CROSS COMPATIBILITY IN *Anthurium andreanum*. Lind.

By

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THESIS

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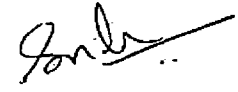
1995

DECLARATION

I hereby declare that this thesis, entitled Cross Compatibility in *Anthurium andreanum*. Lind. is a bonafide record of the research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar titles of any University or Society.



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CERTIFICATE

Certified that this thesis, entitled Cross Compatibility in Anthurium andreanum. Lind. is a record of research work done independantly by Kum. Sindhu.K (Kottapurathu) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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(SINDHU.K)

Dedicated to my loving grandma

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INTRODUCTION

INTRODUCTION

The genus Anthurium belongs to the family Araceae. This genus consists of more than 500 species. But only less than fifteen are commercially exploited (Bailey, 1963). Anthurium is one of the most morphologically diverse and taxonomically complex genus of the family and comprises about one-third of its total number of species (Croat, 1980). Anthurium was placed under a separate tribe (Tribe 4) Anthuriae by Hutchinson (1934).

The name anthurium is derived from the Greek word "anthos", flower and 'aura', tail referring to the spadix. Among the various species, Anthurium andreanum. Lind and Anthurium scherzerianum. Schott are cultivated extensively for the production of flowers. A. andreanum is known as oil cloth flower', 'tail flower' or 'palette flower' and A. scherzerianum as 'flamingo flower' or 'flame plant'. Both are having attractive coloured spathes and handsome foliage. The present day flowering anthuriums are mostly hybrids of different species involving mainly A. andreanum and A. scherzerianum.

The species A. andreanum is a native of south west Columbia. (Singh, 1987). It is an epiphyte with some what creeping habit of growth and produce aerial roots for anchorage. Anthuriums undergo two distinct developmental stages, a juvenile

phase with only vegetative buds in the axils and a generative phase. (Christensen, 1971). A. andreanum produces flowers all round the year, one from each leaf axil with the sequence of leaf, flower and new leaf being maintained throughout the life of the plant (Singh, 1987).

The karyotype analysis and meiotic studies by Lalithambika, (1978) and Satyadas, (1985) revealed that there is an abundance of genetic variability present in some species of Anthurium. The genetic variability present in A. andreanum provides great scope for achieving crop improvement through controlled hybridisation and selection.

Hybridisation and selection are the most common method used for improving anthuriums (Kamemoto and Nakasone, 1955). Cross compatibility analysis is done before undertaking genetic improvement in any cultivated species. Cross compatibility analysis in 56 species of Anthurium through intra and intergroup pollinations have been reported earlier (Sheffer and Kamemoto, 1976).

The present work is taken up with a view to analyse the cross compatibility in six different commercially important varieties of A. andreanum by intervarietal hybridisation which serves as a preliminary step to develop desirable new hybrids and achieve crop improvement.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The study was initiated to analyse the cross compatibilities among six varieties of Anthurium andreanum through intervarietal hybridisation which might aid future hybridisation programme. Very little work of this kind has been reported in literature. The review of work relevant to the investigation is given below.

1. MORPHOLOGICAL/FLORAL CHARACTERS

The importance of studying morphological characters in identifying species as well as varieties is well known. In the genus Anthurium also, different varieties can be identified and classified on the basis of external morphology.

1. PLANT HEIGHT

Plant height is one of the indices for measuring growth (Tisdale et. al., 1985). He reported that height of the plants would increase as their age increases until maturity stage, thereafter height would remain constant.

Hetman et al (1981) assessed the heights of Anthurium andreanum plants grown on 14 different substrates. The effect of pH on plant height was reported by Higaki and Imamura (1988). They reported a decrease in plant height with increased pH upto eight.

Bindu (1992) observed plant heights in five varieties of the species Anthurium andreanum. The height ranged from 45 cm. to 85 cm. Mercy and Dale (1994) reported that the mature plants showed a compact bushy appearance growing to a height upto 50cm. to 100cm.

2. **NUMBER OF LEAVES/YEAR**

Anthuriums grew slowly and produced only six to eight new leaves and vegetative buds on a stem axis per year (Higaki and Rasmussen, 1979).

Klapwijk and Spek (1984) studied the monthly patterns of leaf formation for four years in Anthurium cultivars. The average leaf number/m^2 of glass house rose from 1.5 in March to 5 in June, thereafter declining until the following March.

Klapwijk and Spek (1988) found out that the leaf plastochron duration was fairly constant from March until September at an average of 72 days. Around 10th October, the duration was more than doubled. It then decreased linearly to 72 days again resulting in high leaf production around April. Leaf plastochron seemed to be related to radiation, but day length was probably not involved, as leaf emergence continued during winter.

A switch from monopodial to homeophyllus sympodial growth was common among species in the genus Anthurium. In homeophyllus sympodial growth, each renewal shoot produced a fixed number of leaves (Ray, 1990).

Mercy and Dale (1994) reported that Anthurium was slow growing and produced only five to eight new leaves on a stem axis per year and generally with each new leaf, a new root also emerged.

3. LEAF SIZE INDEX

Sheffer and Kamemoto (1978) made crosses between Anthurium scherzerianum and A. wendlingerii to produce a hybrid and they observed the leaf size of parents and hybrids for comparison.

TABLE.1 LEAF SIZE OF A. scherzerianum, A. wendlingeri and the species hybrid.

	Leaf blade length (Cm)	Leaf blade width (Cm)
A. scherzerianum	28.5	10
A. wendilingerii	106.0	7.5
Hybrid	49.3 1.2	10.0 0.3

The length and position of the leaf blade were intermediate between the highly contrasting characters of the parental species. (Table 1)

The leaf size of five A. andreanum varieties was observed by Bindu (1992). The length of leaves ranged from 13.5cm. to 26cm. and width from 8.7cm. to 23cm. Leaf size was maximum for Pink and minimum for Lady Jane and Chillired varieties. Mercy and Dale (1994) were of the opinion that the leaves of commercially valuable floral anthuriums should be small to medium sized, narrow and elongated. Large and exuberantly growing leaves indicated primitiveness and were undesirable.

4. COLOUR OF YOUNG LEAVES

The young tender leaves of A. andreanum varied in colour from light green to deep reddish brown (Mercy and Dale, 1994).

5. NUMBER OF SPADICES PER YEAR

Christensen (1971) conducted morphological studies on the growth and flower formation of A. scherzerianum. Schott and A. andreanum. Linden and found that the plants had a long juvenile phase during which vegetative growth occurred. Flower buds were produced later in the generative phase.

The productivity and inflorescence quality of 120 individual anthurium plants were compared for nearly two years by Steen and Vijverberg (1973). They reported that the individual plants varied greatly in productivity, producing between 4 to 16 flowers over the 2 years.

Leffering (1975) reported that growth rate increased and average flower production rose from 5 to 12 flowers per plant per year when plants were shaded, so as to receive 45% of the available light by means of an automatic system outside the green house.

Higaki and Poole (1978) conducted a study on Anthurium andreanum Lind. cv. ozaki red testing different media and fertiliser levels for flower production, stem length and flower size. Flower production decreased with age of the plant.

Rodriquez et al (1979) compared several materials with peat moss for the production of Anthurium flowers. Plants on bagasse produced the highest number of flowers followed by those on spent ground coffee.

Voogt (1979) reported that the cut flower yields of A. andreanum declined progressively as the salinity of water used for glass house irrigation increased.

Klapwijk and Spek (1984) studied the monthly patterns of inflorescence formation for 4 years in 6 Anthurium cultivars. They found that the time required for buds to develop into blooms ready for harvest ranged from about 45 to 53 days during May to October and from about 65 to 75 days during December to March.

Mercy and Dale (1994) reported that on an average one plant produced about 5 to 8 spadices per year, each from the axil of a leaf.

6. **SPATHE SIZE INDEX**

The size of Spathe is an important factor which determines the value of Anthurium flowers.

Studies conducted on A. andreanum. Lind cv. ozaki red, testing different media and fertiliser levels, revealed that the flower size increased with age of the plant (Higaki and Poole, 1978).

Singh (1987) graded the flowers in different categories as per United States Department of Agriculture standards based on the average length and width of Spadix as miniature (under 8cm.), small (8-10cm), medium (10-13cm), large (13-15cm) and extra large (15cm).

Criley (1989) reported the spathe size of the important anthurium cultivars in Hawaii including obake and novelty types. The highest spathe size was observed for the cultivar Anuenue (27 x 22.5 cm.) and smaller for tulip types (10 x 7, 10.5 x 7.5 cm) and smallest for Deweese (9.5 x 9.5 cm).

Bindu (1992) observed the spathe size of five varieties of A. andreanum and reported the largest spathe size for pink (10.4 x 9.7 cm) and the smallest for Lady Jane (6.5 x 3.5 cm).

Mercy and Dale (1994) graded spathe size as super large (30cm. and above), Large (25-29 cm.), medium (20-24 cm.), small (15-20 cm.), mini (12-14 cm.) and micro (9-11 cm.)

8. SPATHE COLOUR

Forsyth and Simmonds (1954) reported the presence of 3 - cyanidin glycosides and 1 - pelargonidin glycoside in the spathes of A. andreanum.

According to Birdsey (1956), Linden described the spathe of A. andreanum from Columbia as orange scarlet or vermillion whereas, the plants offered in the trade have a complete color range from white to dark red.

Lowry (1972) reported the presence of both pelargonidin and cyanidin 3 - rutinoside in the spathe of all the cultivars of Anthurium andreanum.

Bailey Hortorum (1976) referred A. andreanum Lind, as "one of the parents of a group of hybrids with large showy puckered spathes from black red to red, salmon pink and white...."

Iwata et al (1979) identified the anthocyanins in the spathes of various A. andreanum cvs. as cyanidin 3-rhamnosyl glucoside and Pelargonidin 3-rhamnosyl glucoside and clarified the genetics of spathe colour. Both the pigments were present in the red cultivars ozaki, kaumana, kozohara, kansako No.1 and Nakazawa and in the Pink cultivar, Marian seefurth. The orange and coral coloured contained only pelargonidin 3-rhamnosyl glucoside.

A maximum night temperature of 22°C has been recommended by Schenk and Brundert (1981) for good colour development and for bigger flowers. Kunisaki (1982) reported that the pink colours required 80% shade or greater for best colour development.

Iwata et al (1985) found that the spathe colour in A. andreanum was determined by the relative concentrations of anthocyanins. A predominance of cyanidin 3-rhamnosyl glucoside along with pelargonidin resulted in pink to dark red colours whereas pelargonidin 3-rhamnosyl glucoside alone resulted in coral to orange.

Kamemoto et al (1988) reported the genetics of major spathe colours in anthuriums. Two major genes M and O controlled the production of anthocyanin pigments and were responsible for the five major colours of A. andreanum : red, orange, pink, coral and white. Pink was heterozygous for both M and O. Coral was heterozygous for O and recessive for M. The dosages of M and O affected colours and the incremental effect of M appeared to be greater than O.

Criley (1989) reported the colours of the important cultivars in Hawaii and new introduction as defined by Royal Horticultural Society colour chart.

According to Mercy and Dale (1994) spathe is the most attractive part of the floral type anthuriums. Spathe colours varied from white to pink to coral to orange to brown to red to crimson to deep maroon (liver red) and some varieties had spathes of two or three colours.

9. **SPATHE TEXTURE**

According to Birdsey (1956), Linden described the spathe of A. andreanum and its varying degrees of smoothness to blistering. Mercy and Dale (1994) reported that in general, the spathe in floral anthuriums was smooth, thick and glossy without prominent veins or it may be thinner deeply veined and blistered.

10. CANDLE LENGTH

Bindu (1992) reported the candle length of five varieties of A. andreanum which ranged from 4 cm. to 9.5 cm. In ordinary varieties of Pink, red and white, the candle was long and fleshy, but in highly bred hybrids and exotics, the candle was shorter and more slender (Mercy and Dale, 1994).

11. CANDLE COLOUR

The candle had either a single colour ie, red, pink or green in ordinary varieties and in hybrids, it had yellow, white, pink or red colours in two or more bands (Mercy and Dale, 1994).

12. POSITION OF CANDLE TO SPATHE

Mercy and Dale (1994) reported that the flower bearing candle in good commercial varieties was attached to the base of spathe held at an angle slanting or curving at 25 to 40°. According to them the ideal anthurium spadix with a high market value must have a long straight stalk with a firm neck holding the spadix up above the leaf canopy, short candle curving towards the tip of the spathe and held at an angle less than 45°.

13. **NUMBER OF FLOWERS/CANDLE**

Watson and Shirakawa (1967) reported that the Anthurium flower consisted of a modified leaf, the spathe and a flower spadix with over 300 spirally attached minute flowers.

Croat and Bunting (1978) reported that the flowers of Anthurium were bisexual and was closely conjested in cylindrical spikes and arranged in a series of spirals on the spadix.

The Anthurium flower had a candle bearing about 50-150 sessile flowers (Bindu, 1992). Mercy and Dale (1994) reported that each inflorescence axis contained about 150 to 350 flowers embedded spirally in the fleshy peduncle in acropetal succession.

15. **DAYS TO INITIATION OF FEMALE PHASE**

In some cases, although the stigmas do not form droplets, they were glistening, often exerted and were assumed to be receptive (Croat, 1980).

Mercy and Dale (1994) observed that the flowers were protogynous and the female reproductive structure reached receptivity first, about 4 to 7 days after the opening of the spathes.

16. NUMBER OF DAYS IN FEMALE PHASE

Daumann (1921) observed that the pistillate phase of flowering could be discerned by stigmatic droplets which were formed as the stigma become receptive.

Croat (1980) reported that the duration of pistillate phase was quite variable which ranged from only a few hours in Anthurium ravenii to 21-28 days in A. luteynii. The female phase for the species A. andreanum varied from 3-12 days (Bindu, 1992). Mercy and Dale (1994) observed that the flowers near the base of the candle were older and matured first and female receptivity progressed from base towards the tip with flowers completing the receptive phase in 3-7 days.

17. DAYS IN INTERPHASE

Croat (1980) reported that the emergence of stamens was separated by considerable time from the receptivity of the pistils (10-20 days in A. pittieri (Engler). In some cases it was short and it was uncertain whether the species involved were homogamous or protogynous.

Bindu (1992) observed that during the interphase, stigmatic droplets driedup. The interphase between the female phase and male phase for the Anthurium andreanum ranged from four to seven.

Mercy and Dale (1994) reported that the interphase was about one week.

19. LIFE OF SPADIX

Paull (1982) reported that the senescence of Anthurium flowers was accompanied by many visible changes including spathe-gloss loss, necrosis of spadix, greening of spathe and spadix from the stem. These senescence changes were non-reversible processes leading to death.

Mercy and Dale (1994) observed that the life of an unfertilised spadix was about 8 weeks. The spathes and candle withered and dropped after the peduncle turned yellow. A fertilised inflorescence had a life span of about 4-7 months..

20. SUCKERING ABILITY

Higaki and Rasmussen (1979) reported that some cultivars produced basal suckers readily while others have to be stimulated to produce suckers by foliar application of N-6-Benzyl adenine at 1000 mg/L.

2. COMPATIBILITY STUDIES

The cultivated Anthurium forms were derived from interspecific hybrids which are supposed to have arisen spontaneously in early species collections.

Kamemoto and Nakasone (1955) reported that hybridisation and selection was the most common method for improving anthuriums. Productivity, flower colour, shape and texture, short internodes and suckering ability are different characters to be considered in selection. Controlled hybridisation indicated that neither white nor red flower colour was dominant and pink was an intermediate heterozygous condition.

