shoots was more in Sonia 17 (2.2) than in Sonia 28 (2.0). The total leaf area was significantly higher (336.82 cm^2) in case of Sonia 17 as against 262.56 cm^2 in Sonia 28. There was also differences with the plant spread wherein Sonia-17 had more plant spread (18.4 x 21.2 cm) as compared to Sonia 28 (16.8 x 20.1 cm).

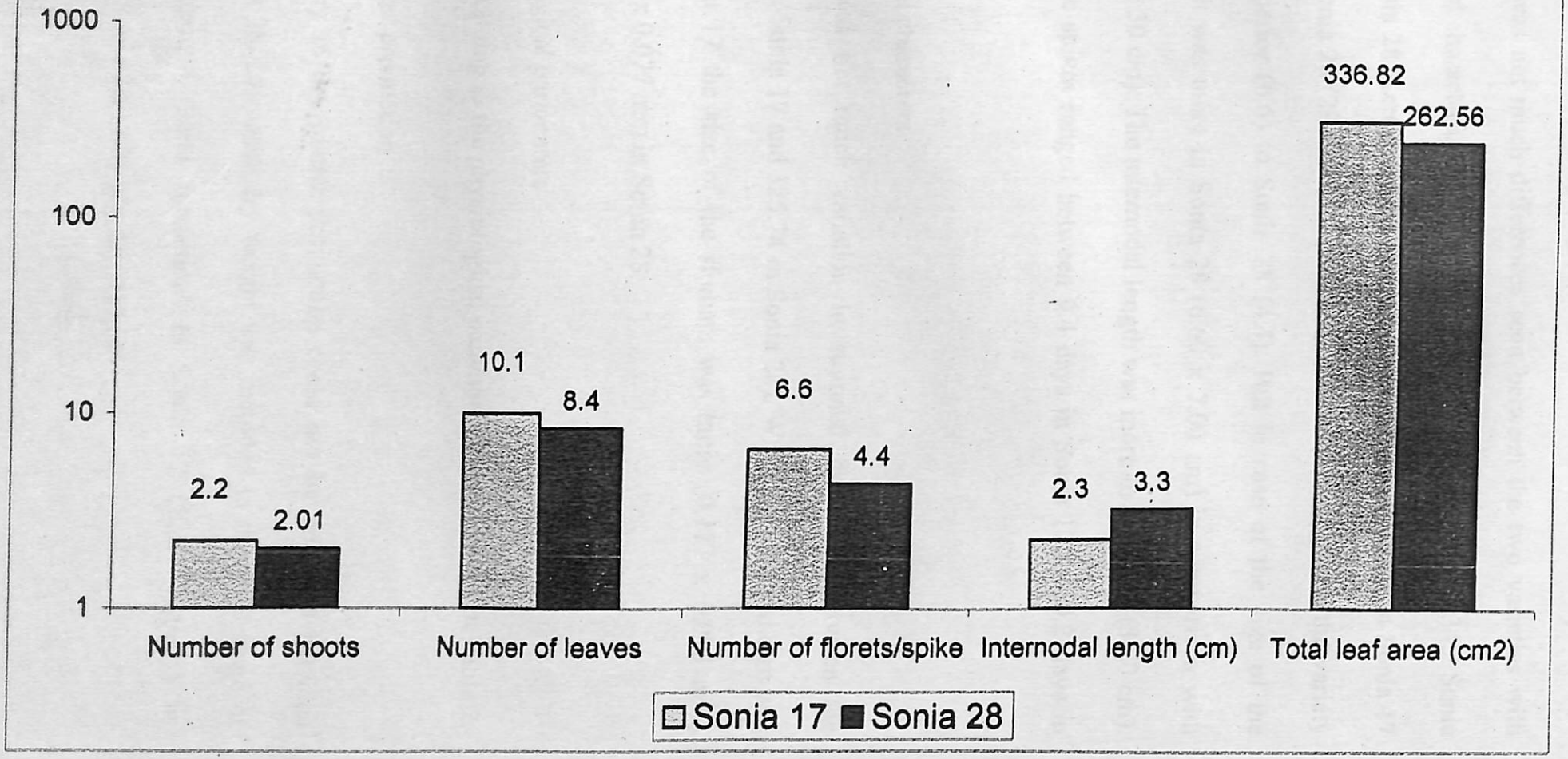
4.1.2 Floral characters

Data pertaining to the floral characters are presented in Table 1(Fig.1).

Table 1. Morphological parameters of one year old plants of *Dendrobium* var. 'Sonia 17' and 'Sonia 28'.

	Character	Sonia 17	Sonia 28	Significance at 5%
1	Growth parameters			
	a. Plant height (cm)	24.27	21.88	NS
	b. Plant spread, EW x NS (cm)	18.4 x 21.2	10.8 x 20.1	
	c. Number of shoots	2.2	2.0	S
	d. Number of leaves	10.1	8.4	S
	e. Total leaf area (cm^2)	336.82	262.56	S
2	Floral characters			
	a. Time taken for spike emergence (days)	34.2	35.4	NS
	b. Spike length (cm)	32	29.1	NS
	c. Number of florets/spike	6.6	4.4	S
	d. Size of the individual floret, l x b (cm)	5.3 x 6.3	6.6 x 7.0	
	e. Internodal length (cm)	2.3	3.3	S
	f. Vaselife (days)	9.4	10.2	NS
3	Stomatal characters			
	a. Stomatal density (no/mm^2)	306.43	325.74	S
	b. Stomatal size, l x b (mm)	0.127 x 0.093	0.113 x 0.077	

Fig. 1. Morphological parameters at 12 months after planting in *Dendrobium* var. 'Sonia 17' and 'Sonia 28'.



There was not much differences seen between the two varieties with respect to the floral characters. The days taken for spike emergence was 34.2 Sonia 17and 35.4 in Sonia 28. Length of the spike was comparatively more in Sonia 17 (32 cm) than in Sonia 28 (29.1 cm). Considering the number of florets, the variety Sonia 17 was superior (6.6) to Sonia 28 (4.4). But in case of the size of the individual floret, it was more in Sonia 28 (6.60 x 7.00 cm) in comparison with Sonia-17 (5.30 x 6.30 cm). The internodal length was more in Sonia-28 (3.30 cm). The vaselife of the spikes ranged between 9.4 days in Sonia 17 to 10.2 days in Sonia 28.

4.1.3 Stomatal characters

There was not much variation in stomatal frequency between the varieties (306.43 in Sonia 17 and 325.74 in Sonia 28). When the stomatal size was compared in Sonia 17 the size of the stomata was more (0.127 x 0.093 mm) compared to 0.113 x 0.077 mm in Sonia 28.

4.1.4 Physiological parameters

Data pertaining to the physiological parameters are presented in Table 2.

4.1.4.1 Dry matter production

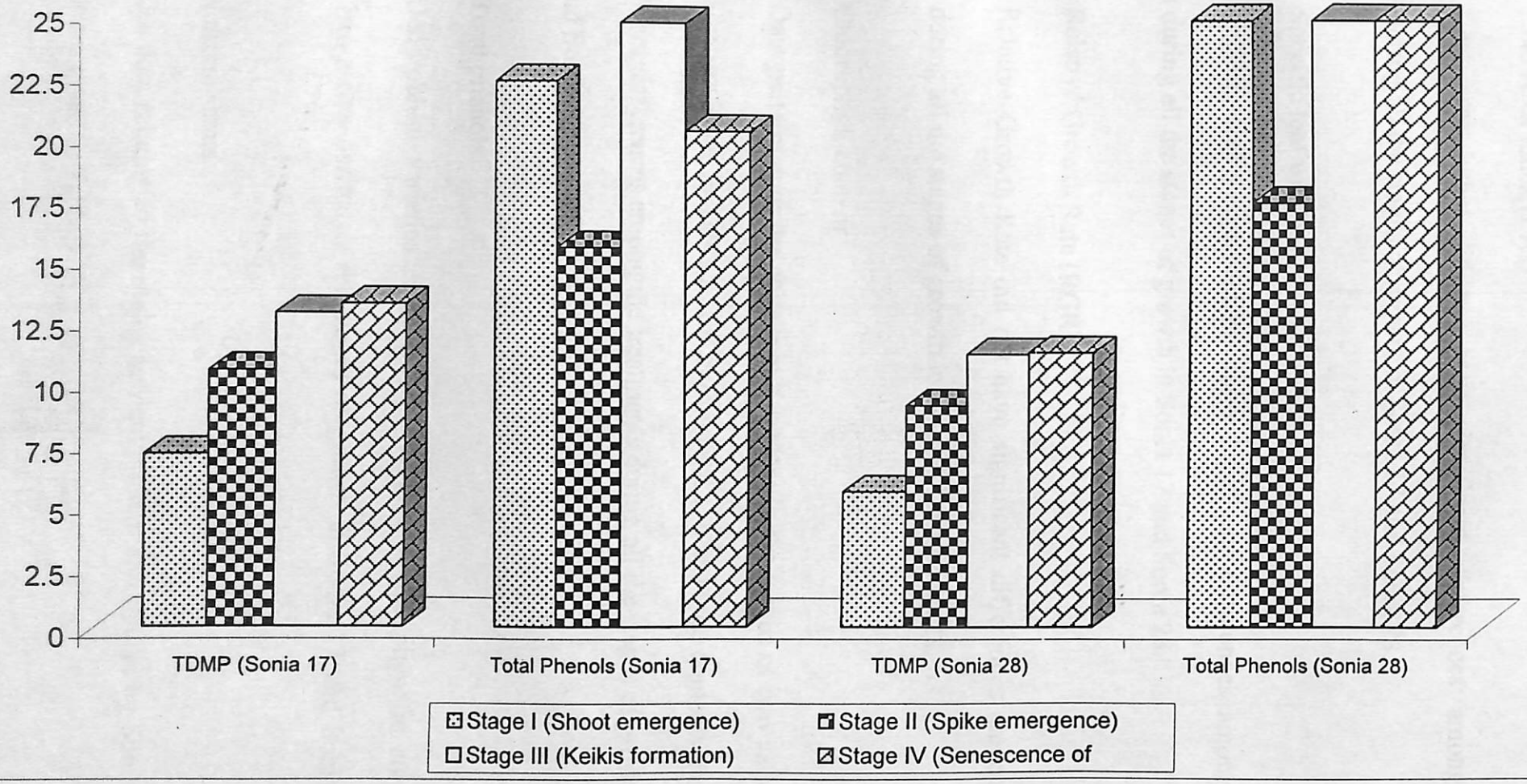
Variability in dry matter production could not be observed between Sonia 17 and Sonia 28. Increased dry weight was recorded in the third stage of growth and development (keiki formation) in Sonia 17 (12.81 g/g/day) as compared to that of Sonia 28(11.21 g/g/day) (Fig.2).

Table 2. Physiological parameters of *Dendrobium* varieties Sonia 17 and Sonia 28 at different stages of growth

Parametrs	Sonia 17	Sonia 28	Significance at 5%
Total DMP (g)			
Stage I	7.03	5.53	NS
II	10.46	9.08	NS
III	12.81	11.21	S
IV	13.20	11.30	NS
LAI			
Stage I	0.473	0.530	NS
II	0.653	0.607	NS
III	0.812	0.807	NS
IV	0.846	0.814	NS
SLW (g/m^2)			
Stage I	0.136	0.133	NS
II	0.135	0.136	NS
III	0.138	0.130	NS
IV	0.160	0.150	NS
RGR (g/g/day)	0.017	0.012	NS
Chlorophyll a (mg/g)			
Stage I	0.297	0.257	NS
II	0.300	0.330	NS
III	0.280	0.340	NS
IV	0.471	0.374	NS
Chlorophyll b (mg/g)			
Stage I	0.047	0.033	NS
II	0.060	0.070	NS
III	0.080	0.104	NS
IV	0.180	0.138	NS
Chlorophyll Total (mg/g)			
Stage I	0.348	0.290	NS
II	0.363	0.407	NS
III	0.370	0.444	NS
IV	0.660	0.572	NS
Total phenols (mg/g)			
Stage I	22.3	27.8	NS
II	15.5	17.5	NS
III	24.7	29.5	NS
IV	20.3	26.2	S

Stage I - Shoot emergence
II - Spike emergence
III - Keiki formation
IV - Senescence of spike

Fig. 2. Physiological parameters of Dendrobium variety 'Sonia 17' and 'Sonia 28' at different stages of growth



4.1.4.2 Leaf Area Index (LAI)

Leaf area index did not have significant differences among the treatments during all the stages of growth in Sonia 17 and Sonia 28.

4.1.4.3 Specific leaf weight

Specific leaf weight did not have significant differences among the treatments during all the stages of growth in Sonia 17 and Sonia 28.

4.1.4.4 Relative Growth Rate (RGR)

Relative Growth Rate did not have significant differences among the treatments during all the stages of growth in Sonia 17 and Sonia 28.

4.1.4.5 Chlorophyll content

Data pertaining to the chlorophyll content in the leaves of two varieties of *Dendrobium* are given in Table 2. The chlorophyll a, b and total contents did not have significant differences among the treatments during all the stages of growth in Sonia 17 and Sonia 28.

4.1.4.6 Total phenols

Dendrobium varieties exhibited no variation in the phenolic content among the treatments during all the stages of growth in Sonia 17 and Sonia 28 (Fig.2).

4.1.5 Nutrient status

The data relating to the major nutrient content and uptake by Sonia 17 and Sonia 28 are given in Table 3.

Table 3. Nutrient content and uptake of nutrients in *Dendrobium* varieties 'Sonia 17' and 'Sonia 28' at different stages of growth

	Nutrient content (%)		Significance at 5%	Nutrient uptake (g)		Significance at 5%
	Sonia 17	Sonia 28		Sonia 17	Sonia 28	
Nitrogen						
Stage I	1.75	1.40	NS	0.12	0.07	NS
II	1.80	1.40	NS	0.19	0.12	NS
III	1.55	1.50	NS	0.20	0.17	NS
IV	1.90	1.90	NS	0.25	0.22	NS
Phosphorus						
Stage I	0.326	0.324	NS	0.02	0.01	NS
II	0.320	0.302	NS	0.03	0.03	NS
III	0.270	0.240	NS	0.04	0.03	NS
IV	0.210	0.190	NS	0.03	0.02	NS
Potassium						
Stage I	1.20	1.10	NS	0.08	0.06	NS
II	2.10	1.80	NS	0.21	0.16	NS
III	1.90	1.80	NS	0.24	0.20	NS
IV	2.10	1.90	NS	0.28	0.22	NS

Stage I - Shoot emergence
II - Spike emergence
III - Keiki formation
IV - Senescence of spike

4.1.5.1 Nutrient content

4.1.5.1.1 Nitrogen

The nitrogen content in the plant did not have significant differences among the treatments during all the stages of growth in Sonia 17 and Sonia 28.

4.1.5.1.2 Phosphorus

The concentration of phosphorus in the plant did not have significant differences among the treatments during all the stages of growth in Sonia 17 and Sonia 28.

4.1.5.1.3 Potassium

The content of potassium in the plants did not have significant differences among the treatments during all the stages of growth in Sonia 17 and Sonia 28.

4.1.5.2 Nutrient uptake

4.1.5.2.1 Nitrogen

The uptake of nitrogen in the plant did not have significant differences among the treatments during all the stages of growth in Sonia 17 and Sonia 28.

4.1.5.2.2 Phosphorus

The uptake of phosphorus in the plant did not have significant differences among the treatments during all the stages of growth in Sonia 17 and Sonia 28.

4.1.5.2.3 Potassium

The uptake of potassium in the plant did not have significant differences among the treatments during all the stages of growth in Sonia 17 and Sonia 28.

4.2 Effect of exogenous factors

Data obtained from the pot culture experiments conducted in *Dendrobium* varieties Sonia 17 and Sonia 28 to study the influence of external application of organic and inorganic nutrients and growth regulators are presented below.

4.2.1 Growth parameters

Monthly observations on of the varieties up to the 7th month of planting are presented in tables 4 to 10. External application of nutrients had no significant effect on the growth parameters.

