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Flori Abstracts

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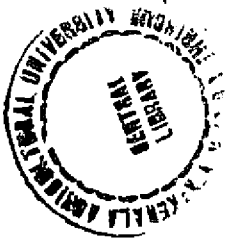
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Contents

<i>Anthurium</i>	<i>1</i>
<i>Bougainvillea</i>	<i>27</i>
<i>Crossandra</i>	<i>29</i>
<i>Dahlia</i>	<i>31</i>
<i>Gerbera</i>	<i>33</i>
<i>Gladiolus</i>	<i>37</i>
<i>Hibiscus</i>	<i>45</i>
<i>Jasmine</i>	<i>48</i>
<i>Orchids</i>	<i>52</i>
<i>Rose</i>	<i>79</i>
<i>Tuberose</i>	<i>86</i>
<i>Foliage plants</i>	<i>91</i>
<i>Dry flowers</i>	<i>99</i>
<i>Miscellaneous crops</i>	<i>102</i>
<i>Economics</i>	<i>105</i>

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Marketing of both the flowers was almost similar as they were usually sold together. Out of four marketing channels identified, the most important one was "Producer @ Local florist @ consumers".

The most significant problem faced by orchid and anthurium growers, especially smaller sized units, was irregular market. High level of intra-farm varietal diversity resulted in non-uniform flowers which are in inadequate quantity.

Effective production planning and marketing management are the key sectors of development.



809413

ANTHURIUM

Chromosome behaviour and pollen analysis in *Anthurium* sp.

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Name of Major Advisor	: Dr. S.T. Mercy
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Chromosome behaviour and pollen characters were studied in five commercially important varieties of *Anthurium andreaenum* viz. Honeymoon Red, White (album), Lady Jane (Pink), Chilli Red and Pink.

The varieties showed distinct differences in morphological characters.

All the varieties had a somatic chromosome number of $30+2B$. The B chromosomes were either acentric or telocentric and round or rod shaped.

The karyotype of all the five varieties was analysed. On the basis of total chromosome length (TCL), average chromosome length (ACL) and arm ratio (r), the variety Pink appeared to be most advanced. When the relative chromosome length (RCL) was taken in to consideration, the variety Chilli Red was found to be most advanced. With regard to the character, chromosome asymmetry, Lady Jane appeared to be most advanced. When the karyotype asymmetry as a whole was considered, all the varieties were falling in the '3B' category which represents a high position in evolution.

During meiosis, all the varieties exhibited a wide range of abnormalities like univalent formation, unequal separation, presence of laggards, micronuclei etc. This pointed out the hybrid nature of the species.

All the varieties were found to be protogynous with distinct interphase.

The varieties Honeymoon Red and Pink produced the highest amount of pollen.

The pollen size among the varieties did not vary significantly. However, the variety Lady Jane had the largest pollen and Lady Jane has the largest pollen.

Pollen fertility was very low.

Morphological variations, karyotypic differences, meiotic abnormalities, high pollen sterility and the wide variability in stomatal characters point out to the basic hybrid nature of the species.

Cross compatibility in *Anthurium andreanum* Lind.

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The varieties showed distinct differences in the morphological/ floral characters. The largest plants were observed in the variety Pink and the shortest variety was Kalympong red. The average number of leaves produced per year ranged from 3.5 to 6.5. The leaf plastochron duration was lowest in the variety white and longest duration was observed in Chilli red. The number of spadices produced annually by a plant varied from four to eight. The duration between the emergence of two successive spadices ranged from 43 to 51 days. The spathe size index of all the varieties was observed. The varieties Pink and Kalympong red produced super large flowers and the smallest flowers were developed in the White variety.

There was significant correlation between leaf size and spathe size.

The maximum angle between the spadix and plane of the spathe was observed in Honeymoon Red. The angle was smallest in Chilli Red. The maximum number of flowers were produced in Pink and Honeymoon Red varieties.

The average percentage of candles bearing fruits was maximum for the variety White and lowest for the variety Kalympong Red. The maximum percentage of fruits was harvested from the cross P x HR (52.3%). The duration of fruit maturity period ranged from 4.5 to 8.0 months.

Pink and Honeymoon Red varieties produced larger sized seeds. Seed germination was observed in all the 23 combinations obtained. The maximum average germination was observed in combinations with White as the female parent (63.4%) and the lowest germination in the variety Kalympong Orange.

Improvement of *Anthurium andreanum* Lind. *in vitro*

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Surface disinfections with 70 per cent ethyl alcohol wipe followed by treatment with 0.1 per cent HgCl_2 for eight minutes recorded maximum survival (99.74%) of cultures in the case of leaf explants. For spadix explants, ethyl alcohol wipe (70%) + emisan (0.1%) dip for three minutes followed by HgCl_2 (0.1%) for 10 minutes recorded maximum survival (87.56%) of the cultures. Among the different explants tried (*in vivo* and *in vitro* derived explants) callus induction was maximum in the case of *in vivo* leaf explants. Callus was initiated (86.50%) within 51 days compared to 90 days reported earlier, when cultured in darkness on to the culture media Nitsch-White (NW) + kinetin 0.5 mg l^{-1} + 2,4-D 0.3 mg l^{-1} + sucrose 20 g l^{-1} + glucose 10 g l^{-1} + agar 6.0 g l^{-1} . Spadix explants and *in vitro* derived explants (leaves, nodes, petiole and roots) showed good response to callus induction treatments. Among the *in vitro* derived explants, root explants recorded the maximum callus multiplication.

Callus induction from spadix explants was better (59.85%) in half strength MS based medium supplemented with 2,4-D 0.3 mg l⁻¹ + kinetin 0.5 mg l⁻¹ + sucrose 30 g l⁻¹ + agar 6 g l⁻¹. Maximum shoot regeneration (92%) was observed after 46 days in Nitsch media supplemented with BAP 0.5 mg l⁻¹ in the case of leaf callus.

Among the explants tried for somatic embryogenesis, *in vitro* derived leaves (53%) and petiole (18.90%) and immature seeds (8.33%) showed positive response. Induction of somatic embryoids was observed in the media Nitsch-Whilte (NW) supplemented with 2,4-D 1.5 mg l⁻¹ + kinetin 0.15 mg l⁻¹ + sucrose 20 g l⁻¹ + glucose 10 g l⁻¹ + glutamine 200 mg l⁻¹ + agar 5 g l⁻¹ in explants derived from *in vitro* leaves and petiole. For immature seeds, response was observed in Nitsch media supplemented with 2,4-D 2.0 mg l⁻¹ + kinetin 0.3 mg l⁻¹ + sucrose 20 g l⁻¹ + glucose 10 g l⁻¹ + glutamine 200 mg l⁻¹. Germination of the somatic embryoids was highest in half strength MS media supplemented with BAP 0.1 mg l⁻¹ + glutamine 200 mg l⁻¹.

The irradiation doses above 150 Gy were found to be lethal to callus as well as for shoot tips. Maximum response in terms of plant height, plant spread and leaf area was recorded at lower dose of 50 Gy.

The biochemical studies using isozymes revealed no difference among the plants regenerated from different subcultures and different doses of irradiation. But, difference was observed between the non-irradiated and the irradiated plants for the number of bands produced. Peroxidase isoenzyme was found to be the most stable and was expressed in plants regenerated from different subcultures as well as those from irradiated cultures.

Cytological study showed no alteration in the somatic chromosome number, which remained uniform at 2n = 30+2B, in all the plants regenerated from the different subcultures and the irradiated cultures.

Intervarietal hybridization in *Anthurium andreanum* Linden

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The analysis of variance revealed significant variation among the ten varieties for the twelve quantitative characters studied.

Variability studies indicated high phenotypic and genotypic coefficients of variation for the characters plant height, position of candle, days to initiation of female phase, number of days in female phase and spathe size. The characters with heritability coupled with high genetic advance values were plant height, spathe size, spathe-candle ratio, position of candle, number of flower per candle and days to initiation of female phase, indicating additive gene action.

Pollen fertility ranged from 42 per cent in Liver Red to 13.7 per cent in Mauritius Orange. Pollen emergence was completely absent in Pompon Red, Nitta Orange and Midori Green during the period of study. Pollen production was high in the cooler months of October to December and was suppressed during the hot months of March to June.

The percentage of fruit bearing candles were highest for Nitta Orange (51.93%) and lowest for Mauritius Orange (9.51%).

The number of fruits per candle ranged from five to 183. The variety Pompon Red had the highest average number of fruits per candle and it was lowest for Lady Jane.

The percentage of fruit set was below 50 per cent for all the crosses except PR x LR. The crosses involved Pompon Red as female parent had the highest percentage of fruit set.

The time taken for seed germination varied from three to twelve days.

The best female parents were identified as Nitta Orange, Liver Red and Pompon Red based on the overall performance.

The analysis of the performance of varieties as pollen parents on the same basis showed that Ceylon Red, Merengue White and Liver Red were the best. Ceylon Red and Liver Red performed well both as female and male parent.

Genetic divergence in *Anthurium andreanum* Linden

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Significant genotypic differences were observed among the hundred genotypes for all the ten characters namely plant height, spathe length, spathe width, number of suckers per plant, length of leaf blade, width of leaf blade, candle length, inclination of candle with the spathe, number of spadices per plant per year and leaf area. Except for number of spadices/plant/year, all the characters were highly influenced by genotypic variation. High heritability with a good genetic advance was found for all the characters studied, except for number of spadices/plant/year which exhibited medium heritability and low genetic advance.

The 100 genotypes of anthurium were grouped into seventeen clusters using Mahalanobis D^2 statistics. The results suggested that selection of parents from these divergent clusters will be effective in future hybridization programmes. Leaf area and suckering ability were found to be the two potential contributing characters for the divergence of the genotypes.

Gene action was studied based on 24 characters in a diallel fashion using five parents and their ten hybrids. Dominance (over dominance) gene action was responsible for all the characters in their expression. Standardised $Yr^1 - (Wr + Vr)^1$ graph revealed that for almost all the characters, except for plant height, the selected parents possessed most of the dominant genes with positive effects.

Based on the *gca* and *sca* effects, varieties, Honeymoon Red, Kalympong Red, Chilli Red and Liver Red were selected as general combiners.

Most of the F_1 hybrids registered negative heterosis, for characters such as plant height, length and width of leaf blade, days

from emergence to maturity of leaves, leaf area, time taken for first flowering and inclination of candle. This is highly desirable in the case of anthurium, because, the best commercial varieties of anthurium should have medium plant height with medium sized leaves for accommodation of more plants within a unit green house area, earliness to maturity of leaves and shorter time taken for first flowering for enhancing the number of leaves and flowers/plant/year and a reduced inclination of candle for accommodating more flowers at the time of packing for transportation.

Based on the anthocyanin contents, the probable spathe colour genotypes of five selected parents and their 10 F₁ hybrids of the present study have been worked out for the first time in anthurium by correlating the total average anthocyanin content of the spathe of each variety to the incremental effect of the two anthocyanin producing genes, M and O.

Genetic variability and character associations in *Anthurium andreaeanum* Linden

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Variability studies indicated that high phenotypic and genotypic coefficients of variation for the characters of total anthocyanin content, pollen fertility, inclination of candle to spathe and duration of interphase. Except for leaf area and number of flowers per candle, all the other characters were highly influenced by genotypic variation. High heritability with a good genetic advance was found for all characters except for suckering ability and number of spadices/plant/year which exhibited medium heritability and high genetic advance. These results indicated that selection of plants which were phenotypically superior with respect to fifteen of the characters studied would certainly result in a significant improvement in the next generations.

Plant height was found to have significant positive phenotypic correlation with internode length, leaf area and days from emergence to maturity of inflorescence. Candle length showed significant positive correlation with leaf area, number of flowers per candle, life of spadix and duration of female phase.

Genotypic correlations were higher and for most of the characters it showed high positive correlations. Most of the estimates of the environmental correlation coefficients for the characters were low and insignificant indicating the least effect of environment in the expression of the characters studied.

Pollen fertility ranged from 7.03 per cent in PR x FR (2) to 50.80 per cent in LJ x MW. the protogynous nature of the flower and low pollen fertility suggests the hybrid nature of the crop.

Path coefficient analysis revealed that the characters leaf area and duration of female phase are more associated with number of flowers per candle and 40 per cent variation in flower production was attributed by the environment. High selection index values were recorded by the genotype LR x DT followed by FR x MW (1), PR x LR (3), MW x FR (1). If parents are selected based on selection index values, 45 per cent genetic gain can be expected in the next generation.

Improvement of *Anthurium andreaenum* Lind by *in vivo* and *in vitro* methods

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Six commercially important varieties of *A. andreaenum*, viz., 'Nitta', 'Candy Queen', 'Lima', 'Red Dragon', 'Eureka Red', 'Agnihothi' and three species of *Anthurium* viz., *A. crystallinum*, *A. ornatum* and *A. amnicola* were selected for the study.

Characterisation of the varieties was done morphologically which showed significant variations with respect to vegetative and floral characters. Year round flowering was obtained in all the varieties. The varieties 'Eureka Red' and 'Red Dragon' produced more number of spikes per year. 'Candy Queen' produced the largest spathe. Shortest spadix was observed in 'Red Dragon'. Peduncle was straight in all the varieties except in 'Candy Queen'.

The true flower of *Anthurium* is protogynous. The duration from spike appearance to unfurling ranged from 19.00 days in 'Lima' and 'Candy Queen' to 25.33 days in 'Agnihothi'. Female receptivity ranged from 12.00 days in 'Red Dragon' to 20.33 days in 'Eureka Red'. An interphase of 3 to 20 days was found in between female phase and male phase. Duration of male phase ranged from 9.33 days in 'Lima' to 20.67 days in 'Red Dragon'. Pollen grains of all the varieties were more or less round in shape. Early ripening of seeds was obtained in 'Red Dragon' (145 days) while it took 208 days in 'Agnihothi'.

The varieties 'Eureka Red', 'Red Dragon' and 'Lima' were superior regarding post harvest qualities.

Heritability was of moderate to high magnitude for most of the characters. Values for PCV were slightly higher than those of GCV. Plant height recorded highest PCV (70.57) and GCV (69.96).

Out of the 42 combinations of hybridization tried, 17 were found compatible. All the self crosses and interspecific crosses were found incompatible. Among all the combinations, 'Lima' produced the largest number of compatible crosses, high seed set and germination percentage. The varieties 'Candy Queen', 'Red Dragon' and 'Eureka Red' also performed well as good female parents. Comparing the performance of male parents, the most successful variety was 'Lima' followed by the varieties 'Red Dragon' and 'Eureka Red'. Out of the 17 successful combinations, the highly compatible crosses were 'Candy Queen' x 'Lima', 'Lima' x 'Red Dragon', 'Lima' x 'Eureka Red' and 'Eureka Red' x 'Red Dragon'.

The protocol for immature hybrid seed culture (*in vitro*) in anthurium was developed. Seeds, 40-45 days before field maturity could be used for *in vitro* culture, thus reducing the time lag for the production of hybrid seedlings. Germination and further development were good in $\frac{1}{2}$ MS + 1 mg l⁻¹ BA. For callus initiation, $\frac{1}{2}$ MS with BA 6 mg l⁻¹, NAA 3 mg l⁻¹ was effective. For rooting and growth enhancement, $\frac{1}{2}$ MS with BA 0.5 mg l⁻¹ and IAA 1 mg l⁻¹ proved good.

Irradiation of seeds reduced germination percentage and further growth. Survival of plantlets was the best in the media sand + cocopeat + husk pieces (1:1:1) and sand + trichoderma treated cowdung + husk pieces (1:1:1). When immature seeds were cultured *in vitro*, plantlets could be transferred to the field by 6-7 months. These plantlets flowered by 12th month. So, in total from hybridization to flowering, it took only 22-24 months whereas in conventional method it took 30-35 months.

Three hybrids produced flowers during the period of evaluation. The hybrid 'Lima' x 'Eureka Red' flowered 11th month of planting out and 'Lima' x 'Red Dragon' and 'Candy Queen' x 'Lima' flowered 12 months after planting out. Colour variations were noticed in the hybrid flowers. Variation in banding pattern was observed in isozyme analysis with the enzymes peroxidase and superoxide dismutase, while comparing parents and hybrids.

Compatibility studies of three way crosses in *Anthurium andreaeanum* Linden

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Evaluation of morphological characters and compatibility analysis of 14 selected genotypes were undertaken.

Variability studies indicated high phenotypic and genotypic coefficients of variation for the characters internode length, number of leaves and spadices per plant per year and days from emergence to maturity of leaves. The characters with high heritability coupled with high genetic advance values were leaf area, anthocyanin content and inclination of candle indicating additive gene action.

Plant height was found to be positively correlated with number of leaves or spadices per plant per year. Candle length had positive genotypic correlation with position of candle.

Pollen fertility ranged from 9.26 per cent in PR x DT to 35.70 per cent in Carre. Pollen emergence was completely absent in the genotype W x LJ during the course of the study. Pollen production was high in the cooler months of October to December and was suppressed in the months from March to June.

From the cross compatibility analysis, it was seen that the percentage of fruit bearing candles was highest for W x LJ (100.11%) with two crosses. The cross PR x LR with all the possible four crosses gave a value of 79.15 per cent.

The number of fruits per candle ranged from 12 to 120. OO x KR had the highest average number of fruits per candle and it was lowest for OO x PR.

The percentage of fruit set was below 50 for all the crosses. The number of days taken for germination varied from four to nine days. No cross showed 100 per cent survival beyond four to six months.