Several investigations of the inheritance of inflorescence color in intraspecific and interspecific hybridisation involving A. andreanum were reported and a general mode of colour inheritance was suggested (Kamemoto and Nakasone, 1955, 63)., Kamemoto, Nakasone and Arajaki, 1969., Sheffer and Kamemoto, 1977).

According to Birdsey (1956), Linden described the range of colours of the spathe of A. andreanum and varying degrees of smoothness to blistering. He attributed much of this variation to hybridisation of A. andreanum and with A. lindenianum, A. ornatum and A. nymphaefolium and suggested the name A. xcultorum to express the hybrid character.

In order to select suitable cultivars, some investigations were made in different parts of the world. Of 113 clones evaluated by Kamemoto and Nakasone (1963), 13 were recommended

for commercial cut flower production. Two cultivars uniwai (an exceptionally high yielding white) and Marian seefurth with a rose coloured spathe were evolved by clonal selection.

Kamemoto and Nakasone (1963) postulated a multiple allelic system for the inheritance of spathe colour and also suggested the possibility of multiple factors and modifying genes. The pink cultivar 'Marian seefurth' which arose from a cross between a white clone and a pink clone contained both the orange and magenta pigments. The presence of both the pigments in 'Marian seefurth' supports the hypothesis that separate genes designated as M and O are responsible for the production of magenta and orange pigments respectively.

Kamemoto et al (1969) described two seedling selections Anuenue and Chameleon for cut flower production and a compact clone Red Elf suitable for growing as a pot plant.

Bailey Hortorum (1976) referred A. andreanum Lind. as "one of the parents of a group of hybrids with large showy puckered spathes from black red to red, salmon pink and white .....".

Investigations by Sheffer and Kamemoto (1976) on cross compatibilities among 56 sp. of Anthurium showed that interspecific hybrids with A. andreanum and A. scherzerianum were

not readily obtained; they got hybrids of A. andreanum with six closely related species but no hybrid with A. scherzerianum.

Sheffer and Kamemoto (1977) reported good cross compatibility between A. andreanum, A. concinnatum, A. hoffmani, A. lindenianum, A. micromysterium, A. nymphaefolium and A. pichinchae. All of the hybrids produced were successfully flowered.

Kaneko and Kamemoto (1978) observed that the chromosome number was 2n = 30 for A. andreanum. Linden 'Kaumana' and 2n = 30+2B for 'Uniwai'. Meiotic configurations in pollen mother cells were similar for both with the exception of 2B chromosomes in uniwai. Meiotic irregularities suggested a hybrid origin of cultivated anthuriums.

Kamemoto and Sheffer (1978) made successful crosses between A. scherzerianum and A. wendlingerii to produce a hybrid with a greyish orange spathe. Fertility in this hybrid was very good indicating the relatively close taxonomic relationship.

Kaneko and Kamemoto (1979) analysed the chromosome number of Anthurium sp. as 2n = 30 + 3B chromosomes. These were classified as 2 pairs of large chromosomes, 1 pair of satellite chromosomes, 12 pairs of medium to small chromosomes and 3B

chromosomes. Self pollination resulted in offspring with 2,3 and 4B chromosomes which indicated transmission of B chromosomes through both pollen and egg.

Maurer (1979) described the techniques of cross pollinating A. scherzerianum and discussed the presence of recessive characters. (A = with anthocyanin and a = without anthocyanin, B = whole spathe coloured and b = spotted spathe) when parents were Aa/Bb, the descendants were 9 red (AB), 3 red spots on white (A-bb) and 4 white (aaB-and aabb). The white plants showed a lack of vigour.

The Anthurium cultivars paradise pink and Diamond Jubilee were briefly described by Kamemoto (1983). An evaluation trial was conducted by Leeuwen (1984). The cultivars Avo-nette, Avo-tineke, Favoriet, Germa, Avo-claudia, Avo-Ingrid, Nova-Aurora, Avo-Jose, Jamaica, Hoenette, Sarina and Avo-Anneke were considered the best.

Henny et al (1988) described a new cultivar 'Southern Blush' which was obtained from interspecific hybridisation of a large pink flowered. A. andreanum cultivar with A. amnicola, a drawf species. 'Southern Blush' was intermediate in size between its parents.

Kamemoto et al (1988) reported the genetics of major spathe colours in anthuriums. Two major genes M and O controlled the production of anthocyanin pigments and were responsible for the five major colours of A. andreanum: red, orange, pink, coral and white. Pink was heterozygous for both M and O. Crosses between two pinks produced off springs in the ratio of 5 red : 4 pink : 1 orange : 2 coral : 4 white.

Coral was heterozygous for Q and recessive for M. Crosses between 2 corals gave 1 orange : 2 coral : 1 white. Pink crossed to a recessive white gave 1 red to pink : 1 orange to coral : 2 white. The dosages of M and O affect colours and the incremental effects of M appeared to be greater than O.

Henny (1989) opined that the studies of factors affecting flowering, pollination, seed set and genetics of ornamental tropical aroids have made possible the development of new Anthurium hybrids suitable for use as indoor foliage plants. The selected hybrids could be asexually propagated from cuttings or by tissue culture, for later green house production tests.

Wannakrairoj and Kamemoto (1990) proposed a scheme for the genetic control of purple spathe in Anthurium. The recessive allele 'p' modified the colour of anthocyanins controlled by the M and O loci. A spathe was purple when the genotype was M-O-pp.

If the P locus was dominant, M-O was red, while mmO - was orange. The 'p' allele had no effect on the -oo white genotype.

According to Mercy and Dale (1994) hybridisation done discretely between selected parents with good combining ability could yield valuable and novel new hybrids. The plant type characters to look for are a profusely branching root system, short leaf internodes which give the plant a compact appearance, small to medium sized leaves and long stalked spadices with large spathes and small downward curving candles.

According to Arndt (1991) 'Arabella' a German A. scherzerianum variety was developed from a breeding programme between 1979 and 1985. 'Arabella' was more uniform and compact, early flowering, medium sized plant with dark green, short leaves and red spathe and spadix.

Cross compatibility analysis was done based on the fruit set, seed set and seed germination percentage.

21. PERCENTAGE OF CANDLES BEARING FRUITS

The 1592 pollinations done by Sheffer and Kamemoto (1976) included 20 selfs, 19 intra-sepcific cross combinations, 315 intra- group interspecific cross combinations (including reciprocals) and 29 different inter group cross combinations

(including reciprocals). The species were divided into six distinct morphological groups on the basis of the important Englerian characters of the number of ovules per locule, colour and shape of the berry, shape of inflorescence, and shape and texture of the leaf. Group I and II were separated on the basis of the number of ovules per locule. Groups III and IV were Engler's sections Pachynerium and Schizoplacium respectively. Groups V and VI included the remaining species organised into 2 groups on the basis of leaf texture and berry shape and colour. Fruits were harvested and germinating seeds obtained from intra and inter group pollinations.

Self pollination resulted in 81% fruiting spadices, intra specific and interspecific cross combinations resulted in 65.4% and 28.1% fruiting spadices respectively.

Group II, III and V gave higher percentage of fruiting spadices and flowering hybrids than group I, IV and VI. The low percentage of hybrids in group I is due to the range of chromosome numbers found in the species included in this group. The presence of B-chromosomes also affected the viability. (Bhattaglia, 1964, Sheffer and Kamemoto, 1976).

The high degree of cross compatibility in group V indicated their relatively close inter-relationship. The lowest

percentage of fruits harvested and hybrids flowered were obtained in group VI, the most morphologically diverse of the groups. Only a single flowering hybrid progeny was obtained from the intergroup cross of VI x IV (A. triangulum x A. digitatum). This successful cross suggested the possible misplacement of A. triangulum, since flowering hybrids were not obtained between this species and others within group VI. This cross produced a vigorous, sterile hybrid, but the reciprocal cross resulted in weak seedlings which died early.

22. **NUMBER OF FRUITS PER CANDLE**

According to Mercy and Dale (1994), in a well fertilized candle, about 100-200 or more berries were developed. Within a month of fertilisation, a candle with developing fruits could be visually identified from the unfertilised one. The candle become swollen and fleshy with developing berries embedded on it. In about 8 weeks the tip of the berries start projecting out like small pin heads.

According to Pierik et al (1974), the breeding of Anthurium andreanum was handicapped by the long period from fertilisation to ripening of seeds (6 - 7 months).

23. NUMBER OF SEEDS PER BERRY

Anthuriums were mainly propagated from seeds. The spadix seldom had full fruit set. Berries contained 2-3 seeds and for ripening it took 5-12 months (Zimmer, 1986).

Geir (1989) observed that the time required from pollination to the maturity of seeds was about 6-7 months for A. andreanum and 10-12 months for A. scherzerianum.

Mercy and Dale (1994) reported that in the commercial varieties of A. andreanum, each berry contained one or two seeds and the seeds matured in about 4-72 months. Seeds remain enclosed within the thin fruit wall in a gelatinous pulp and if not harvested, will remain attached to the candle for a few days more before they dry up and fall off the candle.

24. PERCENTAGE GERMINATION OF SEEDS

Szendel et al (1982) found that the seeds of Anthurium andreanum harvested at 3 maturity stages and those of A. scherzerianum at one maturity stage (light orange) were germinated on 3 substrates, at P^H ranging from 4 to 8 in light or darkness at 18, 24 or 28°C. In A. andreanum the best germination was obtained on a high peat substrate, at pH 4-5 in light at 28°C using seeds harvested at an early maturity stage (yellow-green to light orange).

Zimmer and Bahnemann (1982) reported that the A. scherzerianum seeds from different sources varied in their ability to germinate at low, sub-optimal temperatures. Optimum germination temperature was found to be 20-25°C, but some seeds germinated well at 10 or 15°C.

Criley (1989) reported that, in Anthurium, the pulp was removed from ripe berries in water, and the seed was sown immediately on the surface of a damp medium and placed under 80% shade in conditions of high humidity. The germination proceeded within 14 days.

According to Mercy and Dale (1994), the hybrid seeds from crosses between ordinary hardy varieties had above 90% germination and their seedlings showed high survival fitness and vigour. Seeds produced in crosses between exotic varieties were smaller in size and poor in germination.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present study was undertaken in the Department of plant Breeding and Genetics, College of Agriculture, Vellayani during the period 1992-94 in order to analyse the cross compatibility of six commercial varieties of Anthurium andreanum Linden.

MATERIALS

The materials selected for the study were six varieties of Anthurium andreanum. The six varieties with varying phenotypic expressions used for the study were:

1. Honeymoon red (Fig.1)
2. Chilli red (Fig.2)
3. Kalympong orange (Fig.3)
4. Kalympong red (Fig.4)
5. Pink (Fig.5)
6. White (fig.6)

METHODS

Suckers of the six varieties were raised in pots. The bottom one-third layer of the pots were filled with broken bricks, the middle one-third with coconut husk pieces. The plants were placed on this layer over which a top layer of charcoal and coconut husk pieces were put.

Fig.1 Anthurium andreanum. var. Honeymoon red

Fig.2 Anthurium andreanum. var. Chilli red

Fig 3 Anthurium andreanum. var. Kalympong orange


1


2


3


4


5


6

A mixture of dry powdered cowdung, river sand and soil rite (stabiliser) in 1:1:1 ratio was used to fill around the base of the plant to anchor and keep the plant erect. Potting mixture was prepared in such a way as to provide good drainage. Plants were kept under 75% shade. Watering was done twice daily on hot days.

Fertilisers applied includedthe organic groundnut cake and neemcake and the inorganic NPK mixture (17:17:17). For applying organic manure, equal quantities of 1/2 to 1kg groundnut cake and neemcake were fermented for two days in five times the quantity of water to which 10 to 20gms of complex was added. The mixture was then diluted and the clear supernatant solution was applied to the pots at regular weekly intervals.

PLANT PROTECTION

The plant protection chemicals used were

1. Bavistin 50% wp @ 2g/litre
2. Dithane M - 45 @ 2g/litre

Both used against blight and anthracnose diseases.

3. Streptocycline @ 0.05g/litre against bacterial blight
4. BHC 50% WP dusted against termites and ants.

The fungicides were applied at regular weekly intervals throughout the duration of the experiment. Streptocycline and BHC were applied as and when needed.

1. MORPHOLOGICAL/FLORAL CHARACTERS

Observations on 20 morphological and floral characters were recorded by taking the mean values of each variety.

1. PLANT HEIGHT

The height of the plants was measured in centimeters from the base of the plant to the top most leaf.

2. NUMBER OF LEAVES PER YEAR

The total number of leaves produced for one year i.e., from April 1993 to March 1994 was observed and recorded.

3. LEAF SIZE INDEX (L.S.I)

Length and width of a selected mature leaf from each plant of each variety were recorded in centimeters and their means calculated. Leaf size Index (length (cms) + width (cms)) was calculated for all the varieties.

4. COLOUR OF PETIOLE AND YOUNG LEAVES

Colour of petioles and young leaves varied in the six varieties and they were visually observed and recorded.

5. NUMBER OF SPADICES PER YEAR

The number of spadices opened from April 1993 to March 1994 were observed and recorded.

6. SPATHE SIZE INDEX (S.S.I.)

Spathe size Index was obtained by adding the length and width of the spathe in centimeters, and recorded.

7. LEAF INDEX CORRELATION TO SPATHE SIZE INDEX

Correlation between leaf size and Spathe size was recorded by comparing mean values of L.S.I. and S.S.I in each variety.

8. SPATHE COLOUR

Spathe colour was different for different varieties and they were observed visually and recorded.

9. SPATHE TEXTURE

The spathe texture was differentiated by observing the varying degrees of blistering and thickness which were recorded.

10. CANDLE LENGTH

Candle length was measured in centimeters from the base of the candle to its tip.

11. CANDLE COLOUR

The candle colours were observed visually and recorded.

12. POSITION OF CANDLE TO SPATHE

The angle between the base of the candle to the plane of the subtending spathe was taken and recorded.

13. NUMBER OF FLOWERS PER CANDLE

The number of flowers per candle was recorded by counting the total number of the small flowers arranged spirally on the candle from the base to the tip.

14. SPATHE - CANDLE RATIO

This is the ratio of S.S.I to the length of the candle and was calculated by using the mean values of both characters.

15. DAYS TO INITIATION OF FEMALE PHASE

Days to initiation of female phase which is the number of days from the opening of the spathe to the emergence of first

mature stigmas of the basal flowers identified by the presence of honeydew or stigmatic droplets was recorded.

16. NUMBER OF DAYS IN FEMALE PHASE

The number of days of stigma receptivity of the spadix which is the period between the emergence of stigmas in the basal flowers to the top most flowers was recorded.

17. DAYS OF INTERPHASE

The period in days between the end of female phase and the start of male phase, indicated by the emergence of first anthers was taken as the days of interphase.

18. DURATION OF MALE PHASE

Duration of male phase was taken as the number of days the candle remained in the male phase and recorded.

19. LIFE OF SPADIX

The life of spadix was recorded by noting the period from the emergence of the spathe to the time when the peduncle of the inflorescence starts yellowing.

20. SUCKERING ABILITY

Suckering ability is the ability to produce suckers and was judged by noting the appearance of side shoots from the base of the mother plant and was recorded as either positive or negative.

2. COMPATIBILITY STUDIES

Compatibility study was done by intervarietal hybridisation using the six varieties. Hybridisation was carried out on all possible combination using these varieties. Compatibility analysis was done based on the fruit set/seed set, and seed germination. The 36 cross combinations are given in the form of a matrix.