4.2.1.1 Plant height

Influence of chemicals on plant height was non-significant between the varieties of *Dendrobium* Sonia 17 and Sonia 28 (Table 10).

4.2.1.2 Number of leaves

In the variety Sonia 17 had no significant differences among the treatments with respect to number of leaves.

There was significant difference among the treatments with number of leaves in variety Sonia 28. Maximum number of leaves (9.0) was found in

Table 4. Growth parameters of *Dendrobium* varieties 'Sonia 17' and 'Sonia 28'as influenced by exogenous application of nutrients (One month after application)

Treatment	Sonia 17				Sonia 28			
	Plant height (cm)	Number of leaves	Total leaf area (cm^2)	Number of shoots	Plant height (cm)	Number of leaves	Total leaf area (cm^2)	Number of shoots
T_1	12.06	7.60	162.15	2.43	13.10	8.70	185.62	2.96
T_2	12.13	7.20	153.62	2.33	12.50	7.60	162.15	2.93
T_3	12.70	6.40	136.55	2.10	13.10	7.50	160.02	2.76
T_4	12.40	7.70	164.29	2.33	12.76	7.60	162.15	2.70
T_5	12.63	7.20	153.62	2.20	11.90	7.20	153.62	2.76
T_6	12.23	7.30	155.75	2.16	12.56	8.00	170.69	3.53
T_7	11.36	7.60	162.15	2.26	11.66	7.70	164.29	2.83
T_8	11.76	7.50	160.02	2.50	12.23	7.40	157.89	2.93
T_9	13.16	7.70	164.29	2.50	12.26	7.80	166.42	2.53
T_{10}	12.30	7.70	164.29	2.26	10.73	7.40	157.89	2.93
SEm±	0.65	0.353	45.29	0.219	0.807	0.48	45.03	0.278
CD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 5. Growth parameters of *Dendrobium* varieties 'Sonia 17' and 'Sonia 28' as influenced by exogenous application of nutrients (Two months after application)

Treatment	Sonia 17				Sonia 28			
	Plant height (cm)	Number of leaves	Total leaf area (cm^2)	Number of shoots	Plant height (cm)	Number of leaves	Total leaf area (cm^2)	Number of shoots
T_1	13.5	8.70	203.58	2.63	14.16	9.00	210.6	2.86
T_2	13.56	8.50	198.90	2.60	14.23	9.60	224.64	2.93
T_3	13.53	8.20	191.88	2.53	14.16	8.80	205.92	3.03
T_4	13.8	8.20	191.88	2.43	13.46	8.30	194.22	2.6
T_5	14.2	9.60	224.64	3.10	13.36	9.60	224.64	2.86
T_6	12.1	7.30	170.82	2.13	13.73	11.40	266.76	3.16
T_7	13.36	8.70	203.58	2.76	13.46	8.70	203.58	2.93
T_8	12.76	10.10	236.34	3.16	13.66	9.20	215.28	2.93
T_9	14.03	8.70	203.58	2.6	13.96	8.90	208.26	2.63
T_{10}	12.93	7.60	177.84	2.6	11.76	8.40	196.56	3.0
SEm±	0.660	1.10	83.07	0.235	0.954	1.400	61.52	0.24
CD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 6. Growth parameters of *Dendrobium* varieties 'Sonia 17' and 'Sonia 28' as influenced by exogenous application of nutrients (Three months after application)

Treatment	Sonia 17				Sonia 28			
	Plant height (cm)	Number of leaves	Total leaf area (cm^2)	Number of shoots	Plant height (cm)	Number of leaves	Total leaf area (cm^2)	Number of shoots
T_1	13.56	8.80	241.49	3.03	14.06	7.90	216.79	2.83
T_2	14.06	8.90	244.23	2.86	15.06	9.30	255.21	3.06
T_3	15.1	8.30	227.77	2.43	14.4	8.60	236.00	3.1
T_4	13.93	8.90	244.23	2.76	12.7	8.50	233.26	3.06
T_5	15.5	10.40	285.40	3.0	15.06	7.70	211.30	2.43
T_6	12.63	7.00	192.09	2.53	15.16	9.10	249.72	2.96
T_7	14.26	9.30	255.21	2.86	14.13	8.10	222.28	2.8
T_8	13.8	9.30	255.21	3.03	13.6	8.90	244.23	3.6
T_9	13.7	8.00	219.54	2.66	15.1	7.70	211.30	2.26
T_{10}	13.83	7.90	216.79	2.6	13.2	8.20	225.02	2.6
SEm±	0.84	0.78	97.68	0.148	1.063	0.809	69.7	0.265
CD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 7. Growth parameters of *Dendrobium* varieties 'Sonia 17' and 'Sonia 28' as influenced by exogenous application of nutrients (four months after application)

Treatment	Sonia 17				Sonia 28			
	Plant height (cm)	Number of leaves	Total leaf area (cm^2)	Number of shoots	Plant height (cm)	Number of leaves	Total leaf area (cm^2)	Number of shoots
T_1	15.06	9.90	307.01	3.1	15.6	7.50	232.58	2.76
T_2	14.7	8.30	257.39	3.03	16.0	8.90	276.00	3.03
T_3	16.46	8.40	260.49	2.76	14.93	7.70	238.78	2.9
T_4	14.96	8.50	263.59	3.0	14.16	9.10	282.20	2.93
T_5	16.53	10.60	328.72	3.03	15.46	7.50	232.58	2.66
T_6	13.16	7.20	223.28	2.53	16.4	8.50	263.59	2.73
T_7	15.6	9.00	279.10	2.8	14.93	7.50	232.58	2.96
T_8	14.76	9.20	285.30	3.03	14.83	8.30	257.39	3.0
T_9	15.60	7.90	244.99	3.2	15.73	7.90	244.99	2.8
T_{10}	14.67	7.40	229.48	2.6	13.5	7.70	238.78	3.2
SEm±	0.71	0.7	81.81	0.147	1.10	0.91	75.20	0.261
CD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 8. Growth parameters of *Dendorbium* varieties 'Sonia 17' and 'Sonia 28'as influenced by exogenous application of nutrients (five months after application)

Treatment	Sonia 17				Sonia 28			
	Plant height (cm)	Number of leaves	Total leaf area (cm^2)	Number of shoots	Plant height (cm)	Number of leaves	Total leaf area (cm^2)	Number of shoots
T_1	13.63	9.00	273.45	2.86	15.23	6.10	155.33	2.53
T_2	14.13	9.40	285.60	3.26	15.23	7.80	198.62	3.0
T_3	15.3	9.00	273.45	2.93	14.46	6.90	175.70	2.76
T_4	15.13	9.80	322.37	3.2	13.83	8.50	216.44	3.2
T_5	14.96	8.60	261.30	2.76	15.8	7.40	188.43	2.66
T_6	12.56	8.10	246.10	2.93	14.7	6.50	165.52	2.43
T_7	15.26	8.20	269.73	2.63	14.6	7.20	183.34	2.76
T_8	14.10	8.90	270.41	3.0	13.43	6.30	160.42	2.76
T_9	14.6	8.50	258.26	3.03	15.46	6.70	170.61	2.26
T_{10}	15.16	8.80	267.37	2.83	12.53	6.70	170.61	3.03
SEm±	0.88	0.73	113.50	0.22	0.91	0.42	72.19	0.22
CD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 9. Growth parameters of *Dendrobium* varieties 'Sonia 17' and 'Sonia 28'as influenced by exogenous application of nutrients (six months after application)

Treatment	Sonia 17				Sonia 28			
	Plant height (cm)	Number of leaves	Total leaf area (cm^2)	Number of shoots	Plant height (cm)	Number of leaves	Total leaf area (cm^2)	Number of shoots
T_1	14.36	9.30	282.56	3.26	16.83	5.90	164.445	2.53
T_2	15.63	9.30	278.56	3.33	16.43	7.80	217.402	3.06
T_3	16.26	9.00	273.45	2.93	15.63	6.90	192.317	2.76
T_4	16.93	9.80	322.37	3.26	15.16	8.50	236.912	3.2
T_5	16.2	8.60	261.30	2.76	17.16	7.40	206.253	2.76
T_6	13.4	8.10	246.10	3.2	15.86	6.50	181.168	2.53
T_7	16.5	8.20	269.73	2.63	15.8	7.10	197.891	2.76
T_8	14.74	9.00	273.45	3.10	14.73	6.40	178.381	2.43
T_9	16.2	8.60	261.30	2.93	16.86	6.70	186.742	2.6
T_{10}	16.33	8.80	267.37	2.93	13.36	6.70	186.742	2.86
SEm±	0.88	0.75	85.54	0.174	0.98	0.45	73.32	0.249
CD(0.05)	NS	NS	NS	NS	NS	1.34	NS	NS

Table 10. Growth parameters of *Dendrobium* varieties 'Sonia 17' and 'Sonia 28'as influenced by exogenous application of nutrients (seven months after application)

Treatment	Sonia 17				Sonia 28			
	Plant height (cm)	Number of leaves	Total leaf area (cm^2)	Number of shoots	Plant height (cm)	Number of leaves	Total leaf area (cm^2)	Number of shoots
T_1	16.6	9.50	295.83	3.16	18.96	5.90	164.44	2.36
T_2	17.66	9.80	305.17	3.33	18.06	7.80	217.40	2.93
T_3	18.46	9.00	280.26	2.93	17.16	6.90	192.32	2.76
T_4	19.46	10.50	326.97	3.26	17.13	9.00	250.85	2.93
T_5	18.4	8.60	267.80	2.76	18.86	7.40	206.25	2.66
T_6	15.43	9.00	255.35	3.13	17.86	7.40	206.25	2.66
T_7	18.83	8.20	280.26	2.63	17.50	6.70	186.74	2.53
T_8	17.56	8.00	289.60	3.20	15.76	7.30	203.47	2.70
T_9	18.76	9.10	283.37	3.03	18.43	6.70	186.74	2.26
T_{10}	18.46	8.80	274.03	2.83	15.13	6.70	186.74	3.03
SEm±	0.93	0.57	80.32	0.163	0.95	0.55	75.54	0.211
CD(0.05)	NS	NS	NS	NS	NS	1.34	NS	NS

Note: T_1 - Groundnut Oil Cake 1:10 weekly once
T_2 - Groundnut Oil Cake 1:20 weekly once
T_3 - Greencare 13:27:27 weekly twice
T_4 - Greencare 13:27:27 weekly twice
T_5 - Benzyl adenine 250 mg l^{-1} once a month
T_6 - Benzyl adenine 500 mg l^{-1} once a month
T_7 - $T_1 + T_3$
T_8 - $T_3 + T_5$
T_9 - $T_1 + T_3 + T_5$
T_{10} - Control (water spray)

treatment applied with 0.2 per cent Greencare (T_4) except with 1:20 groundnut oilcake (T_2), 250 mg l^{-1} BA (T_5) and combination of 0.1 per cent Greencare + 1:20 groundnut oilcake (T_4). The minimum (5.9) was in treatment with 1:10 groundnut oil cake (T_1). Which were on par with 500 mg l^{-1} BA (T_6) combination of 0.1 per cent Greencare + 250 mg l^{-1} BA (T_8) and control (T_{10}) (Table 10).

4.2.1.3 Total leaf area

Total leaf area did not have any exceptional differences among the treatments in the varieties Sonia 17 and Sonia 28 (Table 10).

4.2.1.4 Number of shoots

Number of shoots did not have any significant difference among the treatments in the varieties Sonia 17 and Sonia 28 (Table 10).

4.2.2 Stomatal studies

Data pertaining to the stomatal size and stomatal frequency at the spike emergence stage are presented in Table 13.

4.1.2.1 Stomatal frequency

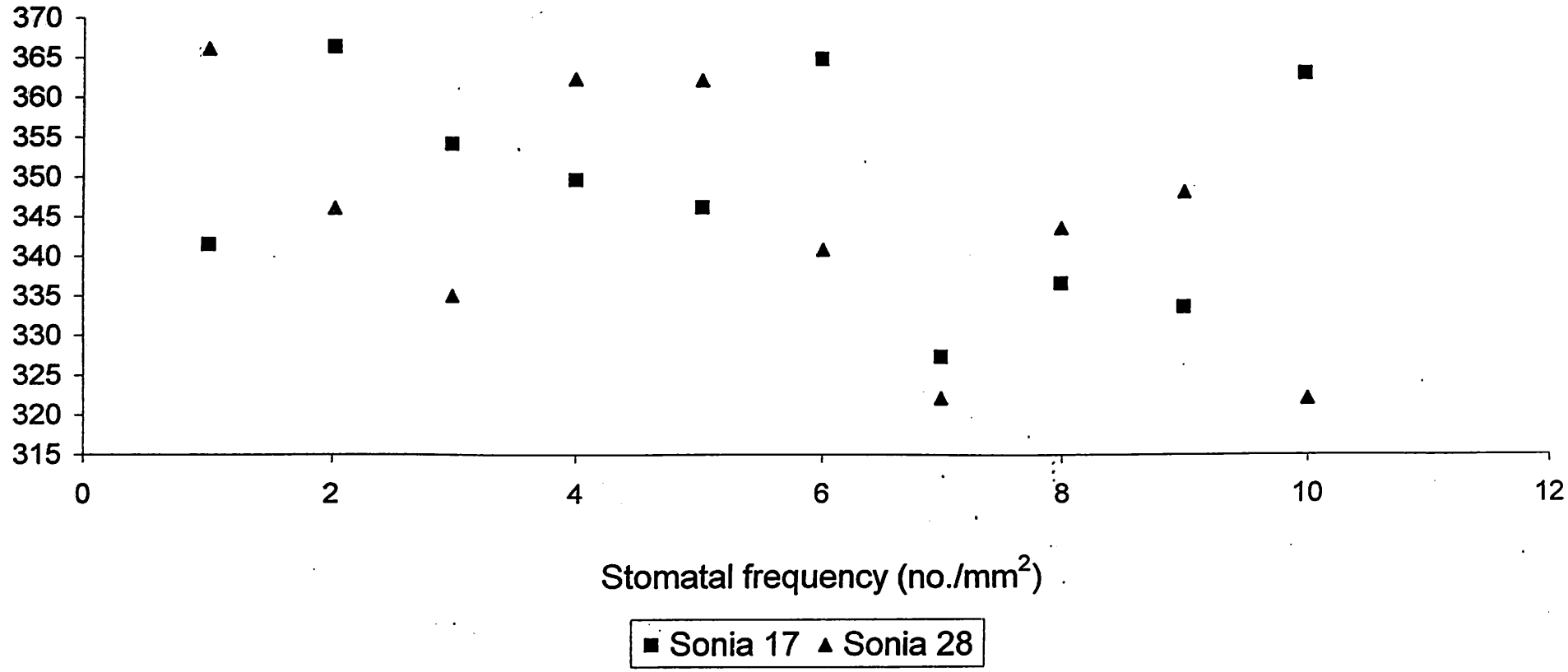
Stomatal frequency in *Dendrobium* variety Sonia 17 and Sonia 28 were significantly influenced by the external application of nutrients. In the var. Sonia 17 the highest number of stomata per mm^2 (366.60) was detected in the treatment with 1:20 groundnut oilcake (T_2) and the lowest (327.44), in the treatment with a combination of 1:10 groundnut oilcake + 0.1 per cent Greencare (T_7) (Fig.3).

Table 11. Stomatal size and stomatal frequency in Dendrobium varieties at spike emergence stage as influenced by exogenous application of nutrients.

