VARIETAL EVALUATION AND GENETIC IMPROVEMENT OF ANTHURIUM (*Anthurium andreanum* Linden) THROUGH HYBRIDIZATION

by

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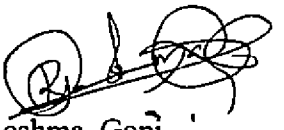
DECLARATION

I, hereby declare that this thesis entitled "**Varietal evaluation and genetic improvement of anthurium (*Anthurium andreanum* Linden) through hybridization**" is bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellow ship or other similar title, of any other University or Society.



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CERTIFICATE

This is to certify that the thesis entitled "**Varietal evaluation and genetic improvement of anthurium (*Anthurium andreanum* Linden) through hybridization**" submitted by **Ms. Reshma Gopi (2014-11-236)** for the degree of **Master of Science (Agriculture)** in **Genetics and Plant Breeding** is a record of research work done by her during the period of her study, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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EXTERNAL EXAMINER

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LIST OF ABBREVIATIONS

^{0}C	Degree Celsius
AG	Arun Gold
AH	Agnihotri
B	Boroque
C	Chikoos
CK	Chikoos
cm	Centimeters
CN	Can Can
CS	Chocos
CW	Cascade White
df	degrees of freedom
DT	Dragon's Tongue
E	Esmeralda
ER	Emperor
et al.	and others
Fig.	Figure
g	Gram (s)
GCV	Genotypic coefficient of variation
GS	Gold Spark
H M	Honeymoon Red
HO	Hawaiian Orange

HR	Honduras Red
i.e.	That is
LJ	Lady Jane
LP	Lucia Pink
LR	Liver Red
mg g^{-1}	Milligram $gram^{-1}$
MO	Mauritius Orange
MW	Merengue White
ml	Millilitre
NO	Nitta Orange
P	Pistache
PCV	Phenotypic coefficient of variation
VR	Vezuvious Red

INTRODUCTION.....

1. INTRODUCTION

Floriculture is one of the rapidly growing industries in the world. It is a profitable business with a higher potential of returns. The demand for cut flowers is increasing day by day both in Indian and International market. Anthurium plays a key role in the commercial cut flower industry. The endurance and attractiveness of spathe are the key features that raise the price rate of anthurium cut flowers.

Flowers occupy an important place in Indian civilization as well as the human minds. The growth and performance of floriculture industry in India is still in its infancy. The Government of India has identified Kerala as the product specific intensive floriculture zone for anthuriums (Madhukumar, 2010). The warm humid tropical climate of our state can easily be adopted for the wide spread cultivation of anthurium.

Kerala now with booming tourism, hotels and resorts has an immediate market for cut-flowers and floral decorations. There is a great demand for new attractive anthurium flowers and potted plants in the domestic and international markets.

The genus *Anthurium,* with 700 species is largest genus of the family Araceae. It has originated in South America. The word anthurium originated from the greek words 'Anthos' which means 'flowering' and 'Oura' means 'tail'. The two known species having commercial importance are *Anthurium andreanum* Linden and *Anthurium scherzerianum* both have beautiful flowers and attractive foliage.

Anthurium andreanum Linden, the best known species was discovered by Eduard Andre in 1870. Anthurium was brought to Europe in 1876 and later it spreads to Brazil and Hawaii. Netherlands is the largest producer of anthuriums followed by Mauritius and West Indies.

Introduction of anthuriums in India from England by coffee and tea planters was to decorate their bunglows with this irresistible beauty. In India its cultivation started commercially in Yercaud, Tamil Nadu, Bangalore and Coorg region of Karnataka, Kochi and Trivandrum in Kerala, Kalympong in West Bengal, Pune and Nasik.

Anthurium andreanum Linden, a native of South West Columbia, is a semi terrestrial and perennial epiphytic plant (Singh, 1987). The anthurium flower consists of a colorful, shiny heart shaped modified leaf (spathe), surrounding a straight or slightly curved inflorescence candle /spadix. The greatest advantage of anthurium is that it produces flowers all the year round. Spathe may be of different shapes according to various colours and varieties. It produces 5 to 8 new leaves per year. Life cycle of anthurium consist of two phases. First is the juvenile phase in which vegetative buds emerge in the axils of the leaves. Second is the generative phase in which inflorescence buds can be found in the leaf axils (Christensen, 1971). Once the juvenile phase has passed, flowers are produced in an alternating cycle with leaves throughout the year (Kamemoto and Nakasone, 1963).

The agro climatic and socio economic situations of Kerala are suitable for the cultivation of anthuriums. Anthurium requires a warm green house with a temperature range of 18- 28 ^{0} C. Since it is shade loving plant it requires a shading as well as humidity of 75 percent. It is a very slow growing plant. It takes 21/2 - 3 years to reach first flowering and for floral characters it will take one more year. The flower production ranges from 5-6 spadices per year. The income that can be gained by the anthurium plant depends upon the number of suckers and flowers produced by the plant (Madhukumar, 2010).

The present day cultivars are mainly hybrids derived from interspecific crosses which are supposed to have arisen spontaneously from the earlier collections (Birdsey, 1951). Hybridisation followed by selection is the best method for improving anthuriums (Kamemoto and Nakasone, 1955, Sheffer and

Kamemoto, 1976). It is being practised in Netherlands, Mauritius, Hawaii, Philippines, Srilanka etc. Hybridisation between selected genotypes with good combining ability can be used for creating novel hybrids of anthurium with desirable characteristics such as compact plant type, medium sized leaves, heart shaped spathe, symmetrical lobes, wrinkled spathe texture, straight long inflorescence axis and a reclining spadix to facilitate packing (Maya Devi, 2001).

Anthurium cultivation is a remunerative agri-business, which can be easily undertaken by unemployed youth and women. At present commercial cultivation of anthurium for cut -flower export is in its infancy in Kerala. Some serious constraints confronting the enthusiastic prospective growers are the lack of suitably adapted good quality planting materials at reasonable rates in sufficiently large numbers for commercial cultivation and the absence of a steady and stable market etc. The present practice is to import mericloned plantlets from the foreign countries by some licensed agencies from which the growers buy the plantlets at exorbitant rates.

Considering the above facts the present study is envisaged to assess the genetic variability of twenty five genotypes of *Anthurium andreanum* to identify suitable parents with commercial qualities and to improve them through intervarietal hybridization.

REVIEW OF LITERATURE.....

2. REVIEW OF LITERATURE

Anthurium, the irresistible beauty, is one of the major cut flower crops in the world. It is one of the export oriented tropical beauties suitable for the cultivation in Kerala. Anthurium, commonly called as painter's palette consists of modified leaf called spathe and hundreds of small bisexual flowers which are arranged in acropetal succession. The climatic conditions of Kerala are ideal for its wide spread cultivation. The only species of anthurium which is having commercial value in tropics is *Anthurium andreanum* Linden.

Hybridization followed by selection is the common method practised in the genetic improvement of anthurium. Since the crop has higher genetic potential due to its heterozygous nature, there is large scope for hybridization programmes. So the present investigation was to evaluate the parents for hybridization and improve its commercial characters. A brief review of the present work is described below.

2.1 CULTIVATION ASPECTS

Anthurium requires a warm green house with 75 percentage shade and 70 - 80 per cent atmospheric humidity. The optimum temperature range of anthurium is between 22 to 25^{0}C and a temperature range between 25 – 28 ^{0}C during the day and 18 to 22^0 C is required. For proper growth and development of anthurium a relative humidity of around 75 per cent is important. Morphological characters which are determining the quality of the flower depends upon the intensity of light. Since anthurium is a halophyte it requires an optimum shade of 75 per cent (Mercy and Dale, 1994).

Sand, cow dung, brick pieces, charcoal and coconut husk are the major components of anthurium growing media which ensure 100 per cent drainage to the plant (Mercy and Dale, 1994).

Prasad *et al.* (2001) reported that the temperature requirement of anthurium ranges from 21-24 ^{0}C during day and 18.3 ^{0}C during night. Also, 50 – 80 per cent atmospheric humidity, low to medium light intensity *i.e.* 2,000 – 6,000 lux and 60- 80 per cent shade are required for its proper growth and flowering.

The growth of anthurium plants consists of a monopodial vegetative growth and the period of this growth was strongly affected by fertilizer application. The deficiency of nitrogen in cultivation of anthurium resulted in reduction in yield and flower quality (Dufour and Guerin, 2005).

The effects of fertilizers on the growth and flowering of *Anthurium andreanum* cv Chocos was studied by Srinivasa (2006 a). The split application of fertilizers 30:20:40 g NPK showed the maximum values for characters such as values for leaf length (17.63 cm), leaf width (8.52 cm), number of suckers (1.88), stalk length (37.31cm), spadix length (5.0 cm), spadix girth (6.04 cm) and number of spadices (2.25). Another split application of 20:15:30 g NPK showed the maximum spathe length (9.88 cm) and spathe width (7.81 cm). Physiological parameters like chlorophyll, carotenoids anthocyanins and wax did not show any significant with varying levels of fertilizers.

Srinivasa (2006 b) observed that at 80 per cent shade level all the vegetative and reproductive characters showed the maximum values in anthurium cv. Honduras. GA_3 application (500 ppm) in the form of foliar spray was found to increase the growth and flowering in different cultivars of anthurium (Dhaduk *et al.*, 2007).

The effects of integrated nutrient management (INM) practices in improving flower yield of *Anthurium andreanum* Cv. Meringue studied by Waheeduzzama *et al* ., 2007. It was observed that the treatment combination of 4 per cent panchagavya + 5 per cent RDF showed an influence in the morphological and flowering characters.

Agasimani *et al.* (2011 b) studied about ten varieties of anthurium in two different seasons (summer and winter) and observed significant differences. The

variety Esmeralda which performs well in both the season compared to other varieties. Cuquel *et al.* (2012) reported that the best quality flowers were produced in the growing media which contain wood shaving and organic compost in the ratio of 1:1.

2.2 VEGETATIVE CHARACTERS

2.2.1 Plant Height

Bindu and Mercy (1994) studied about five varieties of the genus anthurium and observed a significant variation in plant height ranging from 45 cm in the variety Lady Jane to 85 cm in the variety Pink.

A significant variation in plant height was observed by Renu (2000) while comparing the ten varieties of anthurium. The plant height ranged from 29.7 cm in variety Midori Green to 70.9 cm in Pompon Red. Mayadevi (2001) reported that height of twenty genotypes of anthurium ranged from 45.5 cm in variety Midori Green to 96.67 cm in variety White.

Asish (2002) recorded significant variation in plant height ranging from 22.17 cm to 64.80 cm among 50 genotypes of anthurium. Premna (2003) observed that plant height ranged from 21.25cm in the variety Carrie to 44.00 in the hybrid PR x DT.

Talia *et al.* (2003) compared six new anthurium cultivars and observed significant differences in stem height, with Queen the longest and Santé the shortest. Pravin (2004) observed a plant height of 30.80 cm to 76.17 cm among the 14 genotypes of anthurium. Srinivasa and Reddy (2005) studied about five cultivars of anthurium and among those cultivars, Honduras showed the maximum plant height (40.94 cm).

Shiva and Nair (2008) observed significant variation in plant height ranging from 4.27 cm in Taurus to 9.22 cm in Mirage. Madhukumar (2010)

reported significant variation in plant height among 40 genotypes of anthurium ranging from 17.33 cm in Nitta Orange to 43.25 cm in Liver Red.

Jadhav *et al.* (2012) reported that under fertigation, the variety Esmeralda showed the maximum plant height of 57.58 cm. Sheena (2015) reported that the cultivar Marjike has the maximum plant height (59.24 cm) and the cultivar Red Amour has the lowest plant height (29.29 cm).

2.1.2 Leaf Size or Leaf Area

Bindu (1992) studied five varieties of *Anthurium andreanum* and observed the maximum leaf size for the variety Pink and the minimum leaf size for Lady Jane and Chilli Red. Mercy and Dale (1994) opined that the commercial floral anthurium leaves should be small to medium sized, narrow and elongated.

Sindhu (1995) recorded that the variety Pink produced large sized leaves but it is having less commercial value compared to other varieties of anthurium. The variety White and Chilli Red produced smaller sized leaves which are ideal for commercial cultivation.

Mayadevi (2001), while studying 100 anthurium genotypes observed a significant variation in ranging from 66.26 cm^2 to 88.89 cm^2. Asish (2002) studied 50 genotypes of anthurium and recorded the leaf area ranging from 41.32 cm^2 to 323.77 cm^2. Premna (2003) observed the maximum leaf area in the variety Acropolis White (301.10 cm^2) and the minimum leaf area for the variety Carrie (113.62 cm^2).

Pravin (2004) reported significant difference in the leaf area in 14 varieties of anthurium ranging from 91.97 cm^2 to 287.76 cm^2. Among the 14 anthurium genotypes studied by Shiva and Nair (2008), leaf size ranged from 2.95 to 5.36 cm while leaf area ranged from 5.33 cm^2 to 16.43 cm^2.

Agasimani *et al.* (2011a) observed the maximum leaf area of 237.24 cm^2 in the variety Esmeralda and the minimum leaf area of 100.10 cm^2 in the variety Chias. In a nutrient trial conducted, Jacob (2011) observed the highest leaf area of

2939.35 cm^2 in the variety Acropolis. Sheena (2015) observed a leaf size ranging from 92.18 cm^2 (Red Armour) to 239.65 cm^2 (Marjike).

2.1.3. Internode Length

To limit the height of the plant, an ideal anthurium should produce short internodes (Singh, 1987). Mayadevi (2001) compared the internode length of five parents and ten hybrids and observed that the mean internodal length ranged from 1 cm to 1.5 cm among the parents and 1.02 cm to 1.34 cm among hybrids.

Premna (2003) recorded significant differences in internodal length ranging from 1.48 cm (PR x DT and Acropolis White) to 1.20 cm (Carrie). Ravidas (2003) recorded that the variety Red Dragon and Candy Queen have the shortest internodal length of 1.72 cm and 1.78 cm respectively.

Madhukumar (2010) studied 40 genotypes and recorded that Agnihotri had the minimum internodal length (0.97 cm) and it was the maximum for Esmeralda (2.02 cm). Sheena (2015) observed the highest internodal length in the variety Marjike (0.99 cm) and the trait was the lowest in Red Armour (0.45 cm).

2.1.4. Days from Emergence to Maturity of Leaves

Mayadevi (2001) observed significant variation in number of days from emergence to maturity of leaves. It was reported that the maximum number of days in the variety Pink (44.40 days) and the minimum days in the variety Honeymoon Red (41.40 days). Premna (2003) observed a range of 26.25 days (Carrie) to 40.25 days (Pompon Red x Dragon's Tongue), while studying this character.

Madhukumar (2010) observed the least number of days for leaf maturity by the hybrid combination, Pompon Red x Orange Glory (25.89 days) and the maximum number of days for the genotype Agnihotri (36.6 days).

Sheena (2015) in a study with nine exotic anthurium cultivars reported that the time taken from emergence to maturity of leaves showed a variation from

24.55 to 35.95 days. It was also observed that the maximum days for maturity of leaves were in the variety Cynthia and the minimum was in the variety Red Armour.

2.1.5 Number of Leaves Spadices^{-1} Plant^{-1} Year^{-1}

The life cycle of *Anthurium andreanum* consists two phases of growth. First is the juvenile phase in which vegetatative growth occurs and second is the generative phase in which reproductive growth occurs (Christensen, 1971).

Most of the cultivated anthuriums found to produce flowers all the year round. Flower production increases with the emergence of new leaves and the flowers are produced at the rate of one flower from each leaf axil (Singh, 1987).

Mercy and Dale (1994) reported that with the emergence of new leaves, new roots are also emerged. Renu (2000) noticed that the number of leaves and the number of spadices produced plant^{-1} year were the same.

Among the 20 genotypes of anthurium, Mayadevi (2001) observed a spadix production range of 4.67 to 8 and the highest number of spadices was obtained in the variety Honeymoon Red. The annual production of leaves and spadices was observed to be the highest in KO x DT (7) and the minimum in PR x DT and TR x MW (3) (Asish, 2002).

Premna (2003) observed the maximum production of spadices in the varieties Acropolis White, OO x PR, PR x DT and Tropical Red (6) and the minimum production is observed in the variety Carrie. Pravin (2004) observed the maximum number of spadices in the genotype Liver Red (7) and the minimum in the hybrids FR x MW (1) and NO x DT.

