EFFECT OF VARYING LIGHT INTENSITIES ON THE GROWTH AND DEVELOPMENT OF INDOOR FOLIAGE AND FLOWERING PLANTS

BY

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THESIS
submitted in partial fulfilment of the
requirement for the degree
MASTER OF SCIENCE IN HORTICULTURE
Faculty of Agriculture
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Vellayani - Trivandrum
1986

DECLARATION

I hereby declare that this thesis entitled "EFFECT OF VARYING LIGHT INTENSITIES ON THE GROWTH AND DEVELOPMENT OF INDOOR FOLIAGE AND FLOWERING PLANTS" 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, associateship, fellowship, or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "EFFECT OF VARYING LIGHT INTENSITIES ON THE GROWTH AND DEVELOPMENT OF INDOOR FOLIAGE AND FLOWERING PLANTS" is a record of research work done independently by Miss. K. Aasha, under my guidance and supervision and that it has not previously formed the basis for award of any degree, fellowship or associateship to her.

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ACKNOWLEDGEMENTS

I wish to place on record my deep sense of gratitude and indebtedness to

-- Dr.S. Ramachandran Nair, Professor and Head, Department of Horticulture, my guide and Chairman of the Advisory Committee for his sustained interest, expert advice, and help throughout the course of this work

-- Dr.N. Mohanakumaran, Associate Director of Research, N.A.R.P. (Southern Region), Dr.V.K. Sashidhar, Professor and Head, Department of Agronomy and Dr.S. Seshadrinath, Professor, Department of Plant Pysiology; Members of the Advisory Committee for their valuable suggestions in the preparation of this thesis.

-- Professor Abdul Hameed, Shri. Rajendran, Department of Agricultural Chemistry and Shri.Thomas Biju Mathew, Department of Plant Pathology for their sincere help in the laboratory.

-- Shri.V.K.G. Unnithan, Associate Professor, Department of Agricultural Statistics, College of Horticulture for providing necessary help during the computer analysis.

-- Shri.K. Vasanthakumar, Assistant Professor and other staff members of my Department for their co-operation.

-- The labourers in the field for their manual efforts

-- Miss. Jyothi, Kumari Usha and many other friends for their timely assistance

-- Miss. S.L. Shailaja and Miss.C. Susamma of 'Thribhuvana Institute' for the help rendered in typing the manuscript and finally

-- the unknown entity behind every movement in the cosmos without which this too would not have taken shape.

Vellayani,
22·10·86

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INTRODUCTION

INTRODUCTION

An environment devoid of plants is too desolate a place, one that leads to physical and psychological deterioration of human life. Due to unprecedented population explosion and increased technological advancements, most of the people are impelled to live in urban environments, isolated from the green of nature. It is in these context that interior planting becomes important, a necessity rather; in a way, it helps reestablish the broken link with mother nature. A little of this colourful, sometimes fragrant space freshens the tired nerves of the urban individual. In fact it has now become part of the back-to-earth, back-to-nature, back-to-the aesthetic movements slowly evolving in our culture today.

Light intensity is the most important limiting factor in growing plants indoors. Light affects every cell, tissue, organ and physiological processes of the plant. Light is unique in this respect as compared to water, temperature and nutrients which affects the plant destiny.

Tropical foliage plants are well suited for indoor culture because of their ability to survive continuous warm temperature and low light regimes. For each plant there is a minimum light intensity and one may select plants adapted to the light intensity or modify the light intensity to suit the plants. Indoor plants are becoming increasingly important and crop value has increased much in the last several years, but there is relatively little reported research on the light requirement of indoor plants.

Considering all the above factors, the present study was undertaken with the following objectives.

To study the growth behaviour of ornamental indoor foliage and flowering plants under varying light intensities (shade) without considering other growth factors such as temperature, humidity and wind.

Classification of the different indoor plants based on the optimum light requirements.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The importance of light factor in plant communities has been recognised only recently; though Boysen Jensen as quoted by Saeki (1963) elucidated the same as early as in 1918. A deep interest in the subject developed only during the last two decades. Ross (1976) brought out the effects of light intensity on plant growth. The plants grown in full sun appeared stunted with stiff branches and sparse foliage. But were tall and lanky with abundant foliage as shade increased. Leaves developed under 80 per cent shade were larger than those in full sun. Such leaves had more surface area exposed thus, more opportunity to use low light. Chlorophyll content on a leaf basis increased from full sun to 80 per cent shade.

The experimental results on the response of crops to varying intensities of light are highly variable. Comparitively very little work has been done on the effect of shading on the growth and development of indoor ornamental plants. The various aspects of light and shade effects on plants with special reference to ornamental crops are reviewed hereunder:

Effect on Vegetative characters

Structural and morphological characteristics of leaves are found to be influenced by shading. In general, leaf expansion increased and thickness decreased with shading. Duggar (1903) reported the general effect of shading. Plants under shaded conditions exhibited increased growth of the main axis; reduced number of branches, lessened development of woody fibre and deficiency in sugars and various carbohydrates. Acidity was found to increase if the plants had abundant supply of carbohydrates. Vinson (1923) pointed out the effects of shading geranium. Slender stem, greater length of internodes, leaves with larger areas and smaller cross section, increased moisture content and higher ratio of nitrogen to carbohydrates were reported by him as results of shading geranium plants. Crocker (1949) stated that light quality and not the intensity decided the morphological characters of plants. However according to Thompson and Miller (1963) light intensity had the influence on cell enlargement and differentiation and thus influenced height, growth, leaf size and the structure of leaves and stems of plants.

Einert and Box (1967) reported that in *Lilium longiflorum* a decrease in light intensity resulted in an increase plant height. Wassink (1969) found that in iris, leaves were altered in length and breadth as the intensity of light rose; but surface area was little affected. Anatomical studies of shaded leaves showed that the growth of the vascular bundles was less influenced by the intensity of light. Koyoma *et al.* (1970) observed that in *Sinningia speciosa* plants optimal growth in leaf on the main stem occurred under 16 per cent day light. Lateral branch growth was depressed under 16, 10 or 5 per cent day light. Lower light intensities enhanced the ratios leaf area: leaf weight and leaf length: leaf width. Higher light intensities caused yellowing.

Hiroi *et al.* (1970) explained the effect of different intensities of light on *Aphelandra squarrosa*. Taller plants were produced under 30, 16 and 10 per cent of full sun light and stems were thinnest at 5 per cent. The weight of the leaf was highest at 30 and 16 per cent light and the largest leaf area was associated with 16 per cent light intensity. Leaves were found to last longer on shaded plants and they were greenish and smooth-surfaced in contrast to the rough, greenich yellow leaves in unshaded plants. In deeply shaded plants, the root stem was relatively small in relation to the proportion of the leaf.

Bensink (1971) observed that in lettuce plants leaf width generally increased with total light energy either in the form of higher intensity or longer day length whereas leaf length showed a positive response to light only at low intensities. Fretz and Dunham (1971) found that in american holly plants (*Ilex opaca*) leaf size of plants increased under 50 and 92 per cent shade. Same authors in 1972 reported that shading resulted in significant increase in the green colour of the leaves.

Ficus benjamina plants grown under 40 or 80 per cent shade were larger and had better grade foliage colour than sun-grown plants after nine months of growth, but trunk diameter was less (Conover and Poole, 1978). Fails *et al.* (1982) observed that in *Ficus benjamina* plants shade grown leaves were larger, thinner, flatter and darker green than the sun grown leaves. Sun and shade grown plants had the same total leaf area and were the same height. Shade grown plants had a single poorly developed palisade layer with larger chloroplasts.

Jeong et al. (1983) found that in Trachelospermum asiaticum var. intermedium and Hedera rhombea stem elongation was promoted as light intensity decreased. In Fatshedera lizii and Glechoma hederacea cv. variegata, an increase in light intensity promoted stem growth and increased the leaf number but decreased the leaf size. In a fertilizer cum shade trial on container grown plants of Ficus macrophylla Thomas and Teobe (1983) observed that plant height, stem diameter, internode length, leaf area and foliar dry weight were all greatest with 20 per cent shading. Hendriks and Brandis (1984) found that in cyclamens shaded plants had fewer necrotic leaves per plant, greater plant diameter and height and were less compact than unshaded plants.

Effect on chlorophyll and anthocyanin content, photosynthesis and dry matter accumulation

Chlorophyll and Anthocyanins:

According to Clark (1905) certain optimum intensity of light was found to be necessary in plant for chlorophyll production. He found that direct sunlight of high intensity was resulting in destruction of chlorophyll. Priestly (1929) found that chloroplasts in leaves would undergo changes in position according to the differences in light instensity. He also pointed out that in leaves of plants grown under low light intensities, the plastids were limited in number and they were arranged at right angles to the light rays and were larger in size thus increasing the area for light absorption. Bjorkman and Holmgren (1963) reported that leaves of plants grown at lower light intensities contained more chlorophyll per unit weight or per unit volume of leaf, but the chlorophyll content per unit area of leaf surface was very often lower than that of open grown leaves. Einert and Box (1968) observed that in Lilium longiflorum leaf chlorophyll content was highest under full sunlight at the time of initiation and directly proportional to light intensity. Contrary to this Misra et al. (1968) reported increased chlorophyll contents in the leaves of shaded plants of Bougainvillaea.

Allamand (1971) suggested that in Crotons the leaf anthocyanin content was highest between 2900 and 4300 lux.

Conover and Poole (1972) found that leaf colouration of Cordyline terminalis was less intense under 80 per cent shade than under 40 or 60 per cent. Silis et al. (1972) observed that in begonia and ornamental cabbage light shade i.e. 60 to 70 per cent full sun reduced red colour of leaves and deep shade i.e. 20 per cent full sun completely removed the leaf colour in begonia. In Impatiens balsamina Nanda et al. (1973) found that chlorophyll development in the cotyledonary leaves occurred at light levels as low as 50 lux regardless of the stages of seedling growth, whereas that of anthocyanins in the hypocotyle increased with light intensity.

Conover and Poole (1977) reported that in Ficus benjamina plants chlorophyll content was higher under 40 and 80 per cent shade but after six months' indoors chlorophyll content decreased by 50 per cent in all treatments. When ten indoor plants were grown at different light intensities some showed reduced leaf chlorophyll content (photolabile) compared with the control whereas others remained practically unaffected (photostabile). Both light and shade plants belonged to the photolabile and photostabile groups. (Kutas 1979). Lukyanora and Domanskaya (1979) found that in Hedera taurica and Euonymus japonicus chlorophyllase activity increased and chlorophyll content decreased as the light intensity increased. Priessel et al. (1980) observed that in Codiaeum variegatum var. pictum increased light generally reduced chlorophyll and carotenoid contents, but did not affect anthocyanin content. Kunst and Wrischer (1984) reported that in *Liqustrum ovalifolium* leaf chlorophyll increased and carotenoid content decreased under low light intensity. Shaded green leaves contained more thylakoid than the unshaded green leaves.

Iwata *et al.* (1985) stated that spathe colour in *Anthurium andreanum* was determined by the concentration of anthocyanins.

Photosynthesis and Dry matter accumulation

Photosynthesis, the production of food (sugar) from carbondioxide and water in the presence of chlorophyll and light is probably the most important of all photochemical processes. Sunlight being the source of energy for plants for photosynthesis, the rate and subsequent dry matter accumulation in general are found to be adversely affected by shading.

Shading either partial or complete was found to reduce the carbondioxide assimilation and thereby the available constructive material for plants (Duggar, 1903). Gastra (1963) found a linear relationship between photosynthesis and light intensity at low intensities.

Misra *et al.* (1968) observed increased dry matter production in the unshaded leaves of bougainvillaea plants. Wassink (1969) compared the photosynthetic efficiency of iris plants grown at 12 per cent and 100 per cent daylight. He observed that the photosynthetic efficiency decreased with diminishing light intensity. He also noticed that an eight-fold increase (12 to 100 per cent) in light intensity resulted in trebled dry weight of leaves. Koyoma *et al.* (1970) reported that in *Sinningia speciosa* deep shade i.e. 10 and 15 per cent daylight markedly reduced dry weight accumulation in the leaf, tuber and whole plant.

Milks *et al.* (1978) observed that in *Ficus benjamina* increasing shade decreased carbohydrate levels in leaves and roots during the production period. The plants with the highest carbohydrate levels were those grown in the full sun. Carbohydrate accumulation and chlorophyll reduction were associated with water stress in sun plants of *Ficus benjamina*, but there were no stress related changes of carbohydrate or chlorophyll levels in plants grown under 57 per cent shade (Johnson *et al*, 1982).

Hoflacher and Bauer (1982) reported increased photosynthetic rates in the leaves of *Hedera helix*, under high light intensities. Shen and Seely (1983) reported that in *Peperomia obtusifolia*, reducing the light intensity decreased plant fresh and dry weight but did not affect the leaf nutrient content.

Effect of shading on flowering

In the process of flower bud differentiation and initiation the photoperiod plays most important role, rather than the intensity of light. However, Duggar (1903) pointed out that the flowers might develop on plants exposed to partial light, but generally in such case it would be delayed considerably. Gourley (1920) observed that shaded geranium and nastrutium plants put forth only few blossoms compared to those in the open.

Einert and Box (1967) reported that light intensity of 75 and 50 per cent during the forcing period had no effect on flower bud abortion, bloom size or forcing time of *Lilium longiflorum*. However, 50 per cent light intensity resulted in decreased number of flower buds and 75 per cent had no effect on initiation of flower buds. Hiroi *et al*. (1970) observed that in *Aphelandra squarrosa* plants, flower bud formation was dependent on light intensity and did not occur on more shaded plants. Kaname and Tagi (1970) observed that in cucumber 50 and 75 per cent shading lowered the proportion of female flowers. In *Ilex opaca*, flower production was reduced under heavy shading i.e. 92 per cent (Fretz and Dunham, 1971). Boula *et al.* (1973) provided three different levels of shading viz. 25, 50 and 75 per cent for anthuriums. The greatest number of flowers were produced with the least shading but the flower quality was better under heavy shading.

In a trial with *Impatiens wallerana* var. petersiana Zimmer (1980) observed that a temperature in the range of 14 to 18 degree celcius and 16 h at 16 klx gave the best foliage colour, while 26 degree celcius and 16 h at 6 klx produced the greatest number of leaves. Flower bud formation was greatest at 18 degree celcius and 16 h at 6 klx.

Nell *et al.* (1981) found that shading reduced the number of flower heads in chrysanthemum and delayed flowering. Conover and Poole (1981) found that flowering of *Saintpaulia ionantha* (cv. Inge) ceased when the plants were transferred to interior light levels of .5, 1 or 2 klx from a green house at 13 klx. Plants placed under 2 klx flowered after 3 months while plants under 1 klx flowered after 6 months. Only minimal flowering occurred at .5 klx after nine months.