Treatment	Sonia 17		Sonia 28	
	Stomatal size (mm) L x B	Stomatal frequency	Stomatal size (mm) L x B	Stomatal frequency
T_1	0.130 x 0.097	341.48	0.110 x 0.077	366.16
T_2	0.127 x 0.097	366.60	0.117 x 0.073	346.16
T_3	0.130 x 0.080	354.34	0.127 x 0.097	335.10
T_4	0.110 x 0.080	349.80	0.100x 0.073	362.54
T_5	0.117 x 0.097	346.40	0.117 x 0.073	362.54
T_6	0.130 x 0.097	365.34	0.100 x 0.070	341.06
T_7	0.117 x 0.097	327.44	0.117 x 0.087	322.14
T_8	0.117 x 0.087	336.80	0.107 x 0.070	343.82
T_9	0.127 x 0.097	333.84	0.119 x 0.083	348.50
T_{10}	0.123 x 0.080	363.62	0.110 x 0.070	322.14
SEm ±	0.005 0.05	4.07	0.005 0.005	4.07
CD (0.05)	0.017 0.017	12.01	0.017 0.017	12.01

Note: T_1 - Groundnut Oil Cake 1:10 weekly once
T_2 - Groundnut Oil Cake 1:20 weekly once
T_3 - Greencare 13:27:27 weekly twice
T_4 - Greencare 13:27:27 weekly twice
T_5 - Benzyl adenine 250 mg l^{-1} once a month
T_6 - Benzyl adenine 500 mg l^{-1} once a month
T_7 - $T_1 + T_3$
T_8 - $T_3 + T_5$
T_9 - $T_1 + T_3 + T_5$
T_{10} - Control (water spray)

Fig. 3. Stomatal frequency (no./mm^2) in Dendrobium varieties 'Sonia 17' and 'Sonia 28' at inflorescence emergence stage as influenced by exogenous application of nutrients



In the variety Sonia 28, the highest number of stomatal per mm^2 (366.16) was recorded in treatment with 1:10 groundnut oilcake (T_1) and minimum (322.14) with a treatment combination of 1:10 groundnut oilcake + 0.1 percent Greencare (T_7) and control (T_{10}).

4.2.2.2 Stomatal size

The stomatal size exhibited significant differences among the treatments in both the varieties. In Sonia 17, the stomatal size ranged from 0.110 x 0.080 mm in treatment with 0.2 per cent Greencare (T_4), to 0.130 x 0.097 mm recorded in the treatments with 1:10 groundnut oilcake (T_1) and 500 mg l^{-1} BA (T_6).

In the var. Sonia 28 the stomatal size ranged from 0.100 x 0.073 mm in the treatment with 0.2 per cent Greencare (T_4) to 0.127 x 0.097 mm in 0.1 per cent Greencare (T_3).

4.2.3 Growth Analysis

The data pertaining to the growth analysis viz. LAI, SLW, RGR, TDMP are presented in Tables 13 to 15.

4.2.3.1 Leaf Area Index (LAI)

In the varieties Sonia 17 and Sonia 28 the leaf area index did not differ significantly during different stages of growth (Table 14) (Fig.4).

4.2.3.2 Specific leaf weight (SLW)

The treatments showed significant differences in both the varieties with regard to the specific leaf weight at the emergence of shoot (stage I) in var.

Table 12. Leaf area index and Specific leaf weight in *Dendrobium var.* 'Sonia 17' and 'Sonia 28' as influenced by the exogenous application of nutrients.

Treatment	Sonia 17				Sonia 28			
	Stage I		Stage II		Stage I		Stage II	
	LAI	SLW	LAI	SLW	LAI	SLW	LAI	SLW
T_1	0.560	0.133	0.583	0.134	0.580	0.134	0.693	0.131
T_2	0.580	0.133	0.533	0.135	0.553	0.136	0.690	0.131
T_3	0.600	0.134	0.633	0.132	0.560	0.135	0.653	0.133
T_4	0.580	0.133	0.667	0.132	0.630	0.133	0.680	0.132
T_5	0.617	0.134	0.623	0.133	0.647	0.133	0.567	0.135
T_6	0.660	0.132	0.580	0.133	0.607	0.134	0.720	0.130
T_7	0.537	0.136	0.587	0.134	0.517	0.137	0.573	0.133
T_8	0.563	0.134	0.510	0.136	0.547	0.135	0.600	0.133
T_9	0.460	0.137	0.517	0.137	0.447	0.136	0.583	0.133
T_{10}	0.417	0.140	0.423	0.140	0.407	0.142	0.583	0.133
SEm ±	0.05	0.005	0.06	0.005	0.05	0.005	0.05	0.005
CD (0.05)	NS	0.017	NS	NS	NS	0.017	NS	NS

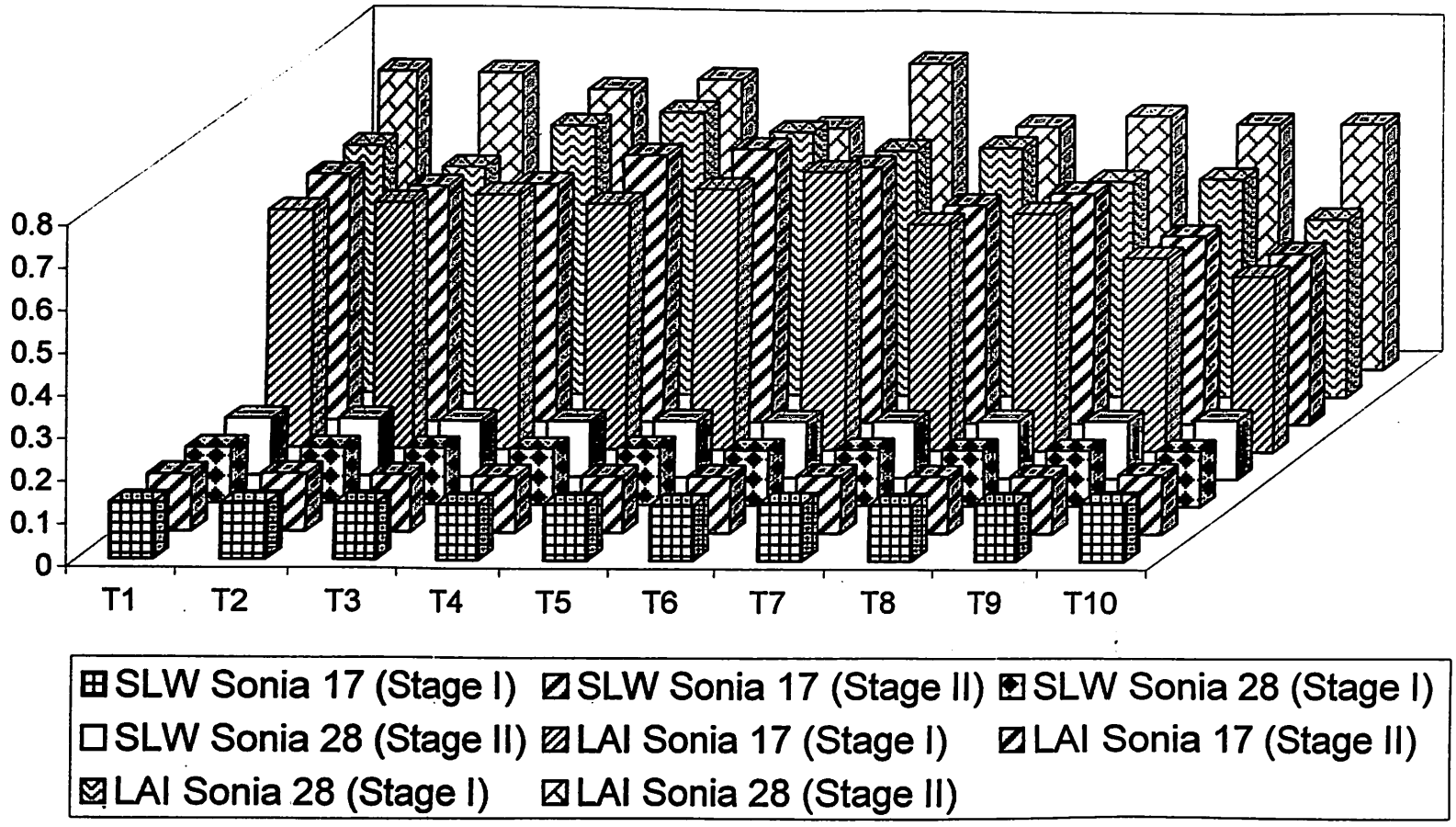
Note: T_1 - Groundnut Oil Cake 1:10 weekly once
T_2 - Groundnut Oil Cake 1:20 weekly once
T_3 - Greencare 13:27:27 weekly twice
T_4 - Greencare 13:27:27 weekly twice
T_5 - Benzyl adenine 250 mg l^{-1} once a month
T_6 - Benzyl adenine 500 mg l^{-1} once a month
T_7 - $T_1 + T_3$
T_8 - $T_3 + T_5$
T_9 - $T_1 + T_3 + T_5$
T_{10} - Control (water spray)

Table 12. Leaf area index and Specific leaf weight in *Dendrobium var.* 'Sonia 17' and 'Sonia 28' as influenced by the exogenous application of nutrients.

Treatment	Sonia 17				Sonia 28			
	Stage I		Stage II		Stage I		Stage II	
	LAI	SLW	LAI	SLW	LAI	SLW	LAI	SLW
T_1	0.560	0.133	0.583	0.134	0.580	0.134	0.693	0.131
T_2	0.580	0.133	0.533	0.135	0.553	0.136	0.690	0.131
T_3	0.600	0.134	0.633	0.132	0.560	0.135	0.653	0.133
T_4	0.580	0.133	0.667	0.132	0.630	0.133	0.680	0.132
T_5	0.617	0.134	0.623	0.133	0.647	0.133	0.567	0.135
T_6	0.660	0.132	0.580	0.133	0.607	0.134	0.720	0.130
T_7	0.537	0.136	0.587	0.134	0.517	0.137	0.573	0.133
T_8	0.563	0.134	0.510	0.136	0.547	0.135	0.600	0.133
T_9	0.460	0.137	0.517	0.137	0.447	0.136	0.583	0.133
T_{10}	0.417	0.140	0.423	0.140	0.407	0.142	0.583	0.133
SEm ±	0.05	0.005	0.06	0.005	0.05	0.005	0.05	0.005
CD (0.05)	NS	0.017	NS	NS	NS	0.017	NS	NS

Note: T_1 - Groundnut Oil Cake 1:10 weekly once
T_2 - Groundnut Oil Cake 1:20 weekly once
T_3 - Greencare 13:27:27 weekly twice
T_4 - Greencare 13:27:27 weekly twice
T_5 - Benzyl adenine 250 mg l^{-1} once a month
T_6 - Benzyl adenine 500 mg l^{-1} once a month
T_7 - $T_1 + T_3$
T_8 - $T_3 + T_5$
T_9 - $T_1 + T_3 + T_5$
T_{10} - Control (water spray)

Fig. 4. Leaf area index (LAI) and Specific leaf weight [SLW (g/m^2)] in Dendrobium varieties 'Sonia 17' and 'Sonia 28' as influenced by the exogenous application of nutrients



Sonia 17 highest value (0.140) was recorded in control (T_{10}) and the lowest (0.132) in the treatment with 500 mg l^{-1} BA (T_6) whereas in Sonia 28 highest (0.142)was recorded in control (T_{10}) and the lowest (0.133) in 0.1 per cent Greencare (T_4) and 250 mg l^{-1} BA (T_5).

During the emergence of spike (stage II) there was no significant difference among the treatments in both the varieties (Table 14) (Fig.4).

4.2.5.3 Relative growth rate (RGR)

Relative growth rate (Table 15) was computed comparing the stages of emergence of shoot (stage I) and emergence of spike (stage II). The treatments did not differ significantly in the varieties Sonia 17 and Sonia 28 with respect to RGR.

4.2.3.4 Total dry matter production (TDMP)

The total dry matter production (Table 16) did not have significant differences among the treatments in both the varieties during the emergence of shoot and emergence of spike.

4.2.4 Nutrient status

4.2.4.1 Nutrient content

Data pertaining to the concentration of major nutrients in *Dendrobium* varieties Sonia 17 and Sonia 28 during different stages of development are presented in Table 17 (Fig.5 to 6).

Table 13. RGR (g/g/day) as influenced by exogenous application of nutrient in *Dendrobium* var. Sonia 17 and Sonia 28

Treatment	Sonia 17 (g/g/day)	Sonia 28 (g/g/day)
T_1	0.009	0.006
T_2	0.008	0.012
T_3	0.014	0.010
T_4	0.010	0.009
T_5	0.010	0.011
T_6	0.011	0.012
T_7	0.012	0.007
T_8	0.014	0.018
T_9	0.011	0.009
T_{10}	0.017	0.012
SEm ±	0.001	0.001
CD (0.05)	NS	NS

Note: T_1 - Groundnut Oil Cake 1:10 weekly once
T_2 - Groundnut Oil Cake 1:20 weekly once
T_3 - Greencare 13:27:27 weekly twice
T_4 - Greencare 13:27:27 weekly twice
T_5 - Benzyl adenine 250 mg l^{-1} once a month
T_6 - Benzyl adenine 500 mg l^{-1} once a month
T_7 - $T_1 + T_3$
T_8 - $T_3 + T_5$
T_9 - $T_1 + T_3 + T_5$
T_{10} - Control (water spray)

Table 14. Biomass production / Dry matter yield (g) in Dendrobium varieties as influenced by exogenous application of nutrients

Treatment	Dry matter yield (g)			
	Sonia 17		Sonia 28	
	Stage I	Stage II	Stage I	Stage II
T_1	9.40	13.14	12.16	14.84
T_2	8.83	11.70	7.33	11.23
T_3	10.70	14.45	6.86	9.20
T_4	7.20	11.85	7.31	10.07
T_5	6.86	9.78	5.63	8.00
T_6	9.92	13.92	6.56	10.01
T_7	7.80	11.70	9.86	12.81
T_8	8.20	12.27	5.40	10.59
T_9	4.36	7.26	7.23	9.93
T_{10}	6.36	9.38	6.53	9.91
SEm ±	1.46	1.80	2.05	2.00
CD (0.05)	NS	NS	NS	NS

Note: T_1 - Groundnut Oil Cake 1:10 weekly once
T_2 - Groundnut Oil Cake 1:20 weekly once
T_3 - Greencare 13:27:27 weekly twice
T_4 - Greencare 13:27:27 weekly twice
T_5 - Benzyl adenine 250 mg l^{-1} once a month
T_6 - Benzyl adenine 500 mg l^{-1} once a month
T_7 - $T_1 + T_3$
T_8 - $T_3 + T_5$
T_9 - $T_1 + T_3 + T_5$
T_{10} - Control (water spray)

4.2.4.1 Nitrogen

Significant differences were obtained in Sonia 17 in the concentration of nitrogen during the emergence of shoots (stage I). Plants that received 1:10 groundnut oilcake (T_1), 1:20 groundnut oilcake (T_2) and combination of 1:10 groundnut oilcake + 0.1 per cent Greencare + 250 mg l^{-1} BA (T_9) recorded the highest nitrogen content (2.1%) and was significantly superior to others except 1:10 groundnut oilcake + 0.1 per cent Greencare (T_7). The minimum nitrogen content (1.4%) was recorded in plants treated with 250 mg l^{-1} BA (T_5) and 500 mg l^{-1} BA (T_6), which were on par with 0.2 per cent Greencare (T_4).

At the time of emergence of spike (stage II) appreciable differences were not obtained among the treatments.

In Sonia 28, there found to be no significant differences among the treated plants during the different stages of growth.

4.2.4.2 Phosphorus

The concentration of phosphorus in the treated plants of *Dendrobium* var. Sonia 17 and Sonia 28 did not have significant differences during the shoot emergence stage and spike emergence stage.