MATRIX SHOWING THE 36 CROSS COMBINATIONS

♀ \ ♂	HR	CR	KO	KR	P	W
HR	HR x HR	HR x CR	HR x KO	HR x KR	HR x P	HR x W
CR	CR x HR	CR x CR	CR x KO	CR x KR	CR x P	CR x W
KO	KO x HR	KO x CR	KO x KO	KO x KR	KO x P	KO x W
KR	KR x HR	KR x CR	KR x KO	KR x KR	KR x P	KR x W
P	P x HR	P x CR	P x KO	P x KR	P x P	P x W
W	W x HR	W X CR	W X KO	W X KR	W x P	W x W

HYBRIDISATION TECHNIQUE IN ANTHURIUM

Clear protogynous condition exists in this plant, and so there was no need for emasculation. Firstly, the unopened in florescence of the plant selected as female parent was covered with a butter paper bag to prevent unwanted pollinations. Controlled pollination was then done by lifting the pollen from the candle of the male parent in full male phase with a fine wet brush and then passing the brush over the candle of the female parent, a few times. After pollination, the inflorescence was again covered with the butter paper bag till the female phase was over.

21. PERCENTAGE OF CANDLES BEARING FRUITS

The number of candles bearing fruits was noted for each treatment and the percentage calculated as

$$\frac{\text{The number of candles bearing fruits}}{\text{Number of candles pollinated}} \times 100$$

22. NUMBER OF FRUITS/CANDLE

The number of fruits in each candle was counted and recorded.

23. PERCENTAGE FRUIT SET

The percentage of fruit set was calculated and recorded on the basis of the total number of flowers in the candle in each treatment and the number of flowers showing fruit set as shown below.

$$\text{Percentage fruit set} = \frac{\text{Number of fruits}}{\text{Number of flowers}} \times 100$$

24. NUMBER OF SEEDS/ BERRY

The seeds in each berry were squeezed out and counted to record the number of seeds/berry.

25. SEED SIZE

The length and breadth of seeds were measured in millimeters and recorded.

26. PERCENTAGE GERMINATION OF SEED

This was observed and recorded as:

$$\frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100$$

STATISTICAL ANALYSIS

Statistical analysis was done in completely randomised design with unequal replications. The ANOVA is given as:

Source	df	S.S	M.S	F
Treatments	(V-1)	SST	SST/(V-1)	SST/SSE
Error	V(r-1)	SSE	SSE/(V(r-1)	

v - number of treatments

r - number of replications

Total sum of squares $= yij^2 - CF$

Treatment sum of squares $= \frac{yi^2}{ri} - CF$

$$tij = \frac{\text{Mean of } i^{th} \text{ treatment - mean of } j^{th} \text{ treatment}}{\sqrt{\text{Error mean sum of squares } (1/ri + 1/rj)}}$$

$$CD = t \sqrt{\frac{2MSE}{ri + rj}}$$

The C.D. for comparing various treatments are given in appendix.

RESULTS

RESULTS

Investigations were carried out on the various morphological and floral characters and the extent of cross compatibility in six varieties of Anthurium andreanum. The salient results obtained from the study are presented below:

1. MORPHOLOGICAL/FLORAL CHARACTERS

Twenty important morphological/floral characters were analysed in six varieties of the species A. andreanum and the results are presented below.

1. PLANT HEIGHT

Considerable variability on plant height was observed among the six varieties with the variety Pink having the tallest plants (70 cm) followed by Honeymoon red (65 cm) (Table 2). Plant height recorded ranged from 43 cm in the variety Kalympong red to 70 cm. in the variety Pink. Statistical analysis revealed that the height of Pink and Honeymoon red varieties were on par. The height of Honeymoon red and Kalympong orange did not show significant difference in height. The heights of Kalympong red, Chillired and White were also on par.

TABLE 2
IMPORTANT CHARACTERS OF THE VARIETIES

VARIETIES	PLANT HEIGHT (cm)	LEAF SIZE INDEX (cm)	COLOUR OF PETIOLE	COLOUR OF YOUNG LEAVES	SPATHE-SIZE INDEX (cms)	SPATHE COLOUR	SPATHE TEXTURE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Honeymoon red	65.0	66.4	green	Light green	25.68	Bright red	Smooth, thick, glossy
Chilli red	45.0	50.2	Greenish-purple	Light green	22.7	Dark red	Medium thick, blishered with veins
Kalympong orange	56.4	53.9	Green	Light brown	28.82	Light orange	Thinly bli stered with veins
Kalympong red	43.0	54.2	Purple	Greenish brown	31.0	Red	Thinly bli stered with veins
Pink	70	75.72	Green	Brown	33.12	Light Pink	Smooth, lightly veined
White	45.3	37.3	Green	Green	13.23	White	Smooth, thin veined

Table 2 Continued.....

CANDLE LENGTH (cms)	CANDLE COLOUR	NUMBER OF FLOWERS/ CANDLE	SPATHE-CANDLE RATIO	LIFE OF SPADIX (Months)	SUCKERING ABILITY	POSITION OF CANDLE TO SPATHE
(8)	(9)	(10)	(11)	(12)	(13)	(14)
10.8	Light red	300-350	2.4	2-3.5	Positive	75°
8.1	White and yellowish orange	150-200	2.8	2.5-3	Positive	25°
10.3	Orange and pink	250-280	2.79	1.5-2	Negative	35°
10.65	Yellow and white	250-280	2.86	2.5-3.5	Negative	42.5°
12.1	Pink	300-350	2.74	2-3	Positive	70°
6.6	White or cream	200-225	2.0	2-3	Positive	30°

2. NUMBER OF LEAVES PER YEAR

The leaves are borne singly on long stalks with sheathing bases in a spiral rosette. The average number of leaves produced per year ranged from 3.5 in Kalympong red to 6.3 in White (Table 3). There was a long interval period between the emergence of two successive leaves in each plant and the average duration varied from 47 days in White to average 62 days in Chilli red.

The number of leaves produced per year by the 5 plants observed in the variety Honeymoon red varied from 5 to 6 with an average of 5.6 leaves/plant/year. The leaf plastochron duration which is the interval between the opening of two leaves varied from 47.5 to 67.5 days with an average of 60 days for the variety (Table 3).

In the variety Chilli red, the number of leaves produced varied from 3 to 6 with an average of 4.4/year/plant. The leaf plastochron duration ranged from 43 to 74 days. The average was 62 days (Table 3).

In Kalympong orange, the average number of leaves produced/year/plant was 5.4, with the number of leaves produced per year ranging from 45 to 56 days with an average of 50 days for the variety (Table 3).

Table 3.

TABLE SHOWING NUMBER OF LEAVES/YEAR AND LEAF PLASTOCHRON DURATION

VARIETY	NUMBER OF LEAVES/ YEAR/PLANT (RANGE)	NUMBER OF LEAVES/YR/ PLANT (AVERAGE)	PLASTOCHRON DURATION BETWEEN LEAF	AV.LEAF PLASTOCHRON DURATION
Honeymoon red	5-6	5.6	47.5-67.5	60
Chilli red	3-6	4.4	43.0-74.0	62
Kalympong orange	3-7	5.4	45.0-56.0	50
Kalympong red	3-4	3.5	49.0-51.0	50
Pink	5-6	5.8	42.0-68.0	52
White	5-8	6.3	35.0-61.0	47

The number of leaves produced per year/plant in Kalympong red was less ie, 3 to 4 leaves with an average of 3.5. The plastochron duration varied from 49 to 51 days. The average was 50 days (Table 3).

The variety Pink produced 5 to 6 leaves/year/plant. The leaf plastochron duration ranged from 42 to 68 days. The average number of leaves produced/year and the average plastochron duration are 5.8 leaves and 52 days respectively (Table 3).

In the variety White, a plant produced 5-8 leaves per year with an average of 6.3. The average leaf plastochron interval was 47 days and the range varied from 35 to 61 days (Table 3).

In the present study, the leaf plastochron duration was fairly constant from March to August in all the varieties except in Chilli red and Kalympong red where the number of leaves produced in some plants under observation was less. From August onwards, a lag in the production of leaves in some plants was noticed. This duration between the opening of two leaves ranged from 72-99 days, on an average.

3 LEAF SIZE INDEX

Pink and Honeymoon red varieties produce large sized leaves. Leaf size index was maximum for Pink variety (75.72cm.) and minimum for White (37.3 cm) (Table 2). The leaf size of Kalympong red, Kalympong orange and Chilli red varieties were not significantly different. (Fig.7).

4 COLOUR OF PETIOLE AND YOUNG LEAVES

Petioles are slender and long and there are variations in the colour of both petiole and young leaves in all the varieties. The petiole colour ranged from green, greenish purple and purple. The young tender leaves showed light green, green, greenish brown, light brown and brown colours. (Table 2)

5 NUMBER OF SPADICES PER YEAR

The anthurium 'flower' is actually a spadix ie, a combination of the colourful modified bract, the spathe and hundreds of small flowers on the pencil like inflorescence axis called candle. The flowers are arranged in a series of spirals on the candle. The spadix is borne on a leafless stalk or peduncle. The spathe is the most attractive part of the floral type anthuriums.

The number of spadices produced by a plant annually varied from 4 to 8 in the six varieties. In all the varieties, the

TABLE 4

NUMBER OF SPADICES/PLANT/YEAR AND INTERVAL BETWEEN SPADIX EMERGENCE

Variety	Number of spadices/ plant/year	AV' number of spadices/variety Year	Interval between emergence of two successive spadices (days)	Interval between emergence of two successive spadices (Average days)
Honeymoon Red	6-8	6.8	45-57	50
Chill red	4-6	5.2	33-51.5	48
Kalympong orange	4-6	5.4	38-55	47
Kalympong Red	5-6	5.5	38-53	45.5
Pink	4-8	6.8	47-54	51
White	7-8	7.7	40-45	43

spadix was generally produced from the leaf axils. But there were instances where the leaf axil does not bear a spadix. More often spadices appeared instead of leaves in most plants. The number of spadices/year and the interval between the emergence of successive spadices are given in Table 4.

In the variety Honeymoon red, the number of spadices produced varied from 6 to 8 with an average of 6.8/plant annually. The duration between two spadices ranged from 45 to 57 days with an average of 50 days (Table 4).

The number of spadices produced per year in the variety Chilli red ranged from 4 to 6 with an average of 5.2. The interval between the opening of two spadices varied from 33-51.5 days. The average was 48 days (Table 4).

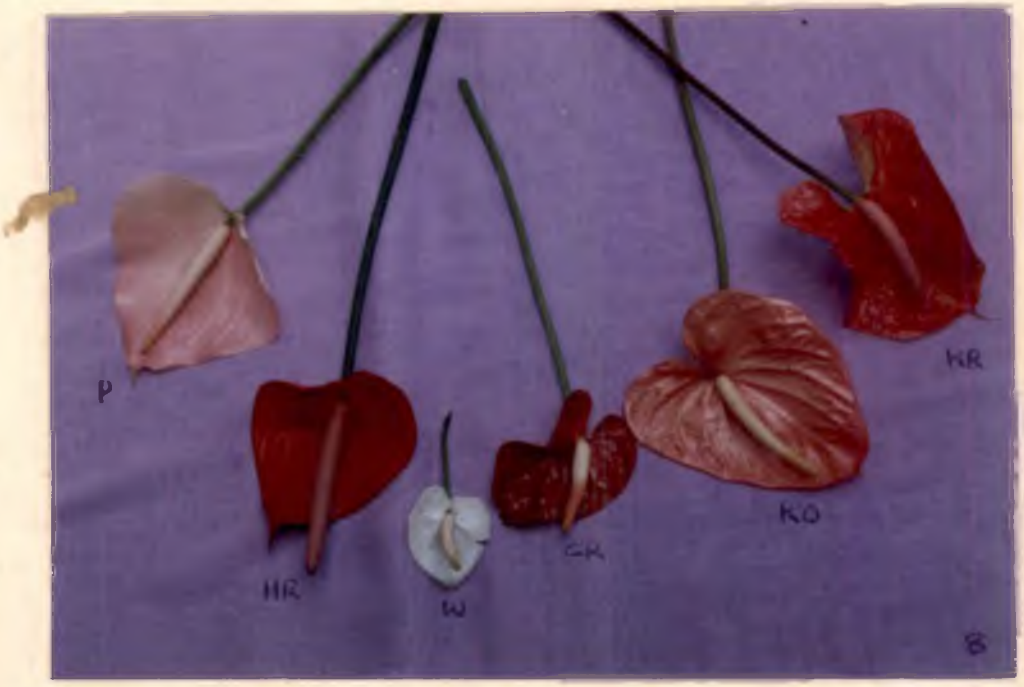
The variety Kalympong orange produced 4 to 6 spadices/year with an average of 5.4. The duration of interval between two spadices ranged from 38 to 55 days with an average of 47 days (Table 4).

The variety Kalympong red produced 5 to 6 spadices/year. The interval between two spadices ranged from 38 to 53 days. The average number of spadices produced per year and the average interval between spadices was 5.5 and 45.5 days respectively (Table 4).

Fig 7 Variation in leaf size

Fig 8 Variation in spathe size index


P
KR
KO
HR
CR
W
7


P
HR
W
CR
KO
HR
8

The number of spadices produced/year in the variety Pink ranged from 4 to 8 with an average of 6.8. The interval between two spadices varied from 47-54 days with an average of 51 days (Table 4).

The variety White produced 7 to 8 spadices. The average was 7.7 spadices. The duration of interval between two spadices ranged from 40-45 days with an average of 43 days (Table 4). There was a slight increase in the duration between the opening of two spadices from August to March, during the period under study. This duration ranged from 63-95 days on an average. In some plants, this duration extended upto 120 days as in Chilli red and Kalympong red.

6. SPATHE SIZE INDEX

Spathe size index which is the length of spathe + width of spathe, is an important factor which determines the value of anthurium 'flowers'. Pink and Kalympong red varieties produced super large flowers where the spathe size index was observed maximum for Pink variety (33.12 cm) followed by Kalympong red (31 cm). Spathe sizes of Kalympong red and Honeymoon red were not significantly different. Kalympong orange and Honeymoon red produced large flowers (28.82 cm. and 25.68 cm. respectively). Chilli red had medium sized flowers. Smallest of the flowers

among the six varieties were developed in the White variety (Table 2). The variation in spathe size index can be seen in Fig.8

7. LEAF INDEX CORRELATION TO SPATHE SIZE

There is significant correlation between leaf size and spathe size ie, as the size of the leaves increased, the spathe size also increased.