Kim and Sang (1982) observed that _Saintpaulia ionantha_ plants subjected to 75 per cent light intensity did not flower at all; and under 25 per cent, flowering was very poor. At 6.25 to 12.5 per cent peduncle number, florets per peduncle and flower diameter were highest.

Mor and Halevy (1984) observed that shade caused by a dense leaf canopy reduced sprouting of the third axillary bud formation (from the top) on decapitated rose (cv. marimba) branches in comparison to less shaded buds on branches protruding above the canopy and sparsely spaced. It is concluded that light affects flowering in two ways. The effect of bud sprouting is related mainly to red: far red ratios while the effect on flower developing is related mainly to photon flux density.

MATERIALS AND METHODS

MATERIALS AND METHODS

Investigations were taken up with a view to studying the effect of various light intensities on the growth and development of different indoor foliage and flowering plants. The experiment was conducted at the Department of Horticulture, College of Agriculture, Vellayani.

The following ornamental foliage and flowering plants were chosen for the study. A description of the plants and their general growing conditions are given below.

Aglaonema (Aglaonema costatum veitch.). Araceae

It is also known as chinese evergreen. This attractive perennial has dark green lance shaped leaves. It will thrive well if protected from direct sunlight.

Alocasia (Alocasia cuprea Koch). Araceae

It has heart shaped leaves which are olive green above and light purple below. It comes up well under semishaded locations.

Aralia (Polyscias guilfoyeli victoriae Bailey). Araliaceae

The leaf is composed of one to several large round green leaflets with serrated edges. It usually needs a fairly sheltered position from the sun.

Balsam (*Impatiens walleriana sultanii* Hook). Balsaminaceae.

Commonly known as busy lizzi, this plant produces a profusion of red, pink or white flowers. In this study, the variegated type (in which the flower is red blotched with white) was used. In winter the plant can be put in full light, while in summer, it has to be protected from the hot sun.

Begonia (*Begonia semperflorens* Link.). Begoniaceae.

This low bushy wax begonia has glossy green or brown purple flushed leaves and pretty little pink or red flowers which may appear on and off throughout the year. Begonia prefers a moist atmosphere and shaded situation.

Chlorophytum (*Chlorophytum comosum* Wood). Liliaceae.

It has long, arching, green and white striped leaves. It can tolerate both shade and partial shade.

Coleus (*Coleus blumei* Benth.). Labiatae.

It is one of the prettiest of foliage plants. It has a wide variety of colour range for leaves, most popular being shades of red. Such types which can thrive in partial shade was usesd in this study. The plants in general require full sun light for the development of good colours.

Cordyline (Cordyline terminalis Kunth.). Liliaceae.

These are tall erect plants with a cluster of leaves towards the top. The leaf color is green flushed with red. The plants remain colorful in semishade. Dense shade brings about a dull color.

Dieffenbachia (Dieffenbachia picta Schott). Araceae.

Usually referred to as the Dumbcane. It has oblong green leaves which are patterned with large, creamy white blotches. They grow well in partial shade.

Dracaena (Dracaena sanderiana Hort.). Agavaceae.

It is also known as Dragon plant. Its glossy dark green leaves have two silver stripes running from the base to the tip. The variety requires shade and cannot tolerate the sun.

Maranta (Maranta zebrina Sims) Marantaceae

Its leaves lie horizontally at day time, but at night they become upright like folded hands. Hence known as prayer plant. The leaves are greyish green with lighter veins and big brown blotches which in time turn dark green. Maranta comes up well in warm semishaded positions.

Rhoeo (<u>Rhoeo spathacea</u> Hance). Commelinaceae.

Its lance shaped leaves are dark green, with reddish purple beneath. It prefers semishaded situations.

Pleomele (<u>Pleomele reflexa</u> Lam). Agavaceae

Its rosette of dark green leaves arranged along the main stem makes it an excellent decorater plant. Medium light conditions are preferred to by the plant.

Peperomia (<u>Peperomia obtusifolia</u> Hbk.).piperaceae

The compact growth of this semi succulent plant makes it an excellent foliage plant. Moderate semishaded conditions are required for its good growth.

Verbena (<u>Verbena incisa</u> Hook.). Verbenaceae

Though a perennial it is usually raised as an annual. Flowers appear in many colors such as red, pink, mauve etc. In this study pink colored type was used. It needs high light for its growth.

The plants were grown in 20 cm pots. A standard pot mixture (soil, sand and compost, 1:1:1) was used. They were watered regularly, and placed under optimum conditions of light and shade till full establishment. After full establishment, the uniform plants were selected and subjected to the following treatments.

Treatments

Treatment 1 - Full sun (Control)
Treatment 2 - 75 per cent sunlight
Treatment 3 - 50 per cent sunlight
Treatment 4 - 25 per cent sunlight
Treatment 5 - 10 per cent sunlight

The experiment was laid out in a Completely Randomised Design, with the five treatments replicated four times.

Provision of shade

A temporary structure was constructed with g.i. pipes, and the top and the sides were covered with layers of wide mesh gunny cloth. The plants under the treatments 2 and 3 were placed inside this structure and the rest (4 and 5) inside the Mandapam. An 'Aplab' luxmeter was used for measuring the light intensities. Frequent checks were made throughout the experiment to maintain the light intensites at the level of the treatments.

Observations

Vegetative characters

The following observations were made at periodic intervals for six months.

Plant Height

The height of the plants were measured from the base of the plant to the tip of the topmost leaf.

Leaf size

The leaf area was measured graphically.

Total leaf production

The number of leaves produced per plant was recorded at periodic intervals, except in the case of coleus and pleomele.

Floral characters

Time taken for flowering:

The date of emergence of flowers in the case of begonia and verbena was recorded and the time taken for flowering after subjecting them to the treatments, worked out.

Spread of flowering:

Visual observations were made on the spread of flowering.

Colour of the flower:

Anthocyanins of flowers were quantitatively estimated.

Effective indoor life:

The general condition of the plants was observed at periodic intervals.

Chemical analyses

Estimation of chlorophyll, anthocyanins and carbohydrates

Chlorophyll content:

Chlorophylls 'a' and 'b' and the total chlorophyll content of each of the plants were estimated periodically (at bimonthly intervals) as described by Starner and Hadley (1965). The last fully mature leaf was used for the estimation.

A known weight of the representative sample collected from the plants at random, was taken in a mortar in the presence of acetone. About 5 ml of water was added and the contents were homogenised. The final volume was made upto 10 ml. 5 ml of the solution was taken and mixed with 45 ml of 80 per cent acetone. The supernatant solution was collected after centrifuging and the optical density measured, at two different wave lengths 645 and 663 nm. Using the following formulae the concentration of the pigment was calculated and expressed as mg g^{-1}.

Total chlorophyll	..	$8.05\ A_{668} + 20.29\ A_{645}$
Chlorophyll 'a'	..	$12.72\ A_{663} - 2.52\ A_{645}$
Chlorophyll 'b'	..	$22.87\ A_{645} - 4.67\ A_{663}$

Anthocyanins:

The anthocyanins were estimated by the method described by Ranganna (1977). The initial step was alcohol extraction. A known quantity of the sample was taken and put in a blender with the required quantity of ethanolic HCl.

They were then transferred to 500 ml glass stoppered bottles and stored overnight in refrigerator at 4°c. It was then filtered through Buchner funnel using Whatman No.1 filter paper, and the volume was made upto 500 ml. A small quantity of the filterate was then diluted with ethanolic HCl to yield the optical density measurements within the optimum range of the spectrophotometer. The anthocyanin content was then calculated using the following relationship and quantity expressed as mg 100 g^{-1} of the sample.

$$\text{Total OD per 100 g of the sample} = \frac{\text{Absorbance at 535 nm} \times \text{Volume made up of the extracts used for colour measurements} \times \text{Total volume} \times 100}{\text{Volume (ml) of the extract used} \times \text{Weight of the sample taken}} = X$$

The absorbance of a solution containing 1 mg ml^{-1} is equal to 98.2.

Therefore

$$\text{Total anthocyanins in mg 100 } g^{-1} \text{ of the berry} = \frac{X}{98.2}$$

Estimation of Carbohydrates

Carbohydrate content in the leaves:

The carbohydrate content was estimated using Anthrone method as suggested by Dubois et al. (1951). The leaf samples were digested with 20 per cent hydrochloric acid. Twenty ml of the dilute hydrochloric acid was used for digesting 100 mg of the samples. The material was taken in a test tube and heated on a hot plate for 45 minutes, keeping a funnel at the top of the test tube. After cooling it was made alkaline with NaOH solution.

Stock solution of glucose:

Stock solution of glucose was prepared by dissolving 1 gram glucose in 1 litre of distilled water.

Standard glucose solution:

Standard glucose solution of concentration 2, 4, 6, 8, 10 and 12 ppm were prepared by dissolving 2, 4, 6, 8, 10 and 12 ml of the stock solution in 100 ml each of distilled water. Fresh Anthrone reagent was prepared by dissolving 2 g of Anthrone in one litre of concentrated sulphuric acid.

Aliquot of 1 ml of the extract was taken in a test tube. To each of it, 4 ml of the Anthrone reagent was added, allowing the reagent to run down the sides of the test tube. After keeping a glass marble on the top of each tube to prevent loss of water by evaporation, the tubes were placed in boiling water bath for 10 minutes. A reagent blank was also treated simultaneously. The absorbance of the solution at 625 nm was measured. The amount of sugar present in the extract was calculated from a standard curve prepared from glucose.

Statistical analysis

The mean values for the different parameters were calculated and the data analysed using the analysis of variance technique for CRD. Their significance was tested by F test (Snedecor and Cochran, 1967).

~~REFERENCES~~

RESULTS

RESULTS

The results obtained on the response of fifteen ornamental foliage and flowering plants to the different light and shade intensities are presented in this chapter.

Aglaonema (*Aglaonema costatum* Veitch.)

Under normal conditions of growth, the plants are not capable of withstanding high light intensities. The results of the present study indicated that under open conditions (full sun light), the plants will remain healthy only for a period of hundred days and will decline afterwards.

The mean values for the plant height, leaf area and leaf production are presented in Table 1, and the values for chlorophyll 'a' and 'b', total chlorophyll as well as carbohydrates are presented in Table 2.

Plant height

Data presented in Table 1 revealed that at the 30th day, the treatments T_2, T_3 and T_5 were statistically at par (20.4, 20.52 and 20.54 respectively) and they were superior to the other two treatments T_1 and T_4 which were also at par (19.78 and 19.65 cm respectively). At the later growth stages

Table 1. Effect of various light intensities on plant height, leaf area and leaf production of aglaonema at different periods of growth

	Plant height (cm)						Leaf area (sq. cm)			Leaf production		
Initial values	17.40						38.65			3.50		
	Days after treatment						Days after treatment			Days after treatment		
Treatments	30	60	90	120	150	180	30	90	180	30	90	180
Full sun T_1	19.80	21.38	22.53	23.30	-	-	43.17	65.60	-	4.50	7.75	-
75 per cent light T_2	20.40	21.63	22.58	23.30	25.63	27.20	43.80	67.25	96.40	6.25	10.50	15.00
50 per cent light T_3	20.52	21.55	22.75	23.30	25.43	27.35	43.00	66.45	100.85	6.50	11.75	18.50
25 per cent light T_4	19.65	21.03	22.33	23.28	25.43	27.35	44.05	66.25	105.45	6.50	13.50	19.75
10 per cent light T_5	20.54	21.15	22.38	23.25	25.33	27.00	45.37	69.40	108.41	5.75	14.50	20.75
C.D. (.05)	0.257	NS	NS	NS	NS	NS	0.543	0.796	1.168	0.825	0.825	1.134
$S.E._m$	0.085	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.180	0.264	0.379	0.274	0.273	0.368

shading had no significant influence on the height of aglaonema plants.

Leaf area

The data indicated that plants grown under 10 per cent light (T_5) had significantly larger leaf area (108.41 sq. cm at the 180th day of treatments) compared to others. Among other treatments no distinct trend could be elucidated.

Leaf production

During the first month of treatment, the plants kept under open conditions (T_1) produced the minimum number of leaves and those under fairly high shade level (T_4, 25 per cent light), the maximum. At the next two stages (90th and 180th day), the number of leaves were found to increase steadily with increasing intensities of shade (upto 10 per cent light)

Chlorophyll content

Visual observations indicated that the plants kept under shade (medium to intense shade) had dark green leaves. The data also revealed that plants grown under 25 per cent light (T_4) had the highest total chlorophyll content and those grown in the open, the lowest. A similar trend was observed in the case of other two components chlorophyll 'a. and'b'.

Table 2. Effect of various light intensities on chlorophylls 'a' and 'b', total chlorophyll ($mg\ g^{-1}$ fresh weight) and carbohydrate (per cent) content of aglaonema at different periods of growth

	Chlorophyll 'a'			Chlorophyll 'b'			Total Chlorophyll			Carbohydrates
Initial values	9.60			11.60			21.20			2.40
	Days after treatment			Days after treatment			Days after treatment			
Treatments	60	120	180	60	120	180	60	120	180	After six months
Full sun T_1	1.52	1.53	-	1.50	1.50	-	2.75	2.75	-	3.25
75 per cent light T_2	5.45	9.70	11.20	7.99	11.50	10.30	13.46	20.98	22.43	3.04
50 per cent light T_3	6.45	9.07	17.36	7.28	15.50	10.35	13.43	24.38	28.35	3.14
25 per cent light T_4	8.08	10.47	17.53	9.45	20.28	16.18	18.68	30.75	34.35	2.55
10 per cent light T_5	7.63	9.06	10.47	9.18	15.23	20.28	16.50	24.45	30.55	3.46
C.D. (.05)	0.229	0.160	0.535	0.273	0.289	0.289	0.283	0.222	0.279	0.126
$S.E._m$	0.076	0.053	0.173	0.090	0.096	0.093	0.093	0.073	0.090	0.041

Carbohydrates

The data presented in Table 2 did not reveal any definite trend for the total soluble carbohydrate content of various treatments. The maximum values were recorded by those plants grown under intense shade (10 per cent light) and the minimum by those under comparatively high shade (25 per cent light). The other treatments recorded intermediate values.

Alocasia (Alocasia cuprea Koch)

Alocasia under normal condition thrives well under subdued light intensities. The plantsthat were kept in the open survived only for three months. The leaves lost their chlorophyll, became yellowish and ultimately scorched off.