Madhukumar (2010) observed the highest number of spadices in the variety Rembolina (7.42) and the lowest number was found in the variety Chocos (4.55). According to Agasimani *et al.* (2011a) the variety Esmeralda (9.33) produced the maximum number of spadices year^{-1} and the minimum was observed in the variety Ivory (3.33).

Islam *et al.* (2013) reported that the cultivar Titiaca (7.2) recorded the highest number of flowers per plant. The highest number of leaves was observed in the cultivar Paradise (8.75) and the lowest number of leaves was recorded in Red Armour and Anastacia (Sheena, 2015).

2.2.6. Number of Suckers Plant^{-1} and Suckering Ability

Suckering can be stimulated by foliar application of N-6 Benzyl Adenine at 1000 mgl^{-1} (Higaki and Rasmussen, 1979). Mercy and Dale (1994) reported that the commercial anthurium varieties and hybrids had poor suckering ability and the propagation using suckers was very slow. Large number of suckers were noted in the variety Pink; but it is not commercially valuable. Application of Benzyl Adenine (BA) (500 -1000 ppm) or Gibberellic Acid (GA_3) as foliar spray was found to have positive effect in increasing the sucker production.

Sindhu (1995) reported that many suckers were produced by the variety Pink. Sucker production was found to be least in the variety Kalympong Red. Abdussammed (1999) reported that the nutrients had no significant effect on the number of suckers produced per plant. But it had been found that there was a significant increase in the production of suckers by the application of growth regulators in anthurium cultivars.

Ability to produce sucker is an important feature considered in the selection of superior types. While studying the ten varieties of anthurium, Renu (2000) observed that suckering ability was found to be very high for varieties like Liver Red, Lady Jane and Ceylon Red and the trait was very low for Pompon Red and Tropical Red.

Mayadevi (2001) reported that the variey Pink and Lady Jane had produced the maximum number of suckers (4) and the cultivars Nitta Orange, Merengue White and Tropical Red exhibited the minimum number of suckers.

Ravidas (2003) observed that the maximum number of suckers of 3.22 was exhibited by the variety Red Dragon and the minimum number of suckers were noticed in the genotype Agnihothri (2.33).

Pravin (2004), in a study with 14 genotypes of anthurium reported that the genotype Liver Red produced the maximum number of suckers of 4 and the minimum number of suckers were noticed in the cultivars Acropolis White and Tropical Red .

Madhukumar (2010) studied forty genotypes of anthurium and reported that the sucker production was the maximum in the cultivar Liver Red (3) and the genotypes, Lady Jane and Esmeralda exhibited the minimum number of suckers during the period of study. Large number of suckers were observed in the variety Salmon Queen (7 suckers) followed by Marjike and Hillary (Sheena, 2015)

2.2.7. Colour of Young Leaves and Petiole

In *Anthurium andreanum*, the colour of young leaves ranged from light green to deep reddish brown (Mercy and Dale, 1994). Sindhu (1995) observed significant colour variation in both petiole and young leaves in six varieties of anthurium.

Asish (2002) recorded a colour range of green to brownish green and brown in the petiole as well as young leaf of anthurium. Madhukumar (2010) observed significant differences in the colour of young leaves as well as petiole ranging from brown to reddish brown to greenish brown to green and to light green among the forty genotypes of anthurium.

Sheena (2015) observed brownish green leaves in the cultivars, Paradise, Mozaik Fresh, Tropical Red, Orange Glory and Rosette and reddish brown in the variety Marjike, Liver Red and Dragon's Tongue. It was reported that the colour of the petiole in most of the cultivars was green where as the varieties like Paradise, Marjike, Mozaik Fresh, Elizabeth, Tropical Red and Rosette exhibited

brownish green colour in the petiole. The variety Liver Red had reddish brown petiole.

2.2.8 Incidence of Major Pests and Diseases

The major diseases that can reduce the yield in anthurium are bacterial blight and anthracnose. Blackening of the stem and leaf axil is the symptom of bacterial blight. Anthracnose can be recognized by the presence of circular black spots on leaf and spadix (KAU, 2007 and Sheela, 2008).

The sucking pests like aphids, scales, thrips and spider mites attacks the anthurium plants. The damage caused by snails and slugs were also reported in anthurium (Mercy and Dale, 1994; KAU, 2007; Sheela, 2008)

2.3 FLORAL CHARACTERS

2.3.1 Floral Quantitative Traits

2.3.1.1 Days from Emergence to Maturity of Inflorescence

Mayadevi (2001) reported that the number of days required for the emergence to maturity of inflorescence was the highest in the variety Honeymoon Red (50.60 days) and the lowest in the variety Chilli Red (44.60 days). Among hybrids a range of 41 to 54 days, was observed.

Ravidas (2003) recorded the maximum days from emergence to maturity of inflorescence in the genotype Agnihotri (25.33 days) and the minimum in the varieties Lima White and Candy Queen (19 days). Pravin (2004) observed that the number of days from emergence to maturity of leaves varied from 31.0 to 37.2 days.

Liver Red (33.39) showed the maximum days for inflorescence maturity among the forty genotypes of anthurium (Madhukumar, 2010). Sheena (2015) observed the lowest number of days in the variety Marjike (20.75 days) followed by Anastacia (22.75 days) and the highest in Cynthia (26.50 days).

2.3.1.2 Number of Flowers^{-1} Year^{-1}

Renu (2000) reported that the number of spadices^{-1} plant^{-1} year^{-1} was the highest in the cultivar Lady Jane (7.6) followed by Liver Red and Pompon Red.

Ehrenberger *et al.* (2003) reported a varying degree of flower yield in different anthurium cultivars. According to Pravin (2004) the cultivar Liver Red had the highest number of spadices (7.00) which was on par with Orange Glory and Acropolis White (6.33).

Madhukumar (2010) reported that the annual production of spadices was the highest in the variety Rembolina (7.42) and the least production was noticed in Chocos (4.83). Sheena (2015) noticed the maximum flower production in the genotype Salmon Queen (6.33) followed by Marjike (6.17) and Paradise (5.92)

2.3.1.3 Spathe Size

Spathe size is a measure of length x width (cm) (Criley, 1989). Higaki and Poole (1978) reported that the size of the flower increases with the age of the plant in the variety Ozaki.

According to United States Department of Agricultural Standards, Singh (1987) suggested that anthurium flowers can be graded according to average length plus width of spadix, as miniature (under 8 cm), small (8-10 cm), medium (10-13 cm), large (13-15 cm) and extra large (15 cm). Bindu and Mercy (1994) observed largest spathe size for Pink (10.4 + 9.7 cm) and the smallest for Lady Jane (6.5 +3.5 c.m) among five different varieties of anthurium studied.

Sindhu (1995) noticed that the variety Pink and Kalympong Red produced super large flowers and Miniature White had the smallest flower. Renu (2000) observed significant differences in spathe size ranging from 17.12 cm (Pompon Red) to 30.74 cm (Dragon's Tongue).

Mayadevi (2001) studied 100 different genotypes of anthurium, and observed average spathe length of 10.80 cm and average width of 7.76 cm. Cristiano *et al.* (2007) reported that the variety Premier showed bigger spathe

compared to other six varieties of anthurium. Shiva and Nair (2008), in a study with 14 genotypes of anthurium, reported that the spathe size ranged from 5.80 to 8.52 cm and the maximum spathe size was observed in the variety Mauritius followed by Honey.

In a study with 40 genotypes of anthurium, Madhukumar (2010) observed the maximum spathe size for Acropolis White (123.43 cm) which was on par with Geisha white (118.18 cm^2), Carrie (115.44 cm^2) and Boroque (107.00 cm^2).

According to Agasimani *et al.* (2011a), the variety Esmeralda showed the maximum spathe length (15.71cm) and variety Ivory had the minimum spathe length (7.54 cm). Jacob (2011) reported that the genotype Acropolis had wider spathe (12.97 cm) than Tropical (12 cm).

Islam *et al.* (2013) noticed significant difference in the length and breadth of spathe according to the varieties. The variety Triticaca recorded the maximum spathe length (15.3 cm) whereas the minimum (6.3 cm) was recorded in Ivory. The cultivar Mozaik Fresh recorded the highest values in spathe length and breadth (12.08 cm and 10.65 cm) and the lowest values were found in the cultivar Red Armour (8.05 cm and 5.98 cm).

2.3.1.4 Spadix Length

To the commercial world, short slender candles have high demand over thick candles. Bindu (1992) evaluated five varieties of anthurium and observed that candles were long among the non commercial varieties like Ordinary Pink, Ordinary Red, and Ordinary White. But in hybrids and exotics, candles were shorter and thicker. The commercial varieties like Tropical Red, Nitta Orange, Mauritius Orange, Lady Jane Red, Pompon Red and Midori Green produced smaller spadices (Renu, 2000).

Praneeta *et al.* (2002) studied eight *Anthurium andreanum* and two *Anthurium scherzerianum* genotypes; and observed the maximum spadix length of

13 cm in the cultivar AA-2. Pravin (2004) observed short candles in the crosses MO x KR (1) (3.83 cm) and PR x LR (1) (4.97 cm).

Srinivasa and Reddy (2005), in a study with five cultivars for cut flower production revealed that the maximum spadix length and girth were observed in the cultivar Honduras (6.57 cm and 7.93 cm respectively). According to Madhukumar (2010), spadix length was the maximum for OG x DT and the minimum was for LR x PR.

Agasimani *et al.* (2011a) observed that variety 'Esmeralda' exhibited the maximum spadix length of 8.24 cm and the minimum spadix length of 3.35 cm was exhibited by the variety Grace. The highest spadix length of 5.73 cm was observed in Paradise (5.73 cm) and the lowest of 4.03 cm observed in Anastasia (Sheena, 2015), in a study of nine exotic anthurium cultivars.

2.3.1.5 Number of Flowers Spadix^{-1}

Non commercial varieties like Honeymoon Red and Pink have large number of flowers with less commercial qualities. According to Kamemoto and Nakasone (1963), the flower of *Anthurium andreanum* are hermaphroditic in nature. Flowers consist of a two-carpelled ovary and four anthers. Anthurium flowers are bisexual in nature and are arranged in a series of spirals on the spadix (Croat and Bunting, 1978).

The flower of anthurium is called spadix. It is a racemose inflorescence with 150 -350 bisexual flowers which are arranged in acropetal succession (Mercy and Dale, 1994). Sindhu (1995) observed that the average number of flowers ranged from 175 (Chilli Red) to 325 (Pink and Honeymoon Red).

Mayadevi (2001) recorded that the number of flowers spadix^{-1} was the maximum in Pink (600) and the minimum in Chilli Red (372) among the parents. In the hybrids, it was found that Pink x Liver Red exhibited the minimum number of flowers spadix^{-1} (400) and Honeymoon Red x Dragon's Tongue and Pink x Kalympong Red had the maximum number of flowers spadix^{-1} (600). Madhukumar (2010) noticed that the maximum number of flowers spadix^{-1} of

518.67 was exhibited by the hybrid Kalympong Red x Liver Red and the minimum number of flowers was found in LR x PR and Corolix. Sheena (2015) observed that the cultivar Hillary (408.25) with the highest number of flowers in the spadix and the lowest in the cultivar Red Armour (164.33)

2.3.1.6 Life of Spadix

According to Mercy and Dale (1994) the fertilized inflorescence has more shelf life (4-7 months) than the unfertilized spathe (2 months). Senscence in anthurium can be identified by yellowing of peduncle followed by withering of spathe and candle.

Sindhu (1995) revealed that the life of fertilized spadix ranged from four and a half to eight months. In the variety Kalympong Orange, the unfertilized spadix spent remained about one and half months in the plant and two to three and a half months in Honeymoon Red.

Valsalakumari *et al.* (1998) noticed the highest longevity of spadix with the application of 1000 ppm GA_3 in the cultivar Agnihotri. Renu (2000) reported that in fertilized spadices, shelf life ranged from 3.8 to 7.5 months. According to Premna (2003), the genotype PR x DT exhibited the highest life span of 101.50 days. The lowest number of days (59.50) was noted in the cultivar Carrie.

Shiva and Nair (2008) in a study with fourteen genotypes of anthurium found that the variety Wrinkled Orange had the maximum life span followed by Honey. Madhukumar (2010) reported that the genotype PR x DT recorded the maximum life span (101.33 days) for spadix and the minimum was in Gold Spark (46.83 days).

2.3.1.7 Days to Initiation of Female Phase

The anthurium inflorescence starts its life cycle with the initiation of female phase (Croat, 1980). The receptive flowers have minute droplets of stigmatic fluid. The flower maturity initiates from the basal portion of the spadix and it progresses towards the apex.

Female phase initiation started 10 days after opening of spathe (Sindhu, 1995). It was observed that the cultivar Honeymoon Red had the longest period for female phase initiation.

Renu (2000) reported that the mean number of days to initiation of female phase ranged from 3.60 days (Lady Jane Red) to 6.80 days (Mauritius Orange). Mayadevi (2001), studied 100 genotypes of anthurium and reported that among hybrids the days to initiation of female phase varied from 3.60 to 6.20 days.

Pravin (2004), in a study with 14 genotypes of anthurium observed that the days to initiation of female phase varied from 4.33 to 9.27 days. The mean number of days to initiation of female phase ranged from 3.55 to 10.55 days in 40 genotypes of anthurium

Madhukumar (2010) recorded the maximum mean value for the genotype Boroque (10.55). Sheena (2015) observed that the mean number of days to initiation of female phase varied from 7.33 days (Elizebeth) to 12.67 days (Anastacia).

2.3.1.8 Duration of Female Phase

Mercy and Dale (1994) reported that the receptive female phase can be identified by a viscous exudate which was sticky in touch. Sindhu (1995) studied six anthurium varieties and observed that female phase varied from 5 to 25 days.

Mayadevi (2001) recorded number of days for female phase was the maximum in the genotype Kalympong Red (13.4 days) and the minimum in the variety Pink (7.4 days). The duration of female phase ranged from 5.50 to 9 days among 14 genotypes of anthurium (Premna, 2003).

2.3.1.9 Days of Interphase

Bindu and Mercy (1994) reported that duration of interphase ranged from four to seven days among five varieties of anthurium.

Sindhu (1995) studied six anthurium varieties and observed that the days for interphase ranged from four to ten. Renu (2000) opined that the interphase can be

identified by the drying up of stigmatic droplets. It was recorded that the cultivar Liver Red had the longest interphase and the shortest by Merengue White.

According to Mayadevi (2001) the duration of interphase ranged from 7.80 days (Chilli Red) to 11.20 days (Pink) among parents and in hybrids the period ranged from 9.39 to 12.60 days. Asish (2002) recorded that the duration of interphase ranged from 2.00 to 11.67 days among 50 genotypes of anthurium. Premna (2003), observed the minimum number of days for interphase in the anthurium variety Carrie (4.50 days) and the maximum of 9.25 days was found in Pompon Red x Dragon's Tongue.

Ravidas (2003) recorded that the anthurium variety Lima exhibited the longest interphase of 20 days and the shortest interphase of 3.67 days was noticed in Red Dragon. Pravin (2004), in a study with 14 genotypes of anthurium noticed that the average number of days for interphase varied from 2.33 to 6.83 days.

Madhukumar (2010) observed that the genotype Nitta Orange (9.22 days) had the highest mean number of days to interphase and the lowest mean number of days 4.5 days to interphase was noticed in the genotype Vezuvious Red.

2.3.1.10 Duration of Male Phase

Among the five anthurium varieties studied, Bindu and Mercy (1994) noticed that the exertion of anther started from the base and later it progresses towards the tip.

Mercy and Dale (1994) reported that within 4-8 days, all the anthers on a spadix emerged out. Sindhu (1995) observed that the male phase duration was different in different varieties and also irregular appearance of stamens on the spadix was reported. Renu (2000) recorded that the average number of days of male phase ranged from 5.4 days (Mauritius Orange) to 10.4 days (Tropical Red).

Mayadevi (2001) noticed that the duration of male phase ranged from 5 days to 7.20 days in 100 genotypes of anthurium. Pravin (2004) noticed that the average duration of male phase ranged from 5.33 days to 10.83 days in fourteen genotypes of anthurium studied.

According to Madhukumar (2010), the maximum mean duration of male phase was found in the genotype, Tropical Red x Merengue White (10.89 days) followed by Acropolis white (10.36 days), Jewel and Arun Gold (10.33 days).