TABLE 5

CORRELATION BETWEEN LEAF SIZE AND SPATHE SIZE

VARIETIES	LEAF SIZE INDEX (length+width in cms)	SPATHE SIZE INDEX (length+width in cms)
Honeymoon red	66.4	25.68
Chilli red	50.2	22.7
Kalympong orange	53.9	28.82
Kalympong red	54.2	31.0
Pink	75.72	33.12
White	37.3	13.23

Correlation = 0.7974* (significant at 5% level)

In all the varieties, as the leaf size of the plants increased, the spathe size also increased. The largest leaf size and spathe size indices were observed for the variety Pink (Table 5). Though the leaf size index of Honeymoon red (66.4 cm) was larger than Kalympong red (54.2 cm.) and Kalympong orange (53.9 cm.), these varieties produced larger flowers than Honeymoon red. The variety White had smaller sized leaves and spadices. (Fig.9)

8. SPATHE COLOUR

The spathe colour in the six varieties varied from dark red to bright red to red, light orange, pink and white (Table 2)

9. SPATHE TEXTURE

Spathe was smooth, thick and glossy without prominent veins as in Honeymoon red or thinner, deeply veined and blistered (Kalympong red, Kalympong orange). Chilli red spathe was medium thick and blistered with prominent veins. Pink and White had smooth, thin and lightly veined spathes and did not show any blistering. (Table 2)

Fig 9 Leaf index correlation to spathe size


P
KR
KO
HR
CR
W
9

10. **CANDLE LENGTH**

Candles were either long and fleshy or shorter and slender. Pink had long and fleshy candles with the largest candle length of 12.1 cm. followed by Honeymoon red (10.8 cm.). Comparatively thinner sized candles were found in Kalympong orange, Kalympong red and White. The candle was shorter for Chilli red which was also slim, a very desirable character. The candle was the shortest for White (6.6. cm.) (Table 2)

11. **CANDLE COLOUR**

The candle has either a single colour or is seen in two or more bands of colours in hybrids. The colour was light red in Honeymoon red and pink in pink variety. Bands of colours like white and yellowish orange, yellow and white, orange and pink are seen in Chilli red, Kalympong red and Kalympong orange varieties respectively. Candle colour was either white or cream in the White varieties. (Table 2)

12. **POSITION OF CANDLE TO SPATHE**

The maximum angle between the base of the candle to the plane of the spathe was observed for Honeymoon red (75^{o}) (Table 2). The angle was smaller for Kalympong orange and White and smallest for Chilli red (25^{o}).

Fig 10 Var. Chillired : Medium candle length

Fig 11 Var. White : Long candle with small spathe


10


11

13. NUMBER OF FLOWERS PER CANDLE

Flowers of anthurium are bisexual and sessile, arranged in a series of spirals in acropetal succession ie, older flowers at the base and younger ones towards the tip. The number of flowers produced varied from 175 to 325. The average number of flowers produced was maximum for Pink and Honeymoon red varieties (325 flowers). The number of flowers was comparatively less (below 200) in the variety Chilli red.

14. SPATHE-CANDLE RATIO

Spathe - candle ratio depends on the spathe size and candle length. This ratio was maximum for Kalympong red (2.86:1) and Chilli red (2.8:1) (Fig.10) (Table 5) followed by Kalympong orange (2.79:1) which meant that these varieties had comparatively larger sized spathes with smaller candles. In White, the spathe-candle ratio was the smallest (2:1) ie, the white flowers had smaller sized spathes with long candles. (Fig.11)

15. DAYS TO INITIATION OF FEMALE PHASE

The initiation of female phase can be identified by the slightly projecting stigmas on the surface of the candle. The styles are short and stigmas generally capitate. From the

Fig 12 a. Honeymoonred flower in female phase

Fig 12 b. Female phase enlarged


12a

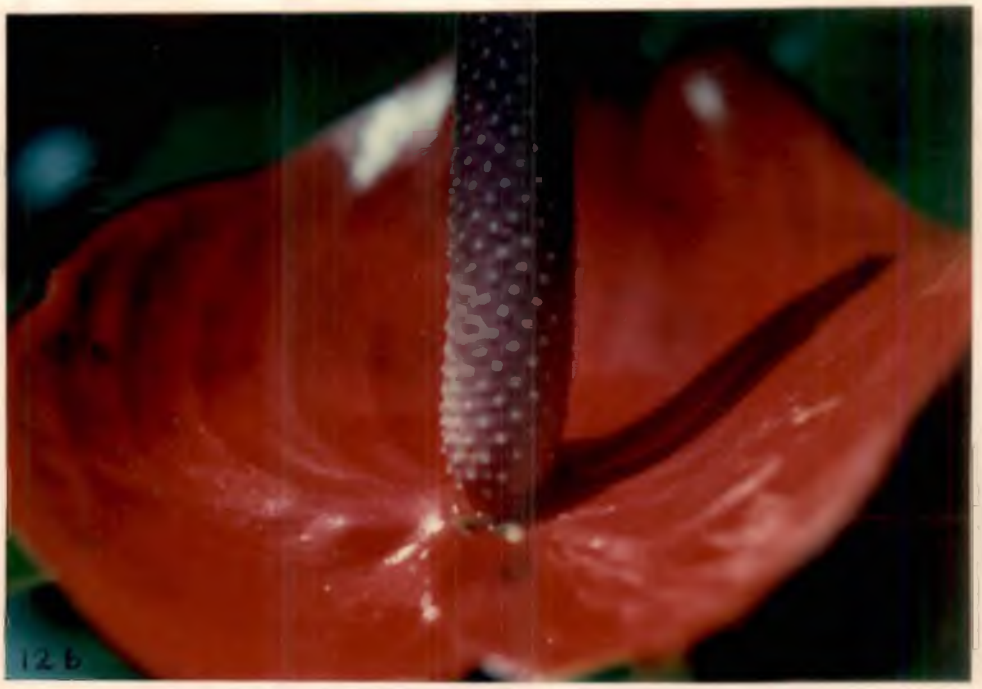

12b

Fig 13 a. Honeymoonred flower in male phase

Fig 13 b. Honeymoonred : Male phase enlarged


13a


13b

observations on six varieties in the present study, it was clear that the days to initiation of female phase of the species Anthurium andreanum varied from 1-10 days (Table 6). Variety Honeymoonred took the longest period for initiation of the female reproductive phase.

16. NUMBER OF DAYS IN FEMALE PHASE

Female phase can be identified by the presence of stigma droplets or honey dew on the candle (Fig.12a). Female phase for the species varied from 5-25 days. Kalympong varieties remained in the female phase for longer periods while the variety Chilli red had the shortest female phase (Table 6).

17. DAYS OF INTERPHASE

The separation period or the interphase between the female phase and male phase for the species A. andreanum ranged from 4-10 days (Table 6). During interphase, the stigmatic droplets dried up. From March to August, the interphase was prolonged with the suppression of the male phase.

18. DURATION OF MALE PHASE

Male phase is identified by the appearance of stamens on the candle. In general, anther exertion started from the base proceeding towards the apex (Fig 13(a), Fig 13(b)). Some times

only a portion of the spadix exhibited male phase as in Kalympong red or some times stamens appeared on the candle irregularly. The candle was in the male phase for 3-8 days in A. andreanum. Linden (Table 6).

The durations of the different phases of flower maturity viz. female phase, interphase and male phase of the varieties were observed and the results are presented in (Table 6).

TABLE 6

DURATION OF REPRODUCTIVE PHASES AND FLORAL MATURITY (in days)

VARIETY	FEMALE PHASE INITIATION	FEMALE PHASE	INTER PHASE	MALE PHASE	DAYS FOR FLOWER MATURITY
Honeymoon red	6-10	8-15	7-8	5-6	32.5
Chilli red	1-3	5-6	6-7	5	17.0
Kalympong orange	2-5	13-14	4-9	3-4	27
Kalympong red	1-3	16-25	7-10	3-4	34.5
Pink	1-2	6-8	4-7	4-8	21.5
White	1-2	6-7	4-7	4-6	20.0

The variety Honeymoon red needed about 6-10 days for the initiation of the female phase. The female phase lasted in this variety for about 8-15 days. The duration of interphase was about 7-8 days and the male phase lasted for 5-6 days. The total period of flower maturity range was 26-39 days.

The variety Chilli red took about 1-3 days for female phase initiation. In this variety, the female phase lasted for 5-6 days. The duration of interphase was 6-7 days and the male phase lasted for 5 days. The total period of flower maturity was 17 days.

The female phase initiation in the variety Kalympong orange took 2-5 days and remained in the female phase for 13-14 days. The male phase in this variety lasted for 3-4 days. On an average, 22-32 days were taken for flower maturity.

The variety Kalympong red needed about 1-3 days for female phase initiation. For completing the female phase it took 16-25 days. The duration of interphase was for 7-10 days and the male phase lasted for 3-4 days. The duration of flower maturity period ranged from 27-42 days.

The variety Pink needed one or two days for female phase initiation. The female phase lasted for 6-8 days. The duration

of interphase was 4-7 days and the male phase was 4-8 days. The total period of flower maturity range was 18-25 days.

The variety White needed 1-2 days for female phase initiation. The duration was 6-7 days, 4-7 days and 4-6 days for interphase, male phase and female phase respectively. On an average the period of flower maturity range for this variety was 18-22 days.

19. **LIFE OF SPADIX**

The period from the emergence of the spathe to the yellowing of the peduncle of the inflorescence in the case of unfertilised spadices was maximum for Honeymoon red and Kalympong red varieties (3 1/2 months) and minimum for Kalympong orange (1 1/2-2 months). In Chilli red, the longivity was 2-3 months. Pink and White spadices lasted for about 2-3 months (Table 2). For fertilised spadices this period ranged from 4 1/2 - 8 months as fruits mature very slowly.

20. **SUCKERING ABILITY**

Suckering ability is the ability to produce suckers. This is one of the important characters to be considered in selection. Suckering ability was positive for Honeymoon red, Chilli red, Pink and White varieties and negative for Kalympong orange and

Kalympong red varieties. The maximum suckering ability was observed for Pink.

2. COMPATIBILITY STUDIES

Intervarietal hybridisation was done in the six A. andreanum varieties as well as corresponding selfings depending on the availability of receptive spadices and fresh pollen. The study involved 36 combinations including self. Only 28 could be attempted. Of these 28 combinations, a total of 110 pollinations were done. These pollinations included 4 selfs and 24 cross combinations (Table 7). Compatibility analysis was done based on 3 parameters ie,

1. The percentage of candles bearing fruits.
2. Percentage fruit set/seed set.
3. Seed germination.

The results are presented below.

21. PERCENTAGE CANDLES BEARING FRUITS

Honeymoon Red

Out of the six cross combinations possible involving this variety, all were successfully be attempted. Percentage of candles bearing fruits was observed to be high for crosses with

Kalympong red, Chilli red, Kalympong orange and White. All these crosses showed 100% fruit set (Table 7). The percentage was the lowest for selfing HR x HR.

Chilli Red

Among the four possible Chilli red cross combinations, only four could be attempted successfully. The maximum percentage of the candles bearing fruits was observed for the cross CR x KR (83.33%) followed by CR x W (75%) and the lowest for CR x HR (33.33%) (Table 7).

Kalympong orange

In the variety Kalympong orange, only three crosses could be attempted successfully. Of these KO x HR showed 75% candles bearing fruits. The lowest percentage was observed for the cross KO x P (60%).

Kalympong red

Among the three Kalympong red crosses that was attempted the maximum percentage of candles bearing fruits was observed for the cross KR x P (75%) followed by its self KR x KR (50%). The lowest percentage was observed for the cross KR x HR (25%) (Table 7).

TABLE 7

RESULTS OF INTERVARIETAL HYBRIDISATION IN *A.andreanum*

Sl. No.	Combination	No.of pollinations	Fruiting Spadices		Fruits harvested		% germination	Number of days for germinations.
			No.	%	Av.	%		
1	HR x HR	7	2	29	61	18.76	61.25	6-8
2	HR x CR	1	1	100	94	28.9	78.0	6-7
3	HR x KO	1	1	100	30	9.2	60.0	7-9
4	HR x KR	5	5	100	95	29.2	69.0	6-9
5	HR x P	5	4	80	144	44.3	71.0	7-9
6	HR x W	4	4	100	45	13.8	32.6	7-10
7	CR x HR	3	1	33.33				
8	CR x CR	-	-					
9	CR x KO	-	-					
10	CR x KR	6	5	83.33	24.66	14.1	46.95	6-7
11	CR x P	4	2	50	-			
12	CR x W	4	3	75	68	38.8	75.64	6
13	KO x HR	4	3	75	52	19.62	54.76	10
14	KO x CR	-	-					
15	KO x KO	-	-					
16	KO x KR	3	-	0				
17	KO x P	5	3	60	32	12.10	36.8	12-14
18	KO x W	3	2	66	30	11.3	-	
19	KR x HR	4	1	25	27	10.2	59	6-7
20	KR x CR	-	-	-				
21	KR x KO	-	-	-				
22	KR x KR	2	1	50	2	0.4	-	
23	KR x P	4	3	75	83	31.3	61.9	6-7
24	KR x W	-	-	-				
25	P x HR	6	5	83.3	170	52.3	65	7-8
26	P x CR	1	1	100	46	14.15	74.5	6
27	P x KO	-	-	-	-	-	-	-
28	P x KR	6	4	66	142	43.6	38.4	8-9
29	P x P	7	6	85.7	92	28.3	65.4	7-8
30	P x W	3	3	100.7	46	14.15	50.4	9
31	W x HR	7	6	85.7	22.33	9.9	64.1	7-8
32	W x CR	1	1	100	-			
33	W x KO	1	1	100	-			
34	W x KR	7	6	85.7	60.66	29.96	64.8	7-9
35	W x P	9	8	88	22.66	10.1	56.7	9
36	W x W	3	3	100	40.33	17.9	68.2	8-9

Pink

Five crosses were done successfully in the variety Pink. Of these, the percentage of candles bearing fruits was maximum for the crosses with Chilli red and White (100%) followed by the selfs (85.7%). The lowest was 66% for the cross P x KR (Table 7).

White

In this variety, all possible six combinations could be successfully attempted of which the crosses W x CR, W x KO and W x W showed all candles bearing fruits, followed by W x P (88%). The crosses W x HR and W x KR showed 85.7% candle bearing fruits.

Among all the varieties, the average percentage of fruiting spadices was found to be maximum for the variety White (93%). Variety Pink with 87% and Honeymoon red with 84.8% also showed good percentage of candles bearing fruits. The lowest was for Kalympong red (50%). Among the selfings done, the White varieties showed maximum percentage of fruiting candles compared to the other three selfings.

22 NUMBER OF FRUITS PER CANDLE

The fruit is a berry which is pushed out to the surface of the fleshy candle when it becomes mature. Usually a berry contains one seed and sometimes two seeds. The seeds were

Fig 14 Spadix with three-fourth portion pollinated

Fig 15 Basal portion showing successful pollination

Fig 16 Middle portion showing fruit set

14

15

16

embedded in a sticky jelly like pulp. The fruit wall was transparent. The colour of fruit varied from yellow to reddish brown. The extend of fruit set depended on the pollinations done. (Fig. 14, 15, 16)

In the variety Honeymoon red, the number of fruits harvested from a candle was maximum for the cross HR x P (Fig.17) where the average number of fruits harvested was 144 followed by HR x KR cross ranging from 92 to 100 fruits/candle (Fig.18). The lowest number of fruits were obtained for HR x KO (30).

Chilli red

The maximum average number of fruits per candle in this variety was obtained in the cross CR x W (68) (Fig. 19) followed by CR x KR, the number varying from 44 to 4 with an average of 24.66 berries per candle.

Kalympong orange

Out of the three crosses, where fruits were harvested in this variety, KO x HR cross gave maximum fruits (52) (Fig.20) and the lowest in KO x W (30).

Kalympong red

In Kalympong red crosses, the average fruits harvested per candle ranged from 2 to 83. The maximum number of fruits harvested was in KR x P (83) and minimum in KR x KR (2).