4.2.4.3 Potassium

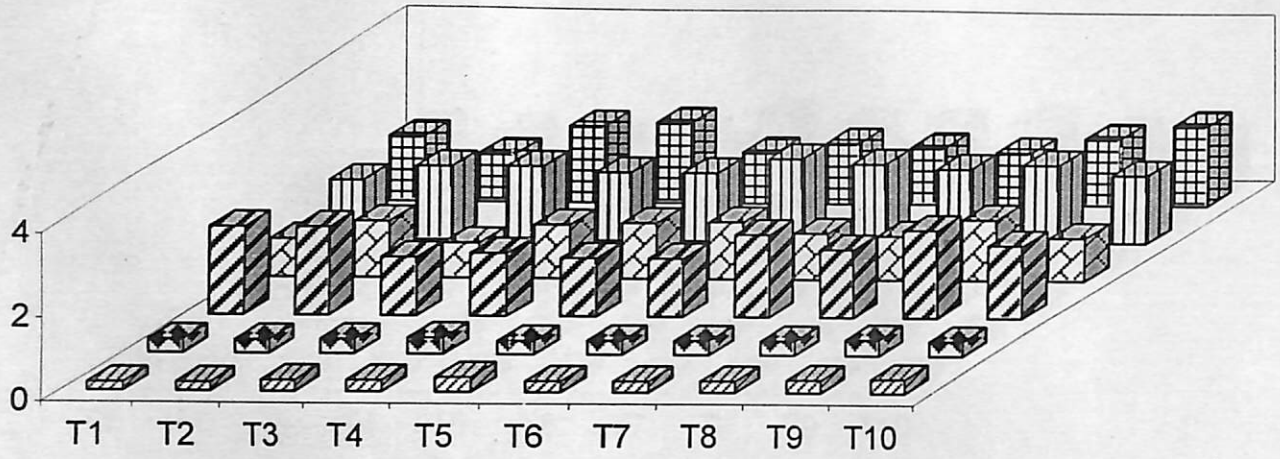
The potassium concentration in the plant had significant differences among the treatments during both the stages in the two varieties.

Table 15. Nutrient content (%) in shoots of Dendrobium varieties as influenced by the exogenous application of nutrients

Treat-ment	Nutrient content (%)											
	Sonia 17						Sonia 28					
	Stage I			Stage II			Stage I			Stage II		
	N	P	K	N	P	K	N	P	K	N	P	K
T_1	2.10	0.324	0.91	1.40	0.208	1.55	1.51	0.286	0.86	1.51	0.402	1.85
T_2	2.10	0.324	1.34	1.75	0.214	1.15	1.75	0.304	0.94	1.51	0.231	1.25
T_3	1.40	0.350	0.83	1.76	0.266	1.83	1.63	0.254	0.693	1.40	0.194	1.55
T_4	1.50	0.387	1.28	1.63	0.277	1.93	1.40	0.308	0.97	1.51	0.361	1.95
T_5	1.40	0.324	1.34	1.63	0.358	1.23	2.10	0.273	0.77	1.98	0.336	0.90
T_6	1.40	0.335	1.37	1.98	0.266	1.45	1.51	0.308	0.83	1.75	0.375	1.45
T_7	1.98	0.335	1.11	1.86	0 266	1.35	1.86	0.254	1.14	1.75	0.214	1.35
T_8	1.63	0.340	1.05	1.75	0.277	1.25	1.75	0.286	0.08	1.86	0.195	1.05
T_9	2.10	0.378	1.45	1.86	0.312	1.60	1.40	0.254	1.65	1.63	0.277	1.50
T_{10}	1.75	0.345	1.03	1.63	0.339	1.93	1.98	0.324	1.14	1.51	0.382	1.30
SEm ±	0.19	0.01	0.07	0.22	0.06	0.18	0.20	0.03	0.07	0.23	0.06	0.18
CD (0.05)	0.56	NS	0.20	NS	NS	0.54	NS	NS	0.20	NS	NS	0.55

Note: T_1 - Groundnut Oil Cake 1:10 weekly once
T_2 - Groundnut Oil Cake 1:20 weekly once
T_3 - Greencare 13:27:27 weekly twice
T_4 - Greencare 13:27:27 weekly twice
T_5 - Benzyl adenine 250 mg l^{-1} once a month
T_6 - Benzyl adenine 500 mg l^{-1} once a month
T_7 - $T_1 + T_3$
T_8 - $T_3 + T_5$
T_9 - $T_1 + T_3 + T_5$
T_{10} - Control (water spray)

Fig. 5. Nutrient (NPK) content (%) in shoots of Dendrobium variety 'Sonia 17' as influenced by the exogenous application of nutrients



Sonia 17 highest value (0.140) was recorded in control (T_{10}) and the lowest (0.132) in the treatment with 500 mg l^{-1} BA (T_6) whereas in Sonia 28 highest (0.142)was recorded in control (T_{10}) and the lowest (0.133) in 0.1 per cent Greencare (T_4) and 250 mg l^{-1} BA (T_5).

During the emergence of spike (stage II) there was no significant difference among the treatments in both the varieties (Table 14) (Fig.4).

4.2.5.3 Relative growth rate (RGR)

Relative growth rate (Table 15) was computed comparing the stages of emergence of shoot (stage I) and emergence of spike (stage II). The treatments did not differ significantly in the varieties Sonia 17 and Sonia 28 with respect to RGR.

4.2.3.4 Total dry matter production (TDMP)

The total dry matter production (Table 16) did not have significant differences among the treatments in both the varieties during the emergence of shoot and emergence of spike.

4.2.4 Nutrient status

4.2.4.1 Nutrient content

Data pertaining to the concentration of major nutrients in *Dendrobium* varieties Sonia 17 and Sonia 28 during different stages of development are presented in Table 17 (Fig.5 to 6).

Table 13. RGR (g/g/day) as influenced by exogenous application of nutrient in *Dendrobium* var. Sonia 17 and Sonia 28

Treatment	Sonia 17 (g/g/day)	Sonia 28 (g/g/day)
T_1	0.009	0.006
T_2	0.008	0.012
T_3	0.014	0.010
T_4	0.010	0.009
T_5	0.010	0.011
T_6	0.011	0.012
T_7	0.012	0.007
T_8	0.014	0.018
T_9	0.011	0.009
T_{10}	0.017	0.012
SEm ±	0.001	0.001
CD (0.05)	NS	NS

Note: T_1 - Groundnut Oil Cake 1:10 weekly once
T_2 - Groundnut Oil Cake 1:20 weekly once
T_3 - Greencare 13:27:27 weekly twice
T_4 - Greencare 13:27:27 weekly twice
T_5 - Benzyl adenine 250 mg l^{-1} once a month
T_6 - Benzyl adenine 500 mg l^{-1} once a month
T_7 - $T_1 + T_3$
T_8 - $T_3 + T_5$
T_9 - $T_1 + T_3 + T_5$
T_{10} - Control (water spray)

Table 14. Biomass production / Dry matter yield (g) in Dendrobium varieties as influenced by exogenous application of nutrients

Treatment	Dry matter yield (g)			
	Sonia 17		Sonia 28	
	Stage I	Stage II	Stage I	Stage II
T_1	9.40	13.14	12.16	14.84
T_2	8.83	11.70	7.33	11.23
T_3	10.70	14.45	6.86	9.20
T_4	7.20	11.85	7.31	10.07
T_5	6.86	9.78	5.63	8.00
T_6	9.92	13.92	6.56	10.01
T_7	7.80	11.70	9.86	12.81
T_8	8.20	12.27	5.40	10.59
T_9	4.36	7.26	7.23	9.93
T_{10}	6.36	9.38	6.53	9.91
SEm ±	1.46	1.80	2.05	2.00
CD (0.05)	NS	NS	NS	NS

Note: T_1 - Groundnut Oil Cake 1:10 weekly once
T_2 - Groundnut Oil Cake 1:20 weekly once
T_3 - Greencare 13:27:27 weekly twice
T_4 - Greencare 13:27:27 weekly twice
T_5 - Benzyl adenine 250 mg l^{-1} once a month
T_6 - Benzyl adenine 500 mg l^{-1} once a month
T_7 - $T_1 + T_3$
T_8 - $T_3 + T_5$
T_9 - $T_1 + T_3 + T_5$
T_{10} - Control (water spray)

4.2.4.1 Nitrogen

Significant differences were obtained in Sonia 17 in the concentration of nitrogen during the emergence of shoots (stage I). Plants that received 1:10 groundnut oilcake (T_1), 1:20 groundnut oilcake (T_2) and combination of 1:10 groundnut oilcake + 0.1 per cent Greencare + 250 mg l^{-1} BA (T_9) recorded the highest nitrogen content (2.1%) and was significantly superior to others except 1:10 groundnut oilcake + 0.1 per cent Greencare (T_7). The minimum nitrogen content (1.4%) was recorded in plants treated with 250 mg l^{-1} BA (T_5) and 500 mg l^{-1} BA (T_6), which were on par with 0.2 per cent Greencare (T_4).

At the time of emergence of spike (stage II) appreciable differences were not obtained among the treatments.

In Sonia 28, there found to be no significant differences among the treated plants during the different stages of growth.

4.2.4.2 Phosphorus

The concentration of phosphorus in the treated plants of *Dendrobium* var. Sonia 17 and Sonia 28 did not have significant differences during the shoot emergence stage and spike emergence stage.

4.2.4.3 Potassium

The potassium concentration in the plant had significant differences among the treatments during both the stages in the two varieties.

Table 15. Nutrient content (%) in shoots of Dendrobium varieties as influenced by the exogenous application of nutrients

Treat-ment	Nutrient content (%)											
	Sonia 17						Sonia 28					
	Stage I			Stage II			Stage I			Stage II		
	N	P	K	N	P	K	N	P	K	N	P	K
T_1	2.10	0.324	0.91	1.40	0.208	1.55	1.51	0.286	0.86	1.51	0.402	1.85
T_2	2.10	0.324	1.34	1.75	0.214	1.15	1.75	0.304	0.94	1.51	0.231	1.25
T_3	1.40	0.350	0.83	1.76	0.266	1.83	1.63	0.254	0.693	1.40	0.194	1.55
T_4	1.50	0.387	1.28	1.63	0.277	1.93	1.40	0.308	0.97	1.51	0.361	1.95
T_5	1.40	0.324	1.34	1.63	0.358	1.23	2.10	0.273	0.77	1.98	0.336	0.90
T_6	1.40	0.335	1.37	1.98	0.266	1.45	1.51	0.308	0.83	1.75	0.375	1.45
T_7	1.98	0.335	1.11	1.86	0 266	1.35	1.86	0.254	1.14	1.75	0.214	1.35
T_8	1.63	0.340	1.05	1.75	0.277	1.25	1.75	0.286	0.08	1.86	0.195	1.05
T_9	2.10	0.378	1.45	1.86	0.312	1.60	1.40	0.254	1.65	1.63	0.277	1.50
T_{10}	1.75	0.345	1.03	1.63	0.339	1.93	1.98	0.324	1.14	1.51	0.382	1.30
SEm ±	0.19	0.01	0.07	0.22	0.06	0.18	0.20	0.03	0.07	0.23	0.06	0.18
CD (0.05)	0.56	NS	0.20	NS	NS	0.54	NS	NS	0.20	NS	NS	0.55

Note: T_1 - Groundnut Oil Cake 1:10 weekly once
T_2 - Groundnut Oil Cake 1:20 weekly once
T_3 - Greencare 13:27:27 weekly twice
T_4 - Greencare 13:27:27 weekly twice
T_5 - Benzyl adenine 250 mg l^{-1} once a month
T_6 - Benzyl adenine 500 mg l^{-1} once a month
T_7 - $T_1 + T_3$
T_8 - $T_3 + T_5$
T_9 - $T_1 + T_3 + T_5$
T_{10} - Control (water spray)

Fig. 5. Nutrient (NPK) content (%) in shoots of Dendrobium variety 'Sonia 17' as influenced by the exogenous application of nutrients

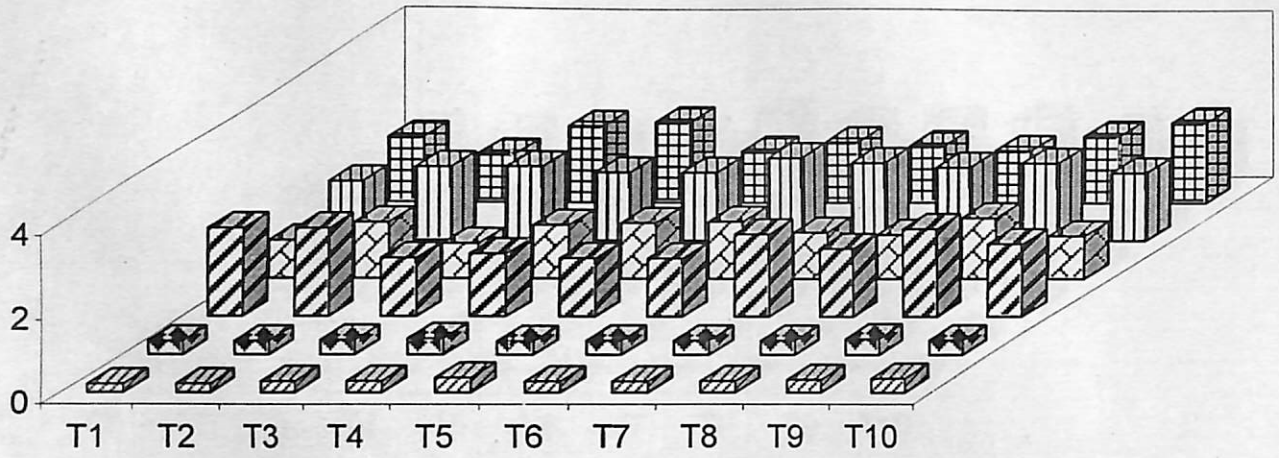
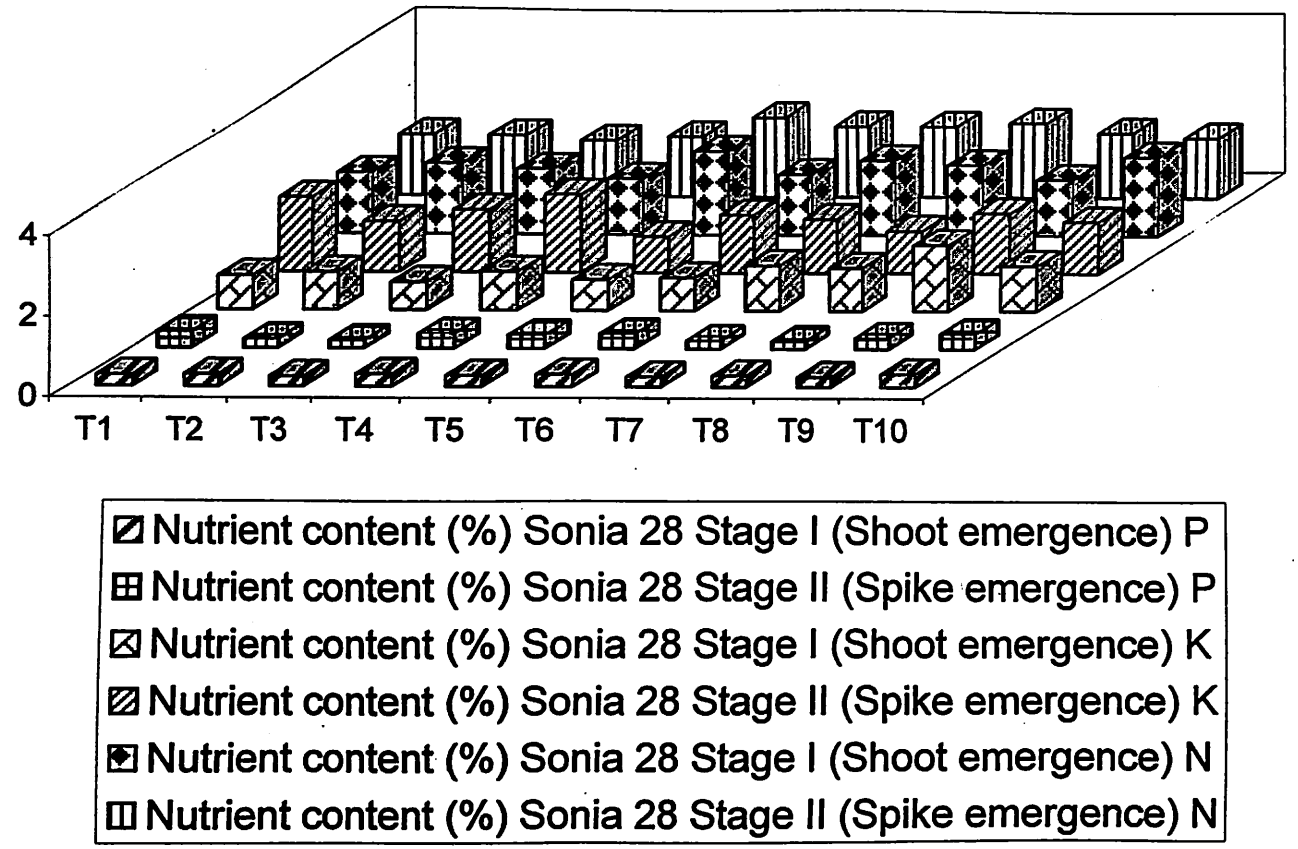


Fig. 6. Nutrient (NPK) content (%) in shoots of Dendrobium variety 'Sonia 28' as influenced by the exogenous application of nutrients



During the emergence of the shoot (stage I) in Sonia 17 the highest concentration of potassium (1.45%) was detected in the plants receiving a combination of 1:10 groundnut oilcake + 0.1 per cent Greencare + 250 mg l^{-1} BA (T_9) and was superior to all other treatments except with 1:20 groundnut oilcake (T_2) 0.2 per cent Greencare (T_4), 250 mg l^{-1} BA (T_5) and 500 mg l^{-1} BA (T6). The minimum potassium content (0.83%) was with plants treated with 0.1 per cent Greencare (T_3) was on par with 1:10 groundnut oilcake treatment (T_1) and control (T10).