Scoring of the compatibility reactions based on the percentage of fruiting candles, fruit set and seed germination on a scale ranging from zero to nine showed the highest compatibility score of nine for (OO x KR) x C. The best female parents identified were OO x KR and PR x LR based on the overall performance

Improvement of propagation efficiency of *Anthurium* species *in vitro*

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Shoot tips from *in vitro* grown seedling were used as explants for the enhanced release of axillary buds. The maximum number of shoots (4.50) was observed with kinetin 2.0 mg l⁻¹ as well as BA 1.0 mg l⁻¹. Treatments with kinetin was free of callus growth. In treatments with BA and 2ip, callus growth was observed at the base of the explant.

Treatments with MS inorganic salts as well as sucrose did not influence multiple-shoot formation. One fourth strength of MS major nutrients with full strength of micro nutrients was ideal for multiple shoot induction. Glucose produced less number of shoots than sucrose. One percent sucrose did not influence multiple shoot induction. The longest shoot (0.95 cm) was observed at 0.4 percentage agar. Light was necessary for the enhancement of axillary buds. In darkness, callus growth was observed, from which many adventitious shoot were produced.

Segments of leaf, petiole, spathe, spike and inflorescence stalk were used as explants for callus initiation. In *A. andreanum*, 2,4-D 0.08 mg l⁻¹ and BA 1.0 mg l⁻¹ was ideal for callus initiation. Combination of 2,4-D 0.2 mg l⁻¹ and BA 1.0 mg l⁻¹ was the best for callus initiation in *A. veitchii*. In *A. grande*, the best callus initiation was observed with 2,4-D 0.5 mg l⁻¹ and BA 1.0 mg l⁻¹.

Modified MS medium with reduced salt concentrations was ideal for callus initiation in all the species. Inositol when reduced to half concentration (of the normal) influenced callus initiation. The leaf explant (with the smallest vascular bundles) among the other explants, had the highest number of cultures free of microbial contamination. Basal portions of leaf responded better than the apical portions, to *in vitro* culture. Continuous darkness was necessary for callus initiation and growth. MS medium with ¼ strength major nutrients was ideal for callus multiplication.

The shoots rooted spontaneously without any treatment. Plantlets survived, better than microshoots, *ex vitro*. The plantlets required less hardening treatments. Sand was the best potting medium for planting out. Nutrient solutions when used for irrigation the plantlets, had a negative influence on the survival of plantlets. Treatments with VAM (*Glomus constrictum* and *G. etunicatum*) were beneficial for the survival as well as growth of the plantlets.

Cytological examinations of the root tip squashes made on plantlets, at planting out, showed a normal diploid chromosome count.

Standardisation of media and containers for *ex vitro* establishment of anthurium plantlets produced by leaf culture

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Investigations were carried out to develop suitable methods to plant out *Anthurium andreaeanum* plantlets and to standardize media and containers to maximize the *ex vitro* establishment and growth of *in vitro* derived plantlets.

Segments of leaf were used as explant for producing required number of plantlets for the study. Various factors influencing *in vitro* rooting were standardized. Plantlets of 3 cm length with at least three leaves recorded shortest time (10.24 days) for root initiation and produced maximum number of roots per shoot compared to smaller shoots. Combination of BA 0.5 ppm and IAA 2.0 ppm was found to be the best for *in vitro* rooting. Agar at 0.7 per cent recorded shortest time (10.54 days) for root initiation and the number of roots per shoots decreased by increasing its concentration in the medium, while the length of root increased along with increase in agar concentration. Sucrose level maintained at normal level in MS medium (3.0 per cent) was found to be the best for *in vitro* rooting.

Plantlets with at least 2.5-3.0 cm size (with 3-4 leaves and two or more roots) recorded 90.0 to 100.0 per cent survival irrespective of media and containers. Of the various media and containers tried, plastic pot as the container and soilrite as the media recorded highest number of leaves in the transplanted plants at fortnightly intervals. Both one and two months after transplanting, mud pot outdid other containers and soilrite outdid other media with respect to plant height. In the case of leaf area at second and fourth fortnight, plastic pot and at third fortnight polythene cover was found to be the best container, and soilrite was the best medium at third fortnight onwards. The plants

grown in polythene cover with media soilrite recorded maximum number of roots and length of roots at two months after transplanting.

It is evident that among the media, soilrite was the best for *ex vitro* establishment of anthurium plantlets but containers showed no uniform response with various growth factors.

Micropropagation in selected varieties of *Anthurium andreanum* Lind.

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Regeneration was obtained within one month on Murashige and Skoog basal medium supplemented with BA 0.5 mg l⁻¹, IAA 2.0 mg l⁻¹, sucrose 30.0 g l⁻¹ and agar 6.0 g l⁻¹. Light was essential for regeneration.

The maximum rate of shoot proliferation (13.49 shoots) was observed on Murashige and Skoog basal medium supplemented with kinetin 1.5 mg l⁻¹, IAA 3.0 mg l⁻¹, casein hydrolysate 150.0 mg l⁻¹, sucrose 30.0 g l⁻¹ and agar 6.0 g l⁻¹ after a period of six weeks.

Improvement in growth of shoots was obtained by culturing in MS basal medium supplemented with activated charcoal (1.0 g l⁻¹) and further subculturing to MS supplemented with kinetin 0.5 mg l⁻¹ and IAA 16.0 mg l⁻¹.

A separate rooting phase was not necessary since satisfactory rooting was obtained in the shoot proliferation medium itself.

Rooted plantlets gave a survival rate of 60.0 per cent on planting out.

Improvement of propagation efficiency of *Anthurium andreanum* Andre.

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Two growth regulators, GA₃ and BAP at four levels (250 mg l⁻¹, 500 mg l⁻¹, 750 mg l⁻¹ and 1000 mg l⁻¹) were tried on intact and topped plants. Topping alone could induce lateral shoot production. Size of the lateral shoots was also high in topped plants. Effect of BAP was evident from fifth month after first spray whereas effect of GA₃ was expressed only after 8 months. GA₃ 750 mg l⁻¹ on topped plants produced highest number of lateral shoots per plant among all the treatments. In intact plants BAP 250 mg l⁻¹ was found to be more effective. GA₃ treatments produced longer sized shoots compared to BAP treatments. Plants sprayed with GA₃ 500 mg l⁻¹ produced flowers with maximum angle between spathe and spadix.

Application of growth regulators, BAP and GA₃ manifested profound variation in the potassium (K), calcium (Ca) and Magnesium (Mg) content in the spadix. The angle between spathe and spadix increased with an increase in the content of Ca and Mg in the spadix.

Callus was formed in explants from the leaf, petiole and spadix. Callus production was good in explants from spadix in ½ MS medium supplemented with 2,4-D 2 mg l⁻¹ and kinetin 0.3 mg l⁻¹. Addition to casein hydrolysate in the medium improved callusing in leaf explants. However, the calli did not respond to somatic embryogenesis induction treatments.

Optimization of shade, nutrients and growth regulators for cut-flower production in anthurium

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The effects of three growth regulators, viz., GA, BA and Ethephon with two concentration each, 750 ppm and 1500 ppm, in combination with four nutrients, viz., 1 per cent fertilizer complex, Hoagland solution, Knop's solution and Ohio solution, were assessed at four levels of shade, viz., 80, 70, 60 and 50 per cent. Post harvest studies were also carried out with an objective to prolong the longevity of cut blooms, following different stages of harvest and giving different pulsing and holding treatments.

The different levels of shade and growth regulators significantly influenced all the morphological characters of the plant, viz., height, spread, number of leaves, leaf area, petiole length, number of branches and suckers.

Plant height was significantly superior under 80 per cent shade (5.68 cm). One per cent fertilizer complex sprays (5.46 cm) and BA 750 ppm sprays (6.11 cm), were superior individually. The superior treatment combination was 70 per cent shade + Knop's solution + 750 ppm BA (7.60 cm).

The highest values were recorded under 80 per cent shade and 750 ppm BA, viz., 14.03 and 14.02, respectively, for number of leaves. The treatment combination involving 70 per cent shade + 1500 ppm BA with Hoagland solution was the best for maximum index leaf area (90.90 cm²) while same with 1 per cent fertilizer complex was the best for total leaf area (872.00 cm²) and LAI (0.89).

Branching started only after 6 months from the commencement of the experiment. It was one month earlier under 80 per cent and 70 per cent shade levels.

Sucker production was the best under 80 per cent shade (1.35) and 750 ppm BA (1.35). Treatment combination involving 80 per cent shade + Ohio solution + 750 ppm BA produced the maximum number of suckers (2.5) per cent.

Growth behaviour with respect to height, number of leaves, leaf area, number of suckers and branches showed a linear trend. The linear growth rate was consistent and positive under the treatment combination of 80 per cent shade + Ohio solution + 750 ppm BA.

The dry weight ratio of shoot : root was the highest (2.15) under the treatment combination of 80 per cent shade + Knop's solution + 750 ppm Ethephon.

Leaf longevity was significantly high (161 days) in the treatment combination, 70 per cent shade + 1 per cent fertilizer complex + 750 ppm BA.

The aerial root production decreased significantly with decrease in shade intensity.

Inflorescences with normal size were produced at the age of 13 months, first under 80 per cent shade followed by 70 per cent, 60 per cent and 50 per cent.

There was a decrease in chlorophyll content with decrease in intensity of shade. Eighty per cent shade and 1500 ppm Ethephon was superior with respect to the content of green pigments.

The leaf nutrient content and uptake of nutrients was maximum under 80 per cent shade and BA 750 ppm, individually.

Post harvest studies showed that the right stage of harvest of inflorescence was when 1/3 flowers were open on the spadix. Among the pulsing treatments, BA 50 ppm for 12 hrs, recorded maximum vase life (20.00 days).

Among the different holding solutions tried, 8-HQ 30 ppm, BA 20 ppm and Triadimefon 30 ppm recorded the optimum values of PLW, uptake of vase solution, change in pH and EC, and recorded late spathe blueing, late spadix necrosis and high gloss retention. Highest vase life period (27.00 days) was recorded in 8-HQ 30 ppm (25.00 days) and Triadimefon 30 ppm (25.00 days). Among the combinations tried, BA 20 ppm + Bavistin 0.1 per cent showed longest vase life (23.67 days).

Maximum net profit per pot (Rs.204.60) was recorded by the treatment combination involving 80 per cent shade + Ohio solution + 750 ppm BA.

Regulation of flowering and post-harvest behaviour of *Anthurium andreaeanum* cv. 'Hawaiian Red'

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The treatments included the application of nutrient solutions with different ratios of NPK (1:1:1, 1:1:2 and 1:2:2), at different concentrations (0.25%, 0.50% and 1.00%) and intervals of application (weekly and biweekly); Ca (0.50%), Mg (0.50%) and Vitamin B₁₂ (100 ppm), all along with control at monthly interval; and growth regulators (BA and GA) at 500 and 1000 ppm and their combinations at 250 and 500 ppm, each, at monthly interval. The treatments were applied on plants growing in ground as well as in pots. The effects of the treatments on growth, flowering and post-harvest longevity of flowers were studied. Experiments were also conducted to enhance the vase life of flowers by means of pulsing, plugging and waxing; to standardize the best method of packing of flowers and to study the effect of ethylene absorbent (KMnO₄) on the post harvest longevity of flowers.

Plants in pots were significantly better than those in ground planting with respect to the plant and flower characters studied, during the course of the experiment.

Vase life of flowers differed significantly among treatments. Flowers from the treatment with high ratio of K at lower concentration (20:20:40 fertigation complex at 0.25%) at weekly interval showed the maximum vase life of 19.00 days, each, in ground and pot planting, compared to 15.00 and 14.25 days, respectively, in the corresponding controls. Plants in this treatment flowered earlier and produced the highest number of flowers.

With regard to the application of growth regulators, the most significant effect was on the production of suckers. Application of GA 1000 ppm at monthly interval produced the maximum number of

suckers in ground (3.00) and pot (3.50) while the control plants produced no suckers.

With respect to the anthocyanin content of flowers, the combined application of BA and GA (500 ppm, each) was significantly better in ground planting than the application of either of these growth regulators alone.

The highest number of flowers/plant in ground (2.34) was produced by the combined application of BA and GA 250 ppm, each, compared to 1.00 in control.

Post harvest studies revealed that, pulsing with BA 150 ppm for 8 hours recorded the highest vase life (19.50 days) compared to 9.00 days in control. Among the plugging treatments, BA 50 ppm recorded the highest vase life (10.44 days) compared to 5.67 days in control. Among the packing methods, that in polythene covers with waxing and KMnO_4 in packing cases, extended the vase life to 13.5 days, compared to 10.5 days in control.

Effect of growth regulators on the growth and flowering of anthurium (*Anthurium andreanum* Linden)

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Effect of growth regulators on growth and flowering of *Anthurium andreanum* Linden was conducted. Mature plants of three varieties of *Anthurium andreanum* viz., Liver Red (L.R.), Ceylon Red (C.R.) and Kalymping Orange (K.O.) were tried. Three growth regulators, namely, Gibberellic Acid (GA), Tri Iodo Benzoic Acid (TIBA) and Kinetin (K) were used at 100 ppm, 300 ppm and 500 ppm concentrations. Growth regulators had significant effect on most of the characters under study.

Vegetative characters, viz., plant height, number of leaves, number of suckers, length of spadix and spathe size were the maximum in plants treated with GA 500 ppm.

Minimum plant spread was recorded for plants treated with TIBA 100 ppm. Longevity of the spadix was significantly superior in plants treated with kinetin 500 ppm.

Based on the economics of growth regulator application, G.A. 500 ppm was the best treatment with positive profit increase in all the three varieties.

Standardization of growing media and organic nutrition for juvenile anthurium plants (*Anthurium andreanum* Lind.)

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Growing media, nutrient treatments and their interactions influenced vegetative growth, flower characters, vase life, fresh weight and dry matter production and nutrient content of leaves in *Anthurium andreanum* 'Tropical', used for the study.

Among the media, sand + coir pith compost was found to be the best for obtaining greater plant height, leaf area, leaf duration, petiole length at third and fourth week after emergence, shortest phyllachron, the high fresh and dry weight of leaves and their N and K content. Plants grown in this medium also recorded earlier flowering, greater number of flowers per plant, increased spathe size, greater length and thickness of flower stalk and enhanced vase life. The inclination of spadix and its length and thickness were also found to be greater tending towards those of mature plants in this medium.

Vegetative growth enhancement was also obtained with 4 g l⁻¹ and 6 g l⁻¹ fresh cowdung extract treatments at varying stages of growth.

Greater fresh weight and dry weight of leaves were recorded in plant receiving 4 g l⁻¹ cowdung extract at 165 and 225 DAT. These plants also recorded greater N and K content during the period while the P content was greater in plants receiving 6 g l⁻¹ at these periods. Increased spathe size, lesser number of days to flowering, maximum length of flower stalk, maximum vase life and lesser number of days to harvestable maturity of flowers was obtained with 4 g l⁻¹ extract.

Application of organic manure mix also gave beneficial effects. Plants receiving 25 g organic manure mix recorded greater plant height, leaf area, leaf duration, and petiole length during the first and second week after leaf emergence. Fresh and dry weight of the leaves recorded were greater in plants receiving 75 g mix. The shortest phyllachron was recorded with 50 g/plant and the longest with 75 g/plant. The N and K content of the leaves were greater in plants receiving 25 g mix while the P content was greater in plants receiving 50 g mix. Spathe size, length of the flower stalk as well as the vase life of flowers was greater in plants receiving 25 g OM mix.

The interaction between media treatment, cowdung and organic manure treatments were also found to influence the performance of plants.

Microclimatic relations on the growth, yield and quality of anthurium (*Anthurium andreaenum* Linden) under different growing systems

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Planting time, variety and growing system differed significantly with respect to growth, flowering and flower quality of anthurium. October planting was found to be good for anthurium. Varieties

recommended are 'Pistache' and 'Tropical'. Low cost structure with UV stabilized shade net to divert 75-80 per cent light intensity and UV stabilized polyethylene film (120 gsm) to provide protection from rainfall on top and sides, covered with 25 per cent of shade net and with irrigation facilities at a cost of construction of Rs.300/m² was found suitable for growing anthurium in tropical areas.

The significant interaction effects showed that a suitable planting time - variety - growing system combination could maximize growth and production in anthurium. Pre-harvest growing conditions influenced the post harvest longevity of flower.

Air temperature both inside the growing systems showed positive correlation with all plant characters except with leaf number.

The R² values obtained in multiple regression analysis showed that the variations controlled by meteorological factors were higher in leaf characters (79.60% in leaf length, 78.10% in leaf area) and plant height (76.20%).

The study brings out the need for an integrated air temperature - relative humidity - light intensity regime to maximize growth, production and quality of anthurium. The most important requirement is to reduce air temperature by increasing relative humidity. This could be achieved by providing humidifiers in shade houses. Under hitech cultivation providing the suitable air temperature - relative humidity - light intensity regime for each variety could maximize yield.

In shade houses which are used for growing anthurium in the plains of Kerala with tropical climate, the most important requirement is to reduce temperature. This can be done by using a water spray system or a mist system, which increases humidity.

Etiology and management of bacterial blight of anthurium (*Anthurium andreaeanum* Linden)

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Bacterial blight incited by *Xanthomonas axonopodis* pv. *Dieffenbachiae* (Mc Culloch and Pirone) Vauterin *et al.* (1995) is a serious disease of anthurium (*Anthurium andreaenum* Linden) causing heavy economic loss to growers in Kerala.