Fig 17 The cross combination HR x P showing high fruit set

Fig 18 The cross combination HR x KR showing high fruit set

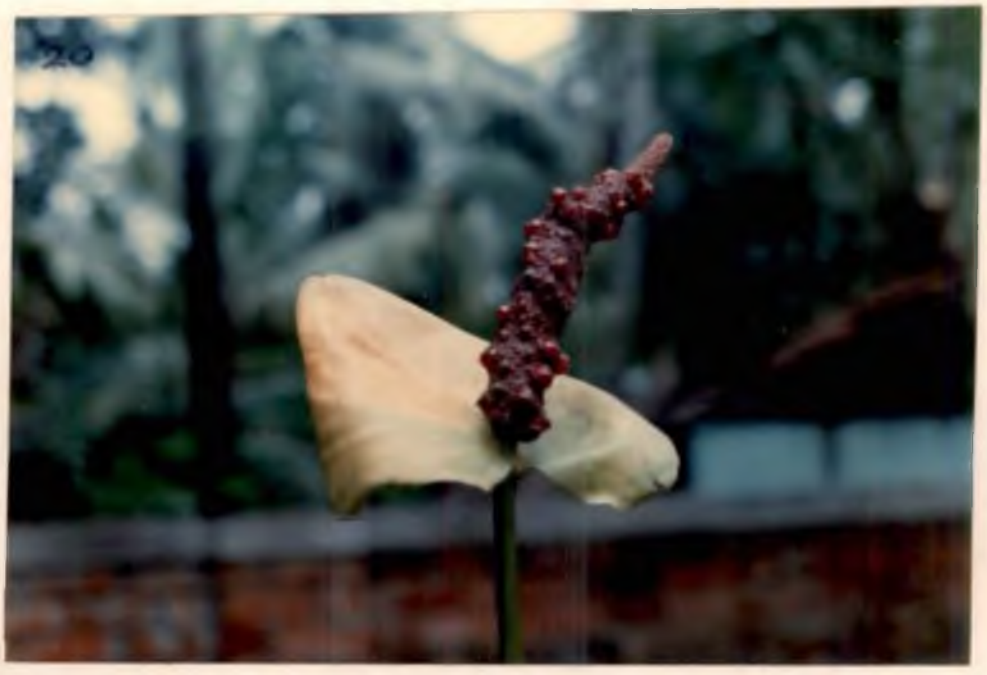

17


18

Fig 19 The cross combination CR x W showing high fruit set

Fig 20 The cross combination KO x HR showing high fruit set


19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Pink

Among the crosses involving the variety Pink, the maximum number of fruits per candle was harvested in P x HR (170), (Fig.21) followed by P x KR (142) and minimum for P x W (46) and P x CR (46).

White

Out of the six cross combinations which set fruits in the White variety, the maximum number of fruits harvested was from the cross W x KR (60.66) and minimum for the cross W x HR (22.33). The cross combination W x CR, showed incompatibility at the level of fruit set. Even though the initial fertilization was high (Fig.22) the fruits did not reach maturity.

Among the six varieties, Pink produced the average maximum number of fruits/candle followed by Honeymoon red, Chilli red, Kalympong orange, White and the lowest values were obtained for Kalympong red. The largest number of fruits harvested from one candle was from Pink variety in the cross P x HR where from one candle 205 fruits were obtained. Among the crosses, P x HR had the maximum average number of fruits harvested/candle followed by P x KR and P x P. The lowest number was obtained in KR x KR (2).

Among the four selfings done, P x P showed maximum fruit set/candle (92) followed by HR x HR (61). The lowest number of fruits/candle (2) was seen in the self KR x KR. Cross combination showing highest number of fruits/candle are given in Fig. 17-21.

23. PERCENTAGE FRUIT SET/SEED SET

Among the crosses of Honeymoon red, maximum percentage of fruit set/seed set was observed for the cross HR x P (44.3%) followed by HR x KR (29.2%) and lowest for the combination HR x KO (9.2%) (Table 7).

In the variety Chilli red, the cross CR x W showed maximum percentage fruit set/seed set (38.8%) followed by CR x KR (14.1%) (Table 7).

In Kalympong orange, the cross combination KO x HR had maximum percentage fruit set/seed set (19.62%) followed by KO x P (12.1%) and KO x W (11.3%) (Table 7).

In Kalympong red, KR x P had maximum percentage fruit set/seed set (31.3%) followed by KR x HR (10.2%) and lowest for the cross combination KR x KR (0.4%) (Table 7).

Fig 21 The cross combination P x HR showing high fruit set

Fig 22 The cross combination W x CR showing fruit set


21


22

TABLE 8

TEN CROSS COMBINATIONS SHOWING MAXIMUM FRUIT SET

	CROSSES	PERCENTAGE FRUIT SET
1.	P x HR	52.3
2.	HR x P	44.3
3.	P x KR	43.6
4.	CR x W	38.8
5.	KR x P	31.3
6.	HR x CR	28.9
7.	HR x KR	29.2
8.	P x P	28.3
9.	W x KR	26.96
10.	KO x HR	19.62

Fig 23 CR x KR : Medium fruit set

Fig 24 P x W : Medium fruit set


23


24

In the variety Pink, the percentage fruit set/seed set was maximum for the cross P x HR (52.3%) followed by P x KR (43.6%) and P x P (28.3%) (Table 7).

In the variety White, the maximum percentage fruit set/seed set was observed for the cross W x KR (26.96%) and lowest for W x HR (9.9%) (Table 7).

Cross combinations with medium fruit set are shown in Fig. 23 and Fig. 24.

Among the various cross combinations, the maximum percentage fruit set was observed for the cross P x HR (52.3%) (Table 8).

DURATION OF FRUIT MATURITY

In the variety Honeymoon red, the duration of fruit maturity ranged from 5 to 6 1/2 months. While self combinations of HR x HR took 5 to 6 1/2 months for maturity, the cross combinations HR x P and HR x KR matured in 5 1/2 to 6 months and HR x W matured in 5 to 6 months (Table 9).

In the variety Chilli red, where only two crosses were obtained, duration of fruit maturity for the combination CR x KR ranged from 4 3/4 to 6 months. The duration of fruit maturity in the other cross CR x W was 4 3/4 months.

In the variety Kalympong orange, all the crosses took a duration of 6 1/2 months or more for fruit maturity. The duration for the combination of KO x P ranged from 6 1/2 to 7 months while it was 6 3/4 months for KO x HR and 6 1/2 months for the combination KO x W.

TABLE 9

TABLE SHOWING DURATION OF FRUIT MATURITY AND COLOUR OF FRUITS

Crosses	Duration of Maturity (Range)	Fruit (Months) (Average for the variety)	Colour of Fruits
HR x HR	6 1/2		
HR x CR	5 3/4		
HR x KO	5 3/4		
HR x KR	5 1/2-6	5.8	Light yellow
HR x P	5 1/2-6		
HR x W	5-6		
CR x KR	4 3/4-6	5.0	Yellow
CR x W	4 3/4		
KO x HR	6 3/4		
KO x P	6 1/2-7	6.66	Light yellow
KO x W	6 1/2		
KR x HR	5 1/2		
KR x KR	4 1/2	5.25	Yellowish-Orange
KR x P	5-6 1/2		
P x HR	6-7		
P x CR	5 1/2		
P x KR	7-7 1/2	6.7	Reddish brown
P x P	6 1/2-7 3/4		
P x W	6 1/2-8		
W x HR	4 3/4-7		
W x KR	5 3/4-8	6.8	Yellow
W x P	7-7 3/4		
W x W	7-7 1/2		

In Kalympong red the duration of fruit maturity ranged from 4 1/2-6 1/2 months. The maximum duration of fruit maturity was observed for the cross KR x P (5-6 1/2 months) and minimum for the cross KR x KR (4 1/2 months).

All the cross combinations in the variety Pink, showed a longer duration for fruit maturity except P x CR where the duration was only 5 1/2 months. The maximum duration of fruit maturity was observed for the cross P x W which ranged from 6 1/2 to 8 months followed by P x P (6 1/2-7 3/4 months) and P x KR (7-7 1/2 months) (Table 9).

In the variety White, the duration of fruit maturity ranged from 4 3/4-8 months. The maximum duration of fruit maturity was observed for the crosses. W x KR (5 3/4-8 months) and W x P (7-7 3/4 months).

In all the six varieties, the duration of fruit maturity varied from 4 1/2-8 months. The average duration of fruit maturity was observed maximum for the variety White (6.8 months) followed by the Pink variety (6.7 months). Duration of fruit maturity was lesser for Honeymoon red (5.8 months) and Kalympong red (5.2 months) and lowest average fruit maturity period was found in Chilli red (5 months) (Table 9).

Fig 25 Berries : P x W


25

COLOUR OF FRUITS

The colour of fruits varied in different varieties. All the cross combinations of a variety showed the same colour. The colour ranges from light yellow to yellow to yellowish orange to reddish brown (Table 9). The berries were darker in colour in Pink and Honeymoon red varieties while they were lighter in shade for the others. The lightest yellow berries were produced by Kalympong orange. Berries taken from the cross combination P x HR, from the variety Pink is given in Fig. 25.

24. NUMBER OF SEEDS PER BERRY

The berries are usually single seeded and sometimes two seeded (Table 10).

In Honeymoon red, the percentage of single seeds ranged from 82-89.75% in the various crosses. The maximum number of single seeds was observed for the cross HR x P (89.75%). The percentage of two seeds was maximum for the cross HR x KO (23%) and lowest in HR x P (10.25%) (Table 10).

In the variety Chilli red, only single seeds were produced by the cross CR x KR followed by CR x W cross combination which produced 88.2% single seeds.

In Kalympong orange maximum number of single seeds of 96% was produced in the cross combination KO x W, followed by KO x P (91.15%). The percentage of two seeds was observed maximum in the cross KO x HR (25%) and minimum for KO x W (4%) (Table 10).

The variety Kalympong red produced all single seeds in the selfings, followed by the KR x P combination which produced 79.6% single seeds. Maximum percentage of two seeds was developed in the cross KR x HR (63%).

In the variety Pink the percentage of single seeds produced ranged from 84.8 to 95.2% among the various crosses. The maximum

TABLE 10

TABLE SHOWING PERCENTAGE SINGLE AND TWO SEEDS

CROSSES	SINGLE SEEDS (%)	TWO SEEDS (%)
HR x HR	89	11
HR x CR	82	18
HR x KO	77	23
HR x KR	89.2	10.8
HR x P	89.75	10.25
HR x W	87.5	12.5
CR x KR	100	-
CR x W	88.2	11.8
KO x HR	75	25
KO x P	91.15	8.85
KO x W	96	4
KR x HR	37	63
KR x KR	100	-
KR x P	79.6	20.4
P x HR	95.2	4.8
P x CR	80	20
P x KR	84.8	15.2
P x P	86.93	13.07
P x W	85.75	14.25
W x HR	87.85	12.15
W x KR	72.87	27.13
W x P	93.75	6.25
W x W	90	10

percentage of single seeds was found in the cross P x HR (95.2%). The percentage of two seeds produced was maximum for the cross P x CR (20%) (Table 10).

In the White variety, the percentage of single seeds produced was maximum in the cross W x P, which showed 93.75% single seeds and the lowest percentage of single seeds was produced in the cross W x KR (72.87%).

In all the six varieties, the percentage of single seeds produced was more than the double seeds, except in the cross KR x HR, where the percentage of double seeds was 63% ie, much higher than the single seed percentage. The percentage of single seeds produced ranged from the lowest value of 37% in KR x HR cross to 100% in the crosses CR x KR and KR x KR.

25 SEED SIZE

Among all the varieties, Pink and Honeymoon red varieties produced larger sized seeds, followed by Chilli red and White varieties. The Kalympong varieties produced comparatively smaller sized seeds. Berries with single seeds and two seeds were produced by all the six varieties except in CR x KR and KR x KR cross combination. When berries contained two seeds, one of them was smaller in size than the other, except in the cross

combination P x W where both seeds were similar in size (4x3.5mm.).

In Honeymoon red variety, the single seeds developed in the cross HR x P had largest size (5.125 x 4mm.) followed by HR x CR (5 x 4 mm.). A comparatively smaller seed size was observed for the cross HR x KR (4 x 3.5 mm.). Both seeds in the two seeded berries were larger in the crosses HR x P (4.5 x 4 mm., 4 x 3.5 mm.) and HR x HR (4.2 x 4 mm., 4 x 3.8 mm.) (Table 11).

Both the successful cross combinations in the variety Chilli red produced similar sized single seeds (4.5 x 3 mm.). In CR x KR, berries produced only single seeds. In CR x W, one of the two seeds was larger than the other (4 x 3 mm., 3.5 x 2 mm.) (Table 11).

Out of the three successful cross combinations in the variety Kalympong orange, KO x P produced berries with larger sized single seeds (3.75 x 3mm.). Whenever two seeds developed, they were also larger for this cross (3.5 x 2.5mm., 3.5 x 2mm.) and berries with the smallest pair of seeds were produced in the cross KO x HR (3.5 x 1.5 mm., 3 x 2 mm.) (Table 11). In all these cross combinations, the width of the seeds was smaller than length, varying from 2mm to 3mm.

TABLE 11

TABLE SHOWING SEED SIZE

CROSS COMBINATIONS	Berries with single seeds		Berries with two seeds	
	(Av.) Length mm.	(Av.) Width mm.	Length mm.	Width mm.
HR x HR	4.35	4.0	(1) 4.2 (2) 4.0	4.0 3.8
HR x CR	5	4.0	(1) 4.25 (2) 4.5	3.75 3.5
HR x KO	4.2	4.0	(1) 4.0 (2) 4.0	3.8 3.0
HR x KR	4.0	3.5	(1) 4.0 (2) 4.0	3.5 3.0
HR x P	5.125	4.0	(1) 4.5 (2) 4.0	4.0 3.5
HR x W	4.25	4.0	(1) 4.25 (2) 4.5	3.75 3.5
CR x KR	4.5	3.0		
CR x W	4.5	3.0	(1) 4.0 (2) 3.5	3.0 2.0
KO x HR	3.5	2.25	(1) 3.0 (2) 3.5	2.0 1.5
KO x P	3.75	3.0	(1) 3.5 (2) 3.5	2.5 2.0
KO x W	3.5	2.0	(1) 3.5 (2) 3.0	2.0 2.5
KR x HR	4.0	3.0	(1) 4.0 (2) 4.0	3.0 2.5

Table 11 continued.....

CROSS COMBINATIONS	Berries with single seeds		Berries with two seeds	
	(Av.) Length mm.	(Av.) Width mm.	Length mm.	Width mm.
KR x KR	3.5	3.0		
KR x P	4	3.5	(1) 4.0 (2) 3.0	3.0 2.75
P x HR	5.0	4.0	(1) 4.5 (2) 4.0	3.0 3.5
P x CR	4.5	4.0	(1) 4.5 (2) 4.0	3.0 3.0
P x KR	5.0	4.0	(1) 4.5 (2) 4.0	3.0 3.0
P x P	4.5	4.0	(1) 4.5 (2) 3.5	3.0 3.0
P x W	4.0	3.5	(1) 4.0 (2) 4.0	3.5 3.5
W x HR	4.5	3.0	(1) 4.0 (2) 4.0	3.0 2.5
W x KR	4.5	3.0	(1) 4.0 (2) 4.0	3.0 3.5
W x P	4.5	3.5	(1) 4.0 (2) 4.0	3.0 3.5
W x W	4.0	3.0	(1) 4.0 (2) 4.0	2.0 2.5

Fig 26 Cross combinations of Honeymoon red


26

Among the cross combinations in the variety Kalympong red, the cross KR x P produced larger sized single seeds (4 x 3.5 mm) in the berries. The single seeds developed in the self combination were smaller (3.5 x 3mm) (Table 11).

In the variety Pink the single seeds produced by the crosses P x HR (5 x 4mm) and P x KR (5 x 4mm) were larger, followed by P x CR and P x P where the average seed size was 4.5 x 4 mm for both the crosses. Smaller sized single seeds were produced in the cross P x W. Pairs of seeds developed in the crosses P x CR and P x KR were similar sized (Table 11). Both seeds were similar sized in the cross P x W (4 x 3.5mm).