Plant height

Shading had significant influence on plant height. The data presented in Table 3 revealed that plant height steadily increased with increasing intensities of shade. The maximum height was recorded by the plants grown under 10 per cent light (60.13 cm) after 180 days of treatment.

Table 3. Effect of various light intensities on plant height, leaf area, and leaf production of alocasia at different periods of growth

Initial values	Plant height (cm) 5.68						Leaf area (sq. cm) 87.60			Leaf production 3.50		
	Days after treatment						Days after treatment			Days after treatment		
Treatments	30	60	90	120	150	180	30	90	180	30	90	180
Full sun T_1	7.18	16.55	26.25	-	-	-	100.63	263.18	-	2.75	5.50	-
75 per cent light T_2	8.08	18.28	28.25	38.15	46.90	54.80	106.23	270.18	330.05	3.50	6.75	10.50
50 per cent light T_3	8.95	19.03	30.25	40.38	48.60	56.70	112.75	279.53	336.28	4.50	8.00	11.50
25 per cent light T_4	9.35	20.08	30.77	42.10	49.93	57.95	117.25	285.78	344.23	4.25	7.50	10.50
10 per cent light T_5	10.18	21.40	32.65	43.20	51.13	60.13	123.20	292.15	353.33	5.25	8.50	11.75
C.D. (.05)	0.247	0.346	0.594	0.580	0.305	0.360	0.508	0.802	3.129	0.802	0.933	0.861
$S.E._m$	0.082	0.115	0.197	0.188	0.098	0.117	0.169	0.266	1.020	0.266	0.309	0.279

Leaf area

The data (Table 3) also showed a significant increase in leaf area as the shade intensity was increased. The trend followed a similar path as that was observed for plant height.

Leaf production

The plants grown under 10 per cent light (T_5) produced the largest number of leaves (Table 3). This was closely followed by those grown under 50 per cent light (T_3). The smallest leaf number was shown by those plants kept in open (T_1) which was inferior to all the other treatments.

Chlorophyll content

The two chlorophyll components 'a' and 'b' as well as the total chlorophyll were found affected by varying intensities of light (Table 4). Visual observations also indicated that leaves of shade grown plants had dark greener leaves. Chlorophyll contents increased substantially with diminishing intensities of light.

Carbohydrates

The data have been presented in Table 4. The treatment were statistically at par for the total content of soluble carbohydrates.

Table 4. Effect of various light intensities on the chlorophylls 'a' and 'b', total chlorophyll (mg g^{-1} fresh weight) and carbohydrate (per cent) content of alocasia at different periods of growth

	Chlorophyll 'a'			Chlorophyll 'b'			Total Chlorophyll			Carbohydrates
Initial values	2.10			2.20			4.40			4.20
	Days after treatment			Days after treatment			Days after treatment			
Treatments	60	120	180	60	120	180	60	120	180	After six months
Full sun T_1	2.25	3.03	-	1.18	3.28	-	3.30	6.30	-	-
75 per cent light T_2	2.23	3.58	5.35	1.23	4.10	5.18	3.40	7.68	10.53	4.14
50 per cent light T_3	2.20	4.18	6.15	2.18	4.20	6.23	4.25	8.38	12.37	4.15
25 per cent light T_4	3.30	4.40	8.03	2.18	4.60	8.18	5.38	9.00	16.20	4.15
10 per cent light T_5	4.28	4.53	7.78	1.33	5.23	9.13	5.58	9.63	18.18	4.14
C.D. (.05)	0.167	0.430	1.870	0.122	0.498	0.285	0.248	0.317	0.345	NS
$S.E._m$	0.056	0.142	0.608	0.040	0.165	0.092	0.802	0.802	0.112	-

Aralia (Polyscias quilfoyeli victoriae Bailey)

Usually the plants prefers partial shade but it can gradu get acclimatized to almost full sun light.

Plant height

The data presented in Table 5 showed that at the 30th day of treatment, plant height was significantly influenced by the treatment T_2 (75 per cent light) and this was superior to all the other treatments. But from the 60th day onwards the trend was rather different and T_1 (full sun) excelled the other treatments (Fig.1).

Leaf area

Data revealed that (Table 5) plants grown in 10 per cent light (T_5) had significantly larger leaf area at 90th and 180th day of treatment(19.74 sq.cm and 28.81 sq.cm respectively) At the 30th day, T_4 and T_5 were found statistically at par. The other treatments recorded lower values for leaf area.

Leaf production

The mean values are presented in Table 5. Leaf production was not found significantly influenced by the shading treatments at the 30th and 180th day of treatment. At the

Table 5. Effect of various light intensities on plant height, leaf area, and leaf production of aralia at different periods of growth

	Plant height (cm)						Leaf area (sq. cm)			Leaf production		
Initial values	12.60						6.80			7.50		
	Days after treatment						Days after treatment			Days after treatment		
Treatments	30	60	90	120	150	180	30	90	180	30	90	180
Full sun T_1	19.40	30.70	40.80	47.73	55.88	69.40	7.95	13.32	17.66	9.50	13.50	22.75
75 per cent light T_2	20.43	30.50	40.70	46.10	54.55	60.05	9.50	13.18	17.85	10.50	14.75	22.75
50 per cent light T_3	18.95	27.55	34.03	41.05	46.03	52.23	9.95	15.86	20.54	10.00	15.50	22.50
25 per cent light T_4	19.23	24.13	29.00	35.75	39.43	42.63	12.23	17.53	25.09	10.50	15.50	23.50
10 per cent light T_5	18.65	24.20	29.13	35.25	39.50	42.63	11.48	19.74	28.81	9.50	16.25	22.50
C.D. (.05)	0.675	0.723	0.658	0.968	0.690	1.149	1.050	0.536	0.362	NS	1.260	NS
$S.E._m$	0.224	0.239	0.219	0.320	0.229	0.382	0.349	0.178	0.120	—	0.418	—

Table 6. Effect of various light intensities on chlorophylls 'a' and 'b', total chlorophyll (mg g^{-1} fresh weight) and Carbohydrate (per cent) content of aralias at different periods of growth

	Chlorophyll 'a'			Chlorophyll 'b'			Total Chlorophyll			Carbohydrate
Initial values	5.9			6.4			12.9			3.5
	Days after treatment			Days after treatment			Days after treatment			
Treatments										
	60	120	180	60	120	180	60	120	180	After six months
Full sun T_1	5.30	3.30	6.60	4.25	8.25	6.33	10.53	11.75	12.60	4.16
75 per cent light T_2	5.30	4.40	8.28	4.35	8.25	4.45	10.65	12.45	13.60	4.16
50 per cent light T_3	6.70	5.38	9.38	6.55	9.65	8.45	13.33	15.00	18.35	4.25
25 per cent light T_4	6.65	5.63	9.23	6.58	9.65	8.50	13.45	15.38	18.38	4.33
10 per cent light T_5	7.25	5.45	9.28	6.65	9.68	8.50	13.55	15.48	18.63	4.53
C.D. (.05)	0.201	0.390	0.223	0.283	0.216	0.189	0.241	0.443	0.430	0.147
$S.E._m$	0.066	0.129	0.074	0.094	0.072	0.063	0.080	0.147	0.143	0.049

90th day, however the plants kept in the open conditions (T_1) were found to have significantly lesser number of leaves compared to those kept under the different shade levels. Among the different shade levels T_3, T_4 and T_5, values were statistically at par.

Chlorophyll content

The contents of total chlorophyll (Table 6) showed a steady increase, with decrease in light intensities. The increment in chlorophyll content followed a regular sequence when the light intensity was proportionately reduced from open sun light to 10 per cent sun light.

Carbohydrates

T_5 (10 per cent light) was found significantly superior to all other treatments for the total carbohydrate content (4.53 per cent). The carbohydrate content varied from 4.16 per cent to 4.53 per cent among the five treatments. (Table 6).

Balsam (Impatiens walleriana sultanii Hook)

In the normal condition the plant prefers to grow under shade. The present study revealed that the plants raised in the open condition remained in fairly good condition hardly for two months. Thereafter they exhibited symptoms like heavy defoliation, reduced flowering and weakened stems (Plate 1).

Plant height

The plants grown under 50 per cent light (T_3) were found significantly taller than the othe treatments at all stages of growth (Table 7). The plants grown under full sun (T_1) and 75 per cent light (T_2) recordedl low values.

Leaf area

Data revealed that plants raised under 50 per cent shade (T_3) had significantly larger leaf area at all the growth stages. At the later growth stages (120th, 150th and 180th day of treatment) the leaves of the plants grown under 75 per cent light had the smallest leaf area (Table 8).

Spread of flowering

The plants grown under 75 per cent light level had the greatest spread of flowering (Plate 1).

Colour of the flowers

The flowers under shaded condition developed an intense red colour.

Plate 1. Effect of various light intensities on the growth of balsam

T_1 - Full sunlight

T_2 - 75 per cent light

T_3 - 50 per cent light

T_4 - 25 per cent light

T_5 - 10 per cent light

PLATE 1 (X 0.11)

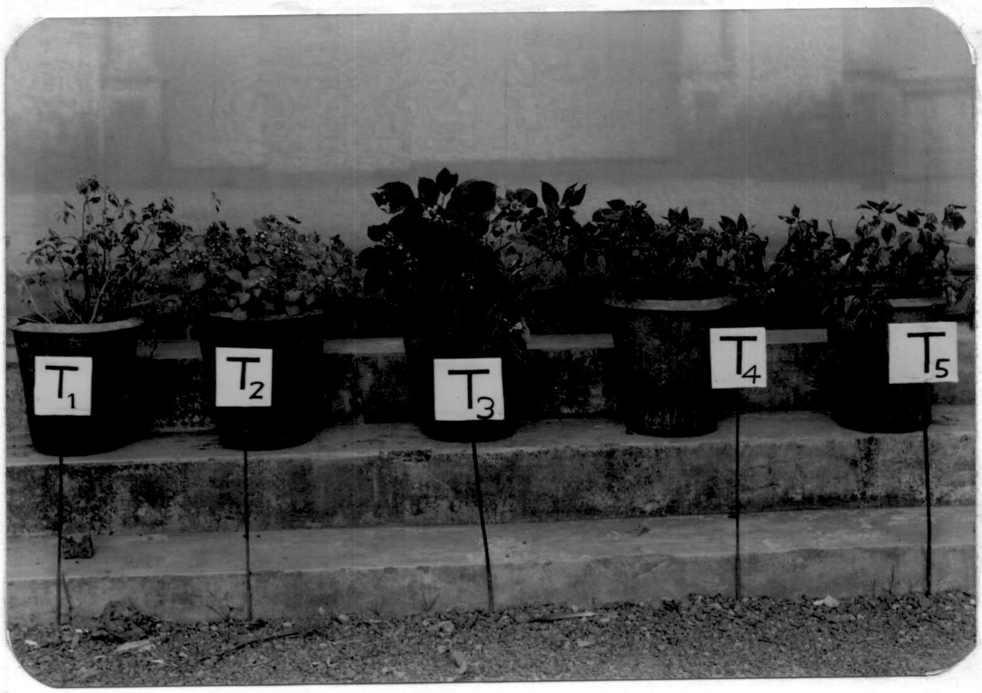


Table 7. Effect of various light intensities on plant height and anthocyanin content of balsam at different periods of growth

Initial values	Plant height (cm)						Anthocyanins (mg 100 g^{-1})		
	20.68						220.80		
	Days after treatment						Days after treatment		
Treatments	30	60	90	120	150	180	60	120	180
Full sun T_1	25.30	30.62	36.13	-	-	-	214.50	-	-
75 per cent light T_2	27.25	31.48	32.78	34.58	36.88	38.30	281.50	462.25	514.00
50 per cent light T_3	30.68	36.95	41.58	46.54	51.10	53.25	304.50	496.75	580.75
25 per cent light T_4	26.30	32.05	35.35	41.15	45.83	48.90	295.50	474.00	503.75
10 per cent light T_5	25.53	31.08	35.68	40.55	45.03	48.85	304.75	505.00	805.00
C.D. (.05)	0.834	2.136	1.05	0.609	1.070	0.536	4.380	2.650	4.020
$S.E._m$	0.278	0.709	0.348	0.198	0.346	0.174	1.453	0.860	1.300

Table 8. Effect of various light intensities on leaf area and carbohydrate (per cent) content of balsam at different periods of growth

	Leaf area (sq. cm)			Carbohydrates
Initial values	3.23			3.30
	Days after treatment			
Treatments	30	90	180	After six months
Full sun T_1	3.50	6.25	-	-
75 per cent light T_2	5.68	10.33	14.13	3.32
50 per cent light T_3	8.50	12.63	18.65	3.30
25 per cent light T_4	6.43	8.13	11.70	3.32
10 per cent light T_5	6.25	8.58	12.58	3.30
C.D. (.05)	0.330	0.533	0.952	NS
$S.E._m$	0.109	0.177	0.304	-

Anthocyanins

The plants grown under intense shade (10 per cent light) had the highest anthocyanin content of flowers (Table 7). Visual observations also indicated more red coloured flowers in this treatment. Increased variegation of flowers (white colour) was observed in plants grown under 75 per cent light. They also registered the least anthocyanin content.

Carbohydrates

The different shade levels were found statistically at par for the carbohydrate content (Table 8). The variation in carbohydrate content was quite low among the treatments (3.30 to 3.32 per cent).

Begonia (*Begonia semperflorens* Link)

This plant under normal conditions prefers to grow in shade. Direct sunlight is detrimental to the growth of these plants. The present study revealed that under open conditions the plants developed an unhealthy appearance with more crinkling and marginal scorching of leaves. However, the colour of the flowers were found intensified under high light intensities.

Plant height

The plants that received 50 per cent light (Fig.1) were taller than those grown under the other light intensities (Table 9). However no definite trend could be observed among the other treatments. At the 180th day of planting the treatments T_1 (full sun), T_2 (75 per cent light), T_4 (25 per cent light) and T_5 (10 per cent light) were at par.

Leaf area

The leaf area recorded at the 30th day (Table 9) was highest for the plants grown under 50 per cent light (30.68 sq.cm). But as the age of the plants progressed, the leaf area showed a corresponding increase when the light intensity was proportionately decreased. The plants grown under 10 per cent light registered the highest values at the 90th and 180th day of treatment (56.35 and 75.23 sq.cm respectively).

Days to flowering

The treatments, 75 per cent light (T_2) and 50 per cent light (T_3) required only lesser number of days for flowering (7.25 and 7.50 respectively). The plants kept in open (T_1) required more days for flowering (14.0). The other two treatments that received low light intensities gave intermediate values.