2.3.1.11 Inclination of Candle with Spathe

An ideal anthurium variety should have angle of inclination less than 45^0, which makes it suitable for packing and they have high market value also (Mercy and Dale, 1994). Sindhu (1995) observed spadices with angle less than 45° in varieties like Chilli Red, Kalympong Orange and Kalympong Red. Renu (2000) also observed the ideal position of spadix less than 45^0 in varieties like Pompon Red, Chilli Red, Tropical Red, Mauritius Orange, Nitta Orange, Merengue White and Midori Green.

According to Mayadevi (2001), the angle of inclination of the spadix with the base of the spathe ranged from 21^0 (Kalympong Red) to 78.20^0 (Honeymoon Red). Pravin (2004) reported that the lowest angle was in the genotype PR x MO (26.10^0) and the highest in the genotype MO x KR (1) (70.07^0).

Madhukumar (2010) observed that the inclination of the spadix with the spathe ranged from 35.33^0 (Orange Glory) to 75.67^0 (Vezuvious Red). Islam *et al.* (2013) revealed that a superior variety called Aymara showed the minimum angle of inclination with the base of the spathe (30°) and variety Jewel exhibited the maximum angle of 60^0. Sheena (2015) compared nine exotic anthurium cultivars and reported that the highest angle of inclination was observed in the variety Salmon Queen (80^0) which was on par with Mozaik Fresh (78.33^0), Marjike (78.25^0) and Cynthia (75^0). The lowest angle of inclination was observed in the cultivar Paradise (58.50^0). The desirable angle of inclination was found in the cultivars like Rosette (41^0), Tropical Red (41.33^0) and Orange Glory (44.67^0).

2.3.1.12 Anthocyanin Content

The genotype Hawaiian Red showed different levels of anthocyanin content when it was treated with different levels of growth regulators and nutrient treatments (Abdussammed, 1999). According to Mayadevi (2001), Liver Red

exhibited the highest anthocyanin content (386.56 mg g^{-1}) and the lowest was in the cv. Pink (121.38 mg g^{-1}), among the parents. In the case of hybrids, the maximum anthocyanin content was observed in the hybrid Kalympong Red x Chilly Red (330.95 mg g^{-1}) and the minimum in the hybrid, Honeymoon Red x Liver Red (146.03 mg g^{-1}).

Asish (2002) reported that mean anthocyanin content among the 50 genotypes was 234.86 mg g^{-1}. Premna (2003) revealed that the mean anthocyanin content was low in Acropolis White (10.09 mg g^{-1}) and it was high in Honduras (259.18 mg g^{-1}).

Madhukumar (2010) in a study with forty genotypes, observed significant difference in the anthocyanin content and obtained a range between 9.73 to 482.05 mg g^{-1}. Sheena (2015) observed significant variation in anthocyanin content among the genotypes studied, which ranged from 2.72 mg g^{-1} to 20.37 mg g^{-1}. The variety Red Armour had the highest anthocyanin content and the lowest was reported in Cynthia.

2.3.1.13 Pollen Fertility

Lalithambika (1978) reported that pollen sterility of *Anthurium andreanum* is about 70-75 per cent. Bindu and Mercy (1994) opined that high pollen sterility in *Anthurium andreanum* may be due to high degree of meiotic abnormalities. Renu (2000) reported that the cultivar Liver Red exhibited the highest pollen fertility of (42 per cent) followed by Tropical Red (29 per cent). The lowest fertility was noticed in the cultivars Mauritius Orange (14.0 per cent) and Lady Jane Red (13.7 per cent).

Mayadevi (2001) observed high pollen fertility of 45.90 per cent for the genotype Liver Red. Asish (2002) noticed that average pollen fertility of 24.24 per cent exhibited by almost all the genotypes studied. Premna (2003) revealed that the genotype Carrie (35.70 per cent) had the maximum pollen fertility followed by Honduras (35.13 per cent).

Most of the genotypes studied by Pravin (2004), showed low pollen fertility values. Madhukumar (2010) reported low pollen fertility in many of the genotypes studied. The cultivar Liver Red had the maximum pollen fertility (43.01 per cent). The minimum value was shown by the variety Diva Pink (2.59 per cent). Sheena (2015) reported the highest pollen fertility in the variety Marjike (57.08 per cent) and the lowest value of 16.75 per cent was exhibited by the variety Hillary.

2.3.1.14 Pollen Size

Bindu (1992) noticed that the size of pollen grains ranged from 87.2 x 86.4 μ (Lady Jane) to 81.8 x 68.0 μ (Pink). Premna (2003) while studying pollen grains of 14 varieties observed that the pollen size ranged from 22.6 μ to 28.4μ. Pravin (2004) noticed that the average pollen size ranged from 16.80 μ to 24.97μ.

Madhukumar (2010) observed that the variety Arun Gold (14.67μ) had the lowest mean size of the pollen and the highest in the variety Lady Jane (25.18 μ). Most of the genotypes have round pollen and the pollen shape ranged from round to oval among the 40 genotypes. Sheena (2015) noticed that the pollen diameter ranged from 11.93μ (Paradise) to 26μ (Cynthia).

2.3.2 Floral Qualitative Traits

2.3.2.1 Spathe Colour

The main colours in anthurium spathes are red, pink, orange, coral and white. A few cases of green and even brown coloured spathes are also known. Cultivars with a red spathe usually have a bright yellow spadix, while the colour of the spadix varies from orange to red in cultivars with a pink spathe. In the orange spathe group, spadices are either orange or yellow, whereas in cultivars with a white spathe, there can be attractive, contrast combinations of pink to bright red spadices (Kamemoto *et al.*, 1988). Other colours such as purple, bronze and green are also found among the spadices. The major colour pigments in the spathe are anthocyanin derivatives. Carotenoid pigments are also present in spadix tissues; they are responsible for the bright yellow colour only. All other

spadix colours are flavonoid-based. Chlorophyll also contributes to spathe colour, either alone, giving a completely green spathe, or in combination with other anthocyanin pigments to give a brown spathe (Kamemoto and Kuehnle, 1996).

Pelargonidin and cyanidin derived anthocyanins are the main colour pigments in the anthurium spathe (Iwata *et al.*, 1979). Orange and coral spathe are contributed by pelargonidin 3-rutinoside where as red and pink colours of spathes are due to the presence of both pelargonidin 3- rutinoside and cyanidine 3-rutinoside. The white spathe contains colourless flavonones and glycosides and they lack both the anthocyanins. Plant breeding has provided significant information concerning the inheritance of flower colour in anthurium. Two genes, M and O, are responsible for anthocyanin production in anthurium and recessive epistasis of the O locus exists over the M locus. Gene M controls the production of cyanidin 3-rutinoside and gene O controls the production of pelargonidin 3-rutinoside. Several other genes also operate to provide the diversity of flower colours. Gene M and O control the production of red, orange, pink, coral and white colours. If gene M and O are Present, it will give rise to red and pink. Double heterozygote will give rise to pink colour. White colour occurs when 'OO' is in combination with M as well as for double recessive 'mmoo'. Orange and white breed true (Kamemoto *et al.* 1988).

The colour of the spathe gradually decreases when they get older and also after fertilization, the colour of the spathe changes to green and becomes photosynthetic to give nutrition to the growing berries (Mercy and Dale, 1994).

Sindhu (1995) found that the cultivars Chilli Red and Kalympong Red have dark and brightly coloured spathes which are of commercial importance. Renu (2000) observed significant variation in colour of spathe; i.e., a colour range of deep maroon to white. Mayadevi (2001) reported that the red spathe varieties showed variation from dark red (Chilli Red) to red (Honeymoon Red).

Spathe colour ranged from deep maroon to white in the 50 genotypes of anthurium studied by Asish (2002). Asish and Mayadevi (2006) observed that

a high concentration of anthocyanins in spathe resulting in deep maroon colour and lower concentration resulted in pink colour. Madhukumar (2010) observed significant differences in spathe colour, ranging from deep maroon to white and double coloured spathe.

2.3.2.2 Spadix Colour

The most common spadix colour at young stage was found to be yellow and it changes to white when the flowers become mature (Kamemoto and Nakasone, 1963). Ordinary anthurium varieties had single colour for spadix (red, pink and green) and hybrids exhibited different colours like yellow, Pink or red in two or more bands (Mercy and Dale, 1994). Renu (2000) recorded different spadix colours in ten varieties of *Anthurium andreanum* such as pink, light pink, yellow, light yellow, green and light green.

Asish (2002) observed wide variation in spadix colour like red to light red, reddish pink, pink, light pink, pinkish yellow, pinkish white, yellow, yellowish white and cream.

Madhukumar (2010) observed different spadix colours in anthrium varieties that ranged from pink, light yellow, yellow, maroon, yellowish white, creamish white to greenish yellow. Sheena (2015) inferred that the colour of the spadix vary according to the cultivars.

2.3.2.3 Type of Inflorescence Axis

Mercy and Dale (1994) opined that short and straight inflorescence axis is the characteristic feature of good anthurium varieties. Mayadevi (2001) observed long, straight and very strong inflorescence axis among all the parents studied. According to Pravin (2004), the type of inflorescence axis which is suited for commercial cultivation was found in varieties like Liver Red, Orange Glory, Acropolis White and Tropical Red.

Madhukumar (2010) studied forty genotypes of anthurium and noticed a wide range of variation in type of spadix ranging from long thick straight, long

thin straight, long thick curved, long thin curved, medium thick straight, medium thick curved, medium thin curved, short thick straight, short thin straight, short thick curved and short thin curved. Sheena (2015) observed that the type spadix varied from short to long, thin to thick and curved to straight.

2.3.2.4 Pollen Emergence Pattern

Mercy and Dale (1994) reported that anther dehiscence in anthurium was observed during 8 to 10 a.m and it will be less from March to July. Renu (2000) observed anther dehiscence in the early morning between 8 to 10 a.m and no pollen emergence was noticed in the varieties like Pompon Red, Nitta Orange and Midori Green. It was also inferred that the pollen emergence follow a regular pattern except in the variety Merengue White.

According to Madhukumar (2010), pollen emergence was found to be the maximum in the months from October to December and it was low from March to June. Sheena (2015) noticed the maximum pollen emergence in the months of October to January and the minimum was noticed in the months from March to May.

2.3.2.5 Pollen Shape and Colour

Croat (1980) revealed that there was wide range in pollen colour ranging from orange, yellow, purplish or white and colour fading occurs when the age progresses. Variable texture of pollen in *Anthurium andreanum* was also noticed.

Most of the genotypes have round pollen and the pollen shape ranged from round to oval among the 40 genotypes studied by Madhukumar (2010). Sheena (2015) noticed that the pollen shape varied from round to oval in all the varieties studied.

2.4 STATISTICAL ANALYSIS

2.4.1 Estimation of Genetic Parameters

2.4.1.1 Variability Studies

Variability studies provide the basis for selection and it is important for a successful crop improvement programme. A high variability in a crop indicates the scope for improvement and also for selection (Allard, 1960).

Renu (2000) studied six genotypes of anthurium and reported that the characters like plant height, position of spadix, days to initiation of female phase, number of days in female phase and spathe size have high PCV and GCV and there is more scope for improvement.

Mayadevi (2001) observed the highest PCV and GCV for the characters such as number of suckers^{-1} plant followed by leaf area, inclination of candle with the spadix, width of leaf blade and the minimum was noticed in number of spadices^{-1} plant^{-1} year^{-1}.

Asish *et al.* (2003) observed high variability in total anthocyanin content followed by pollen fertility, inclination of candle to the spathe, number of days for interphase and leaf area.

According to Pravin (2004) the maximum PCV and GCV were obtained for the characters like number of suckers^{-1} plant followed by pollen fertility and duration of male phase. Madhukumar (2010) recorded the highest variability for the character anthocyanin content followed by pollen fertility, leaf size/leaf area, spathe size and spadix length.

Sheena (2015) observed high GCV of 30.21 per cent and PCV of 31.79 per cent for the character leaf area. It was also noticed that high variability in characters like number of flowers spadix^{-1}, leaf area and plant height.

2.4.1.2 Heritability and Genetic Advance

The magnitude of heritability plays a key role in most of the crop improvement programmes. Because it act as the basis for selection dependent on phenotypic performance (Allard, 1960).

Mayadevi (2001) observed that the characters like plant height, spathe length, spathe width, number of suckers^{-1} plant, length of leaf blade, width of leaf blade, spadix length, inclination of spadix and leaf area had high heritability with high genetic advance.

Asish (2002) recorded that the character anthocyanin content (99.73 per cent) had the highest heritability where as the lowest heritability (39.34 per cent) was recorded for the character number of spadices^{-1} plant^{-1} year^{-1}. The maximum genetic advance of 118.98 per cent was observed for the character anthocyanin content followed by pollen fertility (86.55 per cent).

Premna (2003) observed high heritability coupled with high genetic advance for characters like leaf area, anthocyanin content, inclination of spadix, life of spadix and pollen fertility.

Madhukumar (2010) observed the highest heritability for the character total anthocyanin content (99.65 per cent) followed by pollen fertility (94.92 per cent) and also the maximum genetic advance was found in the same character total anthocyanin content (188.57 per cent) followed by pollen fertility (108.76 per cent).

Sheena (2015) reported that high heritability was found in characters like plant height, days from emergence to maturity of leaves, number of leaves^{-1} spadices $^{-1}$ plant^{-1} year^{-1}, leaf area, number of true flowers spadix^{-1}, internodal length, duration of female phase, inclination of spadix with the spathe, days from emergence to maturity of spathe, length of leaf stalk and days to initiation of female phase.

2.4.2 Correlation Analysis

Correlation refers to the degree and direction of association between two or more variables. Correlation studies are useful in developing an effective basis of phenotypic selection in plant populations. Since, yield is a polygenically controlled character with low heritability, direct selection is not effective. Yield improvement could be achieved by indirect selection.

Asish (2002) found that life of spadix had positive correlation with leaf area and spadix length but it showed negative correlation with number of days from emergence to maturity of leaves.

Premna (2003) reported positive phenotypic and genotypic correlation in the character life of spadix with internodal length, leaf area, number of leaves plant^{-1}, days from emergence to maturity of leaves, number of days from emergence to maturity of inflorescence, number of spadices plant^{-1}, spadix length, inclination of spadix, number of days for initiation of female phase, duration of female phase, duration of inter phase, duration of male phase and pollen fertility.

Madhukumar (2010) revealed that plant height exhibited positive genotypic correlation with most of the characters. Plant height showed significant phenotypic positive correlation with leaf size or leaf area, internodal length, anthocyanin content, spadix length, number of flowers spadix^{-1} and life of spadix. Sheena (2015) reported that almost all the character expressed high genotypic correlation coefficient than phenotypic correlation coefficient.

2.5 COMPATIBILITY STUDIES

2.5.1 Percentage of Candle Bearing Fruits

Sindhu (1995) reported the maximum value for percentage of spadix bearing berries (93 per cent) in the cultivar White and the minimum (50 per cent) in the genotype Kalympong Red. Renu (1999) noticed that the genotype Nitta Orange (51.93 per cent) had the highest percentage of spadix bearing fruits. The lowest per cent was reported in Mauritius Orange.

Premna (2003) recorded 100 per cent fruit bearing spadices in nine crosses of anthurium. Pravin, (2004) in a study with fourteen genotypes of anthurium, six crosses had 100 per cent spadices with fruits.

Madhukumar (2010) observed the percentage of spadices bearing fruits ranged from 50 to 100 per cent and the maximum percentage of spadices bearing fruits was noticed in the hybrid, Pompon Red x Orange Glory (90.0 per cent) followed by Acropolis White (66.67 per cent). The lowest value of 5 per cent was exhibited by the variety Esmeralda. Among the 80 successful cross combinations, 41 crosses were found to have 100 per cent spadices bearing fruits and 50 per cent for 39 crosses.

Sheena (2015) reported that out of the 213 crosses attempted, 34 showed 100 percent spadix bearing berries. More successful crosses were found when the genotypes such as Paradise, Agnihotri Red and Orange glory were used as the female parent.

2.5.2 Number of Fruits Candle^{-1}

Sindhu (1995) reported that the cross Pink x Honeymoon Red had the maximum number of fruits spadix^{-1} (170). The cross Kalympong Red x Kalympong Red had the lowest number of fruits spadix^{-1}. Renu (2000) noticed that the highest average number of fruits spadix^{-1} was in the genotype Pompon Red and it was the lowest in Lady Jane.