During the emergence of spike (stage II) the concentration of potassium was highest (1.93%) in plants treated with 0.2 per cent Greencare (T_4) and control (T_{10}) was superior to all other treatments and the least (1.15%) in plants which received 1:20 groundnut oilcake (T_2).

There was significant differences seen among the treatments during the two stages of growth. In Sonia 28 the concentration of 'K' was highest (1.14%) reorded in plants receiving a combination of 1:10 groundnut oilcake + 0.1 per cent Greencare (T_7) and control (T_{10}) and minimum (0.69%) in treatment 0.1 per cent Greencare (T_3) during the emergence of shoot (stage I).

Significant differences detected among treatments during the emergence of spike with the highest concentration of 'K' (1.94%) recorded in plants treated with 0.2 per cent Greencare (T_4) and the least (0.90%) in plants receiving 250 mg l^{-1} BA (T_5).

4.2.5 Nutrient uptake

The data pertaining to the nutrient uptake are presented in tables 18 to 19 (Fig.7 to 8).

4.2.5.1 Nitrogen

The exogenous application of nutrients significantly influenced the nitrogen uptake in variety Sonia 17 during shoot emergence (Table 18). Uptake of nitrogen was recorded maximum (0.197g per plant) in plants which received 1:10 groundnut oilcake (T_1)whiich was on par with 1:20 groundnut oilcake (T_2), 0.1 per cent Greencare (T_3) and combination of 1:10 groundnut oilcake + 0.1 per cent Greencare (T_7). The minimum uptake of nitrogen (0.093 g per plant) was recorded in plants receiving a combination of 0.1 per cent Greencare + 250 mg l^{-1} BA (T_8) and was on par with 0.2 per cent Greencare (T_4), 500 mg l^{-1} BA (T_6) and combination of1:10 groundnut oilcake + 0.1 per cent Greencare + 250 mg l^{-1} BA (T_9).

Appreciable differences were detected during the emergence of spike (stage II). Maximum uptake nitrogen of (0.273 g per plant) was recorded in plants receiving 500 mg l^{-1} BA (T_6) which was on par with 1:20 groundnut oilcake (T_2), 0.1 per cent Greencare (T_3) and combination of 1:10 groundnut oilcake + 0.1 per cent Greencare (T_7). The minimum (0.137 g per plant) was recorded in plants receiving a combination of 1:10 groundnut oilcake + 0.1 per cent Greencare + 250 mg l^{-1} BA (T_9) and was on par with 1:10 groundnut oilcake (T_1), 0.2 per cent Greencare (T_4) 250 mg l^{-1} BA (T_5) and control (T_{10}).

Table 16. Uptake of nutrients (g) by *Dendrobium* variety Sonia 17 as influenced by exogenous application of nutrients

Treatment	Uptake of nutrients (g)					
	Stage I			Stage II		
	N	P	K	N	P	K
T_1	0.197	0.010	0.086	0.183	0.006	0.204
T_2	0.190	0.009	0.119	0.203	0.006	0.135
T_3	0.150	0.013	0.089	0.253	0.008	0.260
T_4	0.110	0.011	0.093	0.197	0.008	0.225
T_5	0.097	0.008	0.092	0.160	0.008	0.117
T_6	0.137	0.011	0.136	0.273	0.008	0.202
T_7	0.153	0.009	0.087	0.217	0.007	0.158
T_8	0.130	0.010	0.087	0.213	0.008	0.153
T_9	0.093	0.006	0.063	0.137	0.005	0.116
T_{10}	0.110	0.008	0.066	0.153	0.008	0.178
SEm ±	0.053	0.017	0.017	0.076	0.017	0.053
CD (0.05)	0.018	0.005	0.005	0.025	0.005	0.018

Table 17. Uptake of nutrients (g) by *Dendrobium* variety Sonia 28 as influenced by exogenous application of nutrients

Treatment	Uptake of nutrients (g)					
	Stage I			Stage II		
	N	P	K	N	P	K
T_1	0.187	0.010	0.105	0.227	0.016	0.275
T_2	0.127	0.007	0.069	0.173	0.005	0.140
T_3	0.113	0.005	0.047	0.130	0.003	0.142
T_4	0.103	0.007	0.071	0.153	0.009	0.096
T_5	0.120	0.004	0.043	0.160	0.007	0.072
T_6	0.100	0.006	0.054	0.177	0.008	0.145
T_7	0.183	0.007	0.113	0.223	0.006	0.173
T_8	0.093	0.004	0.047	0.200	0.004	0.111
T_9	0.103	0.005	0.077	0.160	0.006	0.149
T_{10}	0.130	0.007	0.075	0.150	0.010	0.129
SEm ±	0.053	0.017	0.017	0.076	0.017	0.053
CD (0.05)	0.018	0.005	0.005	0.025	0.005	0.018

Note: T_1 - Groundnut Oil Cake 1:10 weekly once
T_2 - Groundnut Oil Cake 1:20 weekly once
T_3 - Greencare 13:27:27 weekly twice
T_4 - Greencare 13:27:27 weekly twice
T_5 - Benzyl adenine 250 mg l^{-1} once a month
T_6 - Benzyl adenine 500 mg l^{-1} once a month
T_7 - $T_1 + T_3$
T_8 - $T_3 + T_5$
T_9 - $T_1 + T_3 + T_5$
T_{10} - Control (water spray)

Fig. 7. Nutrient (NPK) uptake (g) by Dendrobium variety 'Sonia 17' as influenced by exogenous application of nutrients

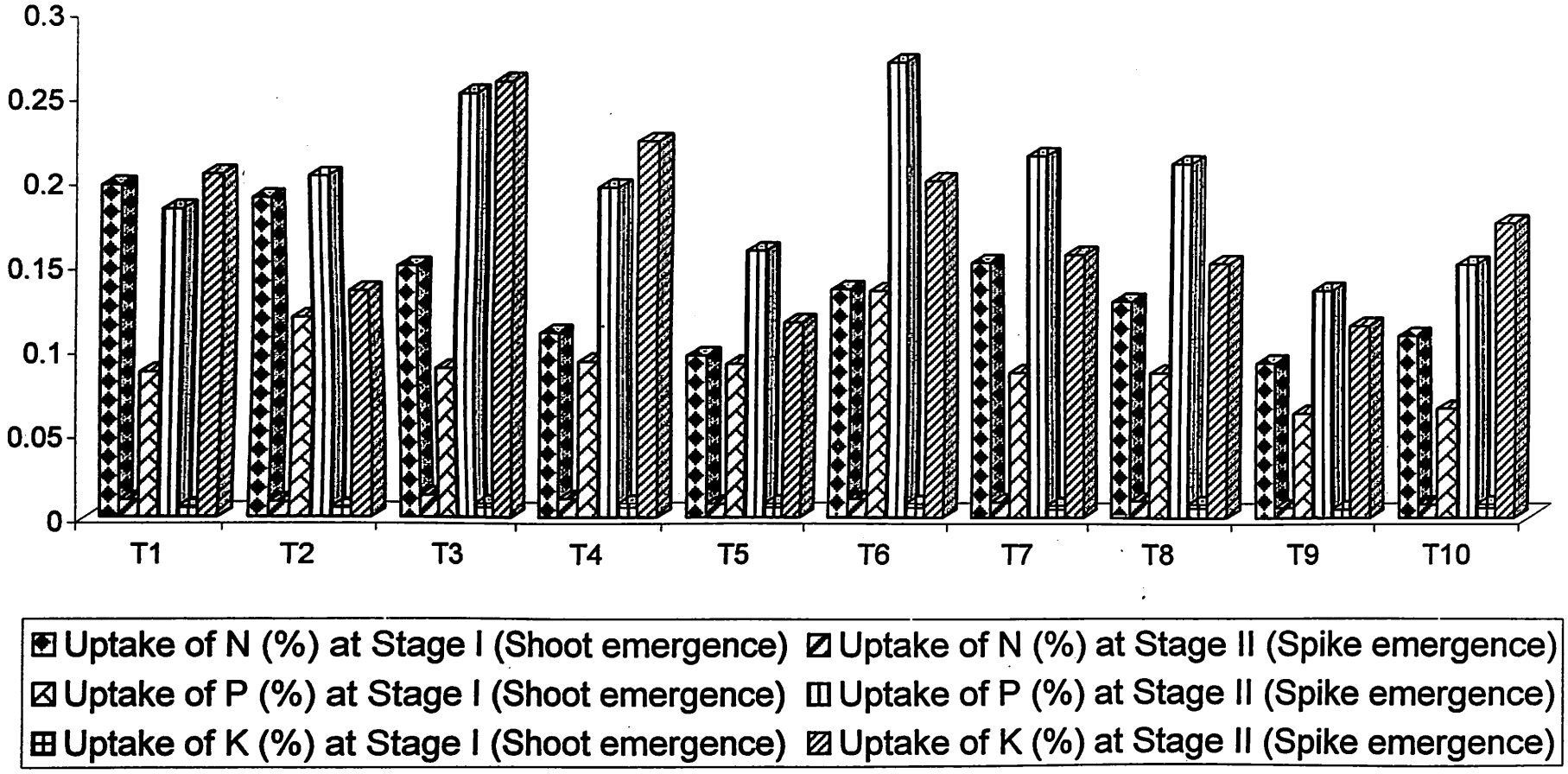
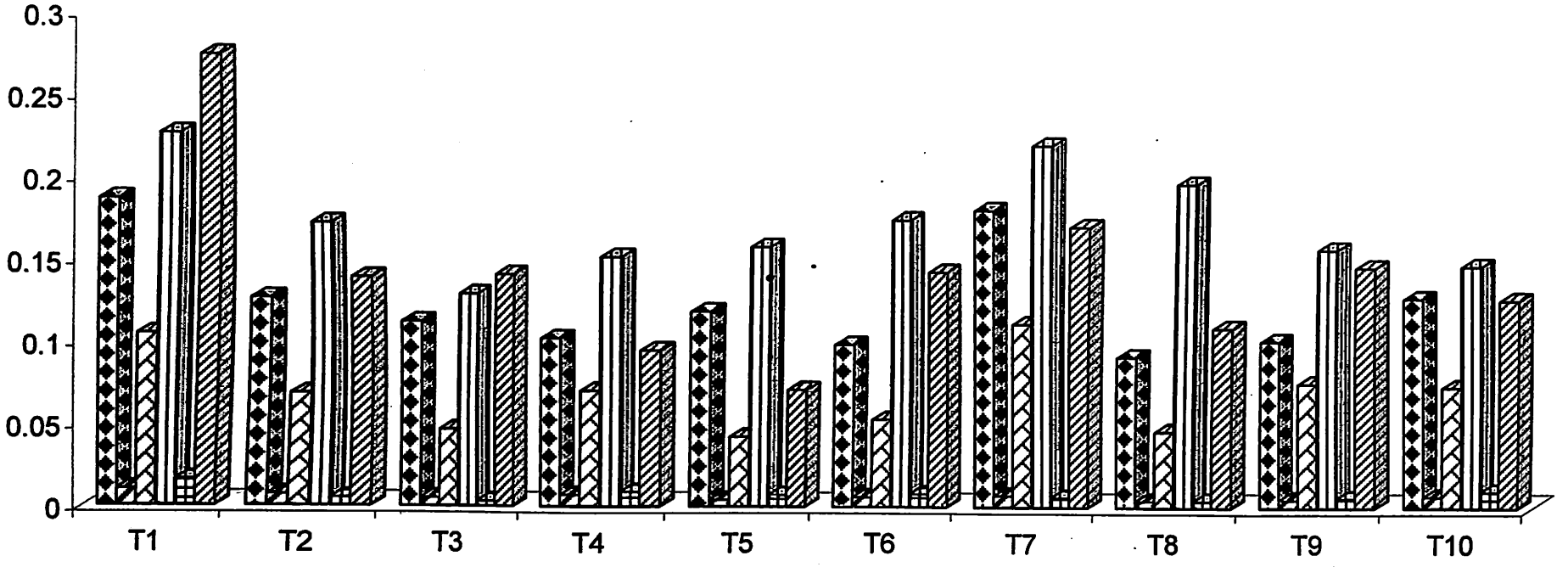


Fig. 8. Nutrient (NPK) uptake (g) by Dendrobium variety 'Sonia 28' as influenced by exogenous application of nutrients



In the var. Sonia 28, there was significant differences among the treatments during the stages of growth with regard to the uptake of nitrogen (Table 19). During emergence of shoot (stage I) the highest uptake of nitrogen (0.187 g per plant) was recorded in plants receiving 1:10 groundnut oilcake (T_1) which was superior to all other treatments except a combination of 1:10 groundnut oilcake + 0.1 per cent Greencare (T_7). The minimum uptake of nitrogen (0.083 g per plant) was recorded in treatment with a combination of 0.1 per cent Greencare + 250 mg l^{-1} BA (T_8).

4.2.5.2 Phosphorus

Appreciable differences were detected among the treatments in both the varieties during the stages of growth. With the emergence of shoot the highest uptake of 'P' (0.013 g per plant) was recorded in plants treated with 0.1 per cent Greencare (T_3) and minimum (0.006 g per plant) was recorded with the treatment combination of 1:10 groundnut oilcake + 0.1 per cent Greencare + 250 mg l^{-1} BA (T_9) in the var. Sonia 17 (Table 18).

During the emergence of spike the uptake of phosphorus also varied significantly among treatments with the highest (0.008 g per plant) in plants receiving 0.1 per cent Greencare (T_3). This was on par with 0.2 per cent Greencare (T_4), 250 mg l^{-1} BA (T_5), 500 mg l^{-1} BA (T_6), combination of 0.1 per cent Greencare + 250 mg l^{-1} BA (T_8), and control (T_{10}) with lowest uptake of 'P' (0.005 g per plant) recorded with a treatment combination of 1:10 groundnut oilcake + 0.1 per cent Greencare + 250 mg l^{-1} BA (T_9).

In the var. Sonia 28, the treatments showed significant differences during the emergence of shoot with the highest uptake of 'P' (0.010 g per plant) recorded in plants receiving 1:10 groundnut oilcake (T_1) and a minimum (0.004 g per plant) with plants receiving 250 mg l^{-1} BA (T_5) and a combination of 0.1 per cent Greencare + 250 mg l^{-1} BA (T_8) respectively.

At the emergence of spike the uptake of 'P' was highest (0.016 g per plant) in plants receiving 1:10 groundnut oilcake (T_1) and the least (0.003 g per plant) in 0.1 per cent Greencare (T_3) (Table 19).