Table 9. Effect of various light intensities on plant height and leaf area of begonia at different periods of growth

	Plant height (cm)						Leaf area (sq. cm)		
Initial values	7.60						11.80		
	Days after treatment						Days after treatment		
Treatments	30	60	90	120	150	180	30	90	180
Full sun T_1	9.70	17.35	24.23	29.33	31.48	34.26	15.88	26.13	46.20
75 per cent light T_2	9.15	17.40	24.50	29.30	31.45	34.30	17.08	33.83	48.15
50 per cent light T_3	10.35	18.25	25.32	30.33	33.35	38.78	30.68	45.93	62.23
25 per cent light T_4	9.35	17.50	24.25	29.30	31.45	34.45	28.03	56.18	74.15
10 per cent light T_5	9.28	17.25	24.25	29.15	31.13	34.35	28.95	56.35	75.23
C.D. (.05)	0.279	0.169	0.225	0.148	0.208	3.380	0.691	0.547	0.880
$S.E._m$	0.092	0.053	0.075	0.049	0.069	1.124	0.229	0.182	0.295

Spread of flowering

The flowering period was more for plants under open conditions.

Colour of the flowers

Intense red colour could be detected in the flowers under more light intensities.

Anthocyanins

A sharp decline in anthocyanin content was detected with decrease in light intensities (Table 10). This declining trend was observed upto 10 per cent light at the 30th day, and upto 25 per cent light at the 90th day. At the 180th day of treatment the anthocyanin content was same for plants grown under 25 per cent and 10 per cent light (183 mg 100 g^{-1}).

Carbohydrates

Shading did not significantly affect the carbohydrate contents (Table 10). The variation in carbohydrate content was from 3.43 to 3.68 per cent among the five treatments.

Table 10. Effect of various light intensities on anthocyanin and carbohydrate content, as well as flowering of Begonia at different periods of growth

	Anthocyanins (mg 100 g^{-1})			Carbohydrates (per cent)	Days to flowering
Initial values	301.80			3.20	
	Days after treatment				
Treatments	30	90	180	After six months	
Full sun T_1	326.50	343.25	352.50	3.50	14.00
75 per cent T_2	303.75	324.25	334.50	3.43	7.25
50 per cent T_3	264.50	292.50	30.50	3.55	7.50
25 per cent T_4	163.00	173.5	183.00	3.68	10.00
10 per cent T_5	153.75	174.75	183.00	3.68	11.75
C.D. (.05)	2.506	2.209	3.25	NS	1.26
$S.E._m$	0.831	0.733	1.080	-	0.418

Chlorophytum (Chlorophytum comosum Wood)

It comes up well under partially shaded conditions. Visual observations revealed that under intense shade , the leaves tend to be narrow.

Plant height

The plants grown under 50 per cent shade (T_3) were found to have greater height (Fig.1) at all the stages of growth except at the fifth month. The plants grown under open conditions (T_1) recorded the minimum values for plant height (Table 11).

Leaf area

The plants grown under full sun light (T_1) had significantly smaller leaf area compared to those under the four shade (Table 11). Among the different shade levels, T_4 and T_5 were found statistically at par and they were superior to the other treatments T_1, T_2 and T_3.

Leaf production

The data presented in Table 11 also revealed that shading had no significant influence on the number of leaves produced by the plant. However, at the 90th and180th days

Table 11. Effect of various light intensities on plant height, leaf area and leaf production of chlorophytum at different periods of growth

Initial values	Plant height (cm)						Leaf area (sq. cm)			Leaf production		
	14.72						22.50			3.40		
	Days after treatment						Days after treatment			Days after treatment		
Treatments	30	60	90	120	150	180	30	90	180	30	90	180
Full sun T_1	18.90	27.08	32.13	34.35	39.20	41.50	29.48	49.18	58.18	4.50	11.50	19.75
75 per cent light T_2	19.53	27.80	34.23	37.75	42.30	44.07	30.58	47.85	70.73	5.25	11.00	19.75
50 per cent light T_3	23.10	32.98	39.30	45.75	45.80	48.25	31.28	48.63	69.50	5.00	11.75	20.75
25 per cent light T_4	20.90	32.13	39.00	43.80	45.50	47.78	32.82	51.30	71.50	5.50	13.00	20.50
10 per cent light T_5	20.63	32.30	38.85	43.88	47.75	48.05	32.98	51.45	70.88	4.75	11.75	20.75
C.D. (.05)	0.536	0.817	0.914	2.313	0.831	0.725	0.678	1.164	1.030	NS	NS	NS
$S.E._m$	0.178	0.171	0.303	0.767	0.276	0.240	0.225	0.386	0.341	-	-	-

Table 12. Effect of various light intensities on chlorophylls 'a' and 'b', total chlorophyll (mg g^{-1} fresh weight) and carbohydrate (per cent) content of chlorophytum at different periods of growth

	Chlorophyll 'a'			Chlorophyll 'b'			Total chlorophyll			Carbohydrates
Initial values	2.70			2.60			5.30			
	Days after treatment			Days after treatment			Days after treatment			
Treatments	60	120	180	60	120	180	60	120	180	After six months
Full sun T_1	1.02	1.15	2.23	0.417	1.23	1.28	1.40	2.48	3.20	2.25
75 per cent light T_2	1.65	1.18	2.15	1.22	2.28	2.20	2.96	3.43	4.37	2.63
50 per cent light T_3	1.63	2.13	3.20	1.42	2.15	2.20	3.08	4.30	5.43	2.60
25 per cent light T_4	1.74	3.10	3.10	1.42	2.20	3.33	3.24	5.33	6.35	2.55
10 per cent light T_5	1.48	3.18	3.23	1.59	2.20	3.05	3.35	5.53	6.45	2.65
C.D. (.05)	0.121	0.130	0.158	0.062	0.240	0.327	0.060	0.273	0.279	0.226
$S.E._m$	0.040	0.043	0.052	0.020	0.080	0.108	0.020	0.090	0.092	0.075

after treatment, the leaf production wascomparitively higher in the plants that received higher shade (T_3, T_4 and T_5).

Chlorophyll content

The data given in Table 12 indicated that the total chlorophyll contents showed a progressive increase with decreasing intensities of light. This trend continued upto the 10 per cent intensity of light (T_5). But the treatment that received 25 per cent light (T_4) gave the maximum value for chlorophyll 'a' at the 60th day (1.74 mg g^{-1} fresh weight) and for chlorophyll 'b' at the 180th day (3.33 mg g^{-1} fresh weight).

Carbohydrates

The minimum value for carbohydrates (2.25 per cent) was shown by the open light treatment (T_1). The other four treatments that received varying intensities of shade showed slightly higher values ranging from 2.55 to 2.65 per cent. Within these shade levels no significant difference could be detected. (Table 12).

Coleus (Coleus blumei Benth.)

Fairly high light is preferable for the normal plant growth and also to have an attractive foliage colour. Under normal conditions colour development is more intense at higher light intensities.

Plant height

The plants grown under open conditions were found to be taller (Fig.1) than the other treatments that received shade. With decrease in the light intensities the values for plant height showed a significant decline at all the stages of growth (Table 13).

Leaf area

The change in leaf area was highly perceptible at all the stages of growth. Leaf area increased progressively with decrease in intensitiesof light (Table 14).

Anthocyanins

Visual observations revealed that medium to high shaded leaves had lower anthocyanin contents compared to those grown under open conditions and 75 per cent light (Table 13). The data also indicated that maximum and minimum values for anthocyanin content was recorded by plants kept in the open and 10 per cent light intensities respectively. When the light intensities and the growth periods were considered, the lowest value was registered by 10 per cent light at the 30th day (75.25 mg 100 g^{-1}) and the highest by 75 per cent light at the 180th day (231.25 mg 100 g^{-1}).

Table 13. Effect of various light intensities on plant height, and anthocyanin content of coleus at different periods of growth

	Plant height (cm)						Anthocyanins (mg 100 g^{-1})		
Initial values	7.50						71.86		
	Days after treatment						Days after treatment		
Treatments	30	60	90	120	150	180	30	90	180
Full sun T_1	20.35	33.25	42.30	48.23	50.20	52.40	146.75	207.75	228.75
75 per cent light T_2	15.83	26.33	35.50	43.13	56.40	48.07	152.75	204.00	231.25
50 per cent light T_3	11.23	19.38	28.45	35.50	38.18	40.68	84.25	145.50	185.50
25 per cent light T_4	10.28	14.38	19.53	22.38	24.30	27.60	96.25	114.25	128.25
10 per cent light T_5	8.13	13.37	17.23	21.25	22.30	24.13	75.25	106.75	129.00
C.D. (.05)	0.426	0.460	0.264	0.410	0.339	0.463	3.600	4.350	6.680
$S.E._m$	0.141	0.153	0.087	0.136	0.113	0.154	1.190	1.440	2.218

Table 14. Effect of various light intensities on leaf area and carbohydrate (per cent) content of coleus at different periods of growth

Initial values	Leaf area (sq. cm)			Carbohydrate
	1.23			4.13
	Days after treatment			
Treatments	30	90	180	After six months
Full sun T_1	1.53	3.05	6.81	4.15
75 per cent light T_2	1.97	3.38	7.34	4.14
50 per cent light T_3	2.03	4.44	8.83	4.16
25 per cent light T_4	2.97	5.14	9.16	4.15
10 per cent light T_5	3.45	6.93	10.36	4.15
C.D. (.05)	0.028	0.025	0.085	NS
$S.E._m$	0.009	0.008	0.028	-

Carbohydrates

The total carbohydrate content estimated at the 180th day of treatment, did not reveal any significant variation among the different treatments (range from 4.14 to 4.16 per cent)

Cordyline (Cordyline terminalis Kunth.)

Plant height

The results indicated that there was progressive increase in plant height with decrease in light intensities (Fig.1). This trend assumed a similar pattern at the six growth stages studied. The maximum plant height was attained by plants grown in 10 per cent light (47.2 cm) and the minimum by those grown in open conditions (40.83 cm) which was recorded at 180th day after treatment (Table 15).

Leaf area

Shading had significant influence on leaf area. It showed a steady increase with a corresponding increase in shade intensity at all the growth stages. At the 180th day of planting, the minimum leaf area was shown by the plants kept

Table 15. Effect of various light intensities on plant height and leaf area of cordyline at different periods of growth

Initial values	Plant height (cm)						Leaf area (sq. cm)		
	24.30						29.80		
	Days after treatment						Days after treatment		
Treatments	30	60	90	120	150	180	30	90	180
Full sun T_1	26.20	29.70	32.00	35.05	36.20	40.83	35.43	95.40	142.35
75 per cent light T_2	27.10	30.28	33.50	35.63	37.28	42.68	39.43	97.38	147.28
50 per cent light T_3	27.35	31.08	34.43	36.85	39.05	44.13	42.13	100.43	150.88
25 per cent light T_4	27.70	32.80	35.43	38.05	40.70	46.03	45.25	105.35	154.33
10 per cent light T_5	28.25	33.05	36.28	38.80	42.15	47.20	50.08	108.55	160.43
C.D. (.05)	0.754	0.292	0.429	0.399	0.423	0.409	0.504	0.401	0.630
$S.E._m$	0.250	0.097	0.143	0.133	0.140	0.136	0.168	0.157	0.209

in open (142.35 sq.cm) asagainst the maximum in plants that received only 10 per cent light (160.43 sq.cm).

Leaf production

A similar trend as that was observed for plant height and leaf area was also observed for the leaf number. The largest leaf production was by plants grown under 10 per cent light (20.25) and the smallest by those grown in open (14.25) which was observed at the 180th day of treatment.

Anthocyanins

The plants grown under intense shade condition had lesser colouration (shades of red) in their leaves. The data also indicated (Table 16) that the anthocyanin contents significantly decreased as the light intensity was reduced from full sun (T_1) to 10 per cent light (T_5). (Table 16).

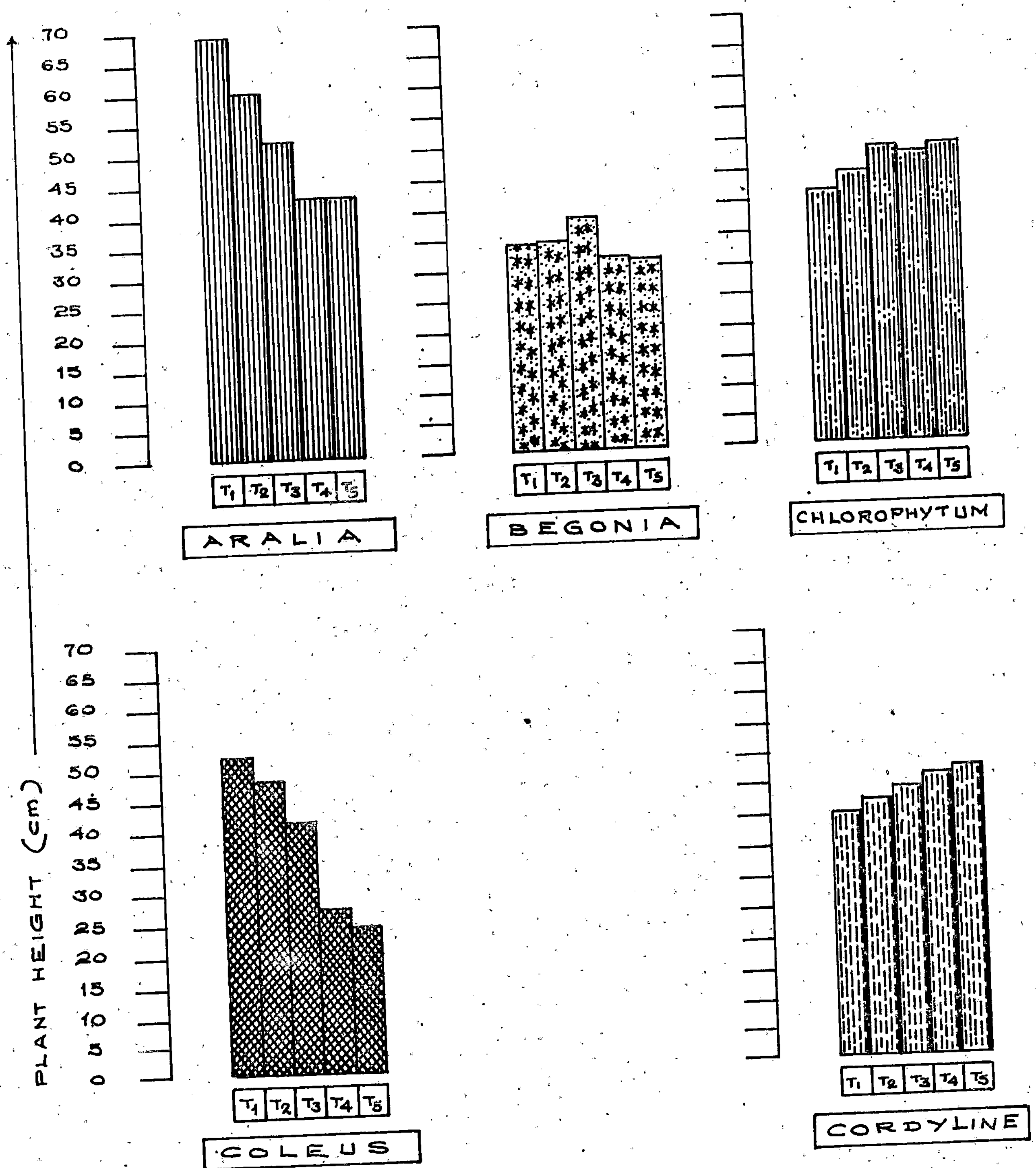
Carbohydrates

The different levels of light intensities had no significant influence on the carbohydrate contents (Table 16). The carbohydrate content ranged from 2.45 to 2.53 per cent among the five treatments.