Pravin (2004) studied 14 genotypes of anthurium and observed 100 per cent fruit bearing spadices in six crosses. Madhukumar (2010) reported that the variety Liver Red had the maximum average number of fruits spadices^{-1} and the lowest was in Esmeralda. Almost all the crosses exhibited below 50 per cent fruit set. The lowest fruit set was found in the genotype Ceasor Violet. The maximum percentage of fruit set was observed in the cultivar Liver Red. Sheena (2015) observed that the number of fruits spadix^{-1} ranged from six (LW x OG) to 137 (M x MF).

2.5.3 Percentage of Fruit Set

Sindhu (1995) conducted cross compatibility analysis using six varieties of *Anthurium andreanum*. The cross Pink x Honeymoon Red (52.30 per cent) was found to have the highest percentage of fruit set followed by the cross Honeymoon Red x Pink (44.3 per cent). Renu (2000) observed the highest percentage of fruit set in the crosses which include Pompon Red as female parent.

Premna (2003) recorded the maximum value of 34.29 per cent fruit set for the cross (Ordinary Orange x Kalympong Red) x Carrie. Pravin (2004) noticed that the cross Liver Red x Pompon Red had the highest percentage of fruit set and it was the lowest for the cross Pompon Red x Fla Red.

Madhukumar (2010) found that, in almost all the successful crosses the percentage of fruit set was below 50 per cent. The maximum fruit set of 21.14 per cent was observed in the cross (Pompon Red x Orange Glory) x (Orange Glory x Dragon's Tongue) and the lowest (1.75) was found in the cross Esmeralda x (Pompon Red x Orange Glory). Sheena (2015) reported that the average number of fruit set varied from 2.58 percent (LW x OG) to 58.33 percent (P x LJ).

2.5.4 Number of Seeds Fruit^{-1}

Mercy and Dale (1994) reported that in commercial varieties of anthurium, each berry contained one or two seeds. Sindhu (1995) noticed that the percentage of single seeds varied from 37 to 100 per cent where as the percentage of double seeds was 63 per cent.

The maximum percentage of single seeded berries was observed in 12 successful crosses attended by Pravin (2004) except in the cross (Liver Red x Pompon Red) x Orange Glory.

Madhukumar (2010) reported that the cross Fla Red x Liver Red exhibited the highest percentage of double seeded berries and all other crosses had single seeded berries. Sheena (2015) found that the cultivar Dragon's Tongue and Orange Glory as female parents produced single and double seeds in all combinations.

2.5.5 Seed Size

Sindhu (1995) in a study with six genotypes of anthurium, found that the crosses involving Pink and Honeymoon Red as the female parents produced larger sized seeds. Kalympong varieties contribute comparatively smaller sized seeds in all the successful crosses.

Madhukumar (2010) reported that the cross Acropolis White x (Pompon Red x Orange Glory) had the largest sized seeds with seed size of 3.53 mm x 2.27 mm. Sheena (2015) observed the maximum seed size for the cross DT x OG (3.88 mm length and 2.97 mm width) and the smallest seed size (2.14 mm x 1.64 mm) was noticed in the cross LJ x MF.

2.5.6 Seed Germination

Mercy and Dale (1994) observed 90 per cent germination in the hybrid seeds which were obtained from crosses between ordinary hardy varieties of *Anthurium andreanum*. The seedlings of such varieties were found to have high survival and vigour.

Sindhu (1995) recorded the maximum germination percentage of 78 per cent for the cross Honeymoon Red x Chilli Red. Renu (2000) observed a wide range of variation in seed germination percentage ranging from 69 per cent in Tropical Red to 2.3 per cent in Midori Green.

Pravin (2004) recorded that the cross Pompon Red x Fla Red exhibited the highest germination percentage (80.86 per cent) and the lowest germination percentage of 63.86 per cent was noticed in Orange Glory x Dragon's Tongue.

Madhukumar (2010) revealed that a minimum of four to nine days was required for germination. According to Sheena (2015), the percentage of seed germination varied from 29.17 per cent (OG x DT) to 92.96 per cent (M x LJ).

MATERIALS AND METHODS.....

3. MATERIALS AND METHODS

The present investigation was carried out to evaluate twenty five genotypes of anthurium and to identify suitable parents with commercial qualities and fifteen genotypes were selected to improve through hybridization. The investigation was carried out at Coconut Research Station, Balaramapuram, during 2014-16. The research programme consisted of two experiments.

Experiment I: Evaluation of parental genotypes

Experiment II: Hybridization among the selected fifteen genotypes

3.1 EXPERIMENT NO. I:

3.1.1 Materials

Twenty five genotypes of anthurium showing variations in spathe colour and shape and other commercial qualities were selected for evaluation (Plate.1). Based on the morphological and floral observations fifteen parental varieties were selected for hybridization.

1. Liver Red (LR)
2. Dragon's Tongue (DT)
3. Chikoos (C)
4. Tropical Red (TR)
5. Chekas (CK)
6. Can Can (CN)
7. Emperor (ER)
8. Honeymoon Red (HM)
9. Cascade White (CW)
10. Merengue White (MW)
11. Boroque (B)
12. Lucia Pink (LP)
13. Chocos (CS)
14. Hawaiian Orange (HO)

Liver Red

Dragon's Tongue

Chikoos

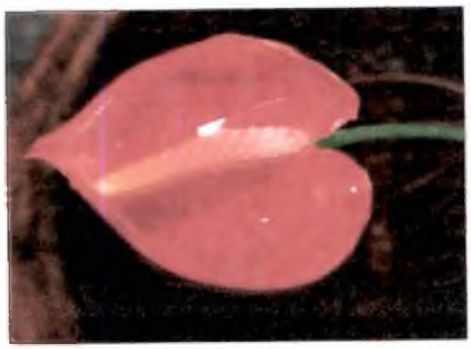
Tropical Red

Chekas

Can Can

Plate 1. List of genotypes used in the study

Emperor



Honeymoon Red

Cascade White

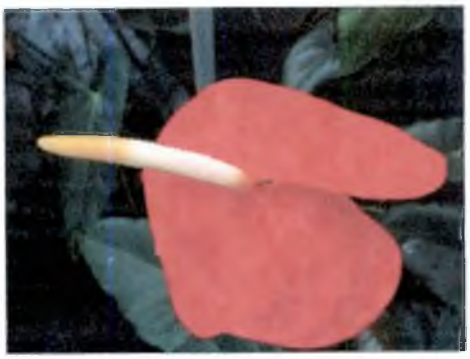
Merengue White

Boroque

Lucia Pink

Plate 1. (Continued) List of genotypes used in the study

Chocos



Hawaiian Orange

Tropical Peach

Mauritius Orange

Honduras Red

Esmeralda

Plate 1. (Continued) List of genotypes used in the study

Vezuvious Red

Gold Spark

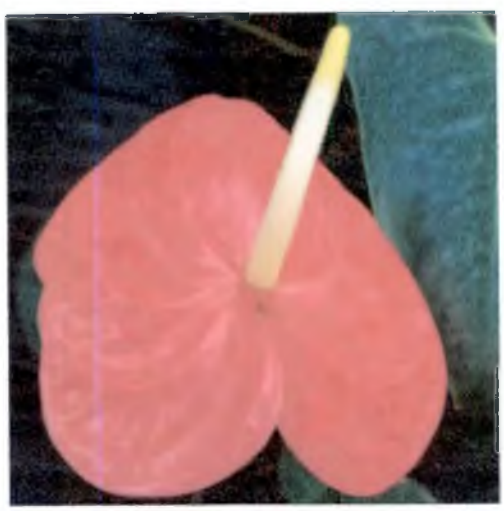
Arun Gold

Plate 1. (Continued) List of genotypes used in the study

Lady Jane

Pistache

Agnihotri



Nitta Orange

Plate : 1 (Continued) List of genotypes used in the study

Plate 2 : Field View

15. Tropical Peach (TP)
16. Mauritius Orange (MO)
17. Honduras Red (HR)
18. Esmeralda (E)
19. Vezuvious Red (VR)
20. Gold Spark (GS)
21. Arun Gold (AG)
22. Lady Jane (LJ)
23. Pistache (P)
24. Agnihotri (AH)
25. Nitta Orange (NO)

3.1.2 Methods

3.1.2.1 Evaluation of Parental Genotypes

The twenty five genotypes were planted in pots in completely randomized design with five replications. Observations were taken on single plant basis. Fifteen parental genotypes were selected based on vegetative as well as floral characters suitable for hybridization (Plate 2).

3.1.2.2. Hybridization

Intervarietal crossing involving the selected fifteen commercially important anthurium varieties were be attempted based on the pollen availability and receptivity of stigma.

3.1.2.2.1 Hybridization Technique in Anthurium

A wet hand or fine moist brush was used for collecting pollen. Pollination was done by passing the wet hand or brush with pollen over the receptive stigma. The receptive stigma was identified by the presence of viscous exudate. The anther dehiscence occurs in the morning in between 8 and 9 am. In fertilized inflorescence, spathe remains strongly attached with the peduncle and becomes green. It takes 4 to 7 ½ months to get mature berries. Spathe was greenish and

Table 1: Possible cross combinations between fifteen selected parents

	LR	DT	C	CK	HR	E	HO
LR		LR x DT	LR x C	LR x CK	LR x HR	LR x E	LR x HO
DT	DT x LR		DT x C	DT x CK	DT x HR	DT x E	DT x HO
C	C x LR	C x DT		C x CK	C x HR	C x E	C x HO
CK	CK x LR	CK x DT	CK x C		CK x HR	CK x E	CK x HO
HR	HR x LR	HR x DT	HR x C	HR x CK	-	HR x E	HR x HO
E	E x LR	E x DT	E x C	E x CK	E x HR	-	E x HO
HO	HO x LR	HO x DT	HO x C	HO x CK	HO x HR	HO x E	-
CS	CS x LR	CS x DT	CS x C	CS x CK	CS x HR	CS x E	CS x HO
B	B x LR	B x DT	B x C	B x CK	B x HR	B x E	B x HO
P	P x LR	P x DT	P x C	P x CK	P x HR	P x E	P x HO
TP	TP x LR	TP x DT	TP x C	TP x CK	TP x HR	TP x E	TP x HO
LP	LP x LR	LP x DT	LP x C	LP x CK	LP x HR	LP x E	LP x HO
CW	CW x LR	CW x DT	CW x C	CW x C	CW x HR	CW x E	CW x HO
MW	MW x LR	MW x DT	MW x C	MW x CK	MW x HR	MW x E	MW x HO
VR	VR x LR	VR x DT	VR x C	VR x CK	VR x HR	VR x E	VR x HO

Table: 1 contd.

	CS	B	P	TP	LP	CW	MW	VR
LR	LR x CS	LR x B	LR x P	LR x TP	LR x LP	LR x CW	LR x MW	LR x VR
DT	DT x CS	DT x B	DT x P	DT x TP	DT x LP	DT x CW	DT x MW	DT x VR
C	C x CS	C x B	C x P	C x TP	C x LP	C x CW	C x MW	C x VR
CK	CK x CS	CK x B	CK x P	CK x TP	CK x LP	CK x CW	CK x MW	CK x VR
HR	HR x CS	HR x B	HR x P	HR x TP	HR x LP	HR x CW	HR x MW	HR x VR
E	E x CS	E x B	E x P	E x TP	E x LP	E x CW	E x MW	E x VR
HO	HO x CS	HO x B	HO x P	HO x TP	HO x LP	HO x CW	HO x MW	HO x VR
CS	CS x CS	CS x B	CS x P	CS x TP	CS x LP	CS x CW	CS x MW	CS x VR
B	B x CS	-	B x P	B x TP	B x LP	B x CW	B x MW	B x VR
P	P x CS	P x B	-	P x TP	P x LP	P x CW	P x MW	P x VR
TP	TP x CS	TP x B	TP x P	-	TP x LP	TP x CW	TP x MW	TP x VR
LP	LP x CS	LP x B	LP x P	LP x TP	-	LP x CW	LP x MW	LP x VR
CW	CW x CS	CW x B	CW x P	CW x TP	CW x LP	-	CW x MW	CW x VR
MW	MW x CS	MW x B	MW x P	MW x TP	MW x LP	MW x CW	-	MW x VR
VR	VR x CS	VR x B	VR x P	VR x TP	VR x LP	VR x CW	VR x MW	-

photosynthetic in fertilized ones. Selfing can be done by using two spadices of same genotype. Pollinated spadix was labelled with the cross combination and date of crossing. The possible cross combinations are shown in the Table 1.

For planting, the bottom one layer was filled with broken bricks and tile pieces. Then it was filled with a mixture of coarse sand, broken bricks, dried coconut husk pieces and charcoal upto half portion of the pot. Healthy plants were placed over this and potting mixture is added for proper anchorage. Sufficient drainage was ensured in this method of planting.

Since anthurium is a shade loving plant, 75 per cent artificial shade was provided by using black polypropylene agro shade netting. Depending on the temperature conditions mist irrigation was provided two to three times each day. NPK mixture 19:19:19 was applied 2g l^{-1} water weekly intervals. Additional manures like cowdung slurry or fermented cowdung + neem cake mixture can be given at weekly intervals. For preparing the latter 0.5 kg cowdung, 250 g neem cake and 250g ground nut cake were mixed together in 5 litres of water and keep it for fermentation for 3 days. Sieve these mixtures on fourth day and then added another 5 litres of water to it and sprayed to each pot as 200ml/pot.

3.1.2.3 Plant Protection

1. To control anthracnose by *Colletotrichum gloeosporioides* regular application of the following chemicals were carried out.

   a. Bavistin 50 per cent WP @ 2gl^{-1} or
   b. Indofil M-45 2g l^{-1}

2. *Pseudomonas fluorescens* @ 2 per cent was applied at weekly intervals as a prophylactic measure against bacterial blight caused by *Xanthomonas axonopodis* pv. dieffenbachiae.

3. For the control of leaf eating cater pillars a new generation chemical called Koragen was applied in the field at the rate of 0.25 ml/l.

4. For the control of bacterial fungal attack – bacteriomycin 6g/20l was applied all over the field

3.1.3 Morphological Studies

The parent plant material with stabilized vegetative and floral characters was used for taking all the 20 observations. The observations were taken and recorded and their mean values were taken.

3.1.3.1 Vegetative Characters

3.1.3.1.1 Plant Height

Plant height was measured from the base of the plant to the tip of the top most leaf in centimetres.

3.1.1.1.2 Leaf Size or Leaf Area

To estimate the leaf area the maximum length and breadth of the third leaf were used. The third leaf was chosen because it will be fully unfurled and has its full growth and spread of the leaf blade.

The leaf area of 25 genotypes measured by applying linear regression

$Y = 9.53 + 0.64x$, Where y denotes the leaf area and x = maximum leaf length x maximum leaf breadth (Mayadevi, 2001)

3.1.1.1.3 Internode Length

Internode length was taken by measuring the distance between the two nodes from the base of the plant and recorded in centimetres.

3.1.1.1.4 Days from Emergence to Maturity of Leaves

Days from the emergence to maturity of leaves were observed and recorded.

3.1.1.1.5 Number of Leaves Spadices^{-1} Plant^{-1} Year^{-1}

The number of leaves spadices^{-1} plant^{-1} year^{-1} during a period of one year was observed and recorded.

3.1.1.1.6 Number of Suckers Plant^{-1} and Suckering Ability

The capacity of a plant to produce new suckers from the base of the mother plant was observed and the number of suckers was recorded.

3.1.1.1.7 Colour of Petiole and Young Leaf

The colour of petiole and young leaf of each parent genotype was observed visually when the leaves were not opened fully.

3.1.1.1.8 Incidence of Major Pests and Diseases

The incidence of pests and diseases during the two year period was recorded.