The diseased plants showed both foliar and systemic infections. The bacterium inciting this disease was identified as *Xanthomonas axonopodis* pv. *dieffenbachiae* based on morphological, physiological and biochemical characters coupled with pathogenicity.

Potato Sucrose Agar was found to be the best medium for growth and slime production of the bacterium.

Dieffenbachia sp., *Philodendron oxycardium*, *Aglaonema robelinii*, *Colocasia esculenta* and *Syngonium podophyllum* were carriers of *Xanthomonas axonopodis* pv. *dieffenbachiae*. The pathogen survived in infected plant debris kept in soil under glass house conditions and in refrigerated conditions for about 45 days and in soil for 60 days.

Under *in vitro* evaluation, 100 ppm streptomycin and 0.3 per cent captan were most effective in inhibiting the growth of the pathogen.

Under *in vivo* conditions, the relative efficiency of four ecofriendly management practices, namely, application of turmeric powder + sodium bicarbonate, *Pseudomonas fluorescens* (proprietary product), neem oil and cowdung extract at three different levels were compared with that of spraying with 100 ppm streptomycin and 0.3 per cent captan. It was observed that the use of 0.15 per cent turmeric powder + sodium bicarbonate (10:1 proportion) was most effective and the extent of disease control achieved after a schedule of five sprayings at one week interval was same as that of 100 ppm streptomycin.

Management of bacterial blight of anthurium

(*Anthurium andreaenum* Linden) using botanicals

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A survey was conducted in Thiruvananthapuram district and information on disease intensity and varietal reaction of the disease was studied from randomly selected thirty anthurium gardens. Generally pink varieties exhibited tolerance while red varieties were susceptible. Both foliar and systemic symptoms were observed.

Among the fifteen botanicals tested under *in vitro* conditions crude extract and 2:1 dilution of *Allium sativum* and *Tagetes erecta*, crude and two per cent concentration of neem cake extract and one and two per cent neem oil and coconut oil were effective in inhibiting the growth of the pathogen.

The relative efficacy of five ecofriendly management practices viz., application of *A. sativum*, *T. erecta*, neem oil, coconut oil and neem cake extract, at two levels and 100 ppm streptomycin were tested on seven month old tissue culture plants. Pre and post inoculation sprayings with crude extract of neem cake and *T. erecta* reduced the disease by 85 per cent.

When the same spraying schedule with these two botanicals and 100 ppm streptomycin was given on flowering plants, crude extract of neem cake was the most effective followed by crude extract of *T. erecta*. The effect of streptomycin 100 ppm was on par with *T. erecta*. The study thus indicates that botanicals could be used as a substitute for antibiotics in the management of bacterial blight of anthurium.

Microbial antagonists and resistance inducers for the management of bacterial blight of anthurium (*Anthurium andreanum* Linden)

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The microbial flora from the rhizosphere and phyllosphere of healthy anthurium plants from various locations were isolated and

screened for their efficiency in inhibiting *X. axonopodis* pv. *dieffenbachiae* under *in vitro* conditions. Among the microbes obtained, isolates of *Bacillus* sp. (B16) and *Talaromyces* sp. (F8) were the most effective. Nutrient agar provided to be the best media for B16 and the antagonist was also non-pathogenic to anthurium. The potential of chemical activators in management of bacterial blight of anthurium was also investigated, both under *in vitro* and *in vivo* conditions. The *in vitro* studies revealed that chemical activators had no direct action on the pathogen, conforming to one of the characteristics of an activator for inducing disease resistance in plants (Systemic acquired resistance, SAR). Among the chemical activators tested under *in vivo* conditions, 5000 ppm potassium phosphonate and 25 ppm acibenzolar-s-methyl showed considerable effect in reducing the disease intensity.

The best treatments from the above trials and some other treatments which exhibited good results against bacterial blight of anthurium from previous works were studied in a green house on ten month old tissue culture anthurium plants of Cancan variety and this revealed that, a prophylactic root dip and foliar spray of *Bacillus* sp. (B16) or turmeric powder + sodium bicarbonate (10:1) @ 1.5 per cent were equally effective in managing bacterial blight of anthurium. The role of chemical activators on the other hand in combating the disease was next only to microbial antagonists and ecofriendly material.

BOUGAINVILLE

Standardization of macro and micro propagation techniques in bougainvillea

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Soaking the basal ends of the cutting in IBA 500 ppm solution for a period of six hours, gave maximum percentage of rooting both in rainy and summer seasons. Maximum percentage of rooting was obtained in the variety 'Jayalakshmy' and minimum in 'Cherry Blossom' during both the seasons. Organic carbon and total nitrogen content showed a significant negative correlation with percentage of rooting. A positive correlation was however observed between C/N ratio and rooting percentage. Number of roots, length and fresh weight of roots/cutting were more during rainy season than in summer. Fresh weight of the shoot/cutting and shoot/root ratio were more during summer than in rainy season.

Shoot apices and immature axillary stem segments were the most potent sources for callus formation. Maximum number of cultures callused in the presence of NAA 1.0 mg l^{-1} + BA 0.5 mg l^{-1} . KIN was found to be less effective than BA. Maximum number of cultures callused, in the case of explants collected from the variety 'Mahara', compared to that from 'Cherry Blossom' and 'Spring Festival'. Attempts to induce proliferation of axillary buds showed that, MS medium containing BA 2.0 mg l^{-1} + IAA 1.0 mg l^{-1} was optimum. Percentage of rooting was maximum in half strength MS medium in the presence of IBA 1.6 mg l^{-1} .

CROSSANDRA

**Effect of bioregulators on growth, flowering and
postharvest life of crossandra**
(*Crossandra infundibuliformis* (L.) Nees.)

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All the GA containing treatments (GA 100 ppm, 200 ppm either alone or in combination with 1% urea) caused a significant increase in height, the most conspicuous one being GA 200 ppm. All the other vegetative growth parameters, viz., spreading habit, number of leaves, leaf area and number of branches were significantly increased by BA 200 ppm + 1% urea, followed by GA 200 ppm treatment.

Spike emergence after spray was earliest in CCC 500 ppm treated ones followed by paclobutrazol 1000 ppm + 1% urea treatments.

BA 200 ppm + 1% urea and GA 200 ppm treatments were found to have maximum desirable influence on number of spikes produced, number of florets per plant, number of florets in a spike, length of spike and stalk length. Eventhough not much consistent and significant, CCC 500 ppm during October to January increased spike and floret yield.

In paclobutrazol containing treatments almost complete suppression of growth and flowering was noticed.

Pulsing, precooling and storage behaviour was not influenced by field treatments, while pulsing with 15% sucrose + 500 ppm 8-HQ and storage under refrigerated conditions in 200 and 300 gauge polythene covers was found superior for extending the storage life and other postharvest characters of crossandra spike.

Vase life without storage was maximum for BA 100 ppm treatment and 3% sucrose + 100 ppm CoCl_2 was found to be the best vase solution. Zinc sulphate 0.25 per cent with and without urea had the maximum vase life in the above solution.

DAHLIA

Effect of growth retardants on growth, flowering, vase-life and tuber formation of dahlia (*Dahlia variabilis* Desf.) propagated through cuttings

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Among the chemicals tried Alar markedly retarded the plant height and at the same time significant increase in the number of branches and leaves compared to control and the effect of CCC was not much pronounced.

Treatment with Alar and CCC markedly increased the size of leaves compared to control.

Chemical CCC was superior to Alar with respect to total chlorophyll content.

There existed a highly significant increase in internodal length at the highest doses of CCC against its control, except at 75th day.

Compared to Alar, the plants treated with CCC show a highly significant increase in thickness at node and internode.

Treatment with Alar delayed flower bud appearance by 3.9 to 5.9 days while CCC induced earliness in flowering by 8 to 10 days. However there was no significant difference between the chemicals for the number of flowers.

Treatment with Alar also improved the size of the flower, increased the number of florets and the flower remained fresh for a longer period on stalk and in vase.

Those plants treated with Alar showed an increase in the weight of tuberous root and maximum tuber production was noticed with Alar 4000 ppm.

GERBERA

Effect of time of planting and growth regulators on flowering and vase life of *Gerbera jamesonii*

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Four varieties, namely, Eoliet, Presley, Pritty and Sunbird and five treatments, viz., GA 50 ppm, GA 100 ppm, CCC 500 ppm, CCC 750 ppm and control, were used for the study.

Variety Presley was found to be early flowering while Eoliet was late flowering. GA 50 ppm and GA 100 ppm hastened flowering whereas CCC 500 ppm and CCC 750 ppm delayed it.

The longevity of flowers was maximum in varieties Eoliet and Sunbird. Variety Presley had the least longevity. Among the treatments, CCC 750 ppm and GA 50 ppm increased the longevity of flowers in field.

Maximum number of blooms was produced by Presley and the minimum by Eoliet. GA 100 ppm and CCC 750 ppm increased the number of blooms.

Vase life was found to be significantly increased by GA 100 ppm and CCC 750 ppm treatments given to the plants. Five per cent sucrose + 20 ppm AgNO₃ significantly increased the longevity of flowers in vase.

Planting in June was found to be better than October planting with respect to vegetative as well as floral characters, especially for number of flowers and flower diameter.

Among the varieties, with respect to growth and number of flowers, Presley was found to be superior.

In the correlation studies flower number was found to have positive and highly significant correlation with plant height and leaf area.

Varietal evaluation of gerbera (*Gerbera jamesonii* BOLUS) under low cost green house

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The varieties differed significantly with respect to vegetative and floral characters. Variety Essandre was found to have maximum plant height, number of leaves, petiole length and leaf area. Plant spread was maximum in variety Yanara and variety Lindessa had maximum number of lobes on leaves.

Variety Essandre produced maximum number of flowers per plant whereas variety Tamara was very poor in flower production. Flower diameter and stalk length were maximum in variety Yanara, while maximum stalk girth was recorded in variety Lindessa. Variety Juvena took minimum number of days for the emergence of first flower bud and from flower bud emergence to flower opening. Field life was maximum in variety Tamara. No significant variation was observed in the vase life of flowers of different gerbera varieties.

A significant negative correlation was observed between relative humidity and number of leaves. A significant positive correlation was observed between plant height and number of leaves, petiole length and leaf area. Correlation between number of leaves and leaf area was also positive.

Period from flower bud initiation to flower opening was significantly and positively correlated with flower diameter, stalk length, stalk girth and field life of flowers. A significant negative correlation was observed between number of flowers and flower diameter, whereas flower diameter had a positive correlation with stalk length. Field life had a significant positive correlation with stalk length and stalk girth.

Correlation between vegetative and floral characters showed that plant height was significantly and positively correlated with number of flowers and stalk length, whereas a negative correlation was observed between plant height and flower diameter. Number of flowers had a significant positive correlation with number of leaves and leaf area.

GLADIOLUS

Floral biology and compatibility in gladiolus

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All the varieties showed significant variation among themselves for all the characters studied. Accession-1 showed maximum corm germination percentage (94.89). Plant height (68.86 cm), leaf number (9.44), spike length (64.67 cm), spike yield per plant (3.11) and took minimum days for spike emergence (46.56) and first flowering (60.44 days). Maximum number of florets per spike was observed in Pacific. It has longest vase life (8.66 days), corm size (5.18 cm) and corm number (1.78) also.

In all the varieties full anthesis occurred from 7.15 a.m. and peak time was 9.00 a.m. Anthers dehisced within two to three hours after unfurling of perianth. Stigma became receptive only after it turned feathery. By 9.30 a.m. on the day of anthesis stigma turned feathery it remained receptive for two days.

White Friendship had maximum pollen fertility (85.90%) and pollen production per anther (39500) while Pacific registered highest pollen diameter (38.09 μ). Maximum pollen germination was observed in 15 per cent sucrose + 75 ppm boric acid medium for the two varieties studied viz., White Friendship and Accession-1. Pollen viability was the highest when stored in desiccator at 4°C.

High heritability and high genetic advance were observed in characters like days to first flowering, spike length and leaf area.

The number of florets per spike which determines the market quality had positive correlation with spike weight, number of florets open at a time and leaf area.

The direct and indirect effects of 12 characters on number of florets per spike showed that spike weight had the maximum direct effect on number of florets per spike. It was followed by duration of

flowering, collar girth, spike length and vase life. Negative direct effects on number of florets per spike was from days to first flowering, plant height, floret size, leaf area, leaf number and spike yield per plant. The highest positive indirect effect on number of florets per spike was of leaf area through spike weight. The indirect effect of duration of flowering on number of florets per spike through number of florets open at a time was the lowest. Ten varieties namely, White Friendship, Tambri, Echo Saunder, American Beauty, Tiger Flame, Wedding Bouquet, Accession-1, Accession-2, Amal and Pacific were selected and crossed in all possible combinations. In Amal and Tambri there was no pod development and seed set in both cross pollination and self pollination tests. In self pollination, pod set, number of seeds per pod and weight of seeds per pod were higher than that in cross pollination.

Response of gladiolus to rapid cloning through *in vitro* techniques

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The best season for the collection of corm axillary buds and cormel tips was from September to May.

Culture establishment of the corm axillary bud, cormel tip explants were better in MS medium supplemented with BAP ranging from 1.0 mg l⁻¹ to 4.0 mg l⁻¹. Multiple axillary bud production was very high when the MS medium was supplemented with BAP 1.0 mg l⁻¹ and NAA 0.5 mg l⁻¹ or BAP 2.0 mg l⁻¹ and NAA 0.5 mg l⁻¹. Callus proliferation from the base of the elongated shoots were observed when the concentration of NAA increased in the medium.

The elongated shoots produced maximum number of roots in the MS medium containing 1.0 mg l⁻¹ IBA under the exclusion of light. Early rooting was obtained in MS liquid medium devoid of growth regulators.

Plantlet survival was maximum when treated with 0.2 per cent Bavistin immediately after removing from the culture vessels, followed by treatment with 0.2 per cent mancozeb and norfloxacin at the time of transplanting and post planting treatment with 1/10 Ms solution and drenching with triadimefon 20.0 mg l⁻¹ at three days interval inside improvised mist chamber.

Direct organogenesis could be obtained from immature inflorescence segments in modified MS medium supplemented with 15.0 mg l⁻¹ NAA and 3.0 mg l⁻¹ BAP.

Among the various explants tried for callus mediated organogenesis, callus index was the maximum (400) when immature inflorescence segments were inoculated to the modified MS medium supplemented with NAA 15.0 mg l⁻¹ in 16 h photoperiod. The callus derived from inflorescence segments differentiated into shoots in the MS medium supplemented with 3.0 mg l⁻¹ BAP.

In vitro production was noticed in the cultures, if planting out was delayed. Earliest and large sized corn induction was made possible in elongated shoots of gladiolus from Stage 2 in MS medium containing 5.0 per cent sucrose, 0.5 mg l⁻¹ NAA and 5.0 mg l⁻¹ triadimefon kept under etiolated condition. The size of the *in vitro* produced corns enlarged from 0.2 cm to 2.3 cm in the MS liquid medium containing 5.0 per cent sucrose and 3.0 mg l⁻¹ triadimefon.

Effect of growth regulators and nutrients on spike qualities of gladiolus

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Five varieties of gladiolus, viz., American Breeding, Friendship, Agnirekha, Mansoer, Red and True Yellow. Growth retardants TIBA and CCC and salts of Ca recorded least height in all the varieties. TIBA 300 ppm and CCC 250 ppm produced the maximum number of leaves,

followed by GA 100 ppm and salts of Ca and K. In leaf area, K_2SO_4 caused a significant increase. TIBA 300 ppm, NAA 100 ppm, GA 100 ppm and salts of Ca were the other superior treatments.

While K_2SO_4 and GA 100 ppm reduced the duration till the appearance of flower spike, that from spike emergence to opening was the shortest with salts of Ca and K.

K_2SO_4 0.5%, $CaSO_4$ 0.5% and GA 50 ppm were superior in increasing the spike length. Diameter of spike was the maximum with growth inhibitors, in most of the varieties. GA and salts of Ca were also superior. GA 50 ppm as well as salts of Ca and K helped in producing the longest rachis.

Salts of Ca at 1.0% level and GA produced the highest number of florets.

TIBA 150 ppm, CCC, GA, $Ca(NO_3)_2$ 1.0% and $CaSO_4$ lengthened the vase life.

Longevity of individual floret was improved by GA 100 ppm, K_2SO_4 and $Ca(NO_3)_2$. Salts of K and Ca (NO_3)₂ 1.0% enhanced the number of florets opened at a time. NAA 100 ppm and GA 50 ppm exhibited maximum water uptake.

Floral characters were superior in the varieties American Beauty and Friendship, whereas vase life was the maximum in Agnirekha and Mansoer Red. True yellow produced heavy corms. Weight of cormels was the maximum in Agnirekha and Mansoer Red.

November planting was found to be better than April planting, in order to obtain quality spikes as well as good corn and cornel yield in gladiolus under Vellanikkara conditions.

Effects of planting dates and floral preservatives on spike qualities of gladiolus (*Gladiolus grandiflorus*)

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Investigations were carried out to study the effect of six planting dates at monthly intervals from mid-August to mid-January on the general performance of three gladiolus cultivars viz., Vink's Glory, Her Majesty and Oscar. A post harvest study was also conducted to find out the effect of seven holding solutions on the post harvest spike characteristics.