In the variety White, the cross combination W x P produced larger sized single seeds (4.5 x 3.5mm). The cross combinations W x HR and W x KR produced similar sized seeds of size 4.5 x 3mm. Smaller sized single and twin seeds were produced in the self combination of W x W (Table 11).

26. PERCENTAGE GERMINATION

Though a total 27 crosses appeared to be successful at the beginning as evidenced by fruit set, four of them (CR x HR, CR x P, W x CR, W x KO) survived only for periods from 3 months upto 5 months and did not complete the maturity cycle. Thus

Fig 27 HR x CR : High seed germination

Fig 28 CR x W : High seed germination

Fig 29 HR x KR : High seed germination


27


28


30-3-94
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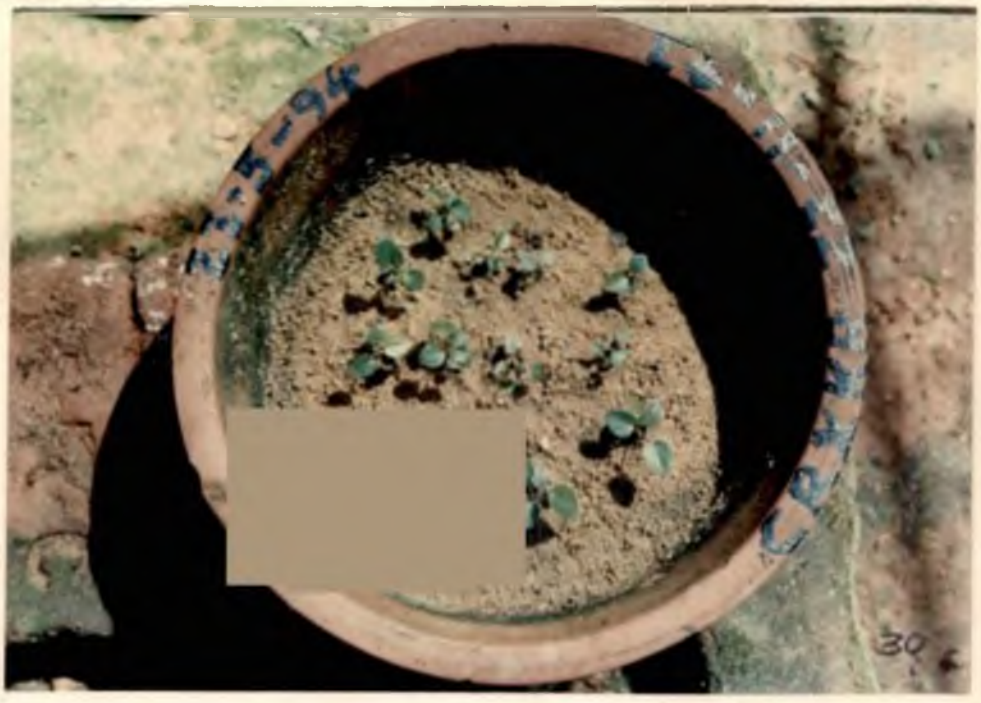
Fig 30 CR x KR : Medium seed germination

Fig 31 KR x P : Medium seed germination

Fig 32 W x HR : Medium seed germination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31


18-3-94
26-3-94
32

mature seeds were obtained only for 23 combinations and they were sown in individual seed trays.

Among these 23 crosses of the six varieties under the study, germination percentage was maximum for the cross HR x CR (78%), (Fig.27) followed by CR x W (75.64%) (Fig.28). The cross combinations KR x KR and KO x W did not germinate at all. The lowest seed germination percentage was observed for the cross KO x P (36.8%) (Table 7).

All the six crosses involving Honeymoon red as female parent showed seed germination. Of these, the combination HR x CR showed the maximum germination of 78% followed by the cross HR x P (71%) (Table 7). The lowest germination was observed in the cross HR x W (32.6%). The cross combinations with Honeymoon red as female parent is given in Fig.26. The number of days taken for germination of the seeds in these crosses varied from 6-10 days. The cross combination HR x W took the longest duration ie, upto 10 days for seed germination (Table 7).

Only four crosses could be attempted with Chilli red as the female parent. Out of these, fruiting spadices in 2 crosses fell off before maturity and thus mature fruits were obtained only for two crosses and they were put for germination. Of these, CR x W showed a germination percentage of 75.64% and CR x KR 46.95%

(Table 7) (Fig.30). Both the crosses germinated within one week. Cross combinations with high germination percentages are shown in Fig.27, 28, 29.

Three crosses with Kalympong orange as the female parent produced mature fruits and seeds. Of these three successful cross combinations, KO x W did not show any germination. The cross combination KO x HR had the maximum germination percentage of 54.76% followed by KO x P (36.8%). The cross combination KO x P took 12-14 days and KO x HR 10 days for seed germination.

Among the three combinations involving Kalympong red as the female parent, the cross combination KR x P showed a maximum seed germination percentage of 61.9%, (Fig.28) followed by KR x HR (59%). The selfed seeds of Kalympong red (KR x KR) did not germinate. The Kalympong red crosses took 6-7 days for germination. (Table 7).

Cross combinations with medium seed germination percentages can be seen in Fig.31, 32 and 33.

Mature fruits were obtained from five crosses where Pink was the female parent. Out of these, the cross P x CR showed maximum seed germination percentage of 74.5% followed by P x HR (65%) (Table 7) the lowest germination was observed for the cross combination P x KR (38.4%) (Fig.34). Seeds of these crosses

Fig 33 P x KR : Low seed germination

Fig 34 KO x P : Low seed germination


33


34

germinated within 6-9 days. The cross combinations P x KR and P x W took a longer duration of 9 days for seed germination while the combination P x CR germinated in 6 days (Table 7).

Among the four successful cross combination involving the variety White as female parent, the selfings showed maximum germination percentage of (68.2%) followed by the cross W x KR (64.8%) (Table 7) (Fig.2?). The lowest seed germination was observed for the cross W (57%). All the cross combinations germinated in 7-9 days. (Table 7).

Low seed germination is seen in the combinations KO x P (Fig.35) and P x KR (Fig.34).

Considering seed germination in all the 23 different crosses studied, maximum average germination was observed in the variety White (63.45%) followed by Honeymoon red (62%). The lowest germination of seeds was observed in the variety Kalympong orange (45.78%).

The best 10 crosses identified in the present study on the basis of seed germination are shown below in (Table 12).

TABLE 12

TEN BEST CROSSES AND THEIR GERMINATION

COMBINATION	PERCENTAGE GERMINATION
HR x CR	78
CR x W	75.64
P x CR	74.5
HR x P	71
HR x KR	69
W x W	68.2
P x P	65.4
P x HR	65
W x KR	64.8
W x HR	64.1

DISCUSSION

DISCUSSION

The morphological and compatibility studies are taken as a preliminary step before undertaking genetic improvement in any cultivated species.In the present investigation, compatibility between different cultivars of Anthurium andreanum is analysed and evaluated by the response of the cultivars to intervarietal hybridisation. Hybridisation, if done between selected parents with good combining ability, can yield valuable and novel hybrids. The cross compatibility analysis has been done earlier by Sheffer and Kamemoto (1976) in 56 sp. of Anthurium through intra and intergroup pollinations. The studying of morphological characters helps in identifying species as well as varieties. All the six varieties used in the present study show distinct variability in morphological characters. Some of the morphological and floral characters studied in the present investigation have been studied earlier by Bindu (1992) and Mercy and Dale (1994) in different varieties of A. andreanum.

Height of the plants studied in the six varieties of A andreanum viz. Honeymoon red, Chilli red, Kalympong orange, Kalympong red, Pink and White, ranged from 43cm to 70cm. The variety Pink had the tallest plants with a height of 70cm and the shortest variety was Kalympong red with a height of 43.0 cm. The

height of Pink and Honeymoon red varieties were on par. Similarly the height of Honeymoon red and Kalympong orange did not show significant difference in height. The varieties Kalympong red, Chilli red and White were having short heights and they were also on par. Plant heights of five varieties of A. andreanum have been studied earlier by Bindu (1992), where the height of the plants ranged from 45cm to 85cm.

The leaves are borne singly on long stalks with sheathing bases in a spiral rosette. In all the six varieties, the average number of leaves produced per year ranged from 3.5 in the variety Kalympong red to 6.3 in the variety White. Lesser number of leaves were noted in Kalympong red and Chilli red varieties. There were individual plants producing as low as 3 leaves in a year upto a very high frequency of 8 leaves per year. Higaki and Rasmussen (1979) reported that the anthuriums grow slowly and produce only 6-8 new leaves and vegetative buds on a stem axis per year. Mercy and Dale (1994) reported that anthurium is slow growing and produces only 5-8 new leaves on a stem axis per year.

There was a long interval period noticed between the emergence of two successive leaves in each plant. The average duration between the opening of two successive leaves in the present study ranged from 47 days to 62 days. This average duration was shortest in the variety White and longest in the

variety Chilli red. Klapwijk and Spek (1988) found that the leaf plastochron duration was fairly constant from March until September, at an average of 72 days in six Anthurium cultivars. In the present study also, the leaf plastochron duration was fairly constant from March to August in all the varieties except in Chilli red and Kalympong red where the number of leaves produced in some plants under observation was less. From August onwards a lag in the production of leaves in some plants was noticed. This duration between the opening of two leaves ranged from 72-99 days, on an average. In Chilli red variety there were instances where the leaf plastochron duration extended upto 135 days.

Leaf size index is obtained by adding the length and width of leaves. The leaf size index of the varieties, of A andreanum under the present investigation ranged from 75.72cm. to 37.3cm. The bigger sized leaves were produced by Pink and Honeymoon red varieties. The leaf sizes of Kalympong red, Kalympong orange and Chilli red varieties were not significantly different. The length of the leaves ranged from 48.16cm. to 23.6cm. and width from 27.36cm. to 13.83cm. The leaf size index was lowest for White variety indicating small sized leaves..tb5

Leaf size index of five varieties of Anthurium andreanum was studied by Bindu (1992). She reported that the Pink varieties had maximum leaf size index while smallest leaves were produced by Lady Jane and Chilli red varieties. Kamemoto and Sheffer (1978) made crosses between A. Scherzerianum and A. wendlingerii to produce a hybrid and they observed the leaf size of parents and hybrids for comparison. Mercy and Dale (1994) are of theopinion that the leaves of commercially valuable anthuriums should be small to medium sized as well as narrow and elongated. Large and exuberantly growing leaves indicate primitive ess and are undesirable, as they take up too much growing space. Among the six A. andreanum varieties under the present study, White and Chilli red varieties produced small and medium sized leaves.

The petioles are slender and long and there are variations in the colour of both petiole and young leaves in all the six varieties in the present investigation. The petiole colour was green in Honeymoon red, Kalympong orange, Pink and White varieties. It was greenish-purple in Chilli red and purple in Kalympong red varieties. Colour of tender leaves varied from light green in the varieties Honeymoon red and Chilli red to green in the variety White to greenish-brown in Kalympong red to light brown in Kalympong orange to brown in the variety Pink. According to Mercy and Dale (1994), the young tender leaves of A.

andreanum varied in colour from light green to deep reddish brown.

The spathe, which is the modified bract, is the most attractive part of floral anthuriums. In the present study with six varieties of A. andreanum, it was found that the number of spadices produced by a plant annually varied from 4 to 8. In all the varieties, the spadix was generally produced from the leaf axil. But there were instances where the leaf axil does not bear a spadix. Sometimes spadices appeared in the place of leaves, so that one leaf missed the cycle.

The average number of spadices produced in the six varieties ranged from 5.2 in the variety, Chilli red to 7.7 in the variety White. Steen et al (1973) compared the productivity and inflorescence quality of 120 individual anthurium plants for nearly two years and reported that the individual plants varied greatly in productivity, producing 4 to 16 flowers over the two years.

Klapwijk and Spek (1984) studied the monthly patterns of inflorescence formation for four years in six Anthurium cultivars. They found that the time required for buds to develop into blooms ready for harvest ranged from about 45 days to 53

days during May to October and from 65 to 75 days during December to March. The studies with six varieties of A. andreanum under the present study also showed a duration of 43 days to 51 days on an average, between the emergence of two successive spadices. This average duration was lowest for the variety White ie, 43 days and highest for the variety Pink ie, 51 days. But in all the six varieties, the duration between the opening of two spadices was on par. There was a slight increase in the duration between the opening of two spadices from August to March, during period under study. This duration ranged from 63-95 days, on an average. In some plants, this duration extended upto 120 days as in Chilli red and Kalympong red.

Spathe size index which is the length of spathe + width of spathe, is an important factor which determines the value of anthurium flowers. Singh (1987) graded the flowers in different categories as per United States Department of Agriculture standards based on the average length and width of spadix as miniature (under 8cm), small (8-10 cm) medium (10-13 cm), large (13-15 cm) and extra large (15 cm). Mercy and Dale (1994) graded spathe size of Anthurium as super large (30 cm. and above), large (25-29 cm), medium (20-24 cm), small (15-20 cm), mini (12-14 cm) and micro (9-11 cm). In the present investigation Pink and

Kalympong red varieties produced super large flowers with spathe size index of 33.12 cm and 31 cm respectively. Spathe size index was maximum in Pink variety. Spathe sizes of Kalympong red and Honeymoon red were not significantly different. Kalympong orange and Honeymoon red varieties produced large sized flowers ie, at a range of 25-29 cm. Chilli red produced medium sized flowers with a spathe size index of 22.7 cm. Smallest of the flowers among the six varieties was developed in the White variety, where spathe size index was 13.23 cm. Bindu (1992) observed the spathe size of five varieties of A. andreanum and reported the highest spathe size for Pink (10.4 + 9.7 cm). As plants mature, the spathe size increased.

The spathe colour in the varieties varied from dark red to bright red to red light orange pink, and white. According to Birdsey (1956), Linden described the spathe of A. andreanum from Columbia as orange scarlet or vermillion, whereas, the plants offered in the trade have a complete colour range from white to dark red. Mercy and Dale (1994) reported that some varieties had spathes of two or even three colours. Forsyth and Simmonds (1954) reported the presence of 3-cyanidin glycosides and 1-pelargonidin glycoside in the spathes of A. andreanum. Iwata et al (1985) found that the spathe colour in A. andreanum was

determined by the relative concentrations of anthocyanins. A predominance of cyanidin 3-rhamnosyl glucoside along with pelargonidin resulted in pink to dark red colour whereas pelargonidin 3-rhamnosyl glucoside alone resulted in coral to orange.

The spathe was smooth, thick and glossy without prominent veins in Honeymoon red while it was thinner, deeply veined and blistered in Kalympong red and Kalympong orange. In the variety Chilli red, the spathe was medium thick and blistered with prominent veins. Pink and White varieties had smooth, thin and lightly veined spathes and did not show any blistering. According to Birdsey (1956), Linden described the spathe of A. andreanum and varying degrees of smoothness to blistering. Mercy and Dale (1994) reported that the spathe in floral anthuriums was smooth, thick and glossy without prominent veins or it may be thinner, deeply veined and blistered.

As the size of the leaves increased, the spathe size also increased ie, there was significant correlation between leaf size and spathe size. In all the varieties, as the leaf size of the plants increased, the spathe size also increased. The largest leaf size and spathe size indices were observed in the variety Pink. Though the leaf size index of Honeymoon red was larger

than Kalympong red and Kalympong orange, these varieties produced larger flowers than Honeymoon red. The variety White had smaller sized leaves and spadices.