3.1.3.2 Floral Characters

3.1.3.2.1 Floral Quantitative Characters

3.1.3.2.1.1 Days from Emergence to Maturity of Inflorescence

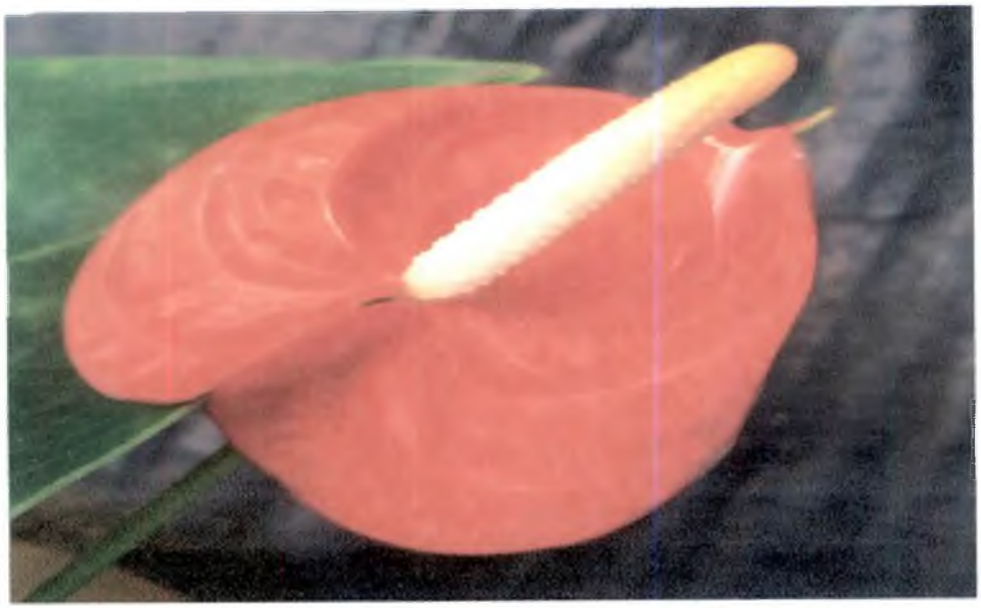
The time taken for the emergence of inflorescence to its full maturity was observed and recorded.

3.1.3.2.1.2 Number of Flowers Year^{-1}

The number of flower produced by each genotype during one year period was recorded.

3.1.3.2.1.3 Spathe Size

Spathe size was recorded by using standard graph sheet method.



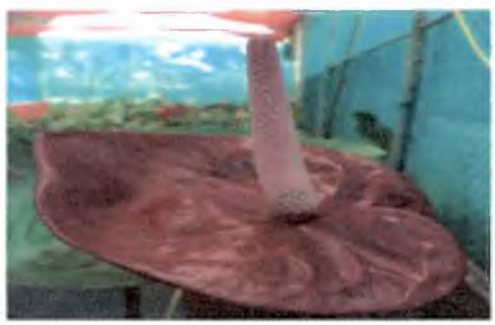
Female phase in Hawaiian Orange

Female phase in Cascade White

Plate : 3 Female phase in anthurium

Drying up of stigmatic fluid in Female phase

Male phase in Merengue White



Male phase of Liver Red

Male phase in Vezuvious Red

Plate : 4 Male phase in anthurium

3.1.3.2.1.4 Spadix Length

Spadix length was measured from the base of the candle to its tip in centimetres.

3.1.3.2.1.5 Number of Flowers Spadix^{-1}

The flowers which are arranged in acropetal succession from the base to the tip was counted and recorded.

3.1.3.2.1.6 Life of Spadix

The time taken between the first day of emergence of inflorescence to the time of its yellowing, withering of spathe and shrivelling of candle was observed and recorded.

3.1.3.2.1.7 Days to Initiation of Female Phase

The period from the emergence of spathe to the first emergence of mature stigmas of the basal flowers, identified by the presence of honey dew or stigmatic droplets was observed and recorded.

3.1.3.2.1.8 Duration of Female Phase

The duration of female phase was noted and recorded.

3.1.3.2.1.9 Days to Interphase

The number of days that taken between the end of female phase and the emergence of anthers from the basal flowers, indicating the start of male phase was recorded.

3.1.3.2.1.10 Duration of Male Phase

The time taken for the emergence of the first anthers in the spadix to the emergence of its last anthers was recorded.

3.1.3.2.1.11 Inclination of Candle with the Spathe

With the help of protractor the angle between the base of the candle to the plane of subtending spathe was taken and recorded.

3.1.3.2.1.12 Anthocyanin Content

The anthocyanin content was estimated by the method described by Rangana (1977). First step was the alcoholic extraction of the plant material (spathe). From each treatment one gram of the spathe sample was extracted with ethanolic hydrochloric acid, filtered through a Buchner funnel using Whatsman No 1 filter paper. The filtrate then diluted with ethanolic hydrochloric acid to 50 ml to get optical density values within the optimum range of spectrophotometer at 535 nm. Then the anthocyanin content was calculated using a formula and the quantity was expressed as mg per 100 gm of the sample.

Total OD per 100g of sample (X) = [(Absorbance at 535 nm) x (volume made up of the extract used for the colour development) x (Total volume) x100] – [Volume (ml of the extract) used x Weight of sample taken]

The absorbance of a solution containing 1 mg per ml is equal to 98.2 (constant).

Therefore, Total anthocyanin in mg per 100 g of the sample = X/98.2.

3.1.3.2.1.13 Pollen Fertility

The fertility of pollen was assessed using acetocarmine staining method. Pollengrains were collected from all the twenty five initials and stained with 1:1 glycerine acetocarmine stain (2 percent). For each variety five slides were prepared and the microscopic fields were scored and data recorded. The fertile pollen grains were uniformly stained and properly filled and sterile ones appear as unstained, undersized, partially stained and shrivelled pollen engrains were scored.

The pollen fertility was calculated as,

Pollen fertility = No of well filled and uniformly stained pollen grains X 100

Total number of pollen grains

3.1.3.2.1.14 Pollen Size

Ocular micrometer after caliberation was used for measuring pollengrains. With the help of stage micrometer caliberation was done to obtain the measurement of ocular micrometer division and converted it to μ.

Pollen grain diameter was measured. To find out the average diameter of the pollengrain, the standard deviation and standard error were calculated based on this mean.

Average diameter = Mean ± standard error.

3.1.3.2.2 Floral Qualitative Characters

3.1.3.2.2.1 Spathe Colour

Spathe colour each genotype was recorded by visual observation

3.1.3.2.2.2 Spadix Colour

Spadix colours were observed visually and recorded

3.1.3.2.2.3 Type of Inflorescence Axis

Nature, strength and length of the inflorescence axis in each variety were observed and recorded.

3.1.3.2.2.4 Pollen Shape and Pollen Colour

The pollen shape and colour of each genotype was recorded by visual observation using microscope.

3.1.4 Statistical Analysis

3.1.4.1 Analysis of Variance

The completely randomized design with two characters X and Y measured in g genotypes with r replications, the variance is as follows:

Source	Df	Mean square		
		X	Y	XY
Between genotypes	(g-1)	G_{xx}	G_{yy}	G_{xy}
Error	(r-1) (g-1)	E_{xx}	E_{yy}	E_{xy}

3.1.4.2 Coefficient of Variation

The coefficient of variation such as phenotypic coefficient of variation and genotypic coefficient variation for a trait X were estimated as

$$GCV = \frac{\sigma_{gx}}{\bar{X}} \times 100$$

$$PCV = \frac{\sigma_{px}}{\bar{X}} \times 100$$

3.1.4.3 Heritability

The proportion of heritable component of variation was estimated as heritability (H^2). Heritability in broad sense can be calculated as percentage by Jain's formula (1982).

$$\text{Heritability coefficient, } H^2 \text{ (in broad sense)} = \frac{\sigma_{gx}^2}{\sigma_{px}^2} \times 100$$

Where,

σ_{gx}^2 ⟶ Genotypic variance of that particular character

σ_{px}^2 ⟶ Phenotypic variance of that particular character

According to classification of Allard (1960) , low heritability (less than 30 percent), medium (30 -60 per cent) and high (above 60 per cent).

$$\text{Genetic advance as percentage of mean (GA)} = \frac{kH^2 \sigma_{px}}{\bar{X}}$$

k ⟶ Selection differential

k ⟶ 2.06 When there is 5% selection to be practiced

H^2 ⟶ Heritability in broad sense

σ_{px} ⟶ Phenotypic standard deviation

$\bar{X}$ ⟶ Mean of the character over all the varieties

Robinson *et al.* (1949) classification

Genetic advance as per percentage

< 20% - Low

> 20% - High

3.1.4.4 Correlation Analysis

The correlation coefficients such as phenotypic, genotypic and environmental between two characters denoted as x and y were calculated as

$$\text{Genotypic correlation } (r_{gxy}) = \frac{\sigma_{gx\,y}}{\sigma_{gx} \times \sigma_{gy}}$$

$$\text{Phenotypic correlation } (r_{pxy}) = \frac{\sigma_{px\,y}}{\sigma_{px} \times \sigma_{py}}$$

$$\text{Environmental correlation } (r_{exy}) = \frac{\sigma_{ex\,y}}{\sigma_{ex} \times \sigma_{ey}}$$

3.1.5 Compatibility Studies

3.1.5.1 Percentage of Spadix Bearing Berries

The percentage of successfully fertilized inflorescence with strong and green peduncles were noted and their percentage was calculated using the following formula

$$\frac{\text{The number of spadices bearing berries}}{\text{Number of spadices pollinated}} \times 100$$

3.1.5.2 Number of Fruits Candle^{-1}

The number of berries in each successfully fertilised candle was noted and recorded

3.1.5.3 Percentage of Fruit Set Candle^{-1}

Percentage of berry set was recorded as the percentage of flowers showing fruit set to the total number of flowers pollinated in a spadix. If the spadix is pollinated four times, hundred percentage of the flowers were assumed to be pollinated, 3 times means 90 percent, two for 60 percent and one for 30 percent. Depending upon the availability of receptive stigma and fresh pollen, the number of pollination done may be varied.

3.1.5.4 Number of Seeds Berry^{-1}

The number of seeds in each berry was noted and recorded.

3.1.5.5 Seed Size

The seed size was measured by taking length and breadth of the seeds in millimetres and recorded.

3.1.5.6 Percentage of Germination of Seed

The percentage of germination was calculated as percentage of number of seeds germinated to number of seeds kept for germination.

RESULTS.....

4. RESULTS

The results of the two experiments of the present project are presented as two experimental results

1. Evaluation of 25 genotypes of anthurium for hybridization programme
2. Cross compatibility analysis

4.1 EVALUATION OF 25 GENOTYPES OF ANTHURIUM FOR HYBRIDIZATION PROGRAMME

The vegetative as well as the floral qualitative characters of *Anthurium andreanum* Linden and their performance were evaluated in the green house. Each genotype had five replications. The data were recorded and statistical analysis was carried out and the results of the data are presented under the following subheadings.

4.1.1 Evaluation of Genotypes Based on their Performance During One Year Period

4.1.2 Estimation of Genetic parameters- PCV, GCV, Heritability and Genetic Advance

4.1.3 Correlation Studies

4.1.1 Evaluation of Genotypes Based on their Performance During One Year Period

The analysis of variance using 20 different characters showed significant variations among the 25 varieties of anthurium. The mean performances of 20 characters studied are furnished in Table 3.

4.1.1.1 Vegetative Characters

4.1.1.1.1 Plant Height

The highest mean plant height (50.6 cm) exhibited by the genotype Cascade White was on par with the genotype Chikoos (46 cm), Liver Red (44 cm) and Boroque. The lowest plant height was noticed in the variety Nitta Orange (22 cm) which was on par with Can Can (23.04 cm), Arun Gold (23.2 cm), Esmeralda (24 cm) and Pistache (25.2 cm).

Table 2: Analysis of variance of vegetative and floral characters in *Anthurium andreanum* genotypes

Sl. No	Characters	Mean square	
		Genotype	Error
1	Plant height	337.88**	52
2	Leaf size/ leaf area	29745.82**	8575.21
3	Internode length	0.137**	0.041
4	Number of leaves/ spadices/plant /year	12.46**	3.76
5	Number of suckers per plant	0.825**	0.438
6	Days from emergence to maturity of leaves	19.77**	2.89
7	Days from emergence to maturity of inflorescence	18.03**	2.87
8	Number of flowers / year	7.46**	1.08
9	Spathe size	678.60**	18.52
10	Spadix length	9.757**	0.815
11	Number of flowers per spadix	20635**	1094.72
12	Life of spadix	356.68**	6.58
13	Days to initiation of female phase	10.99**	0.618
14	Duration of female phase	3.17**	0.626
15	Duration of interphase	11.03**	0.475
16	Duration of male phase	10.33**	0.698
17	Inclination of candle with the spathe	375.20**	18.46
18	Anthocyanin content	41689**	95.05
19	Pollen fertility	650.33**	4.37
20	Pollen size	41.43**	1.81

** Significant at 1 percent level * Significant at 5 per cent level

Table 3a.i. : Mean performance of vegetative characters of *Anthurium andreanum*

Sl. No	Genotype	Plant height (cm)	Leaf area (cm)	Internode length (cm)	Number of leaves Spadices^{-1} plant^{-1}year^{-1}	Number of suckers plant^{-1}	Days from emergence to maturity of leaves (days)
1	Liver Red	44.0	307.93	0.84	5.4	0.6	32.6
2	Dragon's Tongue	30.6	290.494	0.86	5.6	0.8	25.8
3	Chikoos	46.0	391.496	0.88	4.0	0	29.0
4	Tropical Red	31.5	263.672	1.06	3.2	0	31.4
5	Chekas	33.56	209.552	0.66	4.4	0.4	28.6
6	Can Can	23.04	197.000	1.02	6.0	0.6	26.4
7	Emperor	39.6	208.708	1.16	4.6	0.8	30.0
8	Honeymoon Red	41.4	302.594	1.06	9.0	1.6	30.4
9	Cascade White	50.6	450.276	0.90	5.8	0.8	29.0
10	Merengue White	39.0	234.228	1.12	3.8	0.2	29.6
11	Boroque	42.0	417.290	0.96	3.8	0.4	24.4
12	Lucia Pink	25.4	188.98	0.92	4.8	0.4	27.8
13	Chocos	32.2	208.814	1.20	5.8	0	29.2
14	Hawaiian Orange	39.6	273.728	1.24	7.2	0	30.0
15	Tropical Peach	34.2	269.874	1.30	7.6	0.2	30.0
16	Mauritius Orange	42.4	316.004	0.82	7.0	0	26.0
17	Honduras Red	26.2	205.154	0.86	6.6	0	25.0
18	Esmeralda	24.0	176.300	1.00	4.6	0	27.2
19	Vezuvious Red	27.4	231.894	0.70	8.4	0.4	30.0
20	Gold Spark	31.2	230.986	0.96	7.2	0	27.0
21	Arun Gold	23.2	207.300	0.86	5.8	0.6	27.8
22	Lady Jane	28.6	196.368	1.16	8.6	0.8	28.4
23	Pistache	25.2	193.328	0.80	5.6	0	29.0
24	Nitta Orange	22.0	151.044	0.82	7.2	0	29.2
25	Agnihotri	27.2	187.616	0.92	6.0	0	30

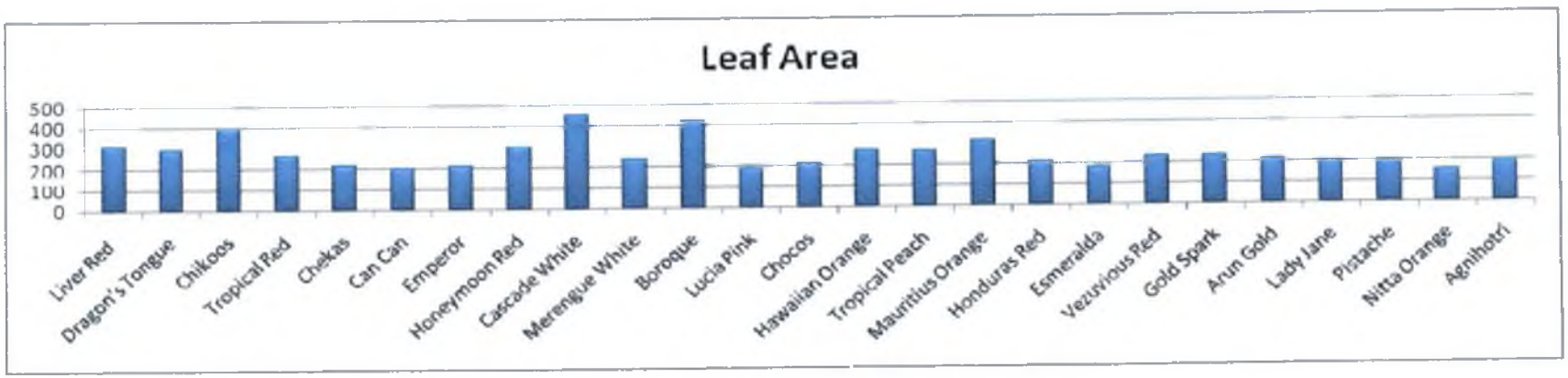
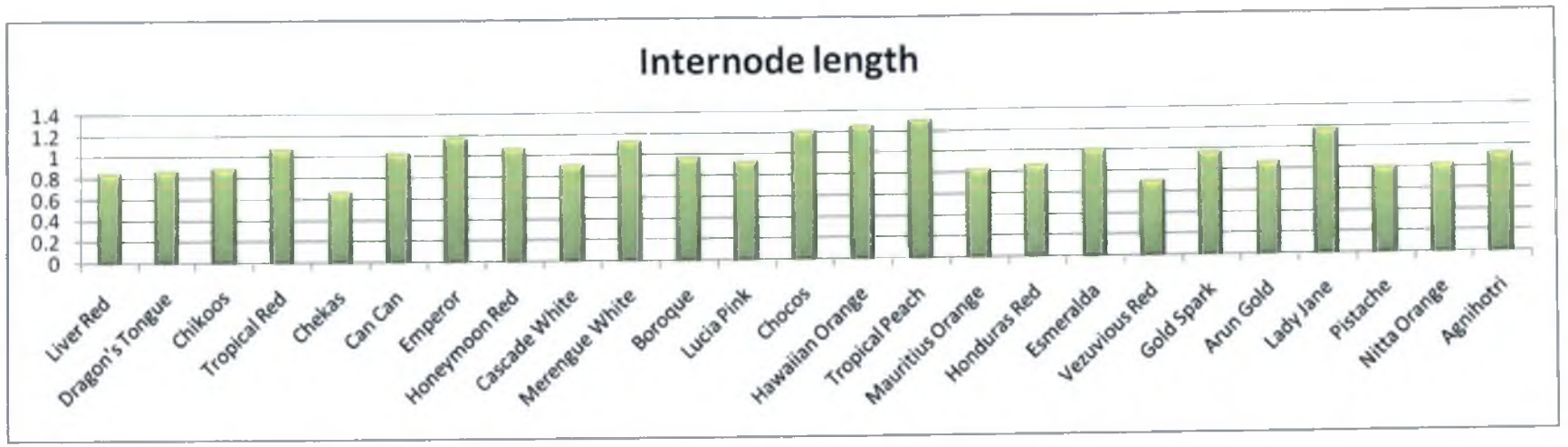