Table 16. Effect of various light intensities on leaf production, carbohydrate (per cent) and anthocyanin content of cordyline at different periods of growth

	Leaf production			Anthocyanins (mg 100 g^{-1})			Carbohydrates
Initial values	3.00			160.76			2.48
	Days after treatment			Days after treatment			
Treatments	30	90	180	60	120	180	After six months
Full sun T_1	3.25	7.00	14.25	320.50	344.75	374.25	2.53
75 per cent light T_2	3.50	7.75	15.25	313.75	324.75	373.75	2.50
50 per cent light T_3	4.25	8.75	16.75	291.00	313.25	324.00	2.45
25 per cent light T_4	4.50	10.50	18.50	207.50	219.50	235.50	2.50
10 per cent light T_5	4.75	11.75	20.25	166.00	175.75	189.25	2.50
C.D. (.05)	0.802	0.892	0.778	9.690	5.073	8.660	NS
S.$E._m$	0.266	0.295	0.258	3.217	1.683	2.87	-

FIG. 1 EFFECT OF VARIOUS LIGHT INTENSITIES ON PLANT HEIGHT AFTER SIX MONTHS



T1 FULL SUNLIGHT
T2 75 PER CENT LIGHT
T3 50 PER CENT LIGHT
T4 25 PER CENT LIGHT
T5 10 PER CENT LIGHT

Dieffenbachia (*Dieffenbachia picta* Schott)

For the satisfactory growth of this plant moderate light is preferred. Under high light intensities the leaves are found to exhibit yellowing and marginal scorching. They also assume a vertical orientation in this situation.

Plant height

After 30 days of treatment the plants grown under full sun (T_1) were taller than the others (Table 17). However, during the other growth stages (60th, 90th, 120th 150th and 180th day) the maximum height was recorded by plants grown under 25 per cent light (48.88, 61.83, 66.05, 67.65 and 69.30 cm) respectively (Fig. 2).

Leaf area

A significant difference was observed among the treatments with respect to the leaf area. The leaf area of plants grown under T_5(10 per cent light) was the greatest followed by T_4 (25 per cent light). The plants kept in the open conditions had the smallest leaf area (Table 17). The corresponding values of leaf area for T_1 was 118.62 sq.cm and for T_5 was 188.19 sq.cm which was recorded at the 180th day of planting.

Table 17. Effect of various light intensities on plant height, leaf area and leaf production of dieffenbachia at different periods of growth

Initial values	Plant height (cm)						Leaf area (sq. cm)			Leaf production		
	33.40						39.30			5.35		
	Days after treatment						Days after treatment			Days after treatment		
Treatments	30	60	90	120	150	180	30	90	180	30	90	180
Full sun T_1	35.35	47.33	55.33	59.05	61.20	61.83	40.13	54.31	118.62	7.75	18.00	31.00
75 per cent light T_2	34.93	47.85	54.03	58.88	60.40	61.28	44.24	68.78	134.28	7.75	18.50	30.50
50 per cent light T_3	34.13	48.86	57.85	64.25	65.78	67.03	50.05	96.84	153.06	8.75	18.50	28.75
25 per cent light T_4	34.18	48.88	61.83	56.05	67.65	69.30	73.54	125.82	173.06	9.00	17.50	29.50
10 per cent light T_5	33.88	48.05	58.83	65.62	67.10	68.88	81.57	138.56	188.19	7.75	15.50	30.75
C.D. (.05)	0.930	1.040	1.130	0.930	0.780	0.560	0.469	1.970	0.960	0.670	1.030	1.190
$S.E._m$	0.309	0.345	0.380	0.308	0.260	0.187	0.156	0.650	0.315	0.220	0.340	0.390

Leaf production

The number of leaves produced per plant ranged from 7.75 to 9.00 at the 30th day, 15.50 to 18.50 at the 90th day and 28.75 to 30.75 at the 180th day of planting. However the treatments did not reveal any significant difference among themselves.

Chlorophyll content

Significantly higher chlorophyll contents were found in the leaves of plants grown under 50 per cent light at all the stages of growth. T_1 (full sun) recorded the minimum values. Visual observations also indicated that the leaves of plants grown under open conditions lost their green colour considerably. They turned brittle and became white.

Carbohydrates

Unlike the other plants studied earlier a significant response was observed for the content of total soluble carbohydrates (Table 18). The plants kept in the open (T_1) as well as those kept in 25 per cent light (T_4) gave higher values (2.87 and 2.83) which were at par. The plants that received 75 per cent light (T_2) and 50 per cent light (T_3) recorded lower values (2.35 and 2.33 per cent respectively) which were also at par.

Table 18. Effect of various light intensities on chlorophylls 'a' and 'b', total chlorophyll (mg g^{-1} fresh weight) and carbohydrate (per cent) content of dieffenbachia at different periods of growth

Initial values	Chlorophyll 'a'			Chlorophyll 'b'			Total Chlorophyll			Carbohydrate
	5.20			7.30			12.10			2.04
	Day after treatment			Day after treatment			Day after treatment			
Treatments	60	120	180	60	120	180	60	120	180	After six months
Full sun T_1	4.22	4.10	3.90	4.48	5.05	6.30	8.40	9.05	10.03	2.87
75 per cent light T_2	4.37	3.40	6.30	5.79	9.75	5.20	10.50	10.68	11.33	2.35
50 per cent light T_3	8.06	11.20	12.15	11.57	11.43	12.30	19.58	22.43	24.93	2.33
25 per cent light T_4	4.15	8.20	12.20	4.60	9.53	12.30	9.53	17.35	24.50	2.83
10 per cent light T_5	5.58	9.10	11.23	7.17	9.23	11.35	12.55	18.38	22.53	2.55
C.D. (.05)	0.379	0.380	0.370	0.144	0.210	0.260	0.480	0.287	0.832	0.089
$S.E._m$	0.126	0.125	0.120	0.048	0.070	0.087	0.160	0.096	0.280	0.029

Dracaena (*Dracaena sanderiana* Hort.)

The plant is very much adaptable to low light intensities, under normal conditions.

Plant height

Plants grown under intense shade (10 per cent light) were found taller than others(Fig. 2). The general trend was a progressive increase in plant height as the intensity of shade increased (Table 19). After 120, 150 and 180 days of planting the treatments T_5 (10 per cent light) and T_4 (25 per cent light) were at par.

Leaf area

Leaf area also showed an increasing trend (Table 19) with increasing intensities of shade. The maximum and minimum values were recorded for plants grown under 10 per cent (T_5) light, and full sun (T_1) respectively. At the 180th day of treatment, T_5 recorded a leaf area of 34.39 sq.cm and T_1 recorded 22.98 sq.cm.

Table 19. Effect of various light intensities on plant height, leaf area and leaf production of dracaena at different periods of growth

Initial values	Plant height (cm)						Leaf area (sq. cm)			Leaf production		
	30.90						11.40			7.60		
	Days after treatment						Days after treatment			Days after treatment		
Treatments	30	60	90	120	150	180	30	90	180	30	90	180
Full sun T_1	37.35	40.33	42.65	43.55	45.35	47.33	11.87	15.83	22.98	8.75	13.25	18.50
75 per cent light T_2	39.38	43.25	45.33	46.25	48.23	51.25	12.41	16.36	2[illegible].12	9.50	17.00	23.50
50 per cent light T_3	40.58	43.85	46.10	48.35	52.88	54.28	12.85	18.55	33.09	10.50	16.25	24.50
25 per cent light T_4	39.45	44.73	43.38	53.35	56.00	58.02	13.14	19.22	32.94	9.50	16.50	24.50
10 per cent light T_5	41.00	45.30	50.18	53.38	56.25	58.38	13.79	21.27	34.39	10.50	17.50	24.00
C.D. (.05)	0.699	0.540	0.633	0.388	0.660	0.577	0.340	0.074	1.110	0.848	1.070	1.230
$S.E._m$	0.232	0.179	0.210	0.127	0.220	0.192	0.114	0.025	0.369	0.281	0.354	0.408

Leaf production

At the first stage of sampling (30th day) T_3 was found superior over other treatments (Table 19). During the next two sampling stages (60th and 90th day) T_2, T_3, T_4 and T_5 were found statistically at par and these four treatments were superior to T_1.

Chlorophyll content

With regard to the three components of chlorophyll, T_4 and T_5 (25 per cent light and 10 per cent light) were found superior over the other treatments (Table 20). These treatments were at par except at the 60th day in the case of total chlorophyll and at the 120th day for chlorophyll 'a'. T_4 was found superior over T_5 at the 60th day for the total chlorophyll content (13.03 and 12.45 mg g^{-1} fresh weight) and at the 120th day for chlorophyll'a' (6.75 and 6.48 mg g^{-1} fresh weight respectively).

Carbohydrates

A gradual increase in the carbohydrate content was observed with decreasing intensities of light. This trend continued upto 25 per cent light (Table 20). With a further decrease in the light intensity to 10 per cent level the carbohydrate content showed a slight decline over the 25 per cent level.

Table 20. Effect of various light intensities on the chlorophylls 'a' and 'b', total chlorophyll (mg g^{-1} fresh weight) and carbohydrate (per cent) content of dracaena at different periods of growth

	Chlorophyll 'a'			Chlorophyll 'b'			Total Chlorophyll			Carbohydrate
Initial values	3.90			4.80			8.70			2.50
	Days after treatment			Days after treatment			Days after treatment			
Treatments	60	120	180	60	120	180	60	120	180	After six months
Full sun T_1	4.60	3.70	2.38	5.03	3.50	2.63	9.28	6.48	5.43	2.25
75 per cent light T_2	2.55	4.57	5.25	3.35	4.63	4.85	5.75	9.38	10.25	2.67
50 per cent light T_3	1.68	5.51	3.45	2.35	6.03	4.55	4.65	11.80	8.50	2.84
25 per cent light T_4	5.55	6.75	8.45	7.25	7.40	7.60	13.03	14.88	16.60	3.45
10 per cent light T_5	5.55	6.48	8.30	7.16	7.58	7.43	12.45	14.65	16.63	3.28
C.D. (.05)	0.289	0.253	0.334	0.188	0.268	0.229	0.458	0.689	0.327	0.110
$S.E._m$	0.095	0.083	0.110	0.062	0.089	0.076	0.151	0.228	0.108	0.037

Maranta (*Maranta zebrina* sims)

Maranta usually prefers to grow under low light intensities. Higher light intensities are found detrimental to the growth of the plants. Visual observations also indicated that the leaves of the plants kept in full sun light developed burnt symptoms at the leaf tips, and leaf margins scorched off. This inturn gave an unhealthy appearance to the plant (Plate 2).

Plant height

The treatments T_1 (full sun light) produced maximum height during the initial stages of treatment. This could be observed from the 30th to the 120th day of treatment (Table 21). After 120 days, T_2 (75 per cent light) dominated the others (Fig.2). A significant difference was observed between the treatments T_1 and T_2 only at the 180th day of planting.

Leaf area

There was a significant increase in the leaf area (Table 21) with decreasing light intensities. This was observed at the three growth stages studied. At the 180th

Plate 2. Effect of various light intensities on the growth of maranta

T_1 - Full sunlight

T_2 - 75 per cent light

T_3 - 50 per cent light

T_4 - 25 per cent light

T_5 - 10 per cent light

PLATE 2 (×0.05)

Table 21. Effect of various light intensities on plant height, leaf area and leaf production of maranta at different periods of growth

Initial values	Plant height (cm)						Leaf area (sq. cm)			Leaf production		
	39.80						34.30			23.40		
	Days after treatment						Days after treatment			Days after treatment		
Treatments	30	60	90	120	150	180	30	90	180	30	90	180
Full sun T_1	43.25	45.95	46.65	47.48	47.49	48.33	30.75	55.98	109.21	25.00	27.75	31.50
75 per cent light T_2	42.93	44.89	46.48	47.30	48.28	49.20	35.41	63.15	119.88	25.00	28.00	33.75
50 per cent light T_3	43.18	44.70	46.05	47.00	47.68	48.45	42.88	75.10	131.50	24.00	26.25	31.00
25 per cent light T_4	41.00	44.72	44.30	45.53	45.98	45.78	61.18	91.40	148.50	28.00	32.00	37.25
10 per cent light T_5	41.05	42.33	43.98	45.96	47.20	47.35	73.61	132.60	160.17	27.00	31.25	35.75
C.D. (.05)	1.017	1.130	1.150	1.080	1.080	0.710	1.000	1.100	0.985	1.450	1.570	1.520
$S.E._m$	0.337	0.377	0.381	0.360	0.357	0.236	0.330	0.367	0.327	0.483	0.520	0.504

day of planting, the treatment T_1 (full sun light) gave a mean leaf area of 109.21 sq.cm as against in T_5 (10 per cent light) the mean leaf area being 160.17 sq.cm.

Leaf production

The maximum number of leaves were produced by plants under 25 per cent light (T_4) closely followed by those grown under 10 per cent light (T_5). Significant difference did not exist between these two treatments (Table 21). This was observed at all the stages of growth. The minimum leaf producer in all the cases was T_3 (50 per cent light).

Chlorophyll content

Both the total chlorophyll and its components 'a' and 'b' were affected by the various intensities of light. Visual observations also showed that the plants grown in shade had dark green leaves. With the advancement of age there was a conspicuous increase in the chlorophyll contents. The maximum and minimum values for chlorophyll contents were recorded in a similar pattern under T_5 and T_1 respectively at all the three stages of observation. The corresponding values of total chlorophyll at the 180th day of treatment were 27.38 and 5.25 mg g^{-1} fresh weight respectively for T_5 and T_1.