4.2.5.3 Potassium

The exogenous application of nutrients had significant differences among the treatments in both the varieties Sonia 17 and Sonia 28 (Table 18). During the emergence of shoot the highest uptake of 'K' was recorded (0.119 g per plant) in plants treated with 1:20 groundnut oilcake and minimum (0.0639 g per plant) with a treatment combination of 1:10 groundnut oilcake + 0.1 per cent Greencare + 250 mg l^{-1} BA (T_9).

During the emergence of spike uptake of 'K' was highest (0.260 g per plant) in plants receiving 0.1 per cent Greencare (T_3) and the lowest (0.116 g per plant) in a treatment combination 1:10 groundnut oilcake + 0.1 per cent Greencare + 250 mg l^{-1} BA (T_9) (Table 18).

In the var. Sonia 28, marked differences were seen among the treatments with the highest uptake of 'K' (0.117 g per plant) in plants treated with

a combination of 0.1 per cent Greencare + 1:10 groundnut oilcake (T_7) and minimum (0.043 g per plant) in plants treated with 250 mg l^{-1} BA (T_5).

During the emergence of spike, the uptake of potassium was maximum (0.275 g per plant) in plants receiving 1:10 groundnut oilcake (T_1) and the minimum (0.096 g per plant) in 0.2 per cent Greencare (T_4) 4.2.8

4.2.6 Physiological characters

Physiological characters as indicated by chlorophyll content and total phenols are presented in Table 20 to 22 (Fig.9 to 11).

4.2.6.1 Chlorophyll content

Exogenous application of nutrients influenced the chlorophyll content significantly among the treatments in the two varieties Sonia 17 and Sonia 28 (Table 20). The highest chlorophyll content was recorded (chl. a = 0.327 mg g^{-1}, chl. b = 0.050 mg g^{-1}, chl. total = 0.380 mg g^{-1}) in plants which received 0.2 per cent Greencare (T_4) and the lowest (chl.a = 0.217 mg g^{-1} chl. b = 0.020 mg g^{-1}, chl. total = 0.237 mg g^{-1}) in 250 mg l^{-1} BA (T_5), during the emergence of shoot in Sonia 17 (Fig.9).

At the time of emergence of spike, the maximum chlorophyll content (chl. a = 0.380, Chl. b = 0.090 Chl. total 0.473 mg g^{-1}) was recorded in plants receiving 0.1 per cent Greencare (T_3) and minimum (chl. a = 0.210, chl. b = 0.030, chl. Total = 0.240 mg g^{-1}) in plants receiving 250 mg l^{-1} BA (T_5) (Table 20).

Table 18. Chlorophyll content (mg/g) as influenced by exogenous application of nutrients in *Dendrobium* variety Sonia 17.

Treatment	Chlorophyll content (mg g^{-1})					
	Stage I			Stage II		
	Chlorophyll			Chlorophyll		
	a	B	Total	a	b	Total
T_1	0.227	0.043	0.270	0.366	0.097	0.460
T_2	0.277	0.033	0.310	0.210	0.030	0.240
T_3	0.360	0.027	0.390	0.380	0.090	0.473
T_4	0.327	0.053	0.380	0.367	0.080	0.450
T_5	0.217	0.020	0.237	0.260	0.050	0.320
T_6	0.223	0.027	0.250	0.230	0.047	0.280
T_7	0.280	0.047	0.330	0.280	0.080	0.360
T_8	0.227	0.020	0.247	0.330	0.110	0.443
T_9	0.287	0.053	0.340	0.330	0.077	0.410
T_{10}	0.307	0.053	0.360	0.290	0.060	0.356
SEm ±	0.017	0.017	0.017	0.017	0.017	0.017
CD (0.05)	0.005	0.005	0.005	0.005	0.005	0.005

Note: T_1 - Groundnut Oil Cake 1:10 weekly once
T_2 - Groundnut Oil Cake 1:20 weekly once
T_3 - Greencare 13:27:27 weekly twice
T_4 - Greencare 13:27:27 weekly twice
T_5 - Benzyl adenine 250 mg l^{-1} once a month
T_6 - Benzyl adenine 500 mg l^{-1} once a month
T_7 - $T_1 + T_3$
T_8 - $T_3 + T_5$
T_9 - $T_1 + T_3 + T_5$
T_{10} - Control (water spray)

Fig. 9. Chlorophyll content (mg g-1) as influenced by exogenous application of nutrients in Dendrobium variety 'Sonia 17'

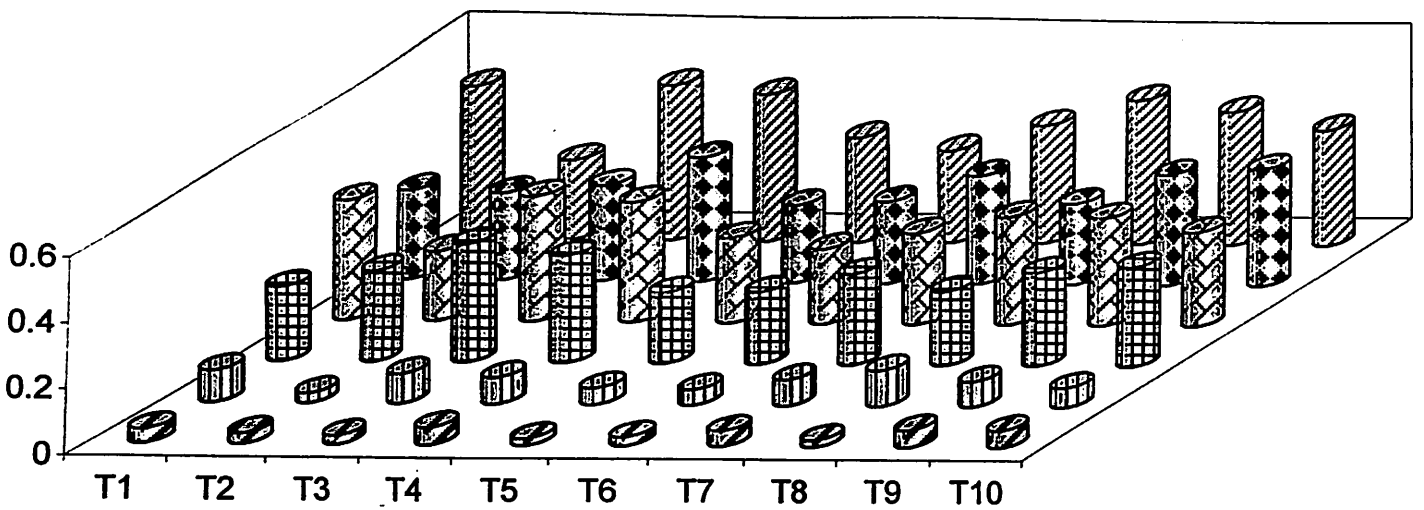
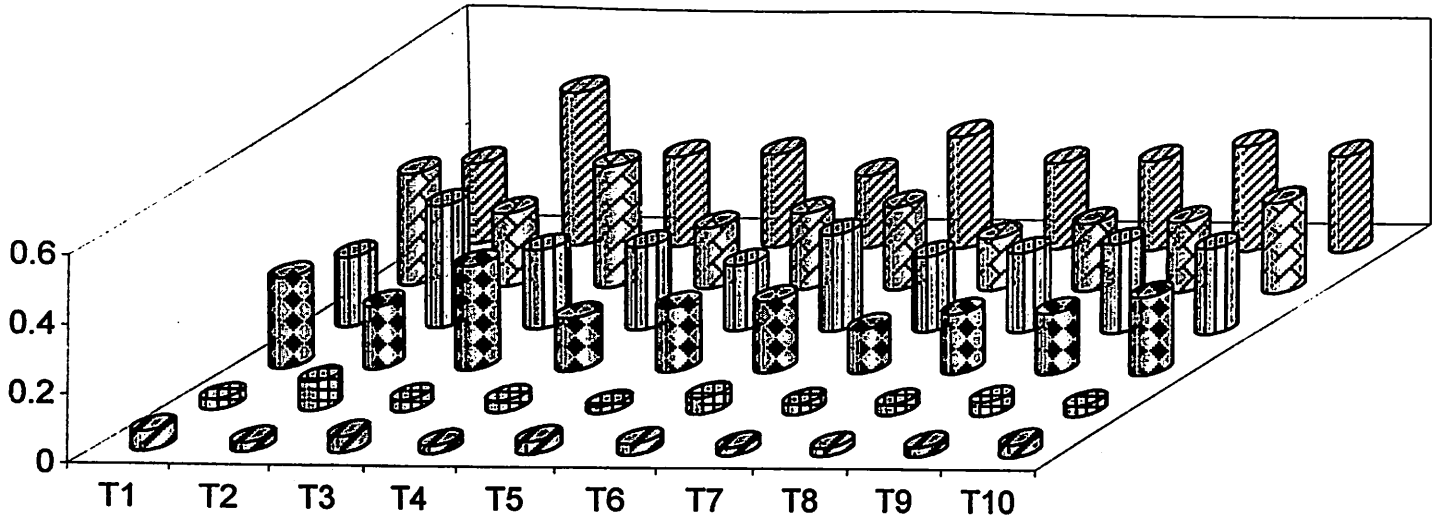


Table 19. Chlorophyll content (mg/g) as influenced by exogenous application of nutrients in *Dendrobium* variety Sonia 28

Treatment	Chlorophyll content (mg/g)					
	Stage I			Stage II		
	Chlorophyll			Chlorophyll		
	a	b	Total	a	b	Total
T_1	0.260	0.057	0.320	0.200	0.030	0.230
T_2	0.180	0.027	0.210	0.350	0.083	0.440
T_3	0.300	0.047	0.350	0.227	0.033	0.260
T_4	0.153	0.023	0.176	0.240	0.033	0.270
T_5	0.187	0.037	0.220	0.190	0.020	0.210
T_6	0.207	0.033	0.240	0.280	0.047	0.323
T_7	0.127	0.023	0.150	0.217	0.030	0.250
T_8	0.173	0.023	0.196	0.230	0.030	0.260
T_9	0.177	0.027	0.204	0.260	0.040	0.307
T_{10}	0.227	0.037	0.264	0.250	0.030	0.280
SEm ±	0.017	0.017	0.017	0.017	0.017	0.017
CD (0.05)	0.005	0.005	0.005	0.005	0.005	0.005

Note: T_1 - Groundnut Oil Cake 1:10 weekly once
T_2 - Groundnut Oil Cake 1:20 weekly once
T_3 - Greencare 13:27:27 weekly twice
T_4 - Greencare 13:27:27 weekly twice
T_5 - Benzyl adenine 250 mg l^{-1} once a month
T_6 - Benzyl adenine 500 mg l^{-1} once a month
T_7 - $T_1 + T_3$
T_8 - $T_3 + T_5$
T_9 - $T_1 + T_3 + T_5$
T_{10} - Control (water spray)

Fig. 10. Chlorophyll content (mg/g) as influenced by exogenous application of nutrients in Dendrobium variety 'Sonia 28'



In the var. Sonia 28, treatments exhibited significant difference during the emergence of shoot with maximum chlorophyll content (Chl. a = 0.300, Chl. b = 0.047, Chl. total = 0.350 mg g^{-1}) recorded in plants receiving 0.1 per cent Greencare (T_3) and minimum (Chl. a = 0.127, Chl. b = 0.023, Chl. total = 0.150 mg g^{-1}) in plants treated with a combination of 1:10 groundnut oilcake + 0.1 per cent Greencare (T_7) (Table 21) (Fig.10).

During the emergence of spike, the highest chlorophyll content (Chl. a = 0.350, Chl. b = 0.083, Chl. total = 0.440 mg g^{-1}) was recorded in plants treated with 1:20 groundnut oilcake (T_2) and minimum (Chl. a = 0.190, Chl. b = 0.020, Chl. total = 0.210 mg g^{-1}) recorded in plants receiving 250 mg g^{-1} BA (T_5) respectively (Table 21).

4.2.6.2 Total phenols

The total phenolic content in the plant(Table 22) at the emergence of shoot in var. Sonia 17 was the highest (29.03 mg g^{-1}) in plants receiving a combination of 1:10 groundnut oil cake + 0.1 per cent Greencare + 250 mg l^{-1} BA (T_9) and the lowest content of 17.60 mg g^{-1} was recorded in 0.1 per cent Greencare (T_3) (Fig.11).

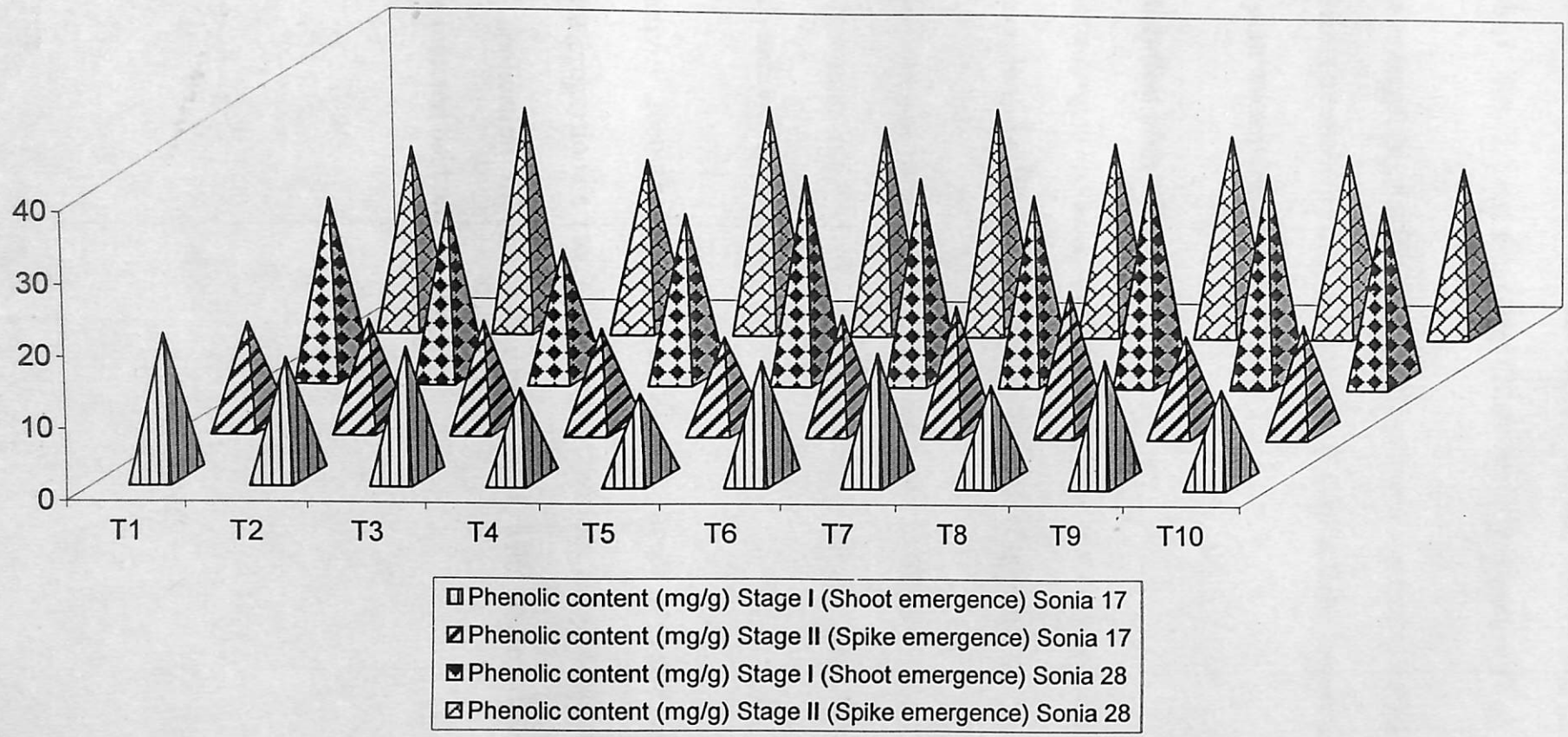
During spike emergence, the maximum phenolic content (19.46 mg g^{-1}) was in plants treated with a combination of 0.1 per cent Greencare + 250 mg l^{-1} BA (T_8) and the lowest (12.70 mg g^{-1}) with 250 mg l^{-1} BA (T_5).