Fig.1a. Mean performance of twenty five genotypes of *Anthurium andreanum* genotypes



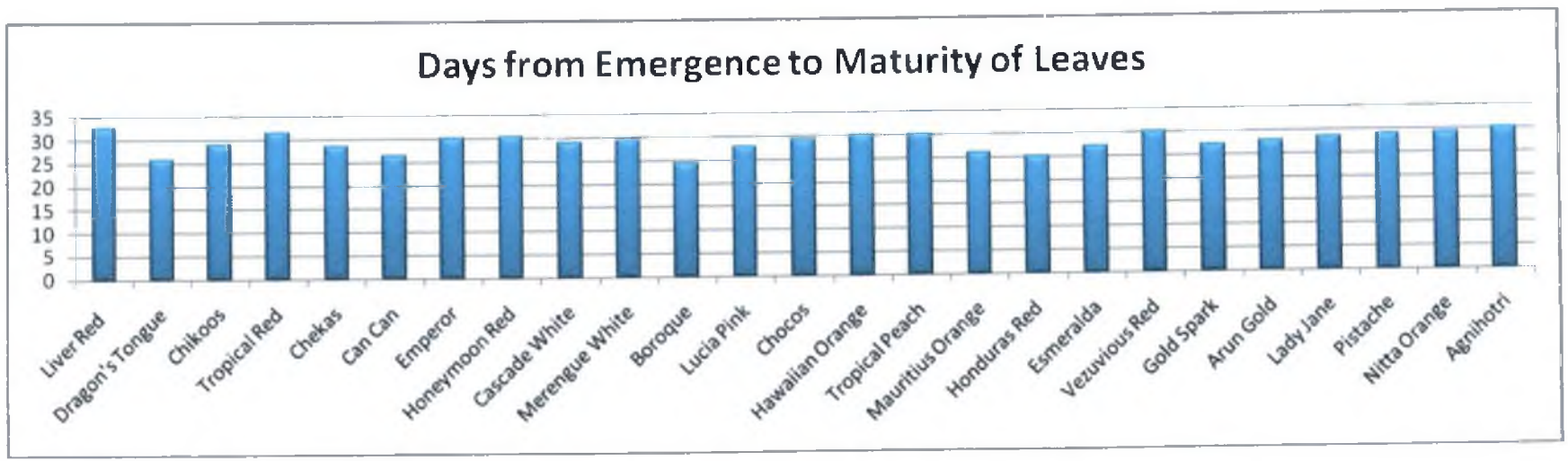


Fig.1b. Mean performance of twenty five genotypes of *Anthurium andreanum* genotypes

4.1.1.1.2 Leaf Area or Leaf Size

The maximum value for leaf area was exhibited by the cultivar Cascade White (450.276 cm^2) which was on par with Boroque (417.29 cm^2) and Chikoos (391.49 cm^2). The minimum leaf area was shown by the variety Nitta Orange which was on par with Esmeralda (176.30 cm^2), Agnihotri (187.61 cm^2).

4.1.1.1.3 Internode Length

The maximum internode length was noticed in the variety Tropical Peach (1.30 cm) which was on par with Hawaiian Orange (1.24 cm), Chocos (1.20 cm), Emperor (1.16 cm), Lady Jane (1.16 cm), Merengue White (1.12 cm), Honey moon Red and Tropical Red (1.06 cm).

4.1.1.1.4 Number of Suckers $^{-1}$ Plant and Suckering Ability

The number of suckers was the highest in the variety Honeymoon Red (1.6) which was on par with Lady Jane (0.8), Emperor (0.8) and Dragon's Tongue. The genotypes like Gold Spark, Nitta Orange, Agnihotri, Pistache, Chocos, Tropical Red, Hawaiian Orange, Mauritius Orange, Honduras Red and Esmeralda doesn't produce suckers. Suckering ability was found to be high in Honeymoon Red and the varieties didn't produced the suckers indicates the low suckering ability.

4.1.1.1.5 Number of Leaves $^{-1}$Spadices $^{-1}$Plant^{-1}

The highest numberof leaves were observed in the variety Honeymoon Red (9) followed by Lady Jane (8.6) which was on par with the varities such as Vezuvious Red (8.4), Tropical Peach (7.6), Gold Spark (7.2), Nitta Orange (7.2) and Hawaiian Orange (7.2).

4.1.1.1.6 Days from Emergence to Maturity of Leaves

The maximum days for maturity of leaves were observed in Liver Red which was on par with Tropical Red (31.4 days). The genotype Boroque exhibited the lowest number days for maturity of leaves (24.4 days) which was on par with Dragon's Tongue (25.8 days), Mauritius Orange (26 days) and Can Can (26.4 days).

Table 3a. ii: Qualitative vegetative characters of *Anthurium andreanum*

Sl. No	Genotypes	Petiole	Young leaf
1	Liver Red	Reddish brown	Reddish brown
2	Dragon's Tongue	Green	Reddish brown
3	Chikoos	Reddish brown	Green
4	Chekas	Greenish brown	Greenish brown
5	Tropical Red	Green	Reddish brown
6	Can Can	Green	Greenish brown
7	Emperor	Green	Reddish brown
8	Honeymoon Red	Reddish brown	Green
9	Cascade White	Green	Green
10	Merengue White	Green	Green
11	Boroque	Green	Green
12	Lucia Pink	Green	Brown
13	Chocos	Green	Green
14	Hawaiian Orange	Green	Greenish brown
15	Tropical Peach	Green	Green
16	Mauritius Orange	Green	Greenish brown
17	Honduras Red	Green	Green
18	Esmeralda	Green	Green
19	Vezuvious Red	Green	Greenish brown
20	Gold Spark	Green	Green
21	Arun Gold	Green	Brown
22	Lady Jane	Green	Light green
23	Pistache	Reddish brown	Light green
24	Nitta Orange	Greenish brown	Greenish brown
25	Agnihotri	Green	Greenish brown

Caterpillar attack

Bacterial leaf blight on fertilized candle

Anthracnose

Bacterial leaf blight of inflorescence

Plate : 5 Pests and disease incidence in anthurium

4.1.1.1.7 Colour of Petiole and Young Leaves

Colour of petiole and young leaves showed a wide variation among the twenty five genotypes of anthurium. The colour of petiole ranged from green to greenish brown and reddish brown and the colour of young leaves varied from green to light green and to reddish green and brown to reddish brown.

4.1.1.1.8 Pests and Disease Incidence

The major pest during the experimental programme was a caterpillar which eats all the newly emerged leaves as well as flowers irrespective of the genotype. Application of new generation chemical called Koragen 0.25ml/l was found to be effective for this pest.

The major diseases in the experimental plot were bacterial leaf blight and anthracnose. Almost all the genotypes were affected by these diseases. The symptoms of bacterial leaf blight were predominant in flowers rather than leaves. Application of Bacteriomycin 6g/ 20 litres of water at fortnightly intervals was found to control this disease to an extent. Anthracnose disease was affected by leaves and it was controlled by using Mancozeb 3 per cent at fortnightly intervals.

4.1.1.2 Floral Characters

4.1.1.2.1 Floral Quantitative Characters

4.1.1.2.1.1 Days from Emergence to Maturity of Inflorescence

Days from emergence to maturity of inflorescence were noticably high in the cultivar Agnihotri (35.2 days) and low in the cultivar Can Can (28.4 days).

4.1.1.2.1.2 Spathe Size (cm)

A wide variation in spathe size was observed ranged from 101 cm^2 to 42.88 cm^2. The maximum spathe size was shown by the genotype Boroque (101 cm^2) followed by Tropical Peach (97.2 cm^2). The minimum spathe size was observed in the variety Lady Jane (42.88 cm^2).

Table 3b. i: Mean performance of floral characters of *Anthurium andreanum*

SL. No	Variety	Days from emergence to maturity of inflorescence (days)	Spathe size (cm^2)	Spadix length (cm)	Number of flowers $spadix^{-1}$
1	Liver Red	28.8	68.16	5.98	380.0
2	Dragon's Tongue	30.6	88.58	6.00	446.6
3	Chikoos	28.8	90.76	8.76	452.2
4	Tropical Red	30.0	76.00	5.70	287.0
5	Chekas	31.0	72.72	5.62	251.6
6	Can Can	28.4	71.22	6.26	256.2
7	Emperor	29.4	77.32	4.68	274.0
8	Honeymoon Red	28.8	73.04	3.10	294.0
9	Cascade White	32.0	84.28	7.18	349.2
10	Merengue White	31.4	72.74	5.70	388.0
11	Boroque	28.8	101.26	6.86	286.0
12	Lucia Pink	30.4	76.82	5.0	260.0
13	Chocos	30.0	88.66	5.66	355.8
14	Hawaiian Orange	31.8	76.24	6.50	278.4
15	Tropical Peach	31.0	97.20	5.00	387.8
16	Mauritius Orange	30.4	74.16	4.92	302.6
17	Honduras Red	31.0	74.92	4.64	288.6
18	Esmeralda	30.4	78.56	6.32	246.2
19	Vezuvious Red	34.4	72.74	4.34	270.8
20	Gold Spark	33.4	69.62	4.54	252.0
21	Arun Gold	28.8	62.78	6.46	414.8
22	Lady Jane	34.6	42.88	6.12	255.8
23	Pistache	31.2	71.94	3.98	251.8
24	Nitta Orange	31.6	69.72	4.90	323.6
25	Agnihotri	35.2	68.39	4.80	289.8

Table 3b.i. Contd.

Sl. No	Variety	Inclination of candle with the spathe (degrees)	Pollen fertility (per cent)	Pollen Size (μ)	Anthocyanin Content (mg g^{-1})	Number of flowers $year^{-1}$
1	Liver Red	54.20	41.18	24.42	339.52	3.80
2	Dragon's Tongue	62.00	27.23	17.82	273.17	4.20
3	Chikoos	70.40	42.58	19.60	213.76	4.40
4	Tropical Red	46.00	21.51	16.10	198.05	3.20
5	Chekas	66.80	8.88	15.85	164.91	4.60
6	Can Can	56.40	9.65	14.03	113.69	4.00
7	Emperor	64.20	8.40	14.52	109.40	3.00
8	Honeymoon Red	44.80	11.36	15.38	114.77	1.80
9	Cascade White	63.20	7.58	17.48	24.01	4.80
10	Merengue White	46.40	30.59	21.47	24.78	2.20
11	Boroque	58.60	4.96	18.60	43.86	4.40
12	Lucia Pink	50.60	12.57	18.00	32.37	1.20
13	Chocos	53.60	20.20	17.45	90.13	3.80
14	Hawaiian Orange	56.60	5.34	19.10	45.50	5.00
15	Tropical Peach	56.40	3.63	14.49	32.44	2.00
16	Mauritius Orange	41.00	14.51	16.01	44.70	1.20
17	Honduras Red	46.20	33.25	22.68	242.44	2.60
18	Esmeralda	50.40	4.14	16.54	35.17	3.40
19	Vezuvious Red	72.60	25.54	14.32	97.03	4.60
20	Gold Spark	67.80	13.16	18.43	26.48	4.20
21	Arun Gold	53.60	18.19	15.02	218.39	4.00
22	Lady Jane	47.20	28.21	23.90	55.35	4.80
23	Pistache	48.00	10.85	17.08	26.23	4.60
24	Nitta Orange	49.60	24.72	18.38	199.06	2.40
25	Agnihotri	51.20	24.17	18.43	110.20	1.60

Table 3b.i. Contd.

SL. No	Variety	Life of spadix (days)	Days from initiation of Female phase (days)	Duration of female phase (days)	Duration of male phase (days)	Duration of interphase (days)
1	Liver Red	88.4	6.8	9.4	6.8	9.6
2	Dragon's Tongue	83.2	6.2	7.4	9.0	7.8
3	Chikoos	81.4	6.2	7.6	8.4	8.0
4	Tropical Red	91.2	6.6	7.6	6.6	6.6
5	Chekas	75.4	6.4	6.8	9.2	4.4
6	Can Can	72.0	5.6	7.4	7.4	4.2
7	Emperor	71.2	6.2	6.4	8.8	4.4
8	Honeymoon Red	72.2	6.2	6.8	7.4	4.6
9	Cascade White	81.2	5.6	8.2	9.0	5.0
10	Merengue White	73.8	8.8	7.6	7.6	4.2
11	Boroque	79.0	10.8	5.6	5.2	5.0
12	Lucia Pink	68.0	6.6	7.8	8.0	6.0
13	Chocos	78.4	5.6	7.8	8.8	4.4
14	Hawaiian Orange	71.0	8.2	6.8	6.6	5.2
15	Tropical Peach	74.8	7.4	7.0	6.6	4.2
16	Mauritius Orange	76.4	7.4	6.8	5.6	6.2
17	Honduras Red	67.0	5.4	6.8	9.2	5.4
18	Esmeralda	65.4	7.2	7.8	4.4	6.2
19	Vezuvious Red	48.2	4.2	6.0	8.2	3.4
20	Gold Spark	71.4	7.0	6.8	7.0	4.0
21	Arun Gold	74.6	7.6	7.6	9.8	7.0
22	Lady Jane	65.2	5.0	7.8	6.4	5.6
23	Pistache	71.8	3.6	6.4	5.2	4.0
24	Nitta Orange	72.6	5.2	6.4	7.8	5.8
25	Agnihotri	68.8	5.6	6.6	8.4	6.4

Table 3b. ii. Qualitative floral characters of *Anthurium andreanum*

Sl. No	Genotypes	Spathe colour	Spadix colour	Type of inflorescence axis	Pollen shape
1	Liver Red	Maroon	Light pink	Long thick straight	Round
2	Dragon's Tongue	Bright Red	Light pink and yellowish	Long thick curved	Oval
3	Chikoos	Red	Pale white and reddish tinge at the tip	Long thick curved	Oval
4	Chekas	Red	Yellowish green	Short thick straight	Round
5	Tropical Red	Red	Yellow with white tinge	Long thick straight	Round
6	Can Can	Red	Yellowish white	Medium thick straight	Round
7	Emperor	Red	Greenish white	Short thick straight	Round
8	Honeymoon Red	Red	Pinkish red	Short thick straight	Round
9	Cascade White	White	White and yellow on its tip	Medium thick straight	Round
10	Merengue White	White	Light Pink	Medium thick straight	Round
11	Boroque	Green	Greenish white	Short thick straight	Round
12	Lucia Pink	Pink	Pink	Short thick straight	Round
13	Chocos	Chocolate brown	Yellowish green	Medium thin curved	Round
14	Hawaiian Orange	Bright Orange	Yellowish white	Long thick curved	Round
15	Tropical Peach	Peach	Cream colour	Long thick straight	Oval
16	Mauritius Orange	Orange	Yellowish white	Long thick straight	Round
17	Honduras Red	Dark Red	Yellowish white	Long thick straight	Round
18	Esmeralda	Green	Green	Short thick straight	Round
19	Vezuvious Red	Red	Cream	Short thick straight	Oval
20	Gold Spark	Light peach	Yellowish white	Short thick straight	Round
21	Arun Gold	Bright Red	Yellow	Long thin curved	Round
22	Lady Jane	Pink	White	Long thick straight	Oval
23	Pistache	Green	Green with brown tinge	Long thin curved	Round
24	Nitta Orange	Orange	Yellowish white	Medium thin curved	Round
25	Agnihothri	Red	Yellowish white	Medium thin curved	Round