Table 22. Effect of various light intensities on chlorophylls 'a' and 'b', total chlorophyll (mg g^{-1} fresh weight) and carbohydrate (per cent) content of maranta at different periods of growth

	Chlorophyll 'a'			Chlorophyll 'b'			Total Chlorophyll			Carbohydrates
Initial values	6.25			6.95			13.25			2.23
	Days after treatment			Days after treatment			Days after treatment			
<u>Treatments</u>	60	120	180	60	120	180	60	120	180	After six months
Full sun T_1	1.54	2.38	2.18	1.47	2.47	3.15	2.65	4.87	5.25	3.04
75 per cent light T_2	4.04	5.80	6.93	5.22	6.63	7.00	10.25	12.35	13.55	3.24
50 per cent light T_3	6.35	8.43	9.40	7.04	8.35	9.25	13.63	16.35	18.25	2.33
25 per cent light T_4	6.35	9.00	10.28	7.04	9.10	10.25	14.65	18.33	20.37	2.47
10 per cent light T_5	9.38	12.11	13.95	11.45	12.33	13.53	20.28	24.60	27.38	2.38
C.D. (.05)	0.251	0.423	0.538	0.211	0.453	0.597	0.200	0.261	0.207	0.134
S.E.$_m$	0.083	0.140	0.178	0.070	0.150	0.190	0.066	0088	0.069	0.044

Carbohydrates

The data revealed that the plants subjected to 75 per cent light had the highest carbohydrate content (3.24 per cent) followed by full sun light (3.04 per cent). At the medium to low (50, 25 and 10 per cent) light intensities the carbohydrate contents were fairly low (2.33, 2.47 and 2.38 per cent respectively.

Peperomia (<u>Peperomia obtusifolia</u> Hbk.)

It has got the best appearance under medium shaded conditions. High light intensity causes yellowing and development of necrotic areas on most of the leaves. Though the plant survives under open conditions for a period upto six months they presented an unhealthy appearance.

Plant height

Plant height was found to increase significantly with decreasing light intensities at all the stages of growth (Table 23). T_1 (full sun) was found significantly inferior to all others (Fig.2). T_5 (10 per cent light) produced the tallest plants at the six growth stages studied.

Table 23. Effect of various light intensities on plant height, leaf area and leaf production of peperomia at different periods of growth

Initial values	Plant height (cm)						Leaf area (sq. cm)			Leaf production		
	25.70						1.35			17.50		
	Days after treatment						Days after treatment			Days after treatment		
Treatments	30	60	90	120	150	180	30	90	180	30	90	180
Full sun T_1	27.18	28.85	30.38	32.38	33.55	34.95	1.75	3.86	6.59	20.25	27.00	41.50
75 per cent light T_2	27.50	30.48	32.35	33.36	35.43	36.33	2.65	5.15	18.56	20.25	27.50	46.25
50 per cent light T_3	28.30	31.45	34.32	36.48	38.60	40.85	3.17	7.41	23.24	22.50	27.50	45.00
25 per cent light T_4	31.80	34.48	36.33	38.48	40.58	43.25	3.72	10.74	30.25	21.00	26.50	45.00
10 per cent light T_5	32.70	38.47	41.00	42.55	44.60	45.95	4.41	13.23	37.56	21.00	27.50	45.50
C.D. (.05)	0.751	0.684	0.500	0.667	0.688	0.801	0.053	0.029	0.105	0.991	NS	1.150
$S.E._{\bar{m}}$	0.249	0.227	0.167	0.221	0.228	0.266	0.017	0.009	0.025	0.329	-	0.381

Leaf area

Leaf area also showed a similar trend as that of the plant height. The maximum and minimum values were recorded for plants grown under 10 per cent light (T_5) and full sun (T_1) respectively (Table 23). At the 180th day after treatment the leaf area for T_5 and T_1 were 37.56 and 6.59 sq.cm respectively.

Leaf production

A significant difference was observed among the treatments only at the 30th day (Table 23). At this stage the plants grown under 50 per cent light (T_3) produced more leaves (22.5). At the later stages the values were found statistically at par.

Chlorophyll content

The variation in chlorophyll contents in the plants under the different shade levels was highly perceptible. During the 60th day after treatment the maximum values for all the three chlorophyll components were found in T_3 (50 per cent light). At all the other stages the components were maximum for plants grown under 10 per cent light. The total

Table 24. Effect of various light intensities on chlorophylls 'a' and 'b', total chlorophyll (mg g^{-1} fresh weight) and carbohydrate (per cent) content of Peperomia at different periods of growth

Initial values	Chlorophyll 'a'			Chlorophyll 'b'			Total Cholorophyll			Carbohydrates
	1.15			1.13			2.26			2.41
	Days after treatment			Days after treatment			Days after treatment			
Treatments										
	60	120	180	60	120	180	60	120	180	After six months
Full sun T_1	0.338	0.865	1.30	0.33	2.23	2.18	0.658	1.43	3.43	4.40
75 per cent light T_2	0.538	2.83	2.23	0.515	1.73	3.37	1.05	4.53	5.65	2.36
50 per cent light T_3	0.900	1.87	2.29	0.817	2.82	3.18	1.45	4.60	5.42	2.38
25 per cent light T_4	0.773	3.14	3.31	0.563	6.68	7.48	1.37	10.38	11.38	2.48
10 per cent light T_5	0.817	3.16	3.60	0.718	6.65	7.58	1.46	10.40	11.52	2.43
C.D. (.05)	0.026	0.264	0.349	0.023	0.176	0.378	0.055	0.480	0.450	0.257
S.E.$_m$	0.008	0.088	0.113	0.008	0.059	0.126	0.018	0.158	0.149	0.085

chlorophyll contents were found to be the minimum in the leaves of plants under the open conditions (Table 24).

Carbohydrates

The total soluble carbohydrate content was high in T_1 (4.40 per cent). This was superior over others. All the other treatments were at par (Table 24). The variation in carbohydrate content was from 2.36 to 2.48 per cent among these four treatments.

Pleomele (Pleomele reflexa Lam)

The plant normally grows well under medium light conditions.

Plant height

Shading had significant influence on plant height as evident from the data presented in Table 25. Compared to those plants grown under open conditions the shaded plants had significantly lesser values for plant height. The shortest plants were produced by the treatment T_3 (50 per cent light) at all the stages of growth (Fig.2).

Table 25. Effect of various light intensities on plant height and leaf area of Pleomele at different periods of growth

Initial values	Plant height (cm)						Leaf area (sq. cm)		
	32.65						4.09		
	Days after treatment						Days after treatment		
Treatments	30	60	90	120	150	180	30	90	180
Full sun T_1	38.50	40.25	43.25	44.00	44.50	46.00	5.05	7.19	13.39
75 per cent light T_2	35.25	36.00	38.00	38.75	41.25	43.00	6.05	9.33	14.20
50 per cent light T_3	33.75	35.50	36.25	37.50	38.50	40.50	6.53	10.79	15.28
25 per cent light T_4	33.75	36.25	37.75	38.75	40.75	42.50	8.27	12.48	18.34
10 per cent light T_5	35.25	37.00	39.50	41.25	42.50	44.50	9.32	13.33	22.58
C.D. (.05)	1.230	1.130	1.180	1.180	1.130	1.030	0.094	0.108	0.430
$S.E._m$	0.408	0.376	0.393	0.393	0.376	0.343	0.031	0.036	0.143

Leaf area

The data indicated in Table 25 showed a proportionate increase in leaf area as the intensity of shade was increased. The maximum leaf area was recorded by plants that were grown at 10 per cent light. The leaf area for this treatment were 9.32, 13.33 and 22.58 sq.cm after 30, 90 and 180 days of planting. The minimum values for leaf area were recorded in the plants grown under open light (5.05, 7.19 and 13.39 sq.cm respectively).

Chlorophyll content

A similar trend to that of leaf area was observed with respect to the three chlorophyll components. A general increment in the chlorophyll components was seen with decreasing intensity of light. The only exception noted was for chlorophyll 'b' at the 120th day of planting which gave rather varying trends.

Carbohydrates

The maximum carbohydrate content was estimated in the leaves of plants grown under 50 per cent light (4.2 per cent) closely followed by those grown under 10 per cent light (3.3 per cent). Plants kept in open conditions had the least value for carbohydrates (2.53 per cent).

Table 26. Effect of various light intensities on chlorophyll 'a' and 'b', total chlorophyll (mg g^{-1} fresh weight) and carbohydrate (per cent) content of pleomele at different periods of growth

	Chlorophyll 'a'			Chlorophyll 'b'			Total Chlorophyll			Carbohydrates
Initial values	10.6			5.4			4.84			2.3
	Days after treatment			Days after treatment			Days after treatment			
Treatments	60	120	180	60	120	180	60	120	180	After six months
Full sun T_1	3.75	4.6	6.58	4.65	4.40	5.37	8.50	10.45	12.53	2.53
75 per cent light T_2	7.14	8.40	11.58	9.65	12.23	12.25	17.25	20.65	23.35	2.70
50 per cent light T_3	7.23	10.75	13.23	10.68	12.38	13.25	18.43	22.05	26.43	4.20
25 per cent light T_4	7.35	12.58	15.43	12.23	9.53	15.63	19.55	24.05	30.90	3.25
10 per cent light T_5	9.35	25.38	19.25	15.30	14.35	18.32	24.75	32.07	38.33	3.30
C.D. (.05)	0.189	0.295	0.252	0.257	0.319	0.312	0.268	0.589	0.518	0.251
$S.E._m$	0.063	0.098	0.084	0.085	0.105	0.103	0.089	0.195	0.172	0.083

Rhoeo (*Rhoeo spathacea* Hance)

It prefers medium light conditions

Plant height

At the initial stage of growth (30th day) the plant height increased correspondingly with the reduction in light intensity. This followed a definite sequence upto the 25 per cent light intensity level. At the later stages, plant height (Fig.2) steadily increased with a decrease in light intensity. This steady pattern of height increment was seen from the open light to the 10 per cent light intensity level.

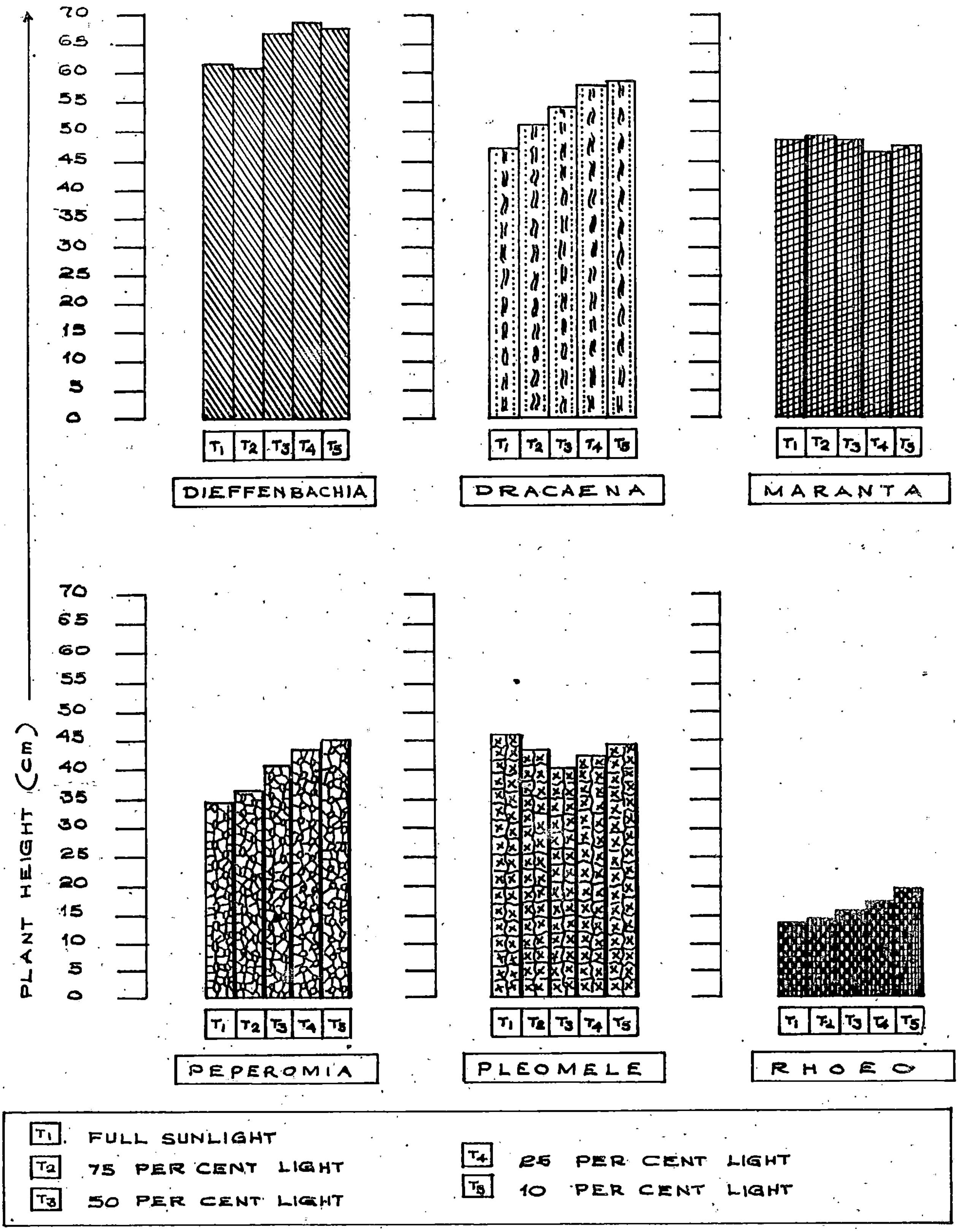
Leaf area

At the 30th day of treatment, the leaf area was greater for plants under 25 per cent light intensity level (28.45 sq.cm) and the minimum leaf area for plants under 50 per cent light. At the 90th day, T_1 (full sun) was found to be superior over other treatments (Table 28). Within the different shade levels (T_2, T_3, T_4 and T_5) there was no significant difference. At the180th day of treatment T_4 and T_5 were statistically at par (98.55 and 98.60 sq.cm respectively) and they were superior over the other treatments.