Studies revealed that corms planted in October sprouted early, and produced tallest plants with large leaves. Spike emergence was early in November planted ones.

Among the three cultivars tested, Oscar was the earliest to sprout and Vink's Glory the latest. Maximum plant height, leaf number and leaf area were recorded in the cultivar Vink's Glory. Vink's Glory also produced the maximum number of tillers per plant.

September plantings registered the maximum spike and rachis lengths. In general, delayed planting resulted in reduced spike and rachis length, floret size and number of florets per spike. Early plantings done in August September and October also produced the maximum number of florets per spike and floret size.

Cultivars, Vink's Glory though late to sprout had maximum plant height, leaf number, leaf area, maximum number of tillers/plant and was the least susceptible to fusarium wilt. It had the maximum blooming period and vase life. In Her Majesty completion of flowering was early. The longest spikes with the maximum rachis length, number of florets and floret size were observed in Oscar.

Early plantings done in August, September and October increased the time taken from spike emergence to opening of first floret, blooming period and vase life of spikes. Delayed planting produced spikes which were inferior.

Weight of corms produced was highest in the cultivar Vink's Glory and lowest in Her Majesty. Her Majesty registered the maximum number of cormels per plant while Oscar produced the maximum cormel weight per plant. Delayed plantings resulted in a reduction of number of cormels per plant.

Optimum holding solution for maximizing the number of days to full bloom and vase life of spikes was a 5 per cent sucrose solution containing 8-hydroxyquinoline (300 or 600 ppm). Holding solutions containing 5 per cent sucrose and silver nitrate (100 or 200 ppm) gave the next best results.

Floret size and number of open florets was maximum in spikes held in 5 per cent sucrose + 8-hydroxyquinoline 600 ppm. This holding solution also significantly delayed the bending of spikes in vase.

Estimation of anthocyanin colour pigments in flower petals 2 and 10 days after harvest also revealed better retention of colour pigments in spikes held in sucrose plus 8-hydroxyquinoline solutions.

Vegetative and floral characters of *Gladiolus* 'Friendship' as influenced by corm size and growth substances

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Degree Programme	: Master of Science in Horticulture (1997)
Name of Major Advisor	: Dr. N.K. Parameswaran
College	: College of Horticulture, Vellanikkara

Corm treatments with GA 50 ppm and ethrel 200 ppm enhanced the sprout emergence. As regards the vegetative characters viz. plant height, number of leaves and leaf area, the medium and large sized corms were superior while ethrel 100 ppm and GA at both levels proved superior among the growth regulators. Paclobutrazol resulted in significantly dwarf plants.

In medium sized corms, the opening of florets was earlier than in small sized corms. GA 100 ppm and ethrel 100 ppm resulted in early spike emergence whereas GA 50 ppm and ethrel 200 ppm enhanced first floret opening. GA 50 ppm lengthened the blooming period while GA and ethrel both at 100 ppm reduced the total crop duration.

An increased corm size resulted in longer spikes, and ethrel at 100 ppm produced longer spikes among growth regulator treatments in both seasons. Maximum spike diameter was observed in the spikes from larger corms and the GA treatments. Rachis length was also more in spikes from larger corms receiving GA 50 ppm.

More number of florets per spike was produced from medium and larger corms and from the GA and ethrel treatments. GA 100 ppm also prolonged the longevity of an individual floret in the vase. The larger corms treated with GA 100 ppm was the best treatment combination resulting in maximum number of florets open at a time, while larger corms treated with ethrel 200 ppm produced maximum percentage of fully opened florets in the spike. The vase life, fresh weight and bending nature of spikes were not affected by the treatments. Minimum electrolyte leakage was registered with GA 100 ppm treatment.

The grades of corms at planting did not influence the corm characters. Maximum weight of corms were observed in the ethrel 200 ppm treatment, while ethrel 100 ppm and GA 50 ppm produced the maximum corm size. GA 100 ppm produced highest number and maximum weight of corms.

HIBISCUS

Pollen production, fertility and compatibility studies in shoe flower (*Hibiscus rosa-sinensis* L.)

Name of student	: Baby Lissy Markose
Degree Programme	: Master of Science in Horticulture (1984)
Name of Major Advisor	: Dr. M. Aravindakshan
College	: College of Horticulture, Vellanikkara

There was distinct variation in the morphology of flowers in the 36 types/varieties or species studied. Flower opening took place during the morning hours and in most of the types/varieties/species anther dehiscence commenced soon after flower opening. The time taken for the folding of the corolla ranged from 12 to 36 hours after flower opening and for the retention of corolla ranged from 24 to 72 hours.

Pollen grains of *Hibiscus* were pantoporate, spheroidal and spinose and were 125.91 to 198.58 microns (μ) in diameter. Pollen production per anther varied from 87 to 500 and percentage of pollen fertility ranged from 4.6 to 97.4. For pollen germination and tube growth a medium consisting of 20 per cent sucrose + one per cent agar + 100 ppm boric acid was the best. The pollen grains commenced germination within 30 minutes of dusting and gave satisfactory germination even after four hours of incubation in the best medium. Polysiphonous germination was observed in majority of cases.

Of the different methods tried for storage of pollen grains, storage of flowers with anther column intact at 4°C over calcium chloride in a desiccator was found to be the best.

Self compatibility was noticed only in five types or varieties of *H. rosa-sinensis* and in the species *H. mutabilis*. The fruits matured in 28 to 38 days and germinated in 10 to 18 days. The number of seeds per capsule ranged from 8.5 to 192.5 and seed germination ranged from 3.33 to 69.77 per cent. Survival of germinated seedlings was more than 95 per cent.

Out of the intraspecific cross combinations tried, compatibility was observed in all the crosses, except in cases where Acc. 11 was used as the female parent.

Morphological studies of different types of *Hibiscus rosasinensis* L. and standardization of propagation techniques

Name of student : Verghese C.A.
Degree programme : Master of Science in Horticulture (1984)
Name of Major Advisor : Dr. M. Aravindakshan
College : College of Horticulture

Thirty four types and fourteen varieties of *Hibiscus rosasinensis*, two types of *H. schizopetalous* and one type of *H. mutabilis* were collected from different zones of Kerala, Tamil Nadu and Karnataka. Acc. 3, Acc. 5, Acc. 13, Acc. 29, Acc. 32, Acc. 33, Acc. 42 and Acc. 52 were found to produce very attractive showy flowers of different shades of colours. Acc. 43 and Acc. 45 were bushy types. Considerable variation existed with regard to pollen viability among different types. Maximum pollen viability of 89.8 per cent was observed in Acc. 22 and minimum of 4.7 per cent in Acc. 7.

Retention of leaves had significant influence over the treatment without leaves on rooting of cuttings. In quick dip method, best performance was recorded by NAA 3000 ppm followed by IBA 5000 ppm and IAA 10000 ppm for rooting percentage and number and length of roots.

Quick dip method was significantly superior to prolonged dip method of growth regulator application. Acc. 19 showed the best response while least response was exhibited by Acc. 7.

From the studies on air layering, it was revealed that maximum rooting percentage of 89.3 was exhibited by Acc. 38. Air layering recorded better rooting than cutting without growth regulator treatment. But, it showed lower rooting percentage when compared to growth regulator treated cuttings.

JASMINE

Effect of growth regulators on rooting of cuttings and layers in jasmine (*Jasminum auriculatum* Vahl.)

Name of student	: Sreelatha U.
Degree programme	: Master of Science in Horticulture (1987)
Name of Major Advisor	: Dr. K. Gopikumar
College	: College of Horticulture

Systematic studies were carried out to standardize various aspects of asexual propagation in jasmine through cutting and layering. IBA was superior to control with regard to rooting percentage. Other root growth parameters such as number, length, fresh weight and dry matter production of roots were also maximum with IBA treatments.

Regardless of the growth regulator treatment, mist had profound influence on root growth as well as vegetative growth parameters in both the species of *Jasminum* studied. Growth regulator treatments were superior to control with regard to rooting percentage as well as number, length, fresh weight and dry matter production of roots. Layering should be done during the rainy season, particularly from June to September, for getting maximum success.

Nutrient requirement for bush jasmine (*Jasminum sambac* Ait.)

Name of student	: Asha Raj
Degree Programme	: Master of Science in Horticulture (1999)
Name of Major Advisor	: Dr. V.L. Sheela
College	: College of Agriculture, Vellayani

Vegetative characters like height, number of branches, spread and yield of flower buds were significantly higher at the highest level of major nutrients viz., 150 kg N, 150 kg P₂O₅ and 150 kg K₂O ha⁻¹.

Analysis of N, P and K in leaves revealed that maximum content of foliar nitrogen was at 150 kg N : 50 kg K₂O ha⁻¹ while foliar potassium content was maximum at 50 kg N : 100 kg P₂O₅ : 150 kg K₂O ha⁻¹. Foliar phosphorus content was not at all influenced by nutrient application. Uptake of nutrients was not found to be influenced by applied nutrients.

Available soil nutrient status revealed that maximum content of nitrogen and phosphorus in soil was noticed at 150 kg N : 150 kg P₂O₅ and 150 kg K₂O ha⁻¹. But maximum available potassium was noticed with 50 kg N : 150 kg P₂O₅ and 150 kg K₂O ha⁻¹.

Maximum essential oil content was obtained with 100 kg N : 100 kg P₂O₅ and 150 kg K₂O ha⁻¹. Carbohydrate content of flowering shoot was found to be the highest with 50 kg N : 150 kg P₂O₅ and 150 kg K₂O ha⁻¹. In general, highest dose tried with the major nutrients, 150 kg N ha⁻¹, 150 kg P₂O₅ ha⁻¹ and 150 kg K₂O ha⁻¹ was found best for cultivation of bush jasmine.

Nutrient requirements and post harvest studies on bush jasmine (*Jasminum sambac* Ait)

Name of student : J. Nirmalatha
Degree Programme : Master of Science in Horticulture
(2001)
Name of Major Advisor : Dr. V.L. Sheela
College : College of Agriculture,
Vellayani

Growth characters like length of main shoot, number of primary branches, length of primary and secondary branches, spread of plant in East-West and North-South direction were better at the highest dose of major nutrients applied, viz., 600 kg N, 600 kg P₂O₅ and 600 kg K₂O ha⁻¹. The maximum number of secondary branches was obtained at 450 kg ha⁻¹ of K₂O and P₂O₅.

The yield of flowers was highest at lower doses of major nutrients applied, viz., 300 kg N, 300 kg P_2O_5 and 450 kg K_2O ha⁻¹.

Regarding monthly yield pattern, lower levels of nutrients (N and P) gave better yield in general; potassium was effective at 450 kg K_2O ha⁻¹. During the growth period of the effect of nutrients applied was significant initially, then declined in between and finally the yield increased in tune with the season.

The 100 bud weight of flower buds was maximum at 300 kg N ha⁻¹ and 300 kg P_2O_5 ha⁻¹. The time taken for flower opening delayed at 600 kg P_2O_5 ha⁻¹.

Uptake of nitrogen and phosphorus was found effective at 600 kg N: 600 kg P_2O_5 : 600 kg K_2O ha⁻¹. But uptake of potassium was maximum at 600 kg N: 450 kg P_2O_5 : 450 kg K_2O ha⁻¹. The uptake of magnesium recorded highest value at 600 kg N: 300 kg P_2O_5 : 300 kg K_2O ha⁻¹ and 450 kg K_2O ha⁻¹. Zinc uptake was maximum with highest dose of nitrogen and phosphorus applied and 300 or 450 kg K_2O ha⁻¹.

Post harvest treatment of buds with ethylene absorbants and newspaper lining along increased shelf life. The time taken for flower opening was delayed maximum by ethylene absorbent treated buds. Low temperature treatment was best to increase the longevity of buds by retaining colour and turgidity.

The present study revealed that lowest dose of fertilizer application (300 kg N: 300 kg P_2O_5 : 450 kg K_2O ha⁻¹) favoured the floral characters, whereas highest dosage increased vegetative growth. The shelf life of flowers can be enhanced by post harvest treatments (ethylene absorbants and low temperature) along with fertilizer application.

ORCHIDS

Floral biology and compatibility studies in *Dendrobium*

Name of student	: Susan Varghese
Degree Programme	: Master of Science in Horticulture (1995)
Name of Major Advisor	: Dr. P.G. Sadhankumar
College	: College of Horticulture, Vellanikkara

Dendrobium hybrids selected for the study included New Pink, Hieng Beauty, Emma White, Sonia 28 Mutant B, Kasem White, (Kiomi Beauty x Banyat Pink), (Hawaiian Beauty x Kasem Pink), Sonia, Sonia # 28 and White Nern.

Pollen grains were found agglutinated in masses called pollinia. The pollen output per pollinia ranged from 38,282 to 1,93,750 and the fertility percentage varied between 4.42 and 73.98, among the different hybrids. Best pollen germination was obtained in a medium comprising two per cent sucrose and one per cent agar. The medium supplemented with 75 ppm boric acid was the best for pollen tube elongation. Pollen viability was retained for the longest period when stored at 4°C.

High rate of self and cross incompatibility was encountered in *Dendrobium*. Hybrids New Pink, Emma White and (Kiomi Beauty x Banyat Pink) were self compatible. From hybridization studies it was evident that Hieng Beauty, Emma White and White nern were best suited as female parents, while, New Pink and (Hawaiian Beauty x Kasem Pink) were better male parents. The hybrids Kasem White and (Kiomi Beauty x Banyat Pink) were suitable as both male and female parents. In the compatible crosses ovary swelled and developed into a pod. It matured in 85-110 days after pollination.

Planting out of mature well developed seedlings (270 days after *in vitro* planting) in coconut husk pieces was found to be ideal for *ex vitro* establishment.

Improvement of *Dendrobium* through hybridization and *in vitro* mutagenesis

Name of student	: Sobhana, A
Degree Programme	: Doctor of Philisophy in Horticulture (2000)
Name of Major Advisor	: Dr. P.K. Rajeevan
College	: College of Horticulture, Vellanikkara

Ten varieties and six species of *Dendrobium* were included for the trial. All the varieties showed significant variations for the characters studied. New Pink had the highest number of shoots (9), maximum leaf length (15.17 cm), largest flowers (8.27 cm x 7.9 cm) and longest vase life (18.33 days). Number of flowers was maximum for Candy Stripe (11.67).

Anthesis in *Dendrobium*, was observed between 7.30 am and 2.30 pm and the stigma receptivity period ranged from second to 10th day of flower opening, in different varieties.

Sabine had the maximum pollen size (47.46 μ). Pollen fertility of the hybrids ranged from 46.77 per cent (*D. chrysanthum*) to 91.93 per cent (New Pink). Maximum pollen germination occurred in two per cent sucrose + 1 per cent agar (80.33%) as well as in 2 per cent sucrose + 2 per cent agar (78.00%). Emma White had the maximum pollen germination (80.63%).

All the varieties, except Hieng Beauty, were self compatible. Emma White had the maximum cross compatibility as the female parent and Sabine had the least. Emma White, New Pink and Pink Tips performed as good male parents. Out of the six species tried, *D. fimbriatum* gave the maximum cross compatibility.

When green pod culture was employed, 90-110 days old pods gave the best results in culture.

Early germination, protocorm formation as well as shoot and root production were observed in the medium containing kinetin/BAP at 4 mg l⁻¹ to 8 mg l⁻¹ and IBA/NAA at 2 mg l⁻¹ to 6 mg l⁻¹. These media also gave higher values for seedling characters like height, number of leaves, leaf length, number of roots and root length.

Callus formation was favoured by NAA 4 mg l⁻¹ + 2,4-D - 2 mg l⁻¹ along with kinetin 2 mg l⁻¹. Formation of PLBs from *in vitro* leaf was obtained in a medium containing BAP 25 mg l⁻¹ + NAA 2 mg l⁻¹.

Protocorms, PLBs and callus were subjected to *in vitro* mutagenesis using gamma rays up to 60 Gy. Higher doses of irradiation produced smaller and broader leaves with dark green colour.

Planting out of different hybrid seedlings was successfully carried out. Out of the different nutrient solutions tried 30:10:10 NPK mixture (0.1 - 0.2%) sprayed on alternate days gave best results in terms of number of shoots and number of leaves. BA at 50 mg l⁻¹ at fortnightly intervals gave maximum number of shoots and leaves. Maximum height of the seedlings was obtained with GA₃ 10 mg l⁻¹ sprayed at fortnightly intervals. Field evaluation of the hybrids revealed variations in the growth and floral characters.

Intra and interspecific hybridization in *Dendrobium* spp.

Name of student : C. Lekha Rani
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Name of Major Advisor : Dr. S.T. Mercy
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Fourteen genotypes of *Dendrobium* comprising of nine commercial varieties, three semi-commercial varieties and two species were selected as parents after initial evaluation. The parental genotypes differed significantly with respect to all the 21 characters studied. High heritability combined with high GCV and genetic advance were observed for length of inflorescence, length of scape, number of flowers per inflorescence and number of nodes per cane. Significant positive inter-correlation in all pair-wise combinations at genotypic and phenotypic levels was observed between seven characters *viz.*, number of leaves per clump, height of cane, leaf area per cane, age at first flowering, cane to flower first, vase life and length of inflorescence.