Bindu (1992) observed the candle length of five varieties of A. andreanum and the values ranged from 4 cm. (var.Lady Jane) to 9.5 cm (var.Pink). In the present study, the candle length ranged from 12.1 cm. in the variety Pink to 6.6 cm. in the variety White. Pink and Honeymoon red varieties had long and fleshy candles and they were on par. The candle lengths of Honeymoon red, Kalympong orange and Kalympong red were not significantly different. Chilli red and White varieties produced smaller sized candles. Comparatively thinner sized candles were found in Kalympong orange, Kalympong red and White varieties. Mercy and Dale (1994) reported that in ordinary varieties of pink, red and white, the candle was long and fleshy but in highly bred hybrids and exotics, candle was shorter and more slender. The small and slender candles are more desirable. In the present study, the Chilli red and White had short and slim candles. The candle was shortest in the White variety.

The candle had either a single colour or two or more bands of colours. The candle was light red in Honeymoon red, and Pink in the Pink variety. Bands of colours like white and yellowish orange, yellow and white, orange and pink were seen in Chilli

red, Kalympong red and Kalympong orange varieties respectively. Candle colour was either white or cream in the White varieties. Earlier observations by Mercy and Dale (1994) revealed that the candle has a single colour red, pink or green in ordinary varieties and in hybrids it has yellow, white, pink or red colours in two or more bands.

According to Mercy and Dale (1994), spadix in good commercial Anthurium varieties should have short candle curving towards the tip of the spathe and held at an angle less than 45^{o}. In the present investigation, the maximum angle of 75^{o} between the base of candle to the plane of the spathe was observed in the variety Honeymoon red which was not desirable. The ideal anthurium spadix with an angle less than 45^{o} are produced by varieties Chilli red, Kalympong orange, Kalympong red and White.

The anthurium 'flower' is a combination of the colourful modified bract, the spathe and hundreds of small flowers on the pencil like inflorescence axis called candle. In the present investigation, it was observed that the candle had about 175 to 325 flowers. The flowers are arranged in a series of spirals. The flowers of anthurium are bisexual and sessile arranged in acropetal succession ie, older flowers at the base and younger ones towards the top.

The average number of flowers produced was maximum in Pink and Honeymoon red varieties (325 flowres). It was comparatively less in the Chilli red variety (175 flowers). Watson and Shirakawa (1967) reported that the anthurium 'flower' consists of a modified leaf, the spathe and a flower spadix with over 300 spirally attached minute flowers. Croat and Bunting (1978) reported that the flowers of Anthurium are bisexual and were closely conjested in cylindrical spikes and arranged, in a series of spirals on the spadix. According to Bindu (1992) the Anthurium 'flower' had a candle bearing about 50-150 sessile flowers.

Spathe-candle ratio depends on the spathe size and candle length. This ratio was maximum in Kalypong red (2.86:1). The spathe-candle ratio was 2.8:1 in the variety Chilli red and 2.79:1 in Kalympong orange. These varieties produced comparatively larger sized spathes with smaller candles. The spathe-candle ratio was smallest in the variety White. (2:1) ie, the white flowers had smaller sized spathes with long candles.

Anthurium flowers are bisexual, regular and protogynous. However the species A. andreanum was not included among the protogynous species of Anthurium reported and listed by Croat

(1980). The flowers matured first from the base and proceeded upwards in an acropetal succession in all the six varieties studied. Croat (1980) had earlier reported a similar behaviour in some other species of Anthurium such as A. purpureospathum, A. ravenii etc. From the observations on six varieties in the present study, it was found that the days to initiation of female phase varied from 1-10 days. The variety Honeymoon red had the longest period for initiation of female phase. The initiation of female phase can be identified by the slightly projecting stigmas on the surface of the candle. In some cases, although the stigmas did not form droplets, they were glistening often exerted and were assumed to be receptive (Croat, 1980). eg. A. armeniense, A. caperatum, A. fatoense, A. panduriformae etc.

The female phase was identified by the presence of honey dew or stigma droplets and insect activity. In the present study, the female phase for the species ranged from 5-25 days. The duration of female phase was shortest in the variety Chilli red. The Kalympong varieties remained in the female phase for longer periods. In the variety Kalympong orange, the female phase lasted for 13-14 days and in Kalympong red, it ranged from 16-25 days. Croat (1980) reported that the duration of pistillate phase was quite variable ranging from only a few hours in

A. ravenii to 21-28 days in A. luteynii. In the species of Anthurium studied by Croat such as A. panduriformae, A. oerstedianum, A. hacumense, A. pittieri, the durat ion of female phase ranged from 3-14 days. In the species A. ochranthum, A. cotobrusii the female phase was for about 21 days and in A. caperatum and A. luteynii, it was 28 days. Bindu (1992) found that the female phase in A. andreanum ranged from 3-12 days. Mercy and Dale (1994) observed that the flowers near the base of the candle were older and matured first and female receptivity progressed from base towards the tip with flowers completing the receptive phase in 3-7 days.

The separation period or the interphase between the female and male phases for the species A. andreanum ranged from 4-10 days. During the interphase, the stigmatic droplets dried up. In the non-commercial species of Anthurium such as A. hacumense A. kunthii, A. lentii etc., Croat (1980) observed that the dry period was only one to two days. In a few species, the interphase period was so short that it was not certain whether the species involved were homogamous or protogynous eg : A. cotobrusii. Croat (1980) also reported that interphase in

A. pittieri ranged from 10-20 days. In the present study, it was observed that the interphase was prolonged with the suppression of the male phase from March to August. Bindu (1992) observed that during the interphase, stigmatic droplets dry up and interphase ranged from 4-7 days. She also noted that during the rainy season, the interphase was prolonged and or the male phase was completely suppressed. Sometimes a few stamens appeared irregularly on the candle. Mercy and Dale (1994) reported that the interphase was about one week in general.

Male phase was identified by the appearance of stamens on the candle. In general, anther exertion started from the base proceeding towards the apex. Sometimes, only a portion of the spadix exhibited male phase as in the variety Kalympong red or sometimes stamens appeared on the candle irregularly. Croat (1980) reported that the initiation of stamen emergence appeared to be equally from all parts of the spadix or initial maturation and staminal exertion appeared for many flowers in the basal fourth, basal third or basal half of the candle and further development proceeded in a systematic manner.

The candle remained in the male phase for 3-8 days in A. andreanum. Croat (1980) observed that in some species of Anthurium, the inflorescence may be in the male phase for several weeks. The anther extrusion was scattered in A. caperatum and

sporadic in A. luteynii. He also reported that in A. hacumense, the anther extrusion started from the middle and proceeded towards the ends. Bindu (1992) recorded that the anther exertion started from the base and proceeded regularly towards the apex and the duration of male phase ranged from 3 to 7 days. Mercy and Dale (1994) reported that in A. andreanum, all the anthers on a candle emerged in about 4-8 days.

The period from the emergence of the young spadix to its yellowing and drying up in the case of unfertilised spadices ranged from 1 1/2-3 1/2 months. The life of spadix was maximum in Honeymoon red and Kalympong red varieties (3 1/2 months). For fertilised spadices, this period ranged from 4 1/2-8 months, as the fruits matured very slowly. Paull (1982) reported that the senescence of Anthurium flowers was accompanied by visible changes including spathe-gloss loss, necrosis of spadix, greening of spathe and spadix. These senescence changes were non-reversible processes leading to the death of the spadix. Observations by Mercy and Dale (1994) showed that the life of an unfertilised spadix was about eight weeks and the fertilised inflorescence has a life span of about 4-7 months.

Suckering ability, which is the ability to produce suckers, is one of the important characters to be considered in selection.

Higaki and Rasmussen (1979) reported that some cultivars produced basal suckers readily, while others would need to be stimulated to produce suckers by foliar application of N-6-Benzyl adenine at 1000 mg/l. In the present study, it was observed that the suckering ability was positive for Honeymoon red, Chilli red, Pink and White varieties and negative for Kalympong varieties. The maximum suckering ability was observed for Pink.

For compatibility analysis, intervarietal hybridisation was done depending on the availability of receptive spadices and fresh pollen, in the six A. andreanum varieties including selfings. The study involved 36 cross combinations. The compatibility was analysed depending on the response of the cultivars to inter-varietal hybridisation at three levels ie, by successful fetilisation, fruit set/seed set and seed germination. Investigations by Sheffer and Kamemoto (1976) on cross compatibilities, among 56 sp. of Anthurium showed that interspecific hybrids with A. andreanum and A. scherzerianum are not readily obtained; they did get hybrids of A. andreanum with six closely related species, but no hybrids with A. scherzerianum.

According to Kaneko and Kamemoto (1978), the cultivated Anthurium forms was derived from interspecific hybrids which are supposed to have arisen spontaneously in early species

collections. Kamemoto and Sheffer (1978) made successful crosses between A. scherzerianum and A. wendlingerii to produce a hybrid with a greyish-orange spathe. Fertility in these hybrids was very good indicating the relatively close taxonomic relationship. According to Mercy and Dale (1994) hybridisation done discretely between selected parents with good combining ability can yield valuable and novel new hybrids. Henny (1989) opined that the studies of factors affecting flowering, pollination, seed set and genetics of ornamental tropical aroids have made possible the development of new Anthurium hybrids suitable for use as indoor foliage plants.

Cross compatibility analysis was done based on the percentage of candles bearing fruits, percentage fruit set/seed set and seed germination. The percentage of candles bearing fruits was found to be maximum for the variety White (93%). The variety Honeymoon red and Pink also showed good percentage of candles bearing fruits. The lowest percentage (50%) was observed in the variety Kalympong red. Among the selfings, the White varieties showed maximum percentage of fruiting candles compared to the other three selfings, obtained in the study. Sheffer and Kamemoto (1976) analysed the cross compatibility in 56 sp. of Anthurium through intra and inter group pollinations. The species were divided into six distinct morphological groups on

the basis of the important Englerian character such as number of ovules per locule, colour and shape of berry, shape of inflorescence and shape and texture of leaf. Compatibility analysis was done based on the percentage of fruiting spadices harvested, average percentage germination and hybrid progenies flowered. Self pollinations resulted in 81% fruiting spadices, intraspecific and interspecific cross combinations resulted in 65.4% and 28.1% fruiting spadices respectively. In the present study, selfings and intervarietal crosses resulted in 66.2% and 76.5% fruiting spadices respectively.

The fruit is a berry which is pushed out to the surface of the fleshy candle when it becomes mature. A candle with developing fruits can be visually identified from an unfertilised one within a month of fertilisation. The candle becomes swollen and fleshy with developing berries embedded in it. In the present investigation with six varieties of A. andreanum, the maximum average number of fruits was produced in the Pink variety and the lowest number of fruits was obtained in Kalympong red. The maximum number of fruits harvested was from the cross P x HR where from one candle 205 fruits were obtained. The lowest number of fruits was obtained in the self combination KR x KR (2). Cross compatibility studies with six groups of Anthurium by Sheffer and Kamemoto (1976) revealed that in intragroup

interspecific pollinations the lowest percentage of fruits harvested and hybrids flowered were obtained in Group VI, the most morphologically diverse of the groups. Group II, III and V gave higher percentage of fruiting spadices and flowering hybrids. Only the intergroup combinations III x VI and V x VI resulted in hybrids.

Among the various cross combinations, the maximum percentage fruit set was observed for the cross P x HR (52.3%) followed by HR x P (44.3%). The lowest percentage fruit set was observed in the cross KR x KR (0.4%). According to Mercy and Dale (1994), in a well fertilised candle about 100-200 or more berries develop.

The average duration of fruit maturity was maximum for the variety White (6.8 months) followed by the Pink variety (6.7 months). The lowest average fruit maturity period was found in Chilli red (5 months). According to Singh (1987), after pollination and fertilisation, the spadix begins to grow and takes on a warty appearance, and the fruits matured after 6-8 months. Geir (1989) observed that the time required from pollination to the maturity of seeds was about 6-7 months for A. andreanum and 10-12 months for A. scherzeranium. The maximun duration of fruit maturity was observed for the crosses P x W and W x KR where this duration extended upto 8 months. According to

Pierik et al (1974), the breeding of A. andreanum is handicapped by the long period of 6-7 months from fertilisation to ripening of seeds. Mercy and Dale (1994) reported that in the commercial varieties of A. andreanum, the seeds matured in about 4-7 1/2 months. According to Zimmer (1986) for the ripening of the seeds of anthurium, it takes about 5-12 months.

The colour of fruits varied in different varieties. All the cross combinations of a variety showed the same colour. The colour ranged from light yellow to yellow to yellowish orange to reddish brown. The berries were darker in colour in Pink and Honeymoon red varieties while they were lighter in shade for the others. The lightest yellow berries were produced by kalympong orange.

The berries are usually single seeded and sometimes double seeded. The seeds are embedded in a sticky jelly like pulp. According to Zimmer (1986), anthuriums are mainly propagated from seeds. The spadix seldom has full fruit set and berries contain 2-3 seeds. In the present study, the percentage of single seeds produced was more than the double seeds except in the cross KR x HR, where the percentage of twin seeds was 63% ie, much higher than the single seed percentage. The percentage of single seeds produced ranged from the lowest value of 37% in the cross KR x HR to 100% in the crosses CR x KR and KR x KR. Mercy and Dale

(1994) reported that each berry contains one or two seeds within the thin fruit wall in a gelatinous pulp and if not harvested will remain attached to the candle for a few days more before they dry up and fall off the candle.

In the present study, Pink and Honeymoon red varieties produced larger sized seeds. The Kalympong varieties produced comparatively smaller sized seeds. Berries with single seeds and two seeds were produced by all the six varieties except in the cross combinations, CR x KR and KR x KR. When berries contained two seeds, one of them was smaller in size than the other except in the cross combination P x W, where both seeds were similar in size (4 x 3.5 mm.). The largest size for single seeds was obtained for the crosses HR x P (5.125 x 4mm.) P x HR (5 x 4mm), P x KR (5 x 4mm) and HR x CR (5 x 4mm). The smallest single seeds were obtained for the cross KO x W (3.5 x 2mm). In berries containing two seeds, the cross combination HR x P produced larger sized seeds (4.5 x 4 mm; 4 x 3.5 mm) and smaller sized seeds were produced in the cross combination KO x KR (3 x 2 mm, 3.5 x 1.5mm).

A total of 27 crosses appeared to be successful at the beginning as evidenced by fruit set. Four cross combinations, viz, CR x HR, CR x P, W x CR, W x KO survived only for periods from 3 months upto 5 months and did not complete the maturity

cycle. Mature seeds were thus obtained only for 23 combinations. According to Szendel et al (1981), seeds of A. andreanum harvested at three maturity stages and those of A. scherzerianum at one maturity stage (light orange) were germinated on 3 substrates at a P^H ranging from four to eight in light or darkness at temperatures of 18,24 or 28°C. In A. andreanum, the best germination was obtained on a high peat substrate at a P^H of 4-5, in light, at 28°C in the case of seeds harvested at an early stage (yellow-green to light orange). In the present study, with six varieties, all fruits were collected in one stage only ie, at full maturity and the maximum average germination was observed in combinations with the variety White as female parent (63.45%) followed by Honeymoon red (62%) and the lowest germination of seeds was obtained in the variety Kalympong orange (45.78%).

Among the 23 crosses of the six varieties, germination percentage was maximum for the cross HR x CR (78%). The cross combinations KO x W and KR x KR did not germinate. The lowest seed germination was observed for the cross combination HR x W (32.6%). Zimmer and Bahnemann (1982) reported that the A. scherzerianum seeds from different sources varied in their ability to germinate at low, sub-optimal temperatures. Optimum germination temperatures were found to be 20-25°C, but some seeds germinated well at 10 or 15°C.