Table 20. Phenolic content (mg/g) in *Dendrobium* var. Sonia 17 and Sonia 28 as influenced by exogenous application of nutrients

Treatment	Phenolic content (mg g^{-1})			
	Sonia - 17		Sonia - 28	
	Stage I	Stage II	Stage I	Stage II
T_1	24.43	14.30	24.53	19.80
T_2	23.93	14.86	29.93	16.56
T_3	17.60	14.76	23.03	18.20
T_4	22.73	13.80	30.56	12.50
T_5	28.23	12.70	27.90	11.86
T_6	27.90	15.90	30.43	16.56
T_7	25.63	17.30	25.83	17.76
T_8	28.83	19.46	27.13	13.36
T_9	29.03	13.26	24.63	16.90
T_{10}	24.63	14.96	22.83	12.90
SEm ±	1.29	1.28	1.30	1.28
CD (0.05)	0.43	0.43	0.44	0.43

Note: T_1 - Groundnut Oil Cake 1:10 weekly once
T_2 - Groundnut Oil Cake 1:20 weekly once
T_3 - Greencare 13:27:27 weekly twice
T_4 - Greencare 13:27:27 weekly twice
T_5 - Benzyl adenine 250 mg l^{-1} once a month
T_6 - Benzyl adenine 500 mg l^{-1} once a month
T_7 - $T_1 + T_3$
T_8 - $T_3 + T_5$
T_9 - $T_1 + T_3 + T_5$
T_{10} - Control (water spray)

Fig. 11. Phenolic content (mg/g) in Dendrobium var. 'Sonia 17' and 'Sonia 28' as influenced by exogenous application of nutrients



In the variety Sonia 28, there were significant differences among the treatments at emergence of shoot and the highest content (30.46 mg g^{-1}) was recorded in 500 mg l^{-1} BA (T_6) and the lowest (22.83 mg g^{-1}) in control (T_{10}).

At the emergence of spike, the highest phenolic content (19.80 mg g^{-1}) was recorded in plants treated with 1:10 ground nut oil cake and the lowest content (11.86 mg g^{-1}) in plants receiving 250 mg g^{-1} BA (T_5).

4.3 Translocation of nutrients

Data pertaining to the studies conducted to find out the translocation of nutrients from backbulb using ^{32}P are presented in Table 23(Fig.12).

Radioactivity was recovered from all shoots (S1 to S4) from the 2nd day of application. Maximum radioactivity was recorded in shoots nearest to the backbulbs to which radioactivity was applied.

Radioactivity recovered from the different shoots revealed that in general there was a proportionate increase of radioactivity in the younger shoots from 2nd day of application till the 10th day in tune with the reduction of radioactivity in the injected bacbulb.

Fig.12. Recovery of radioactivity (DPM/g) in the backbulb applied with 32p in the shoots of Dendrobium var. 'Sonia 28'

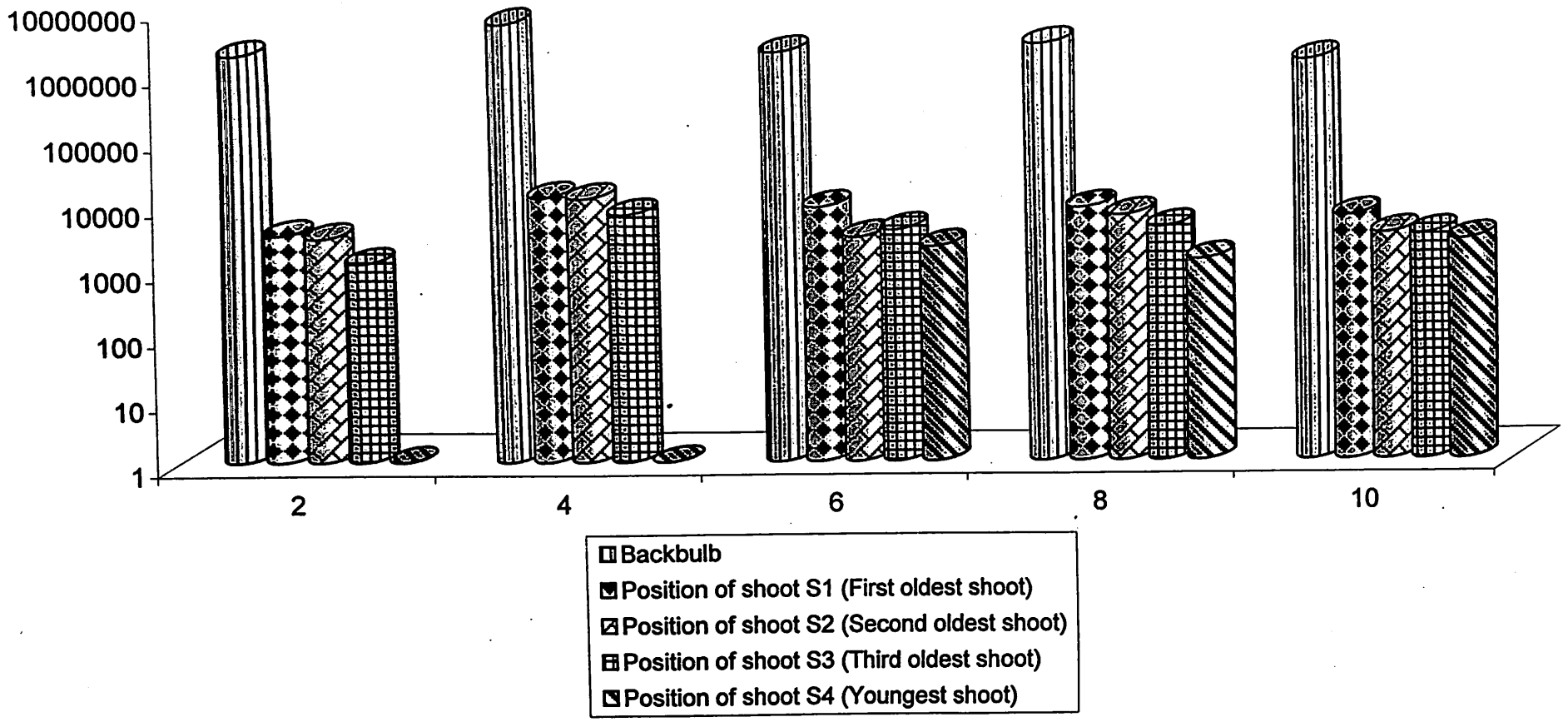


Table 21. Recovery of backbulb applied ^{32}P in the shoots (DPM/g) of *Dendrobium* var. 'Sonia 28'.

Days after application	Content of applied ^{32}P (DPM/g)				
	Position of shoot				
	Backbulb	S_1	S_2	S_3	S_4
2	1820800.34 (99.55)	3226.16 (0.22)	2871.68 (0.17)	1196.13 (0.06)	
4	5639965.51 (99.31)	12387.91 (0.29)	11839.96 (0.24)	6819.19) (0.16)	
6	2294536.84 (99.05)	9139.60 (0.42)	3152.89 (0.23)	4095.61 (0.18)	2230.71 (0.12)
8	3041768.94 (98.99)	8837.73 (0.30)	6778.54 (0.23)	4453.72 (0.14)	1388.94 (0.06)
10	1781437.71 (98.90)	6581.64 (0.44)	3493.89 (0.24)	3410.87 (0.24)	2766.49 (0.14)

DISCUSSION

DISCUSSION

The results generated from the studies on endogenous and exogenous regulation of growth and development in *Dendrobium* var. Sonia 17 and Sonia 28 are briefly discussed in this chapter.

Orchids form a wonderful heritage in Indian flora. They are known for their exquisite beauty and long lasting quality. In orchids *Dendrobium* is the most popular genus cultivated in Kerala. Varieties Sonia 17 and Sonia 28 are the popular hybrids of *Dendrobium*. These varieties, though appear to be closely related, exhibit several differences with respect to morphological and physiological aspects.

The present trial was carried out to study the factors responsible for changes in growth, flowering and post harvest characters of *Dendrobium* var. Sonia 17 and Sonia 28, with a view to solve field problems and to enhance production. It also included studies on the effect of nutrients (organic as well as inorganic) and growth regulators on the growth and development when applied exogenously.

Effect of nutrients on endogenous characters

The present trial was done with two dendrobium, varieties, viz., Sonia 17 and Sonia 28. The plants were compared during four different stages, viz., shoot emergence, spike emergence, development of keikis and senescence of the spike for the nutrient status, stomatal frequency and size, growth analysis.

After comparing both the varieties for growth parameters, viz., plant height, plant spread, total number of leaves, total leaf area and number of shoots. It was found that due to the vigorous growth, Sonia 17 was superior to Sonia 28.

Orchids, according to commercial point of view are known for their long lasting flowers. Therefore the floral characters form an important part. In case of length of spike as well as number of florets per spike Sonia 17 was superior whereas size of the flower and vase life was more in Sonia 28.

In addition to transpiration levels, stomatal frequency is highly related with carbon exchange rates and thereby an appreciable increase in photosynthetic rates in crop canopies. In this trial stomatal frequency was more in Sonia 28 whereas the size of the stomata was more in Sonia 17. This indicates the level of photosynthetic efficiency of Sonia 28 over Sonia 17.

Physiological parameters indicate the efficiency of the plant in terms of yield. This study included the parameters like total dry matter production, leaf area index, specific leaf weight, and relative growth rate, chlorophyll and phenolic content. Results indicate that the total drymatter produced was more in Sonia 17. Similar results were obtained for leaf area index, specific leaf weight and relative growth rate during all the stages of growth. The vigourous growth during all the phenophases of growth and development in Sonia 17 over Sonia 28 is a resultant of these characters.

In plants chlorophyll content indicates the extent of photosynthesis or the accumulation of dry matter. As far as orchids are concerned the photosynthetic efficiency leads to the production of more spikes. In this trial the chlorophyll content (chlorophyll a, chlorophyll b and total chlorophyll) did not vary significantly among the two varieties as the growth advanced during different stages. The phenolic content indicates the resistance of the plant to pests and diseases. In Sonia 28 more phenolic content was seen in comparison to Sonia 17 during different stages of growth. Thus it indicates that Sonia 28 had more tolerance to biotic stresses.

The concentration of nutrients indicates the amount of nutrients absorbed from the foliar spray given. In the present study the results show that nitrogen and potassium concentration increased with the commencement of new stages. In the case of phosphorus the concentration reduced with the progress in growth. In all cases the concentration N, P and K was more in Sonia 17. An increased uptake of nitrogen and potassium was recorded with the advancement in growth and development. But the uptake of phosphorus showed a decrease after the first stage (emergence of shoot) and later it increased third (keikis formation) and the final stage (Senescence of spike) substantially. Sonia 17 recorded more uptake of nutrients. This indicates that the var. Sonia 17 was more vigorous which resulted in the higher nutrient status.

Effect of exogenously applied nutrients

The effect of exogenously applied nutrients (organic and inorganic) and chemicals were studied on the morphological and physiological parameters in Sonia 17 and Sonia 28.

Growth parameters

Plant height indicates the overall growth of the plant. In dendrobium, the growth pattern is of sympodial type and the new shoot blooms after attaining maturity. In the present trial there was no significant difference among the treatments with respect to the plant height in both the varieties.

In a plant the total number of leaves is an indication of photosynthetic area which in turn determines the yield of the plant. In this study maximum number of leaves was produced with 0.2 per cent Greencare (13:27:27) applied twice a week in Sonia 28 (9.0). These were similar to the findings of Banfield (1981) and Steward (1988) in *Paphiopedilum* and Umamaheshwari (1999) in *Dendrobium*. The reason for the maximum number of leaves could be attributed to the optimum dose of nutrients.

In dendrobium the total leaf area is a better prospect of determining the photosynthetic efficiency of the plant. The growth of the plant is mainly dependant on foliar nutrition hence total leaf area is important aspect of concern. In this study it results indicates that there was no significant difference among the treatments with respect to the total leaf area in both the varieties.

Dendrobium being an epiphyte the number of shoots is influenced by the application of nutrients. These shoots grow and after maturity produce spikes, which in turn determines the yield. In the present trial the nutrients did not have any influence on the number of shoots in both the varieties.

Stomatal studies

In a leaf stomata indicates the transpiration efficiency and the fixation of carbondioxide. Studies regarding stomata were conducted on the mature leaf of the plant at the emergence of spike and stomata were observed on lower surface of the leaf. Stomatal frequency was the highest with 1:20 groundnut oilcake applied once a week in Sonia 17. In Sonia 28 the stomatal frequency was maximum with 1:10 groundnut oilcake applied once a week. In the case of stomatal size the highest was with 0.2 per cent Greencare (13:27:27) applied twice a week in both the varieties. Stomatal size and frequency had similar results with *Paphiopedilum* sp., *Cymbidium* sp. etc. (Paeak and Jun, 1995). Withner *et al.* (1975) and Handique and Handique (1996) found stomata on the lower surfaces of the leaf in *Paphiopedilum sp.* It could be said that organic suppliments proved better for the stomatal frequency whereas improved stomatal size with inorganic nutrients.

Growth analysis

Growth analysis assesses the overall growth in terms of leaf area index, specific leaf weight, dry matter production and relative growth rate in a plant. In this particular study the results were recorded at two stages, viz., at the emergence of shoot and at the emergence of spike.

Leaf area index did not show any significant differences among the treatments in both the varieties. Significant differences were recorded with regard to the specific leaf weight too. In Sonia 17 the highest was with control at both the stages and in Sonia 17 the highest was in control during the emergence of shoot whereas at spike emergence the highest was with 250 mg l^{-1} BA, applied once a month. The relative growth rate did not show any significant differences among the treatments in both the varieties.

With regard to the total dry matter production there were no significant differences observed among treatments.

Nutrient status

Nutrient concentration and uptake of nutrients (N, P and K) are of great importance as far as orchids are concerned. Foliar application of nutrients helps in providing the nutrients directly to the site of absorption of plants. But the amount of nutrients absorbed and assimilated also plays an important role.

The study revealed that the concentration of nutrients, especially nitrogen, increased with the stages (from the emergence of shoot to the emergence of spike) and the highest was recorded in 1:10 and 1:20 groundnut oilcake (once a week) and in a combination of 1:10 groundnut oil cake + 0.1 per cent Greencare (13:27:27) + 250 mg l^{-1} BA in the variety Sonia 17. In Sonia 28 the highest concentration of nitrogen was with 250 and 500 mg l^{-1} BA applied once a month. The concentration of phosphorus did not vary significantly among the treatments

in both the varieties during the emergence of shoot and during the emergence of spike. The concentration of potassium varied significantly in both the stages. The highest value in Sonia 17 was found with a treatment combination of 1:10 groundnut oil cake + 0.1 per cent Greencare (13:27:27) + 250 mg l^{-1} BA and 0.2 per cent Greencare (13:27:27) applied twice a week during (emergence of shoot and emergence of spike) respectively. In Sonia 28 the highest values were recorded with a combination of 1:10 groundnut oilcake + 0.1 per cent Greencare (13:27:27) and 0.2 per cent Greencare (13:27:27), respectively during the emergence of shoot and emergence of spike, respectively.

As the growth progresses the concentration of N and K showed a decrease in the contents which indicates it's utilization for vegetative growth whereas phosphorous concentration reduced during the emergence of spike (stage II) such that it was required for flower emergence.

The uptake of nutrients, viz., nitrogen, phosphorous and potassium was also studied. The result revealed that highest uptake of nitrogen was with lower doses of organic nutrients and higher dose of cytokinins during both the stages in both the varieties. Uptake of phosphorous was maximum with lower doses of inorganic and organic nutrients with higher dose during both stages and in both varieties. Uptake of potassium was maximum with lower doses of nutrients in the variety Sonia 17 and in Sonia 18 the highest values were recorded with a combination of lower doses of nutrients during the emergence of shoot as well as the spike.