The 14 parental genotypes were crossed in all possible combinations (196) after preliminary studies on floral biology, anthesis and pollination. Six combinations could not be attempted as the flowering seasons of the genotypes concerned did not synchronise. A total of 1696 pollinations were done covering 190 (88 crosses + 88 reciprocals + 14 selfs) combinations. Progeny from 67 (62 crosses and five selfs) combinations were established successfully in the green house. The levels of incompatibility reactions were grouped under nine heads ranging from flower abscission before the onset of any visible post pollination change to failure of hybrid seedlings to get acclimatized to the *ex vitro* green house conditions. A total of 123 combinations attempted succumbed to incompatibility at these different stages. Percentage capsule yield ranged from 8 to 33 in the various hybrid combinations. Percentage filled seeds ranged from 10.79 to 75.93 and percentage seed germination ranged from 8.00 to 70.73. The basal medium MS half strength was the best for early germination and rapid *in vitro* development as compared to MS quarter strength and MS, KC and VW full strengths.

Transplanting into the humidity chamber under conditions of high relative humidity (85-95%) and controlled irrigation resulted in 94 per cent survival after four weeks. The best among the potting media tried was broken tiles + charcoal + soilrite (2:2:1), favouring high survival and well balanced post transplantation seedling growth. The 67 hybrid combinations differed significantly with respect to all the eight vegetative characters studied at 1.5 to 2.0 years after transplanting. A partial diallel established with 18 cross combinations revealed the *gec* effect of P_3 to be beneficial for number of shoots per clump, as it was positive and significant. Non additive gene action was responsible for character expression, as dominance variance was higher than additive variance. Sixteen hybrid combinations flowered, recording significant differences for all the 12 floral characters studied.

From the 16 flowering combinations, based on three important criteria *viz.*, novelty, distinctness and uniformity of the floral characters, 25 new hybrids were selected.

Compatibility studies in monopodial orchids

Name of student	:	C. Ninitha Nath
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Name of Major Advisor	:	Dr. C. Lekha Rani
College	:	College of Agriculture, Vellayani

Genotypic and phenotypic coefficients of variation were high for number of aerial roots, leaf area and width of leaf characters like number of aerial roots, width of leaf are and number of flowers per inflorescence has high heritability coupled with high genetic advance. Significant positive inter-correlation at genotypic and phenotypic levels was observed for length of flower and width of flower with number of leaves per cane, number of aerial roots, number of spikes per cane, length of inflorescence and length of scape.

The 12 parental genotypes were crossed in all possible combinations after preliminary studies on floral biology. Incompatibility reaction was noticed at different stages ranging from flower abscission before the onset of any visible post pollination change to instances where seeds germinated but aborted in culture. A total of 58 combinations attempted succumbed to incompatibility at these different stages from pollination to deflasking. Harvestable green capsules were obtained from 58 combinations and they were inoculated in MS half strength basal medium. Percentage capsule yield ranged from 8 to 38 and percentage filled seeds ranged from 18 to 76 in the various hybrid combinations. Capsules from twelve combinations did not contain seeds and seeds from ten combinations did not germinate on inoculation. Protocorms of developing seedlings from twelve combinations aborted at various stages in *in vitro* development.

Significant differences among the combinations were observed with respect to number of days taken for germination initiation, number of days taken for development of protocorms, chlorophyll, first leaf and first root primordial and for deflasking.

Significant differences in seedling morphology were observed among the 24 hybrid combinations at deflasking with respect to all the seven vegetative characters studied.

Morpho-anatomical and molecular characterization of *Dendrobium* Sw. cultivars

Name of student	: N. Padmanaba Pillai
Degree Programme	: Doctor of Philosophy in Horticulture (2003)
Name of Major Advisor	: Dr. T. Sabina George
College	: College of Agriculture, Vellayani

Fifteen *Dendrobium* varieties differed significantly for the growth parameters viz., rate of increase in shoot girth, increase of leaf area of the shoot, leaf area at completion of leaf unfurling, leaf area at inflorescence emergence, leaf area at first flower opening, days taken from inflorescence emergence to first flower opening and days taken from inflorescence emergence to full bloom. Significant varietal difference were observed among the fifteen varieties for shoot length, shoot girth, internodal length of shoots, number of nodes per shoot, length and width of leaves, basal internodal length of stalk, number of flowers, length and width of flowers, root thickness, cortex thickness, number of layers in velaman, leaf thickness, number of stomata in the adaxial and abaxial surface of leaf, petal thickness and thickness of pigmented layers.

High GCV and PCV were observed for petal thickness followed by number of flowers, while high heritability was observed for petal thickness and length and width of flowers. Petal thickness, number of stomata in the abaxial surface of leaves and number of flowers exhibit high heritability along with genetic advance.

Genetic diversity among the *Dendrobium* varieties was studied using Mahalanobis D^2 analysis. The fifteen varieties were grouped into three clusters.

Molecular characterization of the varieties was carried out using RAPD technique. The DNA yield varied from 120 to 225 ng ml⁻¹. The primers OPA-19, OPB-02, OPB-04 and OPB-10 yielded good resolution bands out of 40 decamer primers tested. These primers amplify 44 RAPD markers of which 39 were polymorphic and five were monomorphic. The similarity coefficients value of the varieties ranged

from 0.2667 to 0.8824. The genetic distance ranged from 0.1176 to 0.5806. The fifteen varieties got divided into six clusters on drawing a vertical line in the Dendrogram at a distance of 0.425.

A detailed descriptive blank of 24 *Dendrobium* varieties evaluated in the investigation was prepared.

Morphological and cyto-molecular characterization of *Dendrobium* Sw. cultivars

Name of student	: Krishnapriya, M.
Degree Programme	: Master of Science in Horticulture (2005)
Name of Major Advisor	: Dr. T. Sabina George
College	: College of Agriculture, Vellayani

The twelve *Dendrobium* varieties studied differed significantly for almost all the morphological characters. Significant differences were observed among the twelve *Dendrobium* varieties for shoot length, shoot girth, internodal length of shoots, number of flowers, number of stomata on the adaxial and abaxial surface of the leaves, vase life as well as fresh and dry weight of inflorescence.

High GCV and PCV were observed for shoot length, followed by leaf area, internodal length, length of inflorescence and number of flowers per inflorescence. The stomata on the surface of the leaf recorded ever highest GCV and PCV among all the characters. The shape of stomata ranged from oval to perfect round.

Highest heritability values was recorded for number of stomata on the upper surface of the leaf. The genetic advance percentage was found highest for length of flower column. In correlation studies, high positive phenotypic correlation was observed between number of flowers per inflorescence and length of inflorescence. The length of column had significant positive correlation with number of leaves, length of inflorescence, thickness of inflorescences and length of flower pedicel.

Ranking of the varieties were done based on the value of selection

indices. The variety V_8 ranked first among the 12 varieties used in the experiment and the lowest rank was for V_6 . So from the selection index values, the variety V_8 is the best one.

DNA isolated from the 12 varieties was subjected to RAPD analysis. Among the 31 decamer primers, 24 yielded amplification products.

Characterization of these varieties revealed that morphologically distinct and superior lines were genetically differentiable.

Standardisation of explant for *in vitro* propagation in *Dendrobium* spp.

Name of student	: S. Lakshmi Devi
Degree programme	: Master of Science in Horticulture (1992)
Name of Major Advisor	: Dr. P.K. Rajeevan
College	: College of Horticulture

In all the explants, surface sterilization using 0.1 per cent mercuric chloride for 10 minutes was found to be the best. The explants collected during April recorded the minimum rate of contamination and the maximum survival percentage. Axillary bud was found to be the ideal explant for enhanced release of axillary buds.

For *Dendrobium moschatum*, MS medium with the treatment combination of NAA 1.5 ppm + BA 1.0 ppm was found to be effective in influencing early bud initiation and elongation, but for *D. fimbriatum* and *D. noble*, VW medium containing NAA 1.5 ppm + BA 1.0 ppm was found to be the best. When the cultures were subjected to shoot proliferation, VW medium containing NAA 2 ppm + BA 3 ppm gave maximum number of shoots in *D. fimbriatum* (18.8), *D. moschatum* (10.8) and *D. nobile* (7.6).

Addition of CW (15%) into the basal proliferation medium increased the number of shoots in all the three species of *Dendrobium*.

For *in vitro* rooting, MS (half strength) medium containing IBA 4 ppm was found to be the best. Addition of sucrose at 1.5 per cent and AC at 0.10 per cent enhanced the rooting of the shoots produced *in*

vitro.

Of the various explants tried for somatic organogenesis (callus mediated), root segments (aerial as well as from culture) was found to be the best explant in initiating callus. In culture establishment, swelling of the explant was observed in modified VW medium containing NAA 4 ppm + BA 1 ppm. As regards callus induction, 2,4-D at 2.0 ppm in modified VW medium was found to be better for all the explants. Maximum callusing (CI = 240) was observed when in vitro roots were used as explant.

Standardisation of medium supplements for shoot proliferation in *Dendrobium*

Name of student : R. Sudeep
Degree programme : Master of Science in Horticulture (1994)
Name of Major Advisor : Dr. P.K. Rajeevan
College : College of Horticulture

Axillary buds of *Dendrobium nobile* were used as explants for inoculation. The explants were surface sterilized with 0.1% mercuric chloride for 10 minutes. Half strength MS medium and VW medium were employed for culture establishment and shoot proliferation.

Addition of cytokinin related substances viz., adenine and adenine sulphate did not have any significant influence on shoot proliferation in either of the media. Among the amino acid supplements tried, casein hydrolysate influenced multiple shoot production and leaf production in half strength MS medium. Coconut water increased the number of shoots in both half strength MS medium and VW medium. In VW medium length of shoot and number of leaves also were influenced.

Tomato juice in combination with NAA and BA produced the maximum number of shoots and leaves in half strength MS medium. Spathodea flower extract influenced shoot elongation in half strength MS medium. Banana pulp could significantly influence the shoot length and leaf number in VW medium alone.

The maximum survival percentage of the *in vitro* plantlets occurred when coconut husk was used as the potting media and when the plantlets were kept in the open. Among all the treatments tried, the best treatment for multiple shoot production was peptone 40 ppm + NAA 2.0 ppm + BA 5.0 ppm in VW medium which produced 16.67 shoots on an average. The longest shoot (5.53 cm) was produced by the combination of tomato juice 10 per cent + NAA 2.0 ppm + BA 5.0 ppm in VW media. The treatment that produced the maximum leaves (6.33) was tomato juice 5 per cent in VW media.

Micropropagation of *Phalaenopsis*

Name of student	: Jyothi Bhaskar
Degree programme	: Doctor of Philosophy in Horticulture (1996)
Name of Major Advisor	: Dr. P.K. Rajeevan
College	: College of Horticulture

Out of the different explants tried, response was shown by inflorescence stalk node, inflorescence stalk tip and pollinia collected from the field grown plants and apical bud, shoot node, basal portion, leaf and root of plantlets grown *in vitro*.

Maximum survival (40%) of nodal explants was recorded at the sterilant combination involving mercuric chloride (0.01%) for 30 min., streptomycin + penicillin (0.01%) for 90 min.

The $\frac{1}{2}$ MS liquid medium containing BA 5 ppm + NAA 2 ppm + 2,4-D 2 ppm + CW 15 per cent recorded the minimum number of days for nodal swelling and bud development.

Sucrose at 1.5 per cent level in the medium recorded the maximum number of shoots and leaves after 8 weeks of culturing. Thiamine - HCl increased the shoot and leaf number at 20 ppm level at the end of 8 weeks, whereas the presence did not favour the production of roots.

The time taken for callusing in pollinia was minimum (2.0 days) at BA 5 ppm + NAA 2 ppm + 2,4-D 2 ppm in $\frac{1}{2}$ MS medium containing 3 per cent sucrose.

Shoot and leaf number was maximum at $\frac{1}{4}$ MS medium containing BA 20 ppm + 2,4-D 2.5 ppm, whereas root production was maximum at BA 20 ppm + 2,4-D 5 ppm. As to the combined effect of BA, NAA and 2,4-D in $\frac{1}{4}$ MS medium, the combination BA 5 ppm + NAA 2 ppm + 2,4-D 2 ppm recorded the maximum number of shoots and leaves.

Peptone at 1000 ppm was found to influence favourably the induction of multiple shoots from *in vitro* shoots.

Sucrose at 1.5 per cent level recorded the minimum number of days for PLB development. With regard to PLB formation from shoot node, $\frac{1}{2}$ MS medium containing BA 5 ppm + NAA 2 ppm + 2,4-D 2 ppm recorded the minimum number of days for PLB development and maximum number of PLB's.

Light favoured plantlet development, multiple shoot formation and PLB formation from shoot node and *in vitro* root, whereas dark period favoured early development of PLB's from *in vitro* leaf, callusing and PLB proliferation.

The nutrient solution 30:10:10 (0.50%) and 17:17:17 (0.10%) recorded the highest survival percentage and growth after 12 weeks of planting out.

Standardisation of *in vitro* techniques for mass multiplication of *Aranthera* and *Dendrobium*

Name of student	: Sherly Kuriakose
Degree Programme	: Doctor of Philosophy in Horticulture (1997)
Name of Major Advisor	: Dr. S. Ramachandran Nair
College	: College of Agriculture, Vellayani

Variety Annie Black of the monopodial orchid *Aranthera* and five varieties of the sympodial orchid *Dendrobium* were subjected to the initial response studies Sonia - 17 (*Dendrobium*) and Annie Black (*Aranthera*) varieties were selected for detailed studies. Explants like

shoot apices, leaf segments, root segments, keikis, inflorescence stalk were used. Mercuric chloride 0.1 per cent for ten minutes was identified as an effective surface sterilant. The lowest rate of microbial contamination was observed from January to May.

Among the various explants tried culture establishment via enhanced release of axillary buds could be induced only from shoot apex explants of all the varieties. Culture establishment could be best induced in Vacin and Went basal medium.

Maximum shoot proliferation (35.33 shoots per culture) from shoot apex explants of Sonia-17 could be induced in half-strength MS basal medium supplemented with BA 2.5 mg l⁻¹, NAA 1.0 mg l⁻¹, sucrose 30.0 g l⁻¹, boiled and filtered coconut water 150.0 ml l⁻¹ and agar 6.0 g l⁻¹.

Among the *Dendrobium* varieties, only Sonia-17 responded to direct organogenesis. Of the various explants tried only the leaf base (from culture) could initiate direct organogenesis.

Direct organogenesis from the leaf base of *Aranthera* var. Annie Black could be initiated in half-strength MS basal medium supplemented with BA 3.0 mg l⁻¹, NAA 2.0 mg l⁻¹, sucrose 30.0 g l⁻¹, coconut water 150.0 ml l⁻¹, agar 6.0 g l⁻¹ in the presence of light.

In vitro flowering in Sonia-17 was observed when half strength MS basal medium supplemented with BA 2.5 mg l⁻¹ and sucrose 30.0 g l⁻¹, coconut water 150.0 ml l⁻¹ and agar 6.0 g l⁻¹ was left unincubated for 3-4 months.

In vitro regeneration of roots in Sonia-17 could be best obtained in half-strength MS basal medium (solid) supplemented with NAA 1.0 mg l⁻¹, sucrose 30.0 g l⁻¹, agar 6.0 g l⁻¹ in the presence of light.

Hardening the *in vitro* plantlets in a green house with misting facility recorded cent per cent survival.

The cost of production of a single orchid plantlet was found to be Rs. 3.68.

**Physiological aspects of *ex vitro* establishment of tissue cultured orchid
(*Dendrobium* var. Sonia 17) plantlets**

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The investigation was undertaken to elicit information on the physiological, morphological, biochemical, biometric and anatomical changes during *in vitro* propagule multiplication and *ex vitro* establishment in tissue cultured plantlets of orchids.

Net assimilation rate (NAR), relative growth rate (RGR) and photosynthetic rate were found to be high at 40 g/l of sucrose concentration whereas the transpiration rate decreased.

The maximum survival percentage of the *in vitro* plantlets occur when 40 g/l of sucrose incorporated in the rooting medium. This may be attributed to the influence of the sucrose concentration on morphological characters studied viz. plant height, number of leaves per shoot and number of roots per shoot. With regard to photosynthetic pigments an increase in the content of total chlorophyll, chlorophyll a, chlorophyll b and carotenoids occurred in plantlets treated with 40 g/l of sucrose. Also the protein content and carbohydrate content was maximum at the above sucrose level. The leaf area, root length, total fresh weight and dry weight of the plantlets maintained at 40 g/l of sucrose level were higher than other treatments. These effects ultimately lead to better survival percentage.

Triazole treatment of plantlets during planting out helped in better survival percentage. Regarding morphological characters, increasing concentration of triazole had negative influence on plant height.

However, plant height of normal green house grown plants were distinctively higher than tissue culture plantlets. With regard to number of leaves per shoot, triazole treatment showed significant effect only after 30 days of planting out, whereas the number of roots per shoot was very much influenced by triazole. The maximum number of roots was produced at 5 mg/l of triazole treatment and these effects in turn influenced higher survival percentage of plantlets.

Regarding the biochemical aspects total chlorophyll, chlorophyll a, chlorophyll b, carotenoids, protein and carbohydrate contents of plantlets treated with triazole (5 mg/l) were higher and found to be on par with that of green house grown normal plants towards the later stage. The plantlets treated with 5 mg/l of triazole were found to have higher leaf area, root length, root:shoot ratio, total fresh weight and dry weight than other treatments.

Among the different levels of light intensity and humidity plantlets grown at 50 per cent light intensity and 70 to 90 per cent relative humidity exhibited higher CGR, NAR and RGR. Also these plantlets exhibited a marked increase in photosynthetic rate and decrease in transpiration rate.