Results of intra group pollinations done by Sheffer and Kamemoto (1976) revealed that the average percentage germination of seeds of the intra and interspecific crosses ranged from 88% to 21%, and in the intergroup pollinations in Anthurium, the germination ranged from 0-29.7%. According to Mercy and Dale (1994), the hybrid seeds from crosses between hardy varieties show above 90% germination and their seedlings also show high survival fitness and vigour while, seeds produced in crosses between exotic varieties are smaller in size and poor in germination.

The number of days taken for germination in all the six varieties ranged from 6-14 days. The varieties Honeymoon red and Chilli red took 6-10 days for seed germination, in the various cross combinations. The variety Kalympong orange took longest duration of 10-14 days for seed germination. The cross combination KO x P took the maximum number of days for seed germination ie, 12-14 days. The cross combination CR x W and P x CR germinated in about 6 days. According to Singh (1987), the seeds germinate within 6-8 days. Criley (1989) observed that the seeds of A. andreanum. Andre germinated within 14 days.

The compatibility reactions among intervarietal crosses in A. andreanum based on fruiting candles, fruit set/seed set and seed germination are given in Table 13.

TABLE 13

COMPATIBILITY REACTIONS AMONG INTERVARIETAL CROSSES IN *A. ANDREANUM* BASED ON FRUITING CANDLES, FRUIT SET AND SEED GERMINATION

	CROSS COMBINATIONS	% FRUITING CANDLES	% FRUIT SET	% SEED GERMINATION
1.	HR x HR	B	C	A
2.	HR x CR	A	B	A
3.	HR x KO	A	C	A
4.	HR x KR	A	B	A
5.	HR x P	A	A	A
6.	HR x W	A	C	B
7.	CR x HR	B	D	D
8.	CR x KR	A	C	B
9.	CR x P	B	D	D
10.	CR x W	B	B	A
11.	KO x HR	B	C	A
12.	KO x KR	D	D	D
13.	KO x P	B	B	B
14.	KO x W	B	C	D
15.	KR x HR	C	C	A
16.	KR x KR	B	D	D
17.	KR x P	B	B	A
18.	P x HR	A	A	A
19.	P x CR	A	C	A
20.	P x KR	B	A	B
21.	P x P	A	B	A
22.	P x W	A	C	A
23.	W x HR	A	C	A
24.	W x CR	A	D	D
25.	W x KO	A	D	D
26.	W x KR	A	B	A
27.	W x P	A	C	A
28.	W x W	A	C	A

A - Compatibility high
B - Compatibility medium
C - Compatibility low
D - Compatibility nil

The percentage of fruiting candles ranged from 0-100%. For easy computation, these values are divided into four classes as high (76-100%) represented by the symbol A, medium (26-75%)-B, low (1-25%)-C and nil (0%)-D.

The percentage fruit set ranged from 0 to 52.3%. These values are classified as high (above 40%)-A, medium (20-30%)-B, low (1-19%)-C and nil (0%)-D.

The percentage seed germination ranged from 0 to 78% and the values are classified as high (above 50%)-A, medium (20-49%)-B, low (1-19%)-C and nil (0%)-D.

Among the 28 cross combinations, the highly compatible crosses were HR x P and P x HR, where the percentage fruiting candles, percentage fruit set and percentage seed germination were high, ie, (AAA). But these combinations are not much valued commercially. Medium compatibility for all the three characters ie, (BBB) was noticed for the cross KO x P. The cross combinations HR x CR, HR x KR, CR x W, KR x P, P x P and W x KR had medium fruit set and high germination (BA). The incompatible cross combinations were KO x KR, CR x HR, CR x P, W x CR, KR x KR and W x KO. The combination KO x KR showed complete incompatibility at the level of percentage fruiting candles. The cross KR x KR eventhough indicated some amount of percentage

fertilization, was highly incompatible at fruit set and seed germination. The cross combinations CR x HR, CR x P, W x CR and W x KO showed incompatibility at the level of fruit set. In these cases, eventhough the initial fertilization as evidenced by fruiting candles was high, the fruits did not reach maturity. The fruiting candles were shed between 3-5 months after fertilization.

SUMMARY

SUMMARY

It is essential to analyse the morphological/floral characters and compatibility relations in any cultivated species before undertaking its genetic improvement. Detailed studies on these aspects in A. andreanum, the species under the present investigation, are very few. There is a tremendous genetic potential for this crop, which is yet to be exploited.

In the present experiment, morphological and compatibility studies were conducted in six commercially important varieties of A. andreanum viz. Honeymoon red, Chilli red, Kalympong orange, Kalympong red, Pink and White.

Under the morphological/floral characters 20 different characters were taken into consideration. Plant height of all the six varieties was recorded which ranged from 43 cm to 70 cm. The largest plant height was observed for the Pink variety and the shortest variety was Kalympong red.

The average number of leaves produced per year ranged from 3.5 to 6.5 among the varieties. There was a long interval period between the emergence of two successive leaves in each plant. The average duration was lowest in the variety White which indicated more frequent emergence of leaves. The variety Chilli

red had the longest duration and produced comparatively lesser number of leaves. The leaf plastochron duration was fairly constant from March to August. From August onwards, a lag in the production of leaves in some plants was noticed.

The leaf size index of all the varieties under the present study ranged from 75.72cm to 37.3 cm. The bigger sized leaves were produced by the Pink variety. The varieties White and Chilli red produced small sized leaves which are commercially valuable. The larger sized leaves are undesirable as they take up too much growing space.

The petiole colour of the varieties ranged from green, greenish-purple and purple. The young tender leaves showed light green, green, greenish-brown, light brown and brown colours.

The number of spadices produced anually by a plant varied from four to eight. The spadix was generally produced from the leaf axils. But there were instances where the leaf axils did not bear a spadix. More often spadices appeared in the place of leaves, so that one leaf missed the cycle. The duration between the emergence of two successive spadices showed a duration of 43 days to 51 days on an average. There was a slight increase in the duration between the opening of two spadices from August to March.

The spathe-size index of all the six varieties was observed. The varieties Pink and Kalympong red produced super large flowers with a spathe size index of 33.12 cm. and 31 cm. respectively. Kalympong orange and Honeymoon red produced large sized flowers. Chilli red produced medium sized flowers and the smallest flowers were produced in the White variety.

Spathe colour is a valuable attribute in determining the value of the spadix. The spathe colour ranged from dark red to bright red to red to light orange, pink and white. The dark and brightly coloured flowers which are commercially important are produced by Honeymoon red, Chilli red and Kalympong red varieties.

Spathe was either smooth, thick and glossy without prominent veins or thinner, deeply veined and blistered. The deeply veined and blistered spathes which are commercially preferred was found in Kalympong red and Kalympong orange.

There was significant correlation between leaf size and spathe size. The largest leaf size and spathe size indices were observed in Pink. Though the leaf size index of Honeymoon red was larger than Kalympong red and Kalympong orange, these varieties produced larger 'flowers' than Honeymoon red. The variety White had smaller sized leaves and spadices.

The candle was long and fleshy in the variety Pink. Small and slender candles which were more desirable were present in Chilli red and White varieties. The candle was shortest in the White variety. The candle had either a single colour or two or more bands of colours.

In the six varieties under the present study, the maximum angle between the spadix and the plane of the spathe was observed in the variety Honeymoon red (75^{o}). Smaller angles which are curving towards the tip of the spathe, which are ideal for export purposes are seen in Chilli red, Kalympong orange and Kalympong red varieties. This angle is smallest in Chilli red (25^{o}).

The flowers of anthurium are embedded in a spiral manner on the flower bearing axis or 'candle'. The number of flowers ranged from 175 to 325 flowers. The maximum number of flowers was found in Pink and Honeymoon red varieties (>325), and lesser number of flowers (<175) in Chilli red. The larger number of flowers provides a chance for increased fruit set.

The spathe-candle ratio was greater in Kalympong red (2.86:1) and smallest in White (2:1). This means that the white flowers had smaller sized spathes with long candles. Larger sized spathes with smaller candles as seen in Kalympong red, Chilli red and Kalympong orange are more desirable.

The flowers of anthurium are bisexual, regular and protogynous. All the six varieties under the present study, showed a distinct interval between the female and male phases.

The life of unfertilised spadix ranged from 1 1/2 months in Kalympong orange to 3 1/2 months in Honeymoon red and Kalympong red. For fertilised spadices, this period ranged from 4 1/2-8 months.

Maximum suckering ability was observed in the Pink variety.

Compatibility analysis was done on the basis of the response of the cultivars to intervarietal hybridisation at three levels viz. percentage of candles bearing fruits, fruit set/seed set and seed germination.

All the six varieties showed good percentage of candles bearing fruits. This percentage was maximum for the variety White (93%) and lowest for the variety Kalympong red (50%). Among the selfings, White varieties showed maximum percentage of fruiting candles compared to the other three selfings obtained in the study.

In the present investigation with six varieties of A. andreanum, the maximum average number of fruits was produced in the Pink variety followed by Honeymoon red. This indicates that these varieties could be successfully used as female parent in hybridisation. The lowest number of fruits were obtained from

Kalympong red. The maximum number of fruits was harvested from the cross P x HR and the lowest number of fruits in KR x KR. Among the various cross combinations, the maximum percentage fruit set was observed for the cross P x HR (52.3%) followed by HR x P (44.3%). Both these combinations can be considered the most compatible cross combinations while considering the percentage fruit set. The lowest percentage fruit set was observed in the cross KR x KR (0.4%). Ten best combinations based on percentage fruit set are P x HR, HR x P, P x KR, CR x W, KR x P, HR x CR, HR x KR, P x P, W x KR and KO x P.

The average duration of fruit maturity ranged from 5.06 to 6.8 months. This duration was maximum for the variety White (6.8 months) and the lowest fruit maturity period was observed in the Chilli red variety (5.06 months).

The colour of fruits varied in different varieties. All the cross combinations of a variety showed the same colour. The berries were darker in colour in Honeymoon red and Pink and lightest in Kalympong orange.

The berries were usually single seeded and sometimes double seeded. When two seeds were seen in a berry usually one of them was smaller than the other. In the present study, Pink and Honeymoon red varieties produced larger sized seeds. The Kalympong varieties produced comparatively smaller sized seeds.

In all the six varieties, the maximum average germination was observed in combinations with the variety White as the female parent (63.45%) followed by Honeymoon red (62%) and the lowest germination in the variety Kalympong orange. Among the 23 crosses of the six varieties, germination percentage was maximum for the cross HR x CR (78%) followed by CR x W (75.64%). Ten best crosses are selected based on the germination percentage. They are HR x CR, CR x W, P x CR, HR x P, HR x KR, W x W, P x P, P x HR, W x KR and W x HR. The cross combinations KO x W and KR x KR did not germinate.

The number of days taken for germination in all the six varieties ranged from 6-14 days. The cross combinations with Kalympong orange as female parent took the maximum number of days for seed germination ie, 10-14 days. The cross combinations P x CR and CR x W germinated within a week.

Among the 28 cross combinations, the highly compatible crosses were HR x P and P x HR, where the percentage fruiting candles, percentage fruit set and percentage seed germination were high. The cross combinations HR x CR, HR x KR, CR x W, KR x P, P x P and W x KR had medium fruit set and high germination. The incompatible cross combinations were KO x KR, CR x HR, CR x P, W x CR, KR x KR and W x KO.

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APPENDICES

APPENDIX - I

ABSTRACT OF ANOVA

Source	df	Mean Square				
		Plant height	Number of leaves per year	Leaf plastochron duration	Number of spadices per year	Duration between spadix opening
Varieties	5	*505.8797	*3.094666	*165.5016	*3.846668	*34.28203
Error	19	45.76645	1.135087	95.99219	1.092982	89.50082
F		11.05351	2.7264	1.7241	3.5194	0.38304
CD Values						
1,(2,3,5)		8.955	1.410	12.969	1.384	12.523
4,(1,2,3,5)		11.847	1.866	17.157	1.831	16.567
4,6		12.926	2.036	18.720	1.997	18.076
6,(1,2,3,5)		10.341	1.628	14.976	1.598	14.460

* Significant at 0.05 level.

APPENDIX - II

ABSTRACT OF ANOVA

Source	df	Mean Square				
		candle length	position of candle to spathe	Number of flowers per candle	leaf size Index	Spathe size Index
Varieties	5	*15.64727	*2092.3	*16866	*724.2328	*175.5457
Error	19	0.9907227	101.7105	427.3684	31.83142	5.106806
F Values		15.7938	20.57113	39.46478	22.75214	34.37486
CD Values						
1,(2,3,5)		1.318	13.350	27.365	7.468	2.991
4,(1,2,3,5		1.743	17.660	36.201	9.880	3.957
4,6		1.902	19.269	39.498	10.780	4.318
6,(1,2,3,5		1.521	15.415	31.599	8.624	3.454

* Significant at 0.05 level.

CROSS COMPATIBILITY IN *Anthurium andreanum*. Lind.

By

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ABSTRACT OF THE THESIS

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COLLEGE OF AGRICULTURE

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ABSTRACT

Morphological and compatibility studies were conducted in six commercially important varieties of A. andreanum. Viz. Honeymoon red, Chilli red, Kalympong orange, Kalympong red, Pink and White.

The varieties show 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 commercially valuable small sized leaves were produced by White and Chilli red varieties. The bigger sized leaves were produced by the Pink variety. All the varieties showed variations in the colour of petioles and young leaves. 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 were observed. The varieties Pink and Kalympong red produced super large flowers and the smallest flowers were developed in the White variety.

All the varieties showed a wide range of colours; darker shades of red, orange, pink and white.

The texture of the spathe was either smooth thick and glossy without prominent veins or deeply veined and blistered.

There was significant correlation between leaf size and spathe size. The largest leaf size and spathe size was observed in the variety Pink.

The candle was long and fleshy in the variety Pink and shortest in the White variety. The candles had either a single colour or seen in two or more bands of colours.

The maximum angle between the spadix and plane of the spathe was observed in the Honeymoon red variety. The angle was smallest in Chilli red. The flowers of anthurium which are arranged in a spiral manner varied in numbers in the differents varieties. The maximum number of flowers were produced in Pink and Honeymoon red varieties. The spathe candle ratio was greater in Kalympong red and smallest in White. The flowers of anthurium are bisexual, regular and protogynous. All the six varieties under the present study showed a distinct interphase. The longest life of unfertilised spadix was observed in Honeymoon red and Kalympong red (3.5 months). For fertilised spadices, this period ranged from 4.5 - 8 months.

Compatibility analysis was done in all the six A. andreanum varieties depending on the response of the cultivars to intervarietal hybridisation at three levels: percentage candles bearing fruits, percentage fruit set/seed set and seed germination.

The average percentage of candles bearing fruits was maximum for the variety White and lowest for the variety Kalympong red. In this present investigation, the maximum average number of fruits was produced in the Pink and Honeymoon red varieties. The maximum percentage of fruits were harvested from the cross P x HR (52.3%). The duration of fruit maturity period ranged from 4.5 to 8 months. The average duration of fruit maturity was maximum for the variety White. The colour of fruits varied in different varieties. All the cross combinations of a variety showed the same colour.

The berries are usually single seeded and sometimes double seeded. Pink and Honeymoon red varieties produced larger sized seeds. The Kalympong varieties produced comparatively smaller 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.

Among the 28 cross combinations done, the highly compatible crosses were HR x P and P x HR. The cross combinations, HR x CR, HR x KR, CR x W, KR x P, P x P and W x KR had medium fruit set and high germination. The incompatible cross combinations were KO x KR, CR x HR, CR x P, W x CR, KR x KR and W x KO.