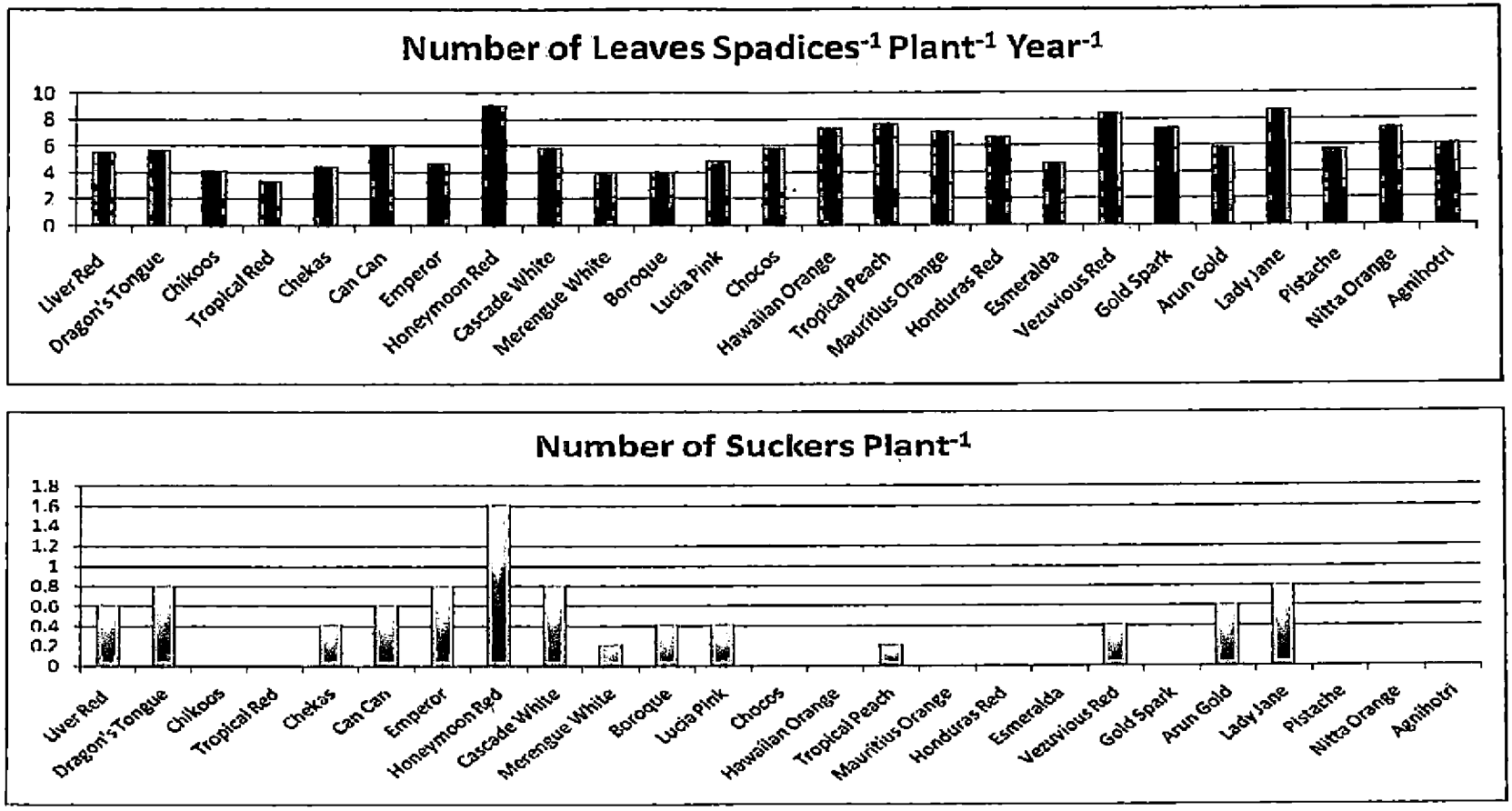
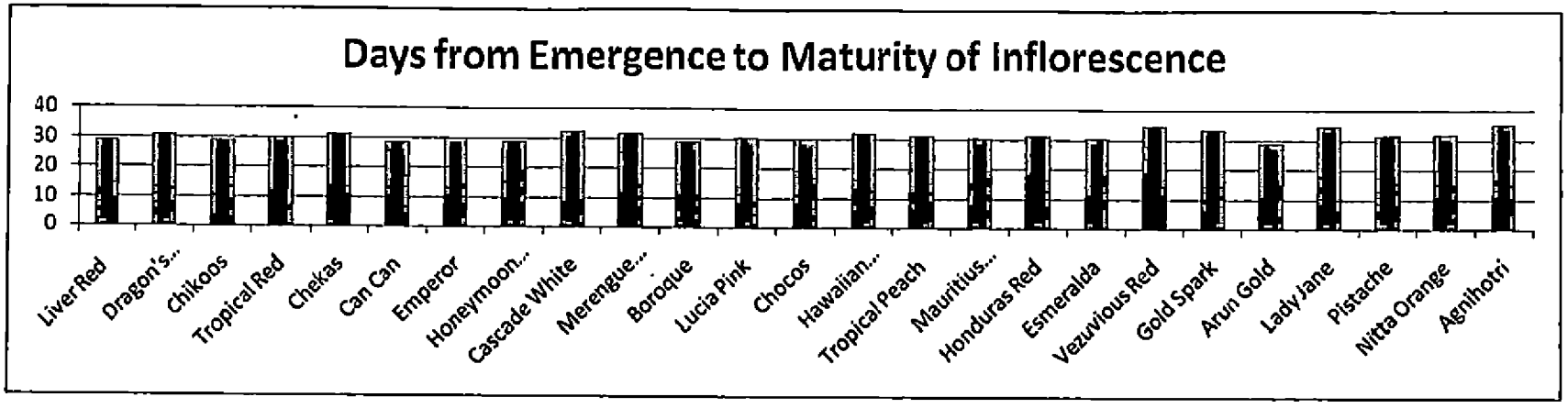


Fig.1c. Mean performance of twenty five genotypes of *Anthurium andreanum* genotypes



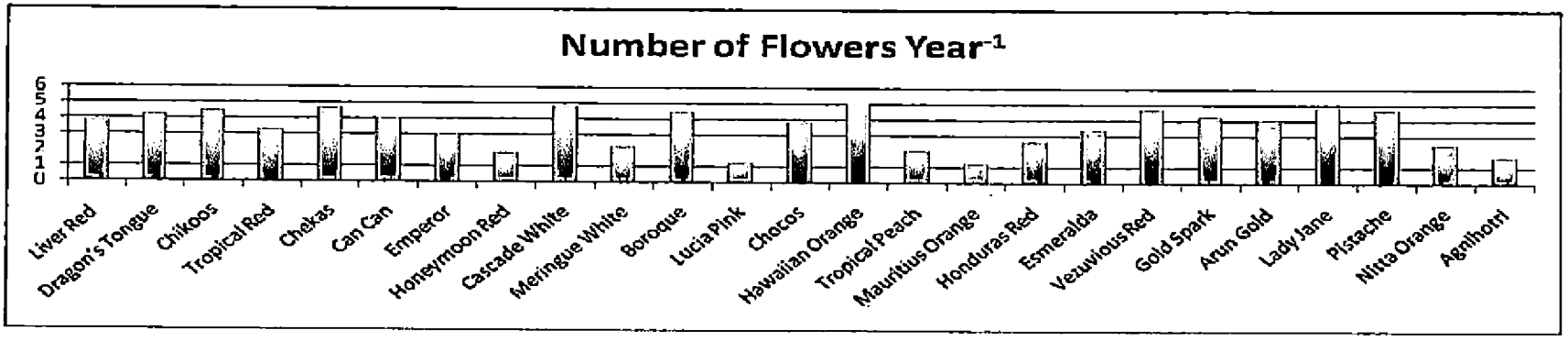


Fig.1d. Mean performance of twenty five genotypes of *Anthurium andreanum* genotypes

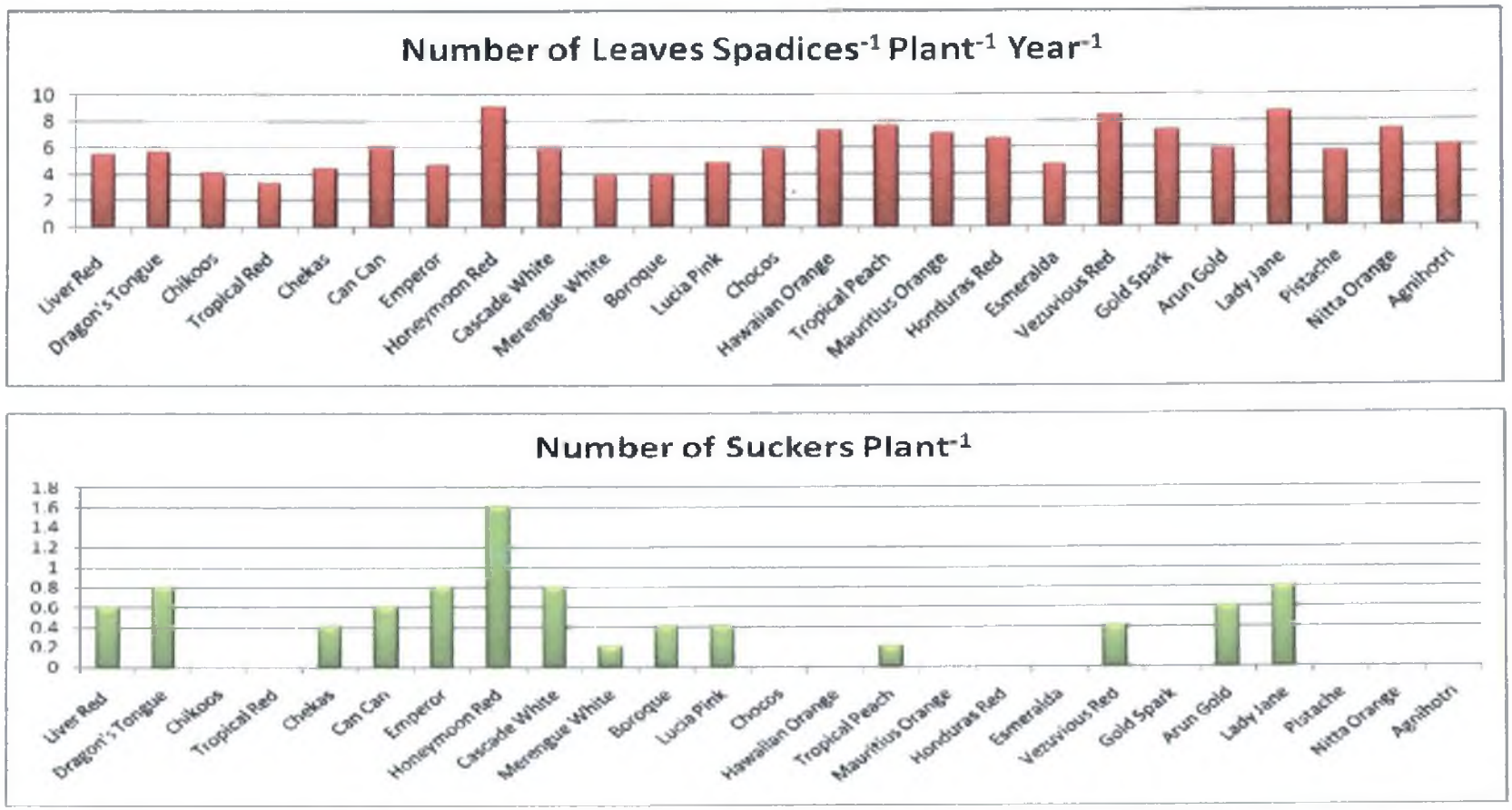
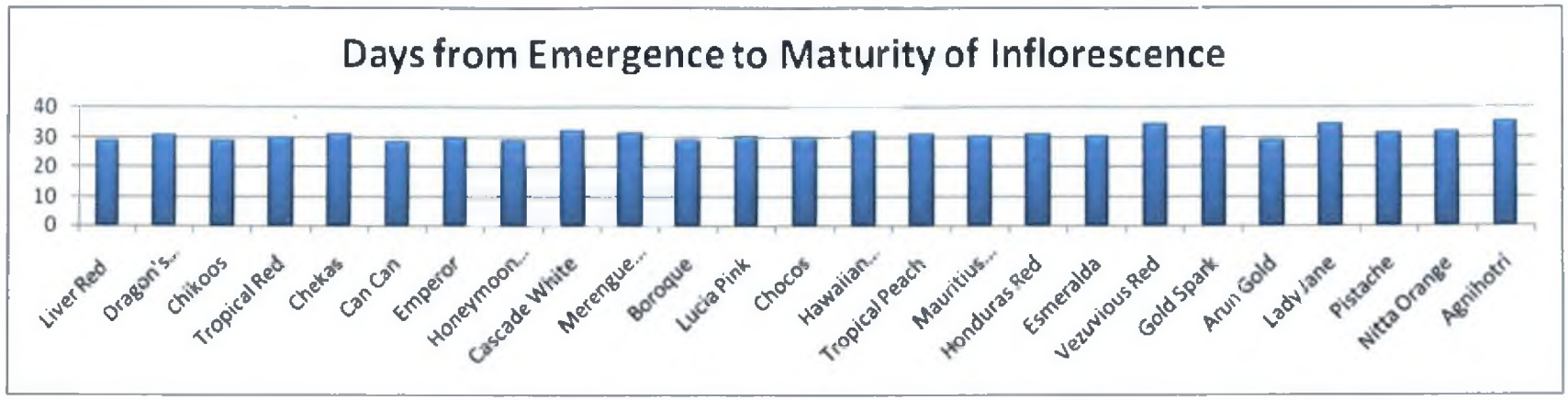


Fig.1c. Mean performance of twenty five genotypes of *Anthurium andreanum* genotypes