There was not much significant difference among the treatments of light and humidity in the case of pigment content. However the plantlets grown in the hardening chamber maintained at 50 per cent light intensity and 70 to 90 per cent of relative humidity recorded maximum value of total chlorophyll, chlorophyll a, chlorophyll b and carotenoids among treatments and the normal green house grown plants exhibited distinctively higher pigment content.

The *in vitro* plantlets observed to have anatomical characters as compared to the normal green house grown plants and hardened plantlets. The stomata remained open and less number of stomata per unit area of leaf was observed as the *in vitro* leaves were concerned. Another peculiarity of the *in vitro* plantlets was the absence of cuticle layer. The mesophyll layers were also found to be less compared to normal plantlets. These anatomical characters were one of the severe limitations of the micropropagated orchid plantlets during *ex vitro* establishment which ultimately resulted in high rate of field mortality.

Micropropagation of *Dendrobium* hybrids

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Among the various explants tried, stem nodal segment responded well showing early PLB differentiation. Since leaf segment and inflorescence axis did not respond even after 45 days of inoculation, they were abandoned and stem nodal segment explant alone was carried forward for further trials. Out of the different basal media tried with stem nodal segment explant, VW medium exhibited early culture establishment and rapid PLB development.

Different levels of the hormone combination, BA and NAA tried showed that BA 2.0 mg l⁻¹ + NAA 2.0 mg l⁻¹ responded with the earliest plantlet development, but number of shoots produced was more in BA 8.0 mg l⁻¹ + NAA 8.0 mg l⁻¹. Combination of BA and IAA at different levels showed that BA 2.0 mg l⁻¹ + IAA 4.0 mg l⁻¹ produced plantlets in a minimum number of days. Number of shoots was maximum in BA and IAA each at 8.0 mg l⁻¹.

In the combination of KIN and NAA tried at different levels, earlier plantlet development was observed in 2.0 mg l⁻¹, each, of the auxin and the cytokinin and the number of shoots produced was highest in 8.0 mg l⁻¹, each, of KIN and NAA. Among the different levels of KIN and IAA combination tried, 4.0 mg l⁻¹, each, of KIN and IAA was found to be the best for rapid plantlet development. Number of shoots produced was highest in the combination KIN 6.0 mg l⁻¹ and IAA 2.0 mg l⁻¹.

Out of the three levels of CW tried, that at 200 ml l⁻¹ was observed to be the best in terms of early plantlet development and the production of more number of shoots. *In vitro* rooting of microshoots was the best in half strength MS medium supplemented with IBA 2.0 mg l⁻¹. Addition of AC did not produce any significant effect on root development.

Standardization of growing media for dendrobium (*Dendrobium* spp.)

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Four species of *Dendrobium*, viz., *D. farmeri*, *D. fimbriatum*, *D. moschatum* and *D. nobile* were used for the study.

Maximum number of shoots was produced in the medium charcoal + gravel.

The medium gravel + coconut fibre could favourably influence the height of the shoots throughout the growing period of *D. moschatum* and *D. nobile*.

Gravel + fibre recorded the highest number of leaves. Gravel + coconut husk the maximum leaf area was recorded throughout the growing period.

The medium gravel + fibre produced consistently high number of pseudobulbs.

In the media gravel + fibre and charcoal + brick + husk, the survival was 100 per cent. In respect of the species, mortality was zero in *D. moschatum*, when considered irrespective of the treatments, indicating the species to be the hardiest among the four species tried.

As to the economics of the media, gravel was the cheapest. The media with superior performance, like gravel + fibre, gravel + husk and brick + gravel costed Rs.0.77, Rs.0.80 and Rs.0.49, respectively, per pot.

Performance of selected orchids under varying light regimes, culture methods and nutrition

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In *Arachnis* Maggie Oei 'Red Ribbon', trench culture was found to promote growth, flowering and the floral attributes.

The trench grown plants under 50 and 75 per cent light had a greater number of leaves and leaf area. The plants receiving 500 ppm of P and K under 100 per cent light had a shorter stature. The direct effect and interactions of nutrients on growth were observed at certain months during the experimental period which was indicative of differences in the requirement at different stages of growth. The dry matter content of the stem and apical shoot was greater in the plants receiving 500 ppm P.

Inflorescence production and the vase life of inflorescences was greater under 100 and 75 per cent light. Branching of inflorescences was greater under 75 per cent light.

In *Dendrobium* Sonia-16 the number of inflorescences produced was greatest under 75 per cent light. The length of the inflorescences was greater under 75 per cent light and the span area of the flowers was greater under 50 and 75 per cent light. Nitrogen at 500 ppm increased the length of the inflorescences, the number of flowers in an inflorescence, and the span area of the flowers. The number of inflorescences produced was also greater in the plants receiving 400 or 500 ppm N, 400 or 500 ppm K and in those receiving 500 ppm P.

Interactions between the nutrients and between light intensities and the nutrients were also observed.

The nutrient composition of the leaves in both the cultivars was enhanced by the 400 and 500 ppm doses of N and P and 500 ppm K.

Based on the observed effects, in *Arachnis* Maggie Oei 'Red Ribbon', trench culture of plants under 75 to 100 per cent light and a nutrient dosage of 300 ppm N, 400 ppm P and 300 ppm K from planting till 9 MAP and thereafter a dosage of 400 to 500 ppm N, 400 ppm P and 500 ppm K can be recommended. In *Dendrobium* Sonia-16 growing in pots under 75 per cent light with 400 to 500 ppm of N, P and K can be recommended.

Nutrition of tissue - cultured plants of *Dendrobium* Sonia - 17

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Nitrogen at 6.0 mg per plant increased the plant height, number of leaves, leaf area, number of backbulbs and length of roots. Up to 90 DAP 2.0 mg of N found to increase the stem girth and after that 6.0 mg found to be favourable. Number of roots was greater with 2.0 mg of N. Phosphorus had less influence on growth. 6.0 mg of P increases, the stem girth and number of backbulbs at early stages. Potassium at 2.0 mg had influence on the plant height, number of leaves, number of backbulbs and number of roots. Interaction between the nutrients was also observed.

Nitrogen and Phosphorus at 6.0 mg influenced the fresh weight and those at 10.0 mg the dry weight. The nutrient composition of the plants was enhanced by 10.0 mg of N, 6.0 mg of P and 10.0 mg of K.

Based on the observed effects of nutrition on *Dendrobium* Sonia-17 plants, a nutrient dosage of 2.0 mg each of N, P and K from three to six months age of *ex vitro* stage, 6.0, 2.0 and 2.0 mg of N, P and K from six to nine months age, 6.0 mg of N, 2.0 to 6.0 mg of P and 2.0 mg of K from nine to twelve months age can be recommended. For plants above one year age a dose of 6.0, 6.0 and 2.0 mg of N, P and K can be recommended for maximum vegetative growth.

Regulation of growth and flowering in *Dendrobium* var. *Sonia* 17

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Plant height was significantly superior with the combination of NPK 30:10:10 at 0.2 per cent applied weekly twice. Among the other vegetative characters, number of shoots, number of leaves, total leaf area and biomass progress were superior with the combination of 30:10:10 NPK at 0.2% GA 200 ppm, applied weekly twice.

The contents of N, P, K, Ca and Mg with higher nitrogen levels and frequencies coupled with IAA 250 ppm (for N, P, K and Mg), IAA 500 ppm (for P and K), BA 200 ppm (for Ca). In the case of micro-nutrients (Cu, Fe, Zn and Mn), lower levels of nitrogen at higher frequencies, in combination with IAA 500 ppm, recorded higher values.

Uptake of N, P and K was the highest with the combination of NPK 30:10:10 at 0.2 per cent, applied weekly twice + BA 200 ppm (11.73 g, 2.71 g and 19.50 g, respectively). Uptake of P was on par for IAA 500 ppm, with the above level of nutrients.

Earliest flowering (300 DAP) was recorded in plants which received at treatment combination of NPK 30:10:10 at 0.2 per cent, applied weekly twice + BA 200 ppm followed by NPK 20:10:10.

Nutrients, their frequency of application and growth regulators markedly influenced flower yield and quality. A combination of NPK 10:20:10 at 0.2 per cent, applied weekly twice + BA 100 ppm recorded the maximum number of spikes per year (12.98 cm) and number of florets per spike (10.50). Spike length was significantly superior (55.40 cm) for NPK 10:20:20 at 0.2 per cent, applied weekly twice + GA₃ 20 ppm. Longest stalks (30.10 cm) were produced at the same level of nutrients, coupled with BA 100 ppm.

Various pulsing and holding treatments and their combinations significantly influenced the post harvest behaviour of spikes. Among the pulsing treatments, minimum loss of weight (0.93 g) of spikes was recorded when kept in HQ 500 ppm + sucrose 5 per cent for 6 hours. Spikes took the longest time (19.92 days) for the wilting of one floret (vase life) when pulsed with HQ 500 ppm + sucrose 5 per cent for 12 hours. Final EC (2.13 mS g⁻¹) and water uptake (19.99 ml) were the highest in hot water dip treatment at 50°-60°C for 10 seconds. Days to wilt of the last floret was the highest (25.00 days) when treated with HQ 500 ppm + sucrose 5 per cent for 12 hours.

Minimum loss of weight of spike (0.13 g), maximum days to wilt of the last floret (30.50 days) and maximum vase life of spike (24.73 days) were recorded by the holding treatment containing AgNO₃ 50 ppm + HQ 400 ppm + sucrose 5 per cent. Maximum EC (3.75 mS g⁻¹) was recorded for Triadimefon 20 ppm. Difference between initial and final EC was maximum (0.11 mS g⁻¹) for AgNO₃ 50 ppm + HQ 400 ppm + sucrose 5 per cent. Water uptake was highest (19.50 ml) in AgNO₃ 25 ppm + sucrose 5 per cent.

Pulsing and holding treatments, in combination, gave significant differences in post harvest characters. Minimum weight loss (0.07 g) was observed when pulsed with HQ 500 ppm + sucrose 5 per cent for 12 hours and kept in the holding solution containing AgNO₃ 50 ppm + HQ 400 ppm + sucrose 5 per cent. Final EC (0.28 mS g⁻¹) of holding solution was the highest for the combination of pulsing treatment of HQ 500 ppm + sucrose 5 per cent for 12 hours and holding treatment of quality more treatments with combinations of GA₃ and BA can be studied.

Endogenous and exogenous regulation of growth and development in *Dendrobium* var. Sonia 17 and Sonia 28

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

The stomatal frequency was higher in Sonia 28 whereas the stomatal size was more in Sonia 17. Increased dry weight was recorded in the third stage (keiki formation) in Sonia 17. The total phenolic content was significantly higher in Sonia 28 during the fourth stage (senescence of spike).

Studies on exogenous factors revealed that Greencare (13:27:27) at 0.2 per cent level improved the in number of leaves in Sonia 28. The stomatal density and size were significantly influenced by the treatments in both the varieties. Specific leaf weight also varied significantly during Stage I (emergence of the shoot) in both the varieties.

The concentration of nitrogen was significantly influenced by the treatments at the shoot emergence stage, in Sonia 17 only. The concentration of phosphorus was not influenced by the treatments and that of potassium differed significantly among the treatments during both the stages in both varieties.

The highest uptake of nitrogen was recorded in the treatment involving 1:10 groundnut oilcake during shoot emergence stage, in both the varieties. During spike emergence, the highest uptake was caused by 500 mg l⁻¹ BA in Sonia 17 and 1:10 groundnut oilcake in Sonia 28. In Sonia 17, the highest value of P during both the stages was recorded in plants treated with 0.1 per cent Greencare. In Sonia 28 the highest uptake of P at both the stages was with the treatment 1:10 groundnut oilcake. In Sonia 17 the highest K uptake was with 1:20 groundnut oilcake during the emergence of shoot while during the emergence of spike the highest uptake was with 0.1 per cent Greencare. In Sonia 28, during the emergence of shoot, the highest uptake of K was with a combination of 0.1 per cent Greencare + 1:10 groundnut oilcake whereas during the emergence of spike the highest value was recorded in plants receiving 1:10 groundnut oilcake alone.

The chlorophyll and total phenolic content differed significantly in the two varieties during both the stages of growth. In Sonia 17, Greencare significantly improved the chlorophyll content at both the stages. In Sonia 28, maximum chlorophyll content during the emergence of shoot, was recorded in plants receiving 0.1 per cent

Greencare, whereas, during the emergence of spike 1:20 groundnut oilcake recorded the highest value. In Sonia 17, the total phenolic content at the emergence of shoot was produced by 1:10 groundnut oil cake + 0.1 per cent Greencare + 250 mg l⁻¹ BA and during spike emergence, by a combination of 0.1 per cent Greencare + 250 mg l⁻¹ BA. In Sonia 28, at the emergence of shoot, the highest phenolic content was recorded by 500 mg l⁻¹ BA and during the emergence of spike, by 1:10 groundnut oil cake.

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

Standardisation of shade requirement in *Dendrobium*

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Different levels of shade significantly influenced the morphological characters of the plant, viz., plant height, shoot production, internodal length, leaf production and leaf area. Maximum plant height was obtained for fifty per cent double level shading. With respect to shoot production, 25 and 35 per cent double levels of shade performed better. The length of the internode was maximum for 50 per cent double level shading. Highest leaf production was noticed in 35 per cent and 50 per cent double levels of shading.

Flower quality and flower production were markedly influenced by shade. 25 per cent single level shading was found to be good for earliness in flowering and high vase life and 25 per cent double level shading increased the spike production. Single level shading of 50 per cent produced the longest spike and increased the longevity of spike on plant. Double level shading at 50 per cent produced spikes of maximum length, high vase life, high longevity of spike on plant, maximum number of flowers per spike, the maximum anthocyanin content of the flowers and the highest content of chlorophyll 'a' in the leaf. Total chlorophyll and chlorophyll 'b' were the maximum under 35 per cent double level shading.

Dry matter accumulation was maximum under 25 per cent double level shading. Nutrient content within the plant indicated an influential effect of shade. Total nitrogen and phosphorus content were maximum in fifty per cent double level shading. Thirty five per cent single level shade had maximum potassium content. A similar trend was observed in the uptake of nutrients also.

Supplementary effect of biofertilizers in *Dendrobium*

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The study was conducted using *Dendrobium* var. Sonia 17, with the main objective of determining the effect of biofertilizers on growth and flowering in combination with inorganic fertilizers.

Different treatments involving combinations of biofertilizers and inorganic fertilizers highly influenced the growth characters of the plant. The plant height obtained was the highest for NPK 10:5:10 along with *Azospirillum*. This treatment also improved vegetative characters like number of leaves per plant, number of leafy shoots, girth of shoot and internodal length. Maximum number of pseudobulbs was obtained for the treatment receiving NPK 10:5:10 inoculated with *Azospirillum* and phosphobacteria at the time of planting.

Root characters and dry matter production were markedly influenced by biofertilizer treatment. Plants which were inoculated with *Azospirillum* at the time of planting and sprayed with 20:10:10 NPK at 0.2 per cent concentration, came to flowering early, produced larger flowers, lengthy spikes and more number of flowers per spike. Number of spikes per plant, colour variation, spike internodal length, pedicel length and longevity of spike on the plant were not found to be influenced by biofertilizer application. Significant incidence of pests and diseases were not noticed during the period under study.

Nutrient content in the plant was found to be high when inoculated with, both the biofertilizers, *Azospirillum* and phosphobacteria and sprayed with 20:10:10 NPK at 0.2 per cent concentration.

The microbial population estimated at the post-experimental stage recorded the presence of *Azospirillum* and phosphobacteria even after 12 MAP in soil less media but AMF spores were found to be absent.

Enhancement of postharvest life of

Dendrobium flower

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The conditioning treatments, pulsing and use of holding solutions significantly influenced the vase life of *Dendrobium* varieties. The best conditioning treatments were tap water altered to pH 3.0 (T_4) and 3.5 (T_5) which recorded a vase life of 20.67 days and 19.67 days, respectively. Irrespective of the treatments the fresh weigh of the inflorescences increased upto the fourth day and by the seventh day a decline proceeded upto the cessation of vase life. So also the flowers were found to maintain their maximum length and width upto the seventh day of the vase life period. Pulsing with a combination of 4% sucrose and 400 ppm 8-HQ for six hours was found to result in the highest vase life of 21.33 days in packed inflorescences subjected to a period of transport and transit (simulated) for 24 hours.

The freshly harvested inflorescences conditioned for two hours in tap water of pH 3.0 were subjected to the holding solution treatments. Vase life was the highest (26 days) in 6% sucrose + 300 ppm 8-HQ + 20 ppm $AgNO_3$. In the conditioned and pulsed inflorescences subjected to the stimulation of transit and transport for 24 hours followed by treatment in holding solutions, the vase life was the highest in 2%

sucrose + 400 ppm 8-HQ + 30 ppm AgNO₃. The sucrose concentration of the treatments which resulted in a high vase life was generally lower for the pulsed flowers when compared to the non-pulsed flowers of experiment. In both the groups, irrespective of the treatments, changes in flower structure measured as changes in the maximum length and width of the flowers, were noticed during the vase life period.

The applicability of these results with the cultivars namely, *Dendrobium* Mary Trowse, *D. Candy Stripe* and *D. Walter Oumae* was studied. The vase life of all the varieties was increased by the treatments.