Physiological characters

Chlorophyll is an indicator of photosynthetic efficiency, which is the primary component of dry matter productivity in plants. In orchids they form the key to economic yield as the chlorophyll helps in efficient carbon assimilation, which reflects on better growth and better spike formation. There was significant differences observed among the treatments in both the varieties and highest chlorophyll content (a, b, total) was with 0.2 per cent Greencare (13:27:27) and 0.1 per cent Greencare (13:27:27) applied twice a week during the emergence of shoot and spike, respectively in var. Sonia 17. In the var. 'Sonia 28' the highest values for chlorophyll content were recorded with lower doses of nutrients during both the stages (emergence of shoot and emergence of spike) respectively. Therefore nutrients (organic as well as inorganic nutrients) play an important role with respect to chlorophyll content of the leaves in orchids.

The phenolic content in a plant indicates its resistance towards insect pests and diseases. In the present study the phenolic content in Sonia 17 was highest with lower doses of nutrients (organic + inorganic + hormones) during the emergence of shoot as well as at the emergence of spike. In the case of Sonia 28 the highest values with regard to phenolic content was with higher doses of hormones and lower doses of organic nutrients during the stages 1 and stage II (emergence of shoot and emergence of spike), respectively. Thus it indicates that phenolic content is related to nutrient concentration.

Translocation of nutrients

In orchids backbulbs are considered as a source of nutrients for the younger developing shoots. Backbulbs after shedding leaves but before senescence transfer the assimilates to the younger shoots. In this study the radioactivity (^{32}P) was recovered in the younger shoots of the plants to which radioactivity was injected in the bckbulb. The amount of radioactivity recovered kept on increasing when the days progressed in the younger shoots. Simultaneously there was a decrease of radioactivity in the injected backbulb also during the course of time. Thus it confirms that translocation occurs from the backbulb to the younger shoots of the plant. This finding was in conformity with that of Wadasinghe and Hew (1995) where it was found that backshoots are an important source of photoassimilates for growth and flower production.

SUMMARY

SUMMARY

Studies on "Endogenous and exogenous regulation of growth and development in *Dendrobium* var. Sonia 17 and Sonia 28" were conducted in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during June 1999 to November 2000. The main objectives of the trial were to study the factors responsible for changes in growth, flowering and post-harvest characters of *Dendrobium* var. Sonia 17 and Sonia 28 with a view to solve field problems and to enhance production. The effects of exogenously applied nutrients and growth regulators on both the varieties were also studied. Organic and inorganic nutrients were applied on the plants. Organic nutrients were applied using groundnut oilcake at two levels, 1:10 and 1:20 at weekly intervals. Inorganic nutrients were applied using Greencare (13:27:27) at two levels, 0.1 and 0.2 per cent twice a week. BA was applied at two levels, viz., 250 and 500 mgl^{-1} at monthly intervals. The results of the experiments are summarized below:

Among the morphological parameters, the varieties Sonia 17 and Sonia 28 differed significantly with respect to the number of shoots, number of leaves and total leaf area. Sonia 17 recorded higher values in all the above characters (2.2, 10.1 and 336.82 cm^2, respectively).

Among the floral characters, number of florets per spike and internodal length varied significantly between the two varieties. The number of florets was

higher in Sonia 17 (6.6) than in Sonia 28 (4.4), while the internodal length was in Sonia 28 (3.3) than in Sonia 17 (2.3).

The varieties varied significantly with respect to the stomatal frequency was higher in Sonia 28 (325.74) compared to Sonia 17 (306.43). The stomatal size was more in Sonia 17 (0.127 x 0.093 mm) than in Sonia 28 (0.113 x 0.077 mm).

Among the physiological parameters increased dry weight was recorded in the third stage (keiki formation) of growth and development in Sonia 17 (12.81) as compared to Sonia 28 (11.21). Leaf area index, specific leaf weight and relative growth rate did not differ significantly between Sonia 17 and Sonia 28.

With respect to the content of chlorophyll (a, b and total) also no significant differences were noticed between Sonia 17 and Sonia 28. The total phenolic content was significantly higher in Sonia 28 (26.2) compared to Sonia 17 (20.3) during the fourth stage (senescence of spike).

The concentration and uptake of all the nutrients were at par during all the stages of growth, between Sonia 17 and Sonia 28.

Exogenous application of nutrients (organic and inorganic) and growth regulators had no significant effect on the growth parameters like plant height, number of leaves, total leaf area and number of shoots in the varieties up to the sixth month. However, during the sixth and seventh month the treatments influenced the number of leaves in Sonia 28. The highest value (9.0) was recorded

in the treatment with 0.2 per cent Greencare whereas the least number (5.9) of leaves was produced when the plants were treated with 1:10 groundnut oilcake.

Stomatal frequency was significantly influenced by the external application of nutrients. In Sonia 17 the highest number of stomata (366.00/mm^2) was observed in the treatment 1:20 groundnut oilcake whereas in Sonia 28 the highest number (366.16/mm^2) was in treatment with 1:10 groundnut oilcake. The stomatal size also exhibited significant differences and in Sonia 17 ranged from 0.110 x 0.080 mm in treatment with 0.2 per cent Greencare to 0.130 x 0.097 mm in the treatments with 1:10 groundnut oilcake and 500 mg l^{-1} BA. In Sonia 28 the stomatal size ranged from 0.100 x 0.073 mm with 0.2 per cent Greencare to 0.127 x 0.097 mm in 0.1 per cent Greencare.

In the varieties Sonia 17 and Sonia 28 the leaf area index did not differ significantly during different stages of growth. Specific leaf weight varied significantly during Stage I (emergence of the shoot) in both the varieties. The highest values were recorded in control (0.140 in Sonia 17 and 0.142 in Sonia 28). During the emergence of the spike, there was no significant differences among the treatments in both the varieties. Relative growth rate and total dry matter production did not vary significantly among the treatments in both the varieties, either at the emergence of shoot or at the emergence of spike.

The highest values for the concentration of nitrogen (2.1%) was recorded in the treatments 1:10 groundnut oilcake, 1:20 groundnut oilcake and

1:10 groundnut oilcake + 0.1 per cent Greencare + 250 mg l^{-1} BA in Sonia 17, at the shoot emergence stage. At the emergence of spike there was no significant differences among the treatments. In Sonia 28, significant differences were not observed among the treatments with respect to N content, during both the stages of growth. The concentration of phosphorus in Sonia 17 and Sonia 28 were not influenced by the treatments during shoot emergence and spike emergence stages. The potassium concentration showed significant differences among the treatments during the emergence of shoot (Stage I) and emergence of spike (Stage II). In Sonia 17 the highest values recorded in stage I (1.45%) was with a treatment combination of 1:10 groundnut oilcake + 0.1 per cent Greencare + 250 mg l^{-1} BA whereas in the stage II the highest (1.93%) was in 0.2 per cent Greencare and control. In Sonia 28 the highest potassium content (1.14%) was recorded during stage I in a treatment combination of 1:10 groundnut oilcake + 0.1 per cent Greencare and control. During stage II the highest value (1.94%) was recorded in plants treated with 0.2 per cent Greencare.

With respect to the uptake of nutrients, that of nitrogen differed significantly among the treatments in both the varieties in the two stages of growth. The highest value (0.197 g/plant) was recorded in 1:10 groundnut oilcake during shoot emergence whereas during the spike emergence the highest uptake was 0.273 g/plant, in plants receiving 500 mg l^{-1} BA in Sonia 17. In Sonia 28 highest uptake of N (0.187 g/plant and 0.227 g/plant respectively during the shoot emergence and spike emergence stages) was with 1:10 groundnut oilcake treated

plants. Uptake of phosphorus differed significantly among the treatments in both varieties during the both the stages of growth. In the variety Sonia 17 the highest value (0.013 g/plant) was recorded with plants treated with 0.1 per cent Greencare during the emergence of shoot whereas during the emergence of spike, the highest uptake (0.008 g/plant) was with 0.1 per cent Greencare. In Sonia 28 the highest uptake of P (0.010 g/plant and 0.016 g/plant, respectively during the emergence of shoot and emergence of spike) was with the treatment 1:10 groundnut oilcake. The uptake of potassium differed significantly among the treatments in both the varieties during both the stages of growth. In Sonia 17 the highest value (0.119 g/plant) was with 1:20 groundnut oilcake treated plants during the emergence of shoot. During the emergence of spike the highest uptake was (0.260 g/plant) with 0.1 per cent Greencare. In Sonia 28 during the emergence of shoot the highest uptake of K (0.113 g/plant) was with a combination of 0.1 per cent Greencare + 1:10 groundnut oilcake whereas during the emergence of spike the highest value (0.275 g/plant) was recorded with plants receiving 1:10 groundnut oilcake (T_1).

With regard to the physiological characters like chlorophyll content and total phenolic content the treatments differed significantly in the two varieties during both the stages of growth. In Sonia 17 during the emergence of the shoot, the chlorophyll content was the highest (a = 0.327 mg g^{-1}, b = 0.050 mg g^{-1}, total = 0.380 mg g^{-1}) in plants which received 0.2 per cent Greencare whereas during the emergence of the spike, the maximum chlorophyll content (a = 0.380, b = 0.090,

total = 0.473 mg g^{-1}) was recorded in plants receiving 0.1 per cent Greencare. In the var. Sonia 28, during the emergence of shoot, maximum chlorophyll content (a = 0.300, b = 0.047, total = 0.350 mg g^{-1}) was recorded in plants receiving 0.1 per cent Greencare and during the emergence of spike, the highest chlorophyll content (a = 0.350, b = 0.083, total = 0.440 mg g^{-1}) was recorded in plants treated with 1:20 groundnut oilcake.

In Sonia 17 the total phenolic content at the emergence of shoot was the highest (29.03 mg g^{-1}) in the plants receiving a combination of 1:10 groundnut oil cake + 0.1 per cent Greencare + 250 mg l^{-1} BA. During spike emergence, the maximum phenolic content (19.46 mg g^{-1}) was in plants treated with a combination of 0.1 per cent Greencare + 250 mg l^{-1} BA. In the variety Sonia 28, at the emergence of shoot the highest phenolic content (30.46 mg g^{-1}) was recorded in 500 mg l^{-1} BA and during the emergence of spike, the highest content (19.80 mg g^{-1}) was recorded in plants treated with 1:10 groundnut oil cake.

Studies conducted using ^{32}P revealed that translocation of ^{32}P occurred from the backbulb to the younger shoots. In general, there was a proportionate increase of radioactivity in the younger shoots from 2nd day of application till the 10th day, in tune with the reduction of radioactivity in the injected backbulb.

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APPENDICES

APPENDIX - I

WEATHER DATA (June 1999 - Nov. 2000)

Month	Temperature		Rainfall	Relative humidity	
	Maximum	Minimum		Morning	Evening
June 1999	29.4	23.0	500.2	94	75
July	28.4	23.0	823.3	96	82
August	29.8	22.9	260.1	94	73
September	31.6	23.4	28.4	89	63
October	30.5	23.2	506.2	94	75
November	31.4	22.7	9.1	81	57
December	30.7	22.7	0.0	72	48
January 2000	32.9	23.2	0.0	76	43
February	33.3	22.8	4.6	85	52
March	35.6	23.9	0.0	87	46
April	34.0	24.6	67.9	89	59
May	33.7	24.4	117.2	88	56
June	29.6	22.8	602.0	94	77
July	28.8	21.9	354.0	93	70
August	29.1	22.6	518.8	94	79
September	30.7	23.0	198.1	91	70
October	30.7	22.7	262.2	91	68
November	33.3	23.1	41.3	77	54
December	30.4	22.0	11.2	70	48

APPENDIX II

Constituents of Greencare 13:27:27

Total Nitrogen (N)	:	13%
Avai. Phosphoric acid (P_2O_5)	:	27%
Soluble Potash (K_2O)	:	27%
Iron EDTA	:	0.33%
Boron (B)	:	200 ppm
Copper EDTA (Cu)	:	700 ppm
Manganese EDTA (Mn)	:	500 ppm
Zinc EDTA (Zn)	:	720 ppm
Molybdenum (Mo)	:	005 ppm
Magnesium EDTA (Mg)	:	500 ppm
Vitamin (B_1)	:	100 PPM

ENDOGENOUS AND EXOGENOUS REGULATION OF GROWTH AND DEVELOPMENT IN *Dendrobium* VAR. SONIA 17 AND SONIA 28

By

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ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

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ABSRTACT

Studies on "Endogenous and exogenous regulation of growth and development in *Dendrobium* var. Sonia 17 and Sonia 28" were conducted in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the period from June 1999 to November 2000. The main objectives of the trial were to study the factors responsible for changes in growth and development of *Dendrobium* var. Sonia 17 and Sonia 28 with a view to solve field problems and to enhance production.

The influence of endogenous factors indicated that the variety Sonia 17 was superior to Sonia 28 with respect to the number of shoots, number of leaves, total leaf area and number of florets, while the internodal length was more in Sonia 28.

The stomatal frequency was higher in Sonia 28 whereas the stomatal size was more in Sonia 17.Increased dry weight was recorded in the third stage (keiki formation) in Sonia 17. Leaf area index, specific leaf weight and relative growth rate did not differ significantly. The chlorophyll (a, b and total) content did not show any significant differences between Sonia 17 and Sonia 28. The total phenolic content was significantly higher in Sonia 28 during the fourth stage (senescence of spike). The concentration and uptake of all the nutrients were at par during all the stages of growth, between Sonia 17 and Sonia 28.

Studies on exogenous factors revealed that Greencare (13:27:27) at 0.2 per cent level improved the in number of leaves in Sonia 28. The stomatal density and size were significantly influenced by the treatments in both the varieties. Leaf area index, relative growth rate and total dry matter production did not vary significantly, either at the emergence of shoot or at the emergence of spike. However, specific leaf weight varied significantly during Stage I (emergence of the shoot) in both the varieties.

The concentration of nitrogen was significantly influenced by the treatments at the shoot emergence stage, in Sonia 17. In Sonia 28, significant differences were not observed among the treatments during both the stages of growth. Though the concentration of phosphorus was not influenced by the treatments,that of potassium differed significantly among the treatments during both the stages in Sonia 17 and Sonia 28.

The highest uptake of nitrogen was recorded in the treatment involving 1:10 groundnut oilcake during shoot emergence stage, in both the varieties. During spike emergence, the highest uptake was caused by 500 mg l^{-1} BA in Sonia 17 and 1:10 groundnut oilcake in Sonia 28. With respect to phosphorus, in Sonia 17, the highest value during both the stages was recorded in plants treated with 0.1 per cent Greencare. In Sonia 28 the highest uptake of P at both the stages was with the treatment 1:10 groundnut oilcake. In Sonia 17 the highest K uptake was with 1:20 groundnut oilcake during the emergence of shoot while during the emergence of spike the highest uptake was with 0.1 per cent Greencare. In Sonia 28, during the

emergence of shoot, the highest uptake of K was with a combination of 0.1 per cent Greencare + 1:10 groundnut oilcake whereas during the emergence of spike the highest value was recorded in plants receiving 1:10 groundnut oilcake alone.

The chlorophyll and total phenolic content differed significantly in the two varieties during both the stages of growth. In Sonia 17, Greencare significantly improved the chlorophyll content at both the stages. In Sonia 28, maximum chlorophyll content during the emergence of shoot, was recorded in plants receiving 0.1 per cent Greencare, whereas, during the emergence of spike 1:20 groundnut oilcake recorded the highest value. In Sonia 17, the total phenolic content at the emergence of shoot was produced by 1:10 groundnut oil cake + 0.1 per cent Greencare + 250 mg l^{-1} BA and during spike emergence, by a combination of 0.1 per cent Greencare + 250 mg l^{-1} BA. In Sonia 28, at the emergence of shoot, the highest phenolic content was recorded by 500 mg l^{-1} BA and during the emergence of spike, by 1:10 groundnut oil cake.

Studies conducted using ^{32}P revealed that translocation of ^{32}P occurred from the backbulb to the younger shoots.