Table 27. Effect of various light intensities on plant height, and leaf production of rhoeo at different periods of growth

Initial values	Plant height (cm)						Leaf production		
	2.98						6.50		
	Days after treatment						Days after treatment		
Treatments	30	60	90	120	150	180	30	90	180
Full sun T_1	3.63	5.20	7.03	10.55	12.25	13.35	10.75	19.75	28.75
75 per cent light T_2	3.75	5.55	8.10	11.15	13.23	14.23	8.25	16.75	28.75
50 per cent light T_3	4.25	6.73	9.38	12.03	14.28	15.38	8.25	16.25	28.00
25 per cent light T_4	4.53	8.05	10.20	13.93	16.13	17.25	7.00	15.00	26.25
10 per cent light T_5	4.23	8.43	11.28	15.23	17.55	19.40	8.00	15.25	27.25
C.D. (.05)	0.276	0.384	0.265	0.247	0.374	0.351	1.660	1.870	1.400
$S.E._m$	0.092	0.128	0.088	0.082	0.124	0.117	0.552	0.619	0.466

FIG. 2 EFFECT OF VARIOUS LIGHT INTENSITIES ON PLANT HEIGHT AFTER SIX MONTHS



Leaf production

The leaf production was maximum under open conditions. Thepplants under 25 per cent light intensity level had the minimum number of leaves (Table 27).

Anthocyanins

With a reduction in light intensity levels (upto 10 percent), the anthocyanin contents steadily declined. The maximum content was recorded for plants grown under open conditions (321.75 mg $100g^{-1}$) as against the minimum in 10 per cent light (153.50 mg $100g^{-1}$) at the 180th day of treatment.

Carbohydrates

The variation in carbohydrate content was from 3.35 to 3.50 per cent among the various treatment. There was no significant difference among the treatments.

Verbena (Verbena incisa Hook.)

The results indicated that plants can thrive only undervery high light intensity levels. The plants were not able to survive when the light intensity was decreased below 75 per cent, limit. With regard to the different characters, the plants grown under 75 per cent light (T_2) and full sun (T_1) did not show any significant difference.

Table 28. Effect of various light intensities on leaf area, anthocyanins and carbohydrate (per cent) content of rhoeo at different periods of growth

	Leaf area (sq. cm)			Anthocyanins (mg 100 g^{-1})			Carbohydrates
Initial values	20.27			80.6			2.5
	Days after treatment			Days after treatment			
Treatments	30	90	180	60	120	180	After six months
Full sun T_1	27.55	63.73	96.48	241.25	292.00	321.75	3.35
75 per cent light T_2	28.18	63.33	96.58	192.50	252.25	272.75	3.47
50 per cent light T_3	27.38	63.35	97.50	142.75	184.50	212.50	3.50
25 per cent light T_4	28.45	63.35	98.55	114.25	153.00	172.50	3.43
10 per cent light T_5	27.65	63.33	98.60	85.25	134.00	153.50	3.35
C.D. (.05)	0.252	0.253	0.395	3.570	3.517	2.480	NS
$S.E._m$	0.084	0.084	0.134	1.183	1.167	0.821	—

Table 29. Effect of various light intensities on plant height, carbohydrate (per cent) content and flowering of verbena at different periods of growth

Treatments	Plant height (cm)						Carbohydrate	Days to flowering
	9.50						2.24	
	Days after treatment							
	30	60	90	120	150	180	After six months	
Full sun T_1	14.13	17.28	20.95	22.90	23.70	26.03	2.24	20.70
75 per cent light T_2	14.40	16.83	21.05	22.35	23.95	25.68	2.23	23.50
C.D. (.05)	NS	NS	NS	NS	NS	NS	NS	NS
$S.E._m$								

GROUPING OF INDOOR FOLIAGE AND FLOWERING PLANTS BASED ON THE OPTIMUM LIGHT INTENSITY REQUIREMENTS

Name of the plant	Botanical name	Optimum light intensity (in percent)
Aglaonema	Aglaonema costatum Veitch.).	10
Alocasia	Alocasia cuprea Koch)	10 to 25
Aralia	Polyscias guilfoyeli victoriae Bailey	50 to 75
Balsam	Impatiens walleriana sultanii Hook	75
Begonia	Begonia semperflorens Link.	75
Chlorophytum	Chlorophytum comosum Wood.	25 to 50
Coleus	Coleus blumei Benth.	75 to full sun light
Cordyline	Cordyline terminalis Kunth.	50 to 75
Dieffenbachia	Dieffenbachia picta Schott	25 to 50
Dracaena	Dracaena sanderiana Hort.	10
Maranta	Maranta zebrina Sims	25 to 50
Rhoeo	Rhoeo spathacea Hance	50
Pleomele	Pleomele reflexa Lam	25
Peperomia	Peperomia obtusifolia HBK.	10
Verbena	Verbena incisa Hook.	75 to full sun light

DISCUSSION

DISCUSSION

Light is a powerful factor in determining the course of development of plants. It brings about changes in the morphological and physiological characters of plants.

In the culture of indoor plants, light intensity is a crucial factor. Proper light is critical for success with house plants. In the following chapter, the results obtained during the course of study on the effect of various light intensities on the growth and development of indoor foliage and flowering plants are discussed. In the present investigation the growth behaviour of plants under varying light intensities viz. full sun, 75 per cent, 50 per cent, 25 per cent and 10 per cent light was studied for a period of six months.

Aglaonema (Aglaonema costatum Veitch.)

The study revealed that best growth of these plants can be obtained by growing them under high shade conditions (10 to 25 per cent light).

Shading was found to havea positive influence on characters like leaf production and leaf area. At the later stages of plant growth, the increase in leaf production was proportional to the increase in shade upto 90 per cent

Largest leaf area was also recorded under the same light intensity. The larger leaf size is the result of earlier and more rapid growth. Differentiation also takes place earlier in shade leaves as compared to sun leaves (Anderson, 1955).

The chlorophyll content of leaves was found to increase progressively with increase in intensity of shade (upto 25 per cent light). Hence for maximum chlorophyll production and dark green foliage, 75 per cent shade (25 percent light) can be considered the best for aglaonema plants. Bjorkman (1968) and Good child (1972) have also reported that the total chlorophyll content of leaves of shade grown plants increased in comparison of sun plants. In this study it was observed that the plants placed under open condition could survive only for a period of hundred days. Moreover, the chlorophyll content in the leaves was reduced and the plants exhibited yellowing. Finally the leaves got dessicated and the entire plant gradually withered. This is because of the fact that a shade race when grown in strong light, photochemical function is severely impaired; probably because photosystem II is inactivated (Bjorkman, 1966). It was seen that high shade conditions (25 per cent light) also increased production of leaves in aglaonema. However, the height of the plants remained more or less the same under all the treatments.

The enlarged leaf surface, increased chlorophyll content, and the enhanced production of leaves brought about considerable increase in the photosynthetic capacity of the plants, thereby the entire growth of the plants was improved, under intense shade conditions. Hence for obtaining best growth of aglaonema plants they may be cultivated under 10-25 per cent light intensity levels.

Alocasia (Alocasia cuprea Koch)

The alocasia plants were found to grow taller with decrease in light levels (upto 10 per cent light). Hiroi et al. (1970) also reported that in Aphelandra squarrosa, tallest plants were produced under 30, 16 and 10 per cent of full sun light. Under the same light levels (10 per cent light) the production of leaves was maximum and the leaf area was also increased in alocasia. The chlorophyll contents also showed a progressive increase with increase in intensities of shade upto 90 per cent (10 per cent light). This indicates that 10 per cent light intensity level is the ideal condition for the growth of these plants. The plants are not able to withstand high light. The plants grown under open conditions could survive only for three months.

The leaves lost their chlorophyll and thereby their green colour, ultimately leading to complete wilting of the plants. This occurs because prolonged exposure to radiant energy results in the decomposition of chlorophyll through photo-oxidation. The problem is more severe in the leaves of shade plants than in those of the sun plants (Mastalerz, 1977).

Aralia (Polyscias guilfoyeli victoriae Bailey)

High light conditions (75 per cent and full sun light) caused the plants to grow taller as compared to those under the different shade levels. This can be attributed to the increased stem growth of the plants. Jeong et al. (1983) have reported that in the indoor plants Fatshedera lizii and Glechoma hederacea, increased light intensity promoted stem growth. But this increased light levels were not favourable with regard to leaf area, chlorophyll content and carbohydrates in aralia. Instead, reduction in light levels upto 10 per cent was found to enhance the leaf area and to increase the contents of chlorophyll and carbohydrates. When radiant flux is limited, however, the photosynthetic unit is a very useful mechanism for collecting radiant energy and transferring it to a reaction site. Apparently, plants have evolved a radiant energy harvesting system that functions effectively when radiant flux is limited (Bonner, 1962).

The results thus indicated that by growing aralia under partial shade levels (50-75 per cent light), plants of medium height, with good coloured foliage are produced.

Balsam (Impatiens walleriana sultanii Hook)

Open conditions (full sun light) are found harmful to the plant. Under such conditions, the plants could survive only for two months. Light at the early and late part of the day did not harm the plant. At other times, when the radiations was intense, the plants appeared wilted.

The plants grown under medium shaded conditions (50 per cent light) were larger than the others. They were taller and their leaves had the largest surface area. This can be considered as an adaptive mechanism of shade plants. Leaves of shade plants have at their disposal an impressive array of adaptive responses to low light intensity. Mesophyll cell size is reduced and laminar surface enlarges (Leopold, and Kriedemann, 1964).

With regard to flowering, 75 per cent light level was found to be the best. The plants exhibited profuse flowering (Plate 1) and their flowering period was also longer. Though flowering is a photoperiodic response, it may also be altered by the amount of light the plant receives.

The anthocyanin production was more in the flowers with increase in intensities of shade levels. This increased the red colour of the flowers and reduced the variegation in the petals. This is however, contrary to the reports of Nanda et al. (1973). who found that in the hypocotyls of Impatiens balsamina anthocyanins increased with light intensity.

Since this is an indoor plant mainly valued for its flowers, 75 per cent light level can be considered the most ideal for its growth. The plant selected was the one with variegated type of flowers. Hence, the increased variegation under higher light levels (at 75 per cent light) can also be considered as a desirable character.

Begonia (Begonia semperflorens Link)

Flowering in begonia was enhanced by shaded conditions. Under open conditions (full sun light), the plants took more days (14) to come to flower than under the different shade levels (7.25 to 11.75 days). Earliest flowering was observed in plants grown under 75 per cent and 50 per cent light levels (7.50 and 7.25 days, respectively). This is in agreement with the findings of Rees (1967) in freesias. He found that shading upto 50 per cent benefited flower production by allowing earlier inflorescence initiation. Unshaded plantsinitiated inflorescence only later.

With regard to the vegetative growth also 50 per cent light was found beneficial. The plants had the maximum height, and there was enlargement of leaf laminar surface, when compared to the plants under open. Full sun light was found detrimental to the growth of the plants. The leaves developed scorch marks on the margins, which later turned grey.

Wax begonias can be grown as foliage or flowering plants. When grown as a flowering plant, the colour of the flowers is of much value. It was found that with reduction in light levels, the anthocyanins in the petals reduced. This can be expected because anthocyanins depend upon light for the production of sugar, one of its building blocks. In bright light, more photosynthate is produced and hence, the increased production of anthocyanin and enhanced red colour (Manaker, 1981). Thus the best growth of the plants can be obtained under partially shaded conditions (75 per cent light level). The shade can be increased further if foliage production is intended.

Chlorophytum (Chlorophytum comosum Wood)

The plants that were grown under low to medium light levels (25 to 50 per cent light) exhibited better growth in terms of leaf area and plant height. The increase in surface area causes more exposure to light thus increasing the opportunities to use low light more efficiently. The chlorophyll content also showed a progressive increase with decrease in light levels (upto 10 per cent light). This is in line with the reports of Ross (1976).

Carbohydrate production was very much reduced in the leaves of plants grown under full sun. This can be attributed to the decreased photochemical efficiency of the plants due to the destruction of chlorophyll under high light by photo-oxidation.

Under intense shade conditions (10 per cent light), the leaves tend to be narrow. This will mar the appearance of the plant. Hence it is not advisable to grow them under such conditions. Therefore, 25 to 50 per cent light levels can be considered the best for the growth of these plants.

Coleus (*Coleus blumei* Benth.)

It was observed that the leaves of coleus under decreased levels of light intensity, had lower anthocyanin content in them compared to those grown under 75 per cent light and full sun light. Lower light intensities are found to promote the development of chlorophyll, resulting in dominance of green colour in the leaves. Because of this, the leaves of plants under intense shade (T_5) appeared greener, whereas those under other light (shade) levels had more purple colour which was characteristic of their foliage (Plate 3). Silis *et al*. (1972) reported that 60 to 70 per cent of full sun reduced the red colour of begonia leaves and deep shade (20 per cent full sun) completely removed the red colour.

Leaf area and plant height also showed significant increases with increase in light levels. This can be attributed to the influence of light intensity on cell enlargement and differentiation which thus influenced the plant height, growth and leaf size of the plants (Thompson and Miller, 1963). This indicates that the growth potential of coleus could be exploited well only if they are grown under high light levels (75 per cent to full sun light).

Plate 3. Effect of various light intensities on colour development in coleus leaves

T_1 - Full sunlight

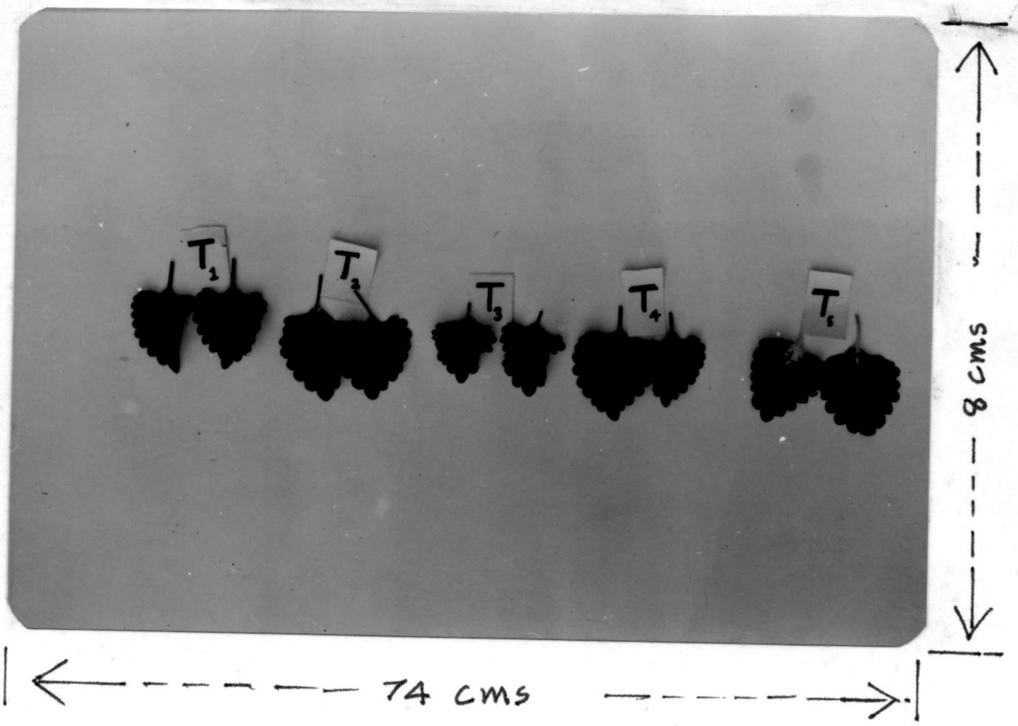
T_2 - 75 per cent light

T_3 - 50 per cent light

T_4 - 25 per cent light

T_5 - 10 per cent light

PLATE 3



Cordyline (<u>Cordyline terminalis</u> Kunth.)