The electrical conductivity of the holding solutions was not observed to be in the detectable range during the vase life period. Spike bending was not observed in *Dendrobium* Sonia and other varieties. The petal colour variations irrespective of the treatments recorded from the start to the cessation of vase life showed that in the coloured cultivars, namely, *Dendrobium* Sonia, *Dendrobium* Mary Trowse and *Dendrobium* Candy Stripe, the petal colour deepened before browning, while in the *Dendrobium* Walter Oumae, in the absence of colouring pigments, the loss of white colour and the onset of browning was gradual.

Biology and management of orchid pests

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In a survey conducted during 1996-97 in Kerala to study the various pests associated with orchids with reference to their biology, morphology, nature of damage and preliminary management studies on the selected pests, a total of thirteen pests were recorded. The grasshopper, *Oxya chinensis* (Thunberg); spiraling whitefly, *Aleurodicus disperses* Russell; bihar hairy caterpillar, *Diacrisia oblique* Walker; were recorded from the leaves of *Spathoglottis* spp.

the larvae and adult of *Megalurothrips distalis* Karny was found infesting the buds and flowers of *Dendrobium* spp. and *Spathoglottis* spp. resulting in the distortion of buds and flowers. The tobacco caterpillar, *Spodoptera litura* F. was recorded from the flowers of *Spathoglottis* and *Dendrobium* spp. The ant, *Monomorium indicum* Forel was recorded to damage the roots of the plants. An unidentified species of *Lema* was recorded damaging the flowers of *Spathoglottis* spp. and *Epidendrum* spp. The grubs and adults of an unidentified curculionid was reported to cause considerable damage to *Dendrobium* spp. by feeding on the pseudobulbs. The banded blister beetle *Mylabris pustulata* (Thunberg) was found as an occasional feeder of *Spathoglottis* spp.

The other pests observed during the survey were sowbug, *Oniscus asellus* L., land snail *Ariophanta* sp., black slug, *Arion* sp. and grey slug, *Limax* sp.

During the studies on the morphology and biology of *M. distalis*, the eggs were found to be bean shaped and the immature stages can be differentiated by the presence of wing pads or wing sheaths and antennal sheaths. The females inserted the eggs in the tissues of the petals and the whole life cycle ranged from 17-32 days.

Among the insecticides tested, quinalphos brought the highest mean mortality of the nymphs of *A. disperses* (48%). In the case of slugs, 5 per cent metaldehyde bait and metaldehyde mixed carbaryl bait (2.5-2.5%) gave the highest mean mortality of 44.44 per cent within 24 hrs of treatment. Treatment with 1 g phorate showed the highest mean mortality of 66.67 per cent after 48 hrs of treatment.

Induced chemical mutagenesis in rose under *in vitro* culture

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Surface sterilization of axillary buds was found to be most successful with mercuric chloride at 0.08 per cent for 15 minutes. Of the various levels of hormonal combinations tested BAP 2 mg l⁻¹ + 2,4-D 1 mg l⁻¹ was found to be the best for culture establishment and BAP 2 mg l⁻¹ + GA 1 mg l⁻¹ for shoot proliferation. Maximum rooting was obtained in full strength MS medium supplemented with IAA 2 mg l⁻¹. Of the two methods of mutagen treatments tried direct treatment of axillary buds with EMS was not effective.

In the cotton swab method, lower concentrations of EMS (0.125 and 0.250%) gave better performance based on days taken for bud take, multiple shoot production and rooting percentage. Higher concentration of EMS (0.375 and 0.500%) curbed multiple shoot production in buds excised at the time of flower harvest. Increase in maturity of buds also delayed multiple shoot production and decreased rooting percentages. Buds excised at the time of flower harvest was found to be the best. The experiment clearly demonstrated that induced mutagenesis in rose can be successfully done adopting *in vitro* culture techniques.

Induced mutagenesis in rose under *in vivo* and *in vitro* culture

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Induced mutagenesis adopting *in vivo* method was carried out with three rose cvs. Alliance, Suraga and Folklore belonging to Hybrid Tea group. Folklore alone was utilized for induced mutagenesis adopting *in vitro* culture.

Gamma irradiation of bud woods induced inhibition and reduction in sprouting and survival. Growth retardation exhibited in the form of reduction in plant height and number of branches. The cultivars showed no significant interaction with different doses of gamma rays for sprouting and survival. The LD_{50} was estimated as 38 Gy.

One reddish yellow mutant was isolated from cv. Folklore from 30 Gy treated population and one mutant for increased number of petals from 40 Gy treated population of the same cultivar. In addition, gamma exposure induced variation in size and shape of leaves at 30 and 40 Gy.

The treatment of mercuric chloride 0.08 per cent for 12 minutes had the minimum contamination rate for shoot tip and axillary bud explants, and 0.06 per cent for 12 minutes was most effective in the case of internodal segments and leaf disc explants.

Axillary buds excised 4 days after flower opening had the best response in culture establishment. Early multiple shoot induction and highest number of shoots/culture were observed in medium supplemented with kinetin 2.0 mg l^{-1} + GA_3 1.0 mg l^{-1} . Addition of BAP 2.0 mg l^{-1} + GA_3 0.75 mg l^{-1} was the best for getting highest percentage of cultures with multiple shoots. Flower bud initiation was observed in combination of BAP 2.0 mg l^{-1} + GA_3 0.5 mg l^{-1} .

The best medium for *in vitro* rooting was found to be IAA and NAA 1.0 mg l^{-1} , each, along with activated charcoal 500 mg l^{-1} . Successful hardening and *ex vitro* establishment of plantlets were achieved by surface inoculation of germinated spores of mycorrhizae (VAM) in liquid suspension.

A combination of BAP 0.5 mg l^{-1} + NAA 2.0 mg l^{-1} + 2,4-D 0.5 mg l^{-1} was the best for callus induction and BAP 0.5 mg l^{-1} + NAA 0.1 mg l^{-1} + ascorbic acid 5 mg l^{-1} had the highest callus proliferation.

In vitro rhizogenesis was obtained from internodal and leaf calli in MS medium supplemented with BAP 0.5 mg/l + NAA 2.5 mg/l + 2,4-D 0.5 mg/l .

Gamma irradiation of axillary buds delayed bud break, reduced percentage of bud break, multiple shoot production and rooting efficiency and also induced morphological variations in leaf and growth pattern. The estimated value for LD_{50} was 33 Gy under *in vitro* culture.

Exposure of multiple shoots to gamma rays induced several morphological abnormalities and reduced the shoot production and rooting efficiency.

Effect of nutrition on the establishment and bud take in budded roses

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The effect of three major nutrients (nitrogen, phosphorus and potassium) on the bud take and further vegetative growth and flowering has been proved by this study. All treatments caused an increase in the girth of the root stock at the time of budding. Application of nutrients greatly prolonged the retention of petiole. A treatment combination of 0.75 g N: 0.75 g P₂O₅: 0.25 g K₂O was effective in promoting early bud take. The emergence of leaves was found to be influenced by various treatments significantly. A treatment combination of 1.0 g N: 0.75 g P₂O₅: 0.25 g K₂O was proved effective in the early emergence of leaves. The maximum height of the plants was observed under a treatment with 1.00 g N: 0.75 g P₂O₅: 0.25 g K₂O. During initial stages a lower dose of potassium was found sufficient to enhance the height of plants. But afterwards a higher dose was needed to increase the height significantly.

Nitrogen and potassium, alone and in combination, were effective in the early induction of first flower bud. But phosphorus was effective only when combined with nitrogen and potassium. The best combination was found to be 0.75 g N: 0.75 g P₂O₅: 0.75 g K₂O. A higher dose of nitrogen delayed flower opening.

Effect of season and position of bud in budding of rose

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There was no significant difference among the three varieties, 'Ambassador', 'Pink Panther' and 'Princess' in respect of success in budding. A high rate of 82-98 per cent success was recorded during the rainy season of second fortnight of August to first fortnight of October. The period from first fortnight of February to second fortnight of March was the least favourable season. Higher temperature was found to be detrimental for the success in budding. Rainfall and relative humidity favoured the bud take. More sunshine hours was detrimental. The preceding, current and succeeding fortnights of budding, were found to be critical, as far as success in rose budding was concerned.

The period of budding significantly influenced the biometric characters under study. The variety and bud position was found to exert significant influence on some of the biometric characters. The first and second buds were early to sprout and flower till the production of first flower bud, but the plants were comparatively weak. The fourth and the fifth buds were found to be better for budding when plant vigour was considered. Correlations were worked out between the thirteen biometric characters under study. The scion C/N ratio significantly influenced the bud take while the rootstock C/N ratio did not significantly influence the take. The carbohydrate and nitrogen content varied significantly throughout the year and with scion bud position and variety.

Effect of split application of N, P & K on the growth and flowering of rose cv. Happiness

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The effect of split application of N, P and K on the growth and flowering of rose plants was studied. Higher levels of K application increased the number of flowers produced, whereas higher levels of N reduced the flower yield. Maximum number of flowers was recorded by treatment with 10 g N: 30 g P: 10 g K applied at 30 days interval. The longest flower shoot was produced by the treatment combination of 20 g N: 30 g P: 5 g K applied at 45 days interval. All the treatments resulted in an increase in thickness of the flower shoot, and also the number of leaves in the flower shoot.

Diameter of the flower was found to increase significantly with increase in N level. The treatment with 20 g N: 15g P: 10 g K applied at 15 days intervals recorded the maximum diameter of the flower. The treatments were not effective for increasing the petal number compared to control. Opening of the flower bud was delayed by an increase in the level of phosphorus and also by the application of fertilizer at longer intervals. The treatment combination of 10 g N: 45 g P: 15 g K applied at 45 days interval recorded the maximum value for the flower life.

Diameter of the flower was seen to be highly correlated with nitrogen application. Phosphorus application showed highest correlation with the mean life of flower. All the biometric characters under the study showed highly significant positive correlation among themselves and also with the application of potassium.

TUBEROSE

Bioecology and control of pests of rose

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The distribution of the major insect and mite pests of rose in Trivandrum taluk and the damages caused by them were studied in a survey adopting standard sampling techniques. The results of the survey revealed that the major pests of rose in the area were the thrips, *Rhipiphorothrips syriacus*, *Scirtothrips dorsalis*, the scale *Aonidiella aurantii*, the leaf feeding beetles *Adoretus* spp. and the mites, *Tetranychus neocaledonicus* and *Tetranychus cinnabarinus*.

The mean levels of population/damage found during the period of the survey showed that *T. neocaledonicus* was the most important pest in all the locations followed by *Adoretus* spp., *Aonidiella aurantii*, *Rhipiphorothrips syriacus*, *Scirtothrips dorsalis* and *Tetranychus cinnabarinus*.

An overall assessment of the seasonal incidence of the pests revealed that the thrips and mites were seen in serious proportions causing drying and withering of leaves during the months of December to May and the beetles caused defoliation from November to January whereas the scale insect was seen damaging the plants throughout the year.

The experiments on chemical control of pests of rose showed that monocrotophos, dimethoate or fenthion at 0.05 per cent spray was effective in controlling the different species of pests. But in the case of flower bud damage caused by *Scirtothrips dorsalis*, a higher concentration of 0.1 per cent of the insecticides was necessary for getting proper control.

***In vitro* multiplication and genetic improvement of tuberose (*Polianthes tuberosa* Linn.)**

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In both direct and callus mediated regeneration, the ideal explant source was found to be the scale stem sections from bulbs and in somatic embryogenesis, inflorescence segments containing immature flower buds were the ideal.

Protocol for the rapid multiplication was standardized. MS medium supplemented into BAP 6.0 mg l⁻¹ + KIN 4.0 mg l⁻¹ was found to be better for release and high rate of multiple axillary buds in all the varieties. For elongation of multiple axillary buds, MS medium of half strength derived of growth regulators was the best. Maximum number of roots were produced in MS medium supplemented with IBA 4.0 mg l⁻¹ + 0.2 per cent activated charcoal.

Survival was maximum when planted out in disposable cups containing cocopeat under mist chamber.

Direct organogenesis was obtained from immature inflorescence segments in MS medium supplemented with NAA 0.2 + BAP 2.0 + KIN 1.0 to 3.0 mg l⁻¹. The inflorescence segments containing immature flower buds was the most ideal for callus mediated organogenesis. Callus index was maximum in MS medium supplemented with NAA 15.0 to 20.0 mg l⁻¹ + adenine sulphate 10.0 mg l⁻¹.

Gamma rays at 15 Gy and 20 Gy and EMS at 1.0 and 2.0 per cent were the most effective mutagens. Nine mutants were obtained and they retained the characters in VH₂ generation.

High estimate of heritability coupled with high genetic gain were noticed for characters like number of flowers per spike, spike length, flower diameter, leaf length and leaf width.

Isozyme analysis revealed the difference in banding pattern of esterase, peroxidase and catalase between parents and mutants.

Regulation of growth and flowering in Tuberose

Polianthes tuberosa Linn.

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The treatments, in general, significantly influenced all the vegetative characters, duration, most of the spike characters and yield of bulbs and bulblets in one season or the other.

Both nitrogen at 30 g m⁻² as well as GA₃ at 50 and 100 ppm gave maximum plant height in both the seasons. Nitrogen 20 g m⁻² and GA₃ 100 ppm produced maximum number of leaves, followed by ethrel 50 ppm. In number of tillers, nitrogen 30 g m⁻² caused a significant increase. Increasing rate of applied nitrogen and GA₃ at 100 ppm reduced the days required for the emergence of spike. The effect of GA₃ 50 ppm and IAA 25 ppm were also found to be significantly superior. Nitrogen 20 and 30 g m⁻² as well as GA₃ 50 and 100 ppm were superior in increasing the spike length. The longest rachis was obtained with nitrogen at 30 g m⁻² and GA₃ 50 ppm.

Among the nutrients, nitrogen and among bioregulators GA₃ 100 ppm increased the number of florets per spike and the longevity of individual floret on a spike.

Nitrogen application, GA₃ 50 ppm and IAA 25 ppm reduced the total crop duration. Among the bioregulators GA₃ 50 ppm and among nutrients nitrogen at 20 and 30 g m⁻² recorded the maximum fresh weight of spike.

GA₃ 100 ppm took minimum days in vase for opening compared to control. Higher doses of nitrogen increased the number of days for floret opening. Time for complete opening of florets in vase were the shortest and the number of florets opening at a time was the maximum with GA₃ 100 ppm.

Higher doses of nitrogen as well as IAA 25 ppm were able to enhance the vase life, followed by GA, 50 and 100 ppm.

Nitrogen and phosphorus at 20 g m⁻² and 15 g m⁻², respectively, were responsible for increased weight of bulbs and bulblets per hill. Bioregulators did not influence this character significantly.

Nitrogen and potassium content of the leaves increased with increasing levels of respective fertilizers while the application of phosphorus did not influence the leaf phosphorus content.

Regulation of flowering and post harvest behaviour of tuberose (*Polianthes tuberosa* L.)

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The treatments, in general, significantly influenced all the morphological, floral and bulb characters.

The height reduction was found to be maximum with paclobutrazol 100 ppm applied at 60 DAP and 200 ppm applied 30 DAP. Highest plant spread was given by CCC bulb dip treatment. Paclobutrazol and BA bulb dip caused a significant increase in the number of leaves. Bulbs dipped in CCC 1000 ppm, BA 50 and 100 ppm produced longer leaves, when compared to control. Maximum tiller production was noticed in bulbs treated with CCC 1000 ppm. But, in the later stages of growth, BA 50 ppm applied 60 days after planting gave more tillers.

Paclobutrazol applied 60 DAP, reduced the days required for the emergence of spike and 200 ppm applied 60 DAP recorded earlier floret opening, while, BA showed delayed opening.

Longer spikes were produced by BA treatments. The longest rachis was obtained with paclobutrazol 200 ppm applied at flowering. In the case of number of florets per spike, paclobutrazol applied as bulb dip was found to be the best. Size of the floret was improved by the

paclobutrazol applied at flowering. Petiole length was increased by BA 100 ppm applied at 60 DAP. Longevity of floret in the field was not affected significantly by the treatments.

Bulb size was improved by BA 50 ppm applied at flowering. Treatment with CCC 500 ppm resulted in more number of small sized bulbs and bulblets, while, the weight of bulb was found to be more with plants treated with BA 50 ppm 60 DAP. Bulblet size was more in plants treated with paclobutrazol 100 ppm 30 DAP and weight of bulblets was maximum with BA 50 ppm bulb dip treatment.

Treatment with 8 HQS 250 ppm, pulsing solution took maximum days for complete opening of florets. Total water uptake was found to be maximum in spikes, pulsed with AgNO_3 100 ppm. Vase life was the maximum with AgNO_3 50 ppm pulsing. Minimum electrolyte leakage was noted with AgNO_3 100 ppm.

Fresh weight of the spike was found to be maximum with pulsing solution sucrose 15 per cent and holding solution sucrose 4 per cent. Maximum number of days taken for each floret to open was recorded by 8 HQS 500 ppm and 400 ppm. Spikes in AgNO_3 100 ppm and sucrose 2 per cent took maximum days for complete opening of florets. Number of florets opened at a time, was more with 8 HQS 400 ppm. Total water uptake was significantly influenced by pulsing with sucrose 10 per cent and kept in holding solution AgNO_3 0.25 mM. Vase life was more in spikes pulsed with AgNO_3 50 ppm and put in holding solution AgNO_3 0.25 mM. Minimum electrolyte leakage was recorded with 8 HQS 500 and 400 ppm.