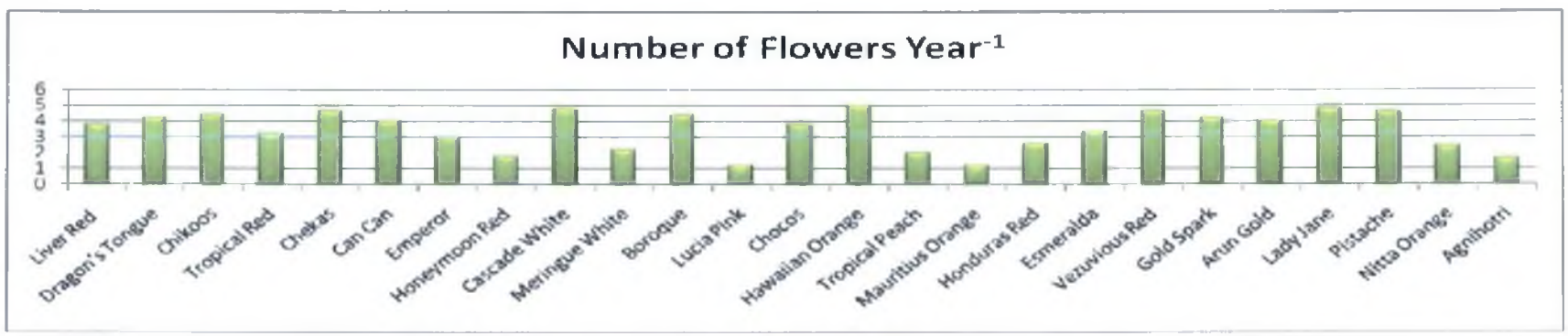
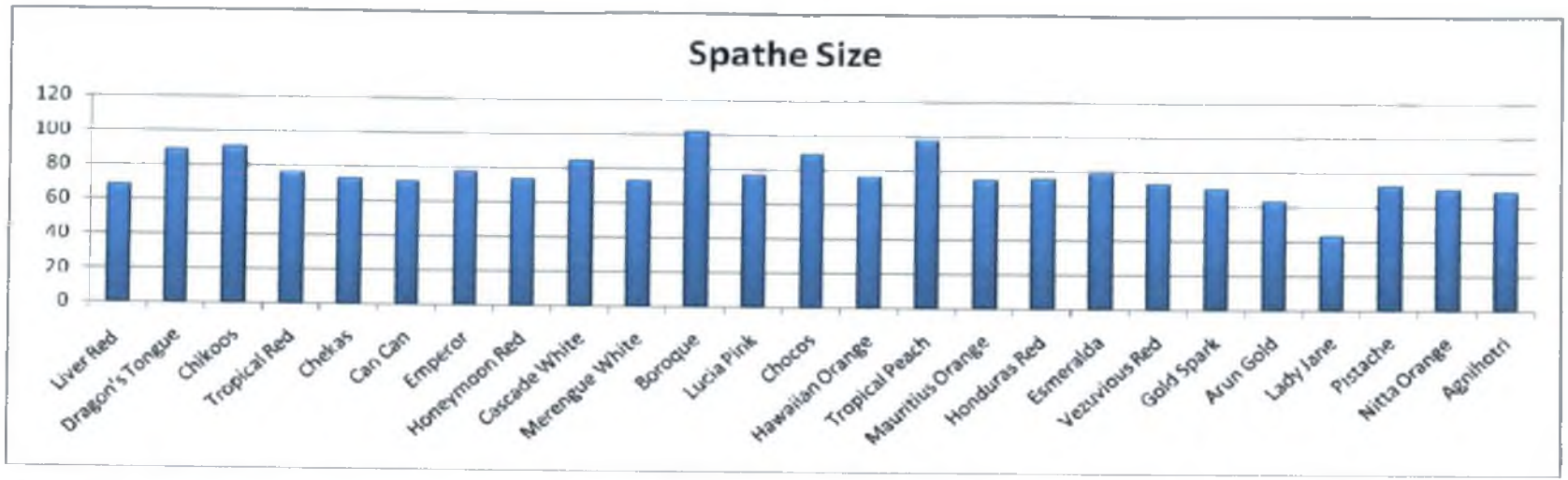


Fig.1d. Mean performance of twenty five genotypes of *Anthurium andreanum* genotypes



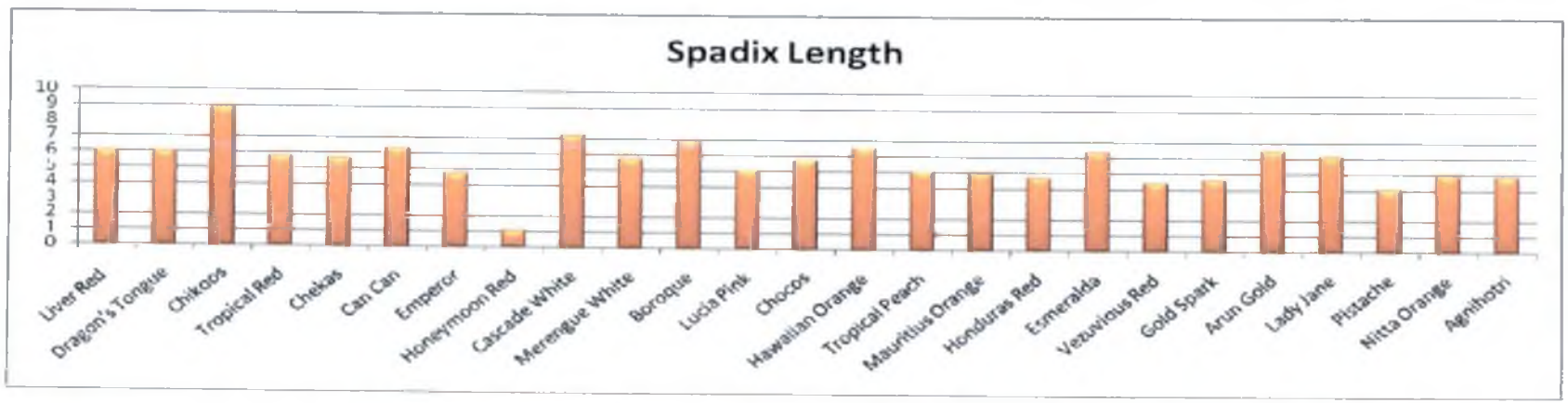
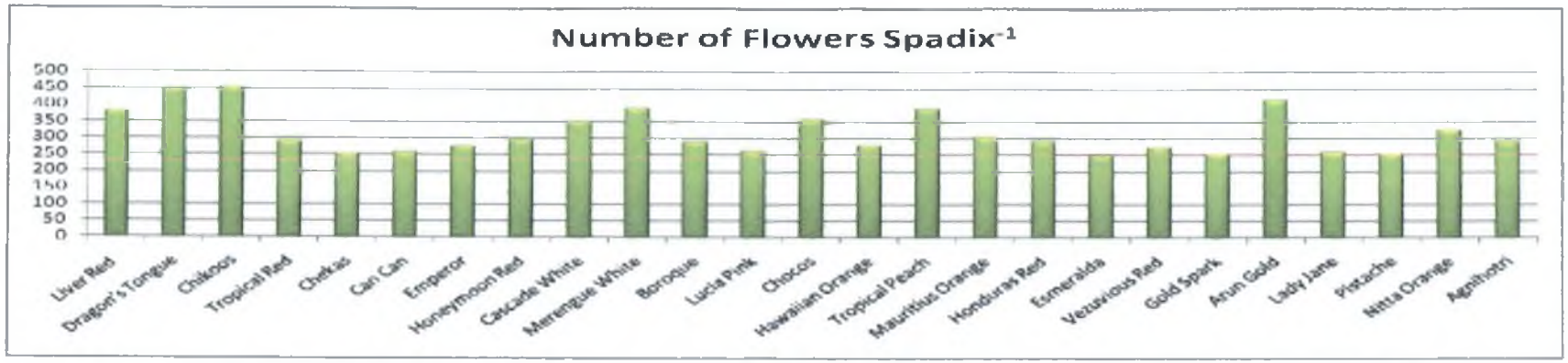


Fig. 1e. Mean performance of twenty five genotypes of *Anthurium andreanum* genotypes



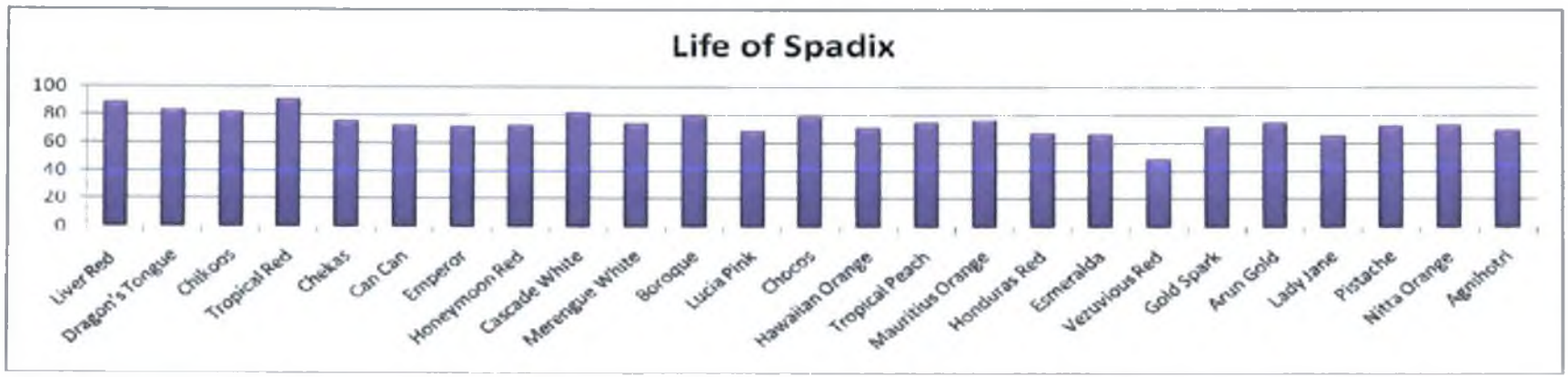
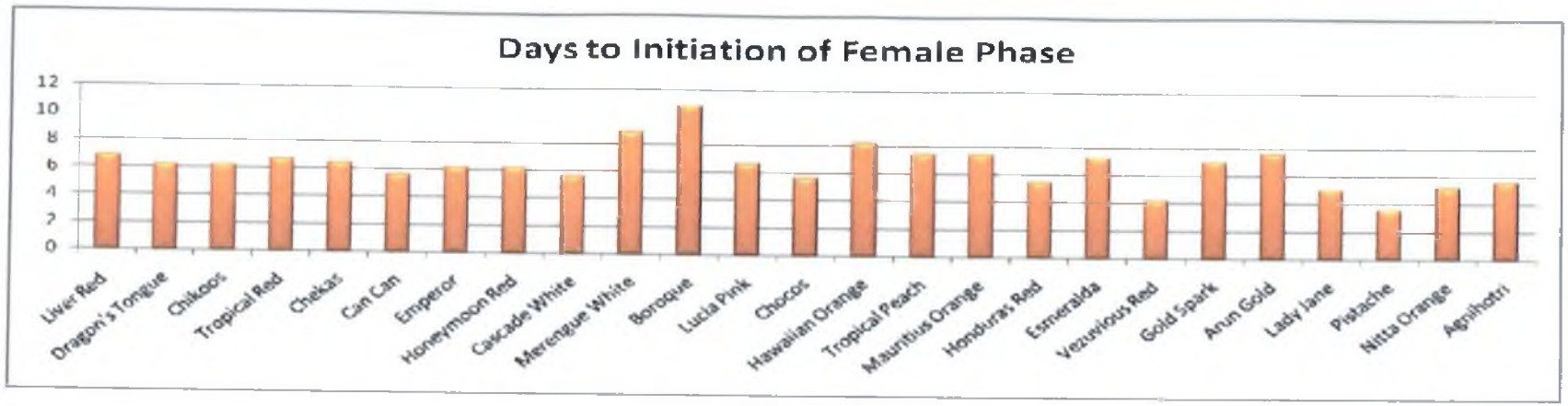


Fig. 1e. Mean performance of twenty five genotypes of *Anthurium andreanum* genotypes



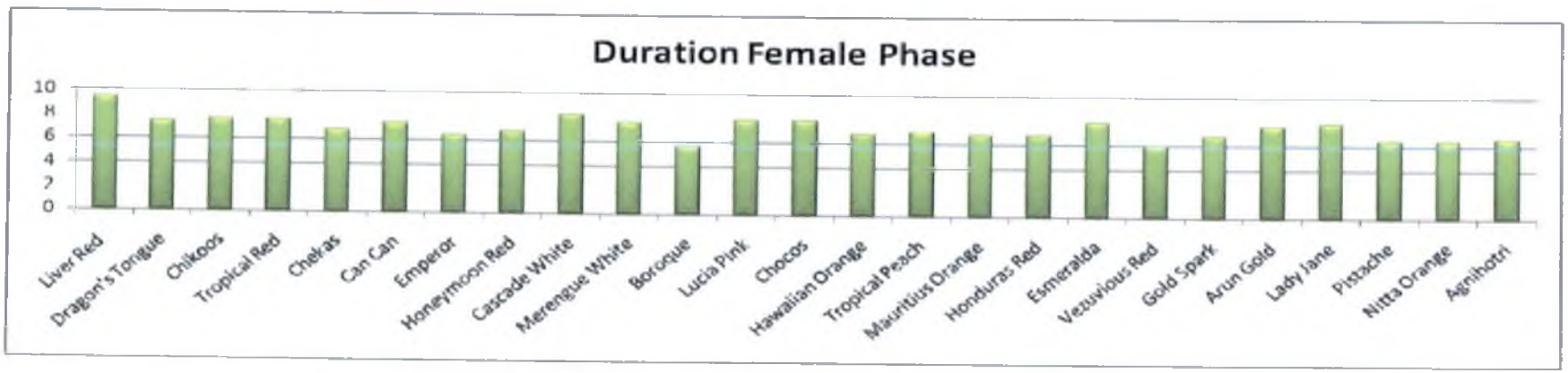


Fig.1h. Mean performance of twenty five genotypes of *Anthurium andreanum* genotypes

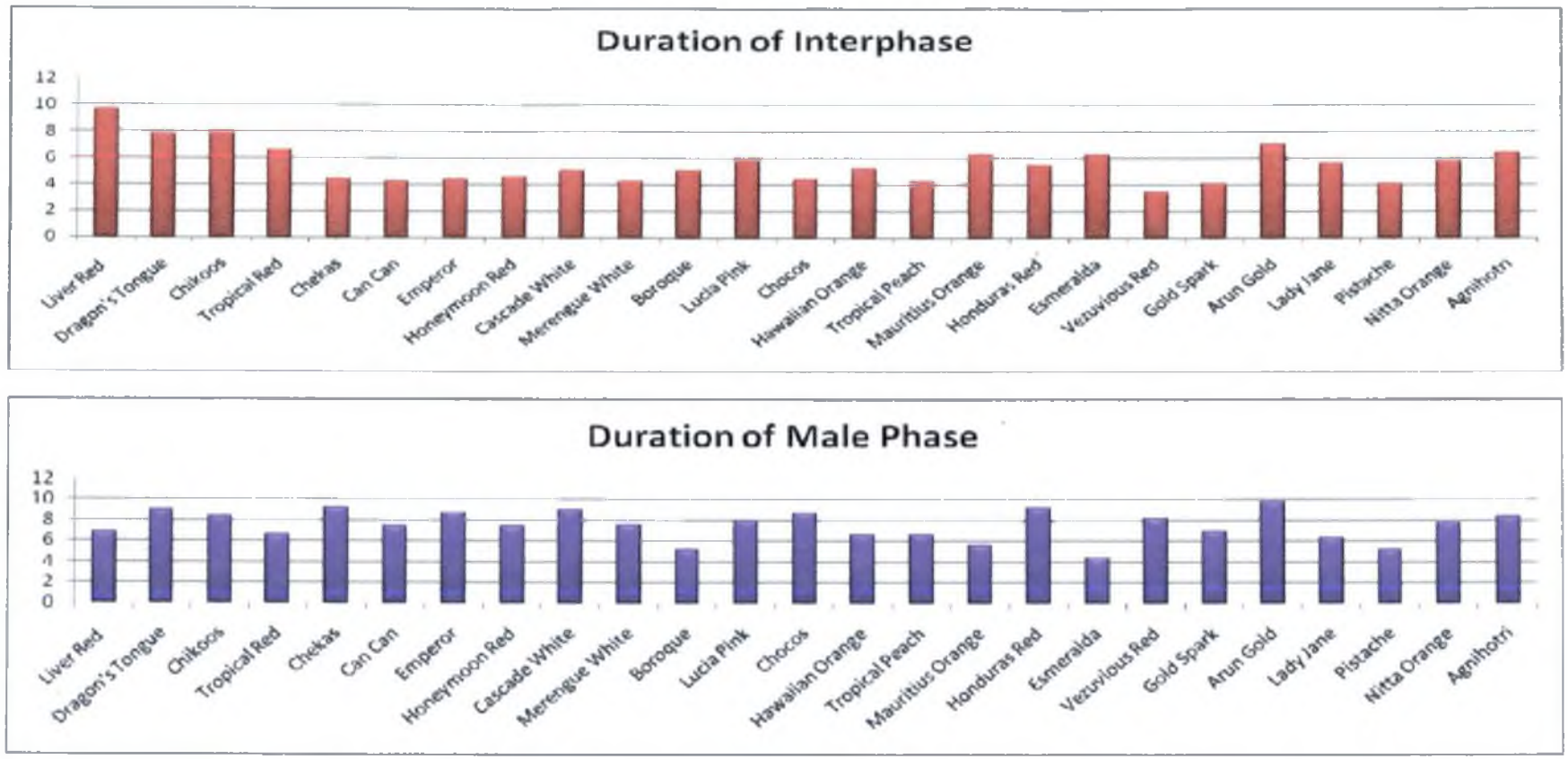


Fig.1i. Mean performance of twenty five genotypes of *Anthurium andreanum* genotypes