In cordyline,shading upto 90 per cent (10 per cent light) was found to enhance leaf production and increase the leaf area and plant height. But the anthocyanin contents in the leaves decreased with increased shade levels. However, as the light intensity lowers, chlorophyll production increases. Together with the anthocyanins in small quantities this provides an intense dark colour to the leaves of cordyline. Similar findings have also been provided by Conover and Poole (1972). In <u>Cordyline terminalis</u> they found that leaf colourationwas less intense under 80 per cent shade than under 40 or 60 per cent. This indicates that for obtaining plants of medium height, having well developed foliage with natural colour, they must be grown under 50 to 75 per cent light intensity levels.

Dieffenbachia (<u>Dieffenbachia picta</u> Schott)

In the case of dieffenbachia plants, high sun light (open conditions) is very much detrimental to the growth of the plants. The chlorophyll content is reduced in the leaves which leads to the development of yellow colour. The leaves also assume a vertical orientation (Plate 4). Conover and Poole (1972) have also reported that under high light

Plate 4. Effect of various light intensities on the growth of dieffenbachia

T_1 - Full sunlight

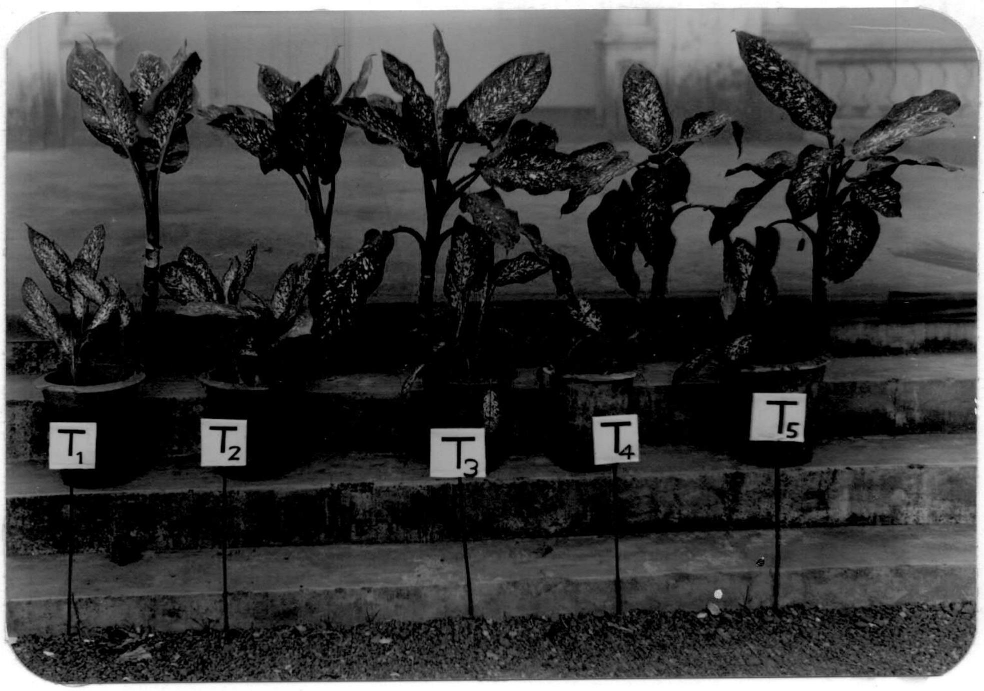
T_2 - 75 per cent light

T_3 - 50 per cent light

T_4 - 25 per cent light

T_5 - 10 per cent light

PLATE 4 (x.07)



intensities, the leaves assume a vertical position, instead of their proper orientation which is 60° to the horizontal. Vertical orientation can be considered as an adaptive mechanism of the plant which helps in avoiding direct exposure to the strong irradiance. With reduction in light levels upto 50 per cent, chlorophyll content in the leaves increased. This is in conformity with the reports of Bjorkman and Holmgren (1963). With further reduction in light levels, plant height increased upto 25 per cent light and leaf area, upto 10 per cent light. These suggest that by growing dieffenbachia under 25 to 50 per cent light intensity level, tall plants with dark green foliage can be produced.

Dracaena (Dracaena sanderiana Hort.)

In this experiment, it was observed that decreasing the light levels from full sun light to 10 per cent (90 per cent shade) brought about an increase in the leaf area and the chlorophyll content in the leaves. Fretz and Dunham (1971-72) found that in american holly plants, leaf size of plants increased under 92 per cent shade. It also resulted in increased green colour of the leaves.

The enlarged leaf surface and the increased chlorophyll content under reduced light levels might have improved the photosynthetic efficiency of the plant, thereby increasing the food production. Increased carbohydrate contents was estimated with reduction in light levels (upto 25 per cent light). However this is contradictory to the reports of Milks et al. (1978) that increasing shade decreased the carbohydrate levels in Ficus benjamina.

High light intensities also influenced the production of leaves. Under open conditions, the plants produced only lesser number of leaves. This suggests that although the plants are able to survive bright light conditions, reduced intensities of light must be provided for the good growth of the plant. Under 10 per cent light intensity (90 per cent shade), the plants will have better growth. Rodriguez and Cibes (1978) have also reported that at 92 per cent shade, the appearance of Dracaena deremensis was superior to that at other shade levels.

Maranta (Maranta zebrina Sims)

Maranta plants were found to grow taller with increased intensities of light (75 per cent to full sun light). But at this light level, the leaf area was found to be reduced.

Jeong *et al*. (1983) reported that in the indoor plants *Fatshedera* and *Glechoma*, an increase in light intensity promoted stem growth anddecreased the leaf size.

However, with further reduction in light levels from 75 per cent to 25 per cent, the production of leaves increased. The chlorophyll contents of the leaves also increased under these light levels, which imparted dark green colour to the foliage.

Although high light favoured the growth of the plants in terms of plant height, visual observations indicated that the plants presented an unhealthy appearance due to scorching of the leaves. Hence for keeping the plants in good condition , and for rich development of foliage, high shade conditions (25 to 50 per cent light) must be provided.

Peperomia (*Peperomia obtusifolia* Mot.)

In peperomia, reducing the light intensity from full sun to 10 per cent, increased the plant height, leaf area and chlorophyll content. This indicates that high shade is preferred to by the plant for its growth. Ross (1976) reported that leaves developed under 80 per cent shade had more surface area and chlorophyll content. The increased chlorophyll content in peperomia should improve production of photosynthates in the plants. But the carbohydrate content in the plants under the different shade leaves were found lesser when compared to those in the open. This is in line with the reports of Shen and Seely (1983) who found that in *Peperomia obtusifolia*, reducing the light intensity decreased the plant fresh and dry weight. However, the leaves of the plants under the open conditions (full sun) exhibited yellowing, thickening and necrosis on the leaf surface (Plate 5) These could perhaps be due to the excess accumulation of carbohydrates in these leaves. Waltz (1970) reported the symptoms thickening, chlorotic mottling, bronzing and actual necrosis of small leaf areas as a result of excess accumulation of carbohydrates in chrysanthemum leaves. For peperomia, this intense shade conditions (10 per cent light) is found the most ideal for its growth.

Pleomele (*Pleomele reflexa* Lam)

Decreasing the light levels upto 10 per cent from full sun light was found to have a positive influence on the leaf area, and carbohydrate and chlorophyll content. This can be considered as due to the high photochemical efficiency

Fig Plate 5. Effect of various light intensities on the growth of peperomia

T_1 - Full sunlight

T_2 - 75 per cent light

T_3 - 50 per cent light

T_4 - 25 per cent light

T_5 - 10 per cent light

PLATE 5 (x.04)

of the shade adapted plants (Wassink, 1960). Open conditions (full sun light) are found to increase the plant height than the different shade levels. This shows that the plants can be grown under high light conditions also, as there were no harmful effects noticed. But for interior planting the growth of the foliage is of more value than the stem extension. Hence, for producing plants with average height and well developed dark green foliage, they have to be grown under 25 per cent light intensity level.

Rhoeo (Rhoeo spathaceae Hance)

In rhoeo, shading the plants upto 90 per cent (10 per cent light) increased the plant height. Internode elongation due to shading causes increase in the plant height (Craig and Walker, 1961).

Maximum leaf area was exhibited by plants under 25 per cent light levels. However, these plants produced only lesser number of leaves when compared to those in the open (full sun). The open conditions also enhanced the production of anthocyanins, which increased the purple colouration in the leaves. The colour decreased with increase in shade levels.

Thus, rhoeo plants can be grown under high shade conditions (10 to 25 per cent light) which will favour the vegetative growth in terms of plant height and leaf area. However, for the development of purple colour of the leaves, anthocyanins are essential and its production is increased only under high light conditions. Increased light levels also enhances leaf production. Hence medium light (50 per cent) conditions will be optimum for the plant.

Verbena (*Verbena incisa* Hook.)

Verbena needs high light (75 per cent to full sun light) for its growth. The plants were not able even to survive under the shade conditions (beyond 75 per cent light). Hence, verbena should be grown under open conditions or in places where plenty of sun light is available. For indoor planting, this can be placed in window sills facing south, where they can be exposed to maximum light.

SUMMARY

SUMMARY

Investigations were carried out in the Department of Horticulture, College of Agriculture, Vellayani during 1985-'86. The effect of various light intensities on the growth and development of fifteen indoor foliage and flowering plants were studied. The results are summarised below.

Light intensities of 10 and 25 per cent were found to produce a substantial increase in the leaf area, leaf production and chlorophyll content in aglaonema.

Alocasias grown under 10 per cent light were taller than others and they had the highest chlorophyll content in the leaves. Under the same light level the area of the leaves was more, and there was increased leaf production.

High light levels (75 per cent and full sun light) brought about an increase in plant height in aralia. However, increase in leaf area, carbohydrates and chlorophyll content was observed for plants grown under intense shade (10 per cent light)

Under medium light intensities (50 per cent) the plant height and leaf area in balsam was maximum. The plants had longest period of flowering under 75 per cent light and the variegation of the flowers were more.

Better vegetative growth in terms of plant height and leaf area was exhibited by begonia plants under 50 per cent light. Higher light intensities (75 per cent and full sun light) brought about earliest flowering in begonia and development of deep red colour in the flowers.

The leaf area and total chlorophyll content was found to be maximum in chlorophytum plants when the light intensity was reduced to 10 per cent. Plant height was greater under 50 per cent light. Shaded leaves had greater carbohydrates compared to those in the open.

High light intensities (75 per cent and full sun light) favoured the growth of the coleus plants in terms of plant height, leaf area and foliage colour.

Reducing the light intensities from full sun to 10 per cent was found to increase the leaf area, leaf production, and plant height in cordyline. But the total anthocyanin content was decreased.

Decrease in light intensities upto 50 per cent maximised chlorophyll production in diffenbachia. Further reduction to 25 per cent light increased the height and leaf area.

In dracaena leaf size, leaf production and chlorophyll content showed an increase with 10 per cent light.

The plant height and carbohydrate content of maranta showed an increase under high intensities of light (75 per cent and full sun light). However, much better growth of the plants with increased production of leaves and highest chlorophyll content was observed under 25 to 50 per cent light.

Low light intensities (10 per cent) significantly increased plant height and leaf area in peperomia. With regard to leaf production significant difference could be observed only at the initial stages, where 50 per cent light intensity was found superior among all the other treatments. Chlorophyll and carbohydrate content was found minimum in plants grown in full sun light.

Diminishing light intensities were found to increase the leaf area, carbohydrate and chlorophyll content in pleomele.

At the later growth stages of rhoeo, increased height and leaf area was exhibited by plants grown under 10 per cent light. But the anthocyanin contents declined significantly.

High light intensities (75 per cent and full sun light) in verbena were found essential for its growth and flowering.

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ABSTRACT

An investigation was carried out in the Department of Horticulture, College of Agriculture, Vellayani, during the year 1985-86 to find out the effect of various light intensities on the growth and development of the important indoor foliage and flowering plants such as aglaonema, aralia, alocasia, chlorophytum, coleus, cordyline, dieffenbachia, dracaena, maranta, peperomia, pleomele, rhoeo, balsam, begonia and verbena.

The treatments consisted of five intensities of light as follows, Full sunlight; 75, 50, 25 and 10 per cent light. The experiment was laid in a Completely Randomised Design. Shading was provided by using gunny cloth stretched over g.i. poles.

Plant height increased with decrease in light intensities in most of the plants except in aralia, coleus, maranta, pleomele and aglaonema. In aglaonema the height of the plants were influenced by the treatments only at the initial growth stages. In others taller plants were produced under high light intensities.

In general diminishing light intensities enhanced leaf production, leaf area and chlorophyll content in all plants except in coleus where leaf area increased with increase in

intensities of light. Destruction of chlorophyll in the leaves of plants kept in the open as evidenced by the yellowish colour was not observed for those plants in shade.

Total carbohydrate content in the leaves were not significantly influenced by the different treatments in plants like alocasia, balsam, begonia, coleus, cordyline, rhoeo and verbena. In aglaonema and dieffenbachia no definite trend could be elucidated with regard to the total soluble carbohydrate content. In peperomia and maranta carbohydrate contents were more under high light intensities. In others, shading increased the carbohydrate content.

Total anthocyanin contents estimated in the leaves of cordyline and coleus as well as in the flowers of begonia showed a decreasing trend with decrease in light intensities. In balsam, greater anthocyanin content was associated with diminishing light intensities.

High light intensities enhanced flowering in balsam, begonia and verbena.