FOLIAGE PLANTS

Evaluation of tropical plant species for use as cut foliage

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In the field conditions the species exhibited wide variation in their growth pattern and leaf characters. Maximum plant height was observed in *Asparagus setaceus*, a twiner, while the maximum spread was recorded in *Schefflera arboricola*, a shrub and *Nephrolepis cordifolia*, a fern. Leaf length was maximum in *Nephrolepis exaltata* while the leaf breadth and petiole length were maximum in *Cyperus alternifolius*. *Philodendron wendlandii* recorded maximum petiole girth. Maximum leaf production was in *Scirpus cernuus*. Leaf area recorded was maximum in *Monstera deliciosa* while *Schefflera arboricola* and *Nephrolepis exaltata* recorded the maximum longevity and maximum interval of leaf production, respectively. The qualitative characters of the species differed in all respects and a wide range of shape, texture, margin and pigmentation could be observed.

In the post harvest evaluation for use as cut foliage, the pulsing treatments were on par and among the holding solutions, distilled water and acidified water proved to be the best, thus eliminating the use of chemicals. Scoring of foliage projected *Asparagus setaceus* to be the best in terms of all the characters of colour/pigmentation, shape/pattern, size and texture. The combinations indicated a significantly higher vase life of the different species in a combination of any pulsing treatment with a holding solution of either tap water or distilled water. Catalase activity reduced in the foliage when treated with hot water and increased when treated with tap water. Foliage kept in acidified water after hot water dip showed an increase in the activity. A lesser increase in pH was seen treatment, whereas EC increased to a greater extent in the most inferior treatment. Storing at a lower temperature of 17°C proved to be better for prolonging the vase life of the foliage species, compared to ambient temperature. Packing with a wet cotton plug at the petiole end increased the vase life of the foliage. Lining materials showed no significant effect on the vase life.

Standardization of propagation techniques in *schefflera* (*Schefflera arboricola* Hayata)

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In both 'green' and 'variegated' types of *schefflera*, double noded cuttings performed better than single noded cuttings. The number and quality of roots produced were improved with growth regulator treatments and the prolonged dip method was found to be the best in both the types. The best growth regulator and its optimum concentration for rooting of cuttings in 'variegated' type was IBA at 200 mg l⁻¹ whereas in 'green' type, NAA at 50 mg l⁻¹ was found to be an effective treatment. Percentage success in rooting of cuttings depended on the growth regulator employed. In 'variegated' type of *schefflera* the percentage success obtained in rooting of double noded and single noded cuttings could be improved with IBA treatment and in 'green' type, NAA treatment was found to be beneficial.

In layering also growth regulator treatment was found to be beneficial. In 'variegated' type NAA at 50 mg l⁻¹ produced maximum rooting whereas in 'green' type NAA at 200 mg l⁻¹ produced longer and stouter roots. The media used and the method of wounding adopted in layering were found to have significant influence on rooting behaviour. Girdling was more effective compared to slanting slit method. The best media were sphagnum moss and sawdust in 'variegated' type whereas in 'green' type, sawdust was the best medium. Percentage success in rooting of layers depended on the growth regulator, media and type of wounding method employed. The success in rooting of layers ('variegated' and 'green') could be improved with an NAA treatment, using sawdust as the medium and girdling as the wounding method.

In micropropagation, callus was formed from immature and young leaves and the callus production was good with 2,4-D at 1-2 mg l⁻¹ and NAA at 10-12 mg l⁻¹ but the calli did not respond to caulogenesis. In direct organogenesis, axillary bud break from nodal explants was noticed in MS medium with BAP at 0.5 mg l⁻¹ and the shoot growth was the best with BAP at 5 mg l⁻¹. The *in vitro* developed shoots were rooted in the medium supplemented with NAA at 3 mg l⁻¹. IBA at 0.3 mg l⁻¹.

Standardisation of propagation technique and growing media in Rex begonia (*Begonia rex* (Putz.) Inimitable)

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From the investigations it was found that leaves were the most reliable and successful propagules compared to stem cuttings. Control treatments performed better than IBA treatments, the only exception being IBA 100 ppm prolong dip treatment for 6 h. Treatment of leaves with IBA 100 ppm was found to give more success in percentage of sprouting and the total number of sprouts produced per leaf. Earlier sprouting and faster growth of the sprouts were also recorded. The total number of leaves produced from new plantlets that originated from the leaf were also more in leaves treated with IBA 100 ppm.

Propagation with stem cuttings was also found to be successful. IBA 10 ppm and 100 ppm had a positive effect on sprouting and establishment of cuttings. The medium comprising of 1:1 sand:leaf mould were the most reliable growing medium producing plants with maximum height, leaf area and flowers.

Micropropagation and crop improvement of cordyline (*Cordyline terminalis* (L.) KUNTH)

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The shoot tips and nodal segments were found to be ideal explants for the enhanced release of axillary buds and for indirect organogenesis in cordyline.

The nodal segment explants collected in the months of January, March, November and December showed no contamination. Survival percentage was the highest in the months of November and December. The shoot tip explants showed the least contamination when collected during August to April.

Early release of buds (4.4 days after inoculation) and further growth of buds was better in MS medium supplemented with BAP 3.0 mg l⁻¹. Maximum shoot proliferation was observed in MS medium with 2.0 mg l⁻¹ BAP. In the case of shoot tips MS medium having KIN 3.0 mg l⁻¹ showed less time (5.5 days) for bud emergence. Maximum number of shoots (2.5) was also obtained when MS medium was supplemented with 3.0 mg l⁻¹ KIN.

MS medium supplemented with BAP in combination with NAA also proved better for culture establishment of nodal segments and shoot tips. Maximum number of shoots was observed in MS medium with NAA 0.5 mg l⁻¹ + BAP 1.0 mg l⁻¹. Of the different media tried, MS medium was found to be the best for early release of buds in nodal segments and shoot tips.

The elongated buds from Stage 1 showed very high rate of axillary bud production in MS medium containing BAP 1.0 mg l⁻¹ + NAA 0.5 mg l⁻¹ and BAP 2.0 mg l⁻¹ + NAA 0.5 mg l⁻¹. Full strength MS medium gave very high rate of axillary bud production within a short time (12.2 days). High rate of callus production was observed in MS medium having 1.0 mg l⁻¹ BAP + 1.0 mg l⁻¹ NAA and 2.0 mg l⁻¹ BAP + 1.0 mg l⁻¹

¹ NAA. The rate of axillary bud production and callusing was less with KIN in combination with NAA. Irrespective of the media, rhizogenesis was observed when higher levels of 2ip was incorporated into the media.

Among the three basal media tried, MS medium was superior with respect to the number of lengthy roots and the time taken for root initiation. Maximum percentage of rooting, early rooting and more number of lengthy roots were obtained in full strength MS basal medium. Among the auxins, IBA was superior for root induction.

Triadimefon in the rooting medium slightly increased the number of days taken for root initiation and decreased the number of roots/culture and length of roots. It also increased the survival percentage during hardening. Maximum survival percentage of the plantlets was obtained when the plantlets rooted in the medium containing Triadimefon 1.0 mg l⁻¹ + IBA 5.0 mg l⁻¹.

Plant height was maximum when the plantlets after planting out were supplied with 0.75 g 17:17:17 NPK mixture per week as soil drench.

Among the various explants tried for somatic organogenesis, nodal segments and shoot tips were the most ideal for callus initiation, growth and differentiation. Various treatment combinations failed to induce morphogenesis in leaf derived callus, but addition of activated charcoal prevented browning of callus upon subculturing. Higher concentration of cytokinins prevented rhizogenesis.

Effect of varying light intensities on the growth and development of indoor foliage and flowering plants *

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The treatments consisted of five intensities of light, such as 100 (open), 75, 50, 25 and 10 per cent. Shading was provided using gunny cloth stretched over galvonised iron 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 was influenced by the treatments only at the initial growth stages. In others taller plants were produced under high light intensities.

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 observed.

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.

Environmental effects on the growth of *Philodendron* 'Wendlandii'

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Treatments significantly influenced all the vegetative parameters, viz., plant height, number of leaves, total leaf area and number of side shoots, at different stages of growth. The superiority of the combination of peat, mud pot and soluble fertilizer at its higher concentration was clearly evident with respect to plant height at 25 and 50 per cent shade levels. Controlled release fertilizer substituted

in the above combination recorded plant height on par with this, at 25 and 50 per cent shade levels whereas the height was significantly superior at 75 per cent shade level.

Number of leaves was higher in the case of peat + mud pot + controlled release fertilizer under all the three shade levels. The above treatment combination produced more leaf area under 50 per cent shade. This was comparable with that of the leaf area produced when soluble fertilizer was used at 75 per cent shade. Number of side shoots was also higher in a combination of peat + mud pot + controlled release fertilizer.

Total biomass was a good indicator of the superiority of peat + mud pot + controlled release fertilizer at 25 and 50 per cent shade levels. The response in uptake was more in the case of peat supplied with controlled release fertilizer. Better plant quality was observed when grown in peat and mud pot.

A shade level of 50 per cent was considerably better with respect to all the growth parameters, such as, height, number of leaves and total leaf area. Overall plant quality too showed superiority under 50 per cent shade level.

DRY FLOWERS

Developing technology for production of dry flowers

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Celosia and aster flowers took 2 days and 5 days, respectively, for shade drying and proved to be cost effective with maximum cumulative score for visual and aesthetic qualities. This was followed by microwave oven drying and hot air oven drying.

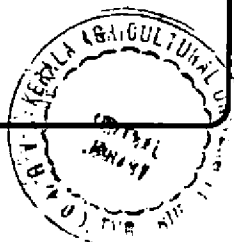
The time taken for perfect drying of gerbera varied from 6 minutes (microwave oven drying) to 4 days (shade drying). Among the drying methods, highest cumulative score was recorded in microwave oven drying, followed by hot air oven drying and shade drying.

Among the desiccants, aster and gerbera flowers embedded in fine clean white sand recorded maximum cumulative score for all quality parameters, viz., brightness, brittleness and colour fading when dried in shade/microwave oven. The flowers retained colour and shape on drying. The dried flowers retained only the colour in borax and had a dull appearance when silica gel powder was used.

Celosia flowers immersed in hydrogen peroxide 30 per cent solution for 6 hours was found to be the best bleaching chemical and recorded maximum score for aesthetic and visual qualities. Sodium hypochlorite (15%) took 14 hours for effective bleaching and recorded as the second best bleaching agent. Calcium hypochlorite recorded low visual and aesthetic qualities for bleached celosia flowers. Hypochlorite bleaching resulted in cellulose damage and yellowing.

Vat colour group of dyes was found good for celosia. Under the Vat group, Basic Rhodamine, Methylene Blue and Auromine Yellow were found to be the suitable. Dyes at 0.2 and 0.3 per cent concentration gave high score for visual aesthetic qualities. Immersion of celosia flowers in dye solution for 10 and 15 minutes recorded similar visual qualities.

Colour fading on storage was minimum in Vat colour group and fast among Base group. The dyed celosia flowers had to be stored in dry cardboard boxes sprinkled with silica gel crystals at the bottom. Lining materials reduced the level of colour fading on storage in celosia flowers dyed with procion colours. Level of colour fading on storage was high in dehydrated aster flowers. Gerbera recorded low colour fading on storage when packed in air tight containers after sprinkling silica gel crystals at the bottom.



**MISCELLANEOUS
CROPS**

Effect of mist and growth regulators on the rooting behaviour and growth of ornamental plants

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Mist propagation with 0.1 ppm IBA was found to be the most suitable method of propagation for the three shrubs viz., *Ficus*, *Bougainvillea* and *Mussaenda*, especially for *Ficus* which rooted poorly under field conditions. Under field conditions, IBA treatment at 250 ppm was optimum for both *bougainvillea* and *mussaenda*. Thin cuttings rooted better than medium thick cuttings for *mussaenda* and medium thick cuttings were better for *bougainvillea*. Under mist propagation, three noded cuttings were found to be ideal; but for *mussaenda* two and three noded cuttings gave more or less similar results. Misting with IBA at 10 ppm concentration was found to be detrimental to all the three species.

Effect of time of planting on the growth and flowering of popular bedding plants

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Time of planting had profound influence on characters like plant height, number of branches per plant, number of days to flower, number of flowers per plant, size of flowers, longevity of flowers and duration of flowering in marigold, zinnia and balsam.

In marigold the number of days taken for 50 per cent germination of seeds and the percentage of germination of seeds were not much influenced by sowing dates. Transplantation during the months of September, October and November was ideal for early flower initiation, maximum number of flowers and branches and less plant height. February and March planting gave longer duration of flowering with medium sized flowers and good flower longevity.

The sowing time influenced the percentage germination of seeds in zinnia. May sowing gave the highest percentages germination of seeds. Transplantation during the months of February, March, April and May was ideal for getting maximum number of large sized long lasting flowers with longer duration of flowering. However, it was noticed that incidence of leaf blight disease was more during these months. September, October and November gave lesser plant height with more number of branches and earlier flowering.

Sowing time influenced the percentage germination of seeds in balsam also. June sowing gave the highest germination percentage. Plant height was reduced by planting in September, October, November, December and January. Transplantation during the months of February, March, April and May was ideal for getting maximum number of large sized flowers with maximum number of branches. However, it was noticed that incidence of leaf spot disease was more during these months, as compared to other months. November, December, January and February transplanting were ideal for getting maximum duration of flowering.

Prospects and constraints of commercial cutflower production in Thiruvananthapuram District

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Relationship of the personal, socio-situational and economic factors with the conceptual skill showed that in the case of Group I, none of the variables correlated with conceptual skill. In the case of Group II attitude towards cutflower growing, knowledge on cutflowers were positively and significantly correlated while mass media exposure was negatively and significantly correlated with conceptual skill. In the case of Group III, variables like cutflower growing experience, attitude towards cutflower growing, knowledge on cut flowers, orientation towards skill development and information seeking behaviour were correlated positively and significantly with conceptual skill. In the case of Group V a positive and significant relationship exists between conceptual skill and cutflower growing experience and orientation towards skill development in farm workers. In the case of Gr. V, a positive and significant relationship exists between conceptual skill and variables like cutflower growing experience, attitude towards cutflower growing, knowledge on cutflowers, self confidence, orientation towards skill development in farm workers, information seeking behaviour and operational area. None of the socio-situational factors related significantly with conceptual skill of the respondents of Group I, Group II, Group III and Group IV except for mass media exposure which was negatively and significantly correlated with conceptual skill of respondents of Group II. None of the economic factors correlated with conceptual skill of the respondents of Group I, Group II, Group III, Group IV and Group V.

Regarding the production practices followed by anthurium growers, majority of growers have ordinary varieties. Majority of the growers follow pot planting using potting media containing sawdust, charcoal, brick and tile pieces, coconut husk and leaf-mould. Orchid growers have the collection of both monopodial and sympodial orchids and majority of the growers plant monopodial orchids in coconut husk alone and sympodial orchids in charcoal pieces alone. Regarding organic manure application, majority of the growers use diluted solution of fermented groundnut and neemcake in both the case of anthuriums and orchids.

In the study various marketing channel has been identified. In which the most important marketing channel of cutflowers identified was 'producer - collection centre - florishop - consumer'.

Orchid and anthurium industry in Kerala - A study of homescale units

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Orchid and anthurium are identified as the most important flowers with commercial potential suitable for the state. Present study aimed to investigate the economics of commercial production and marketing of orchid and anthurium in Kerala and to identify the constraints and analyze future prospects of these two crops in the State. The study was conducted with a sample of 80 growers for each crop. Percentage analysis and capital productivity analysis were used to analyze the data.

Orchid and anthurium growing units have been studied across three scales of operation, viz., small (upto 500 plants: G-I), medium (500 to 1000 plants: G-II) and large (above 1000 plants: G-III) for a standard of 100 plants in each categories.

1. Orchid

Total cost of cultivation for five years was estimated to be Rs.17,471 of which about 57.28 per cent was the establishment cost. Per unit cost of cultivation was more in smaller scale of operation. The total return realized over crop life is found to be about Rs.36,088. Higher returns were realized from larger scale of operation - varying from Rs.33,249 to Rs.40,060.

The estimated project worth parameters were well above acceptance level in all the groups. On an average, pay back period was estimated as three years, net present value as Rs.9,345, benefit cost ratio as 1.61 and the internal rate of return as 39 per cent.

2. Anthurium

Per unit cost of cultivation of anthurium was little higher than that of orchid and showed similar cost structure and increasing pattern towards smaller groups. Total cost of cultivation for five years was estimated to be Rs.19,153, about 57.28 per cent of which was the establishment cost. The total return realized over crop life was found to be Rs.46,236. It varied from Rs.43,474 to Rs.53,037 in different scales of operation.

The pay back period of anthurium enterprise was also estimated to be between two and three years, net present worth as Rs.13,767, benefit cost ratio as 1.82 and internal rate of return as 43 per cent.

Capital productivity analysis of orchid and anthurium showed both the enterprises to be profitable at all the levels (scale of operation), however, larger units were seen comparatively more efficient and profitable than smaller ones.

In both orchid and anthurium, on an average, female labour force contributed about two-third of the total labour use. Proportions of female labour as well as family labour were found higher towards smaller scale of operation.

Sensitivity analysis revealed that orchid and anthurium farming are capable of remaining profitable even if the costs increase by 20 per cent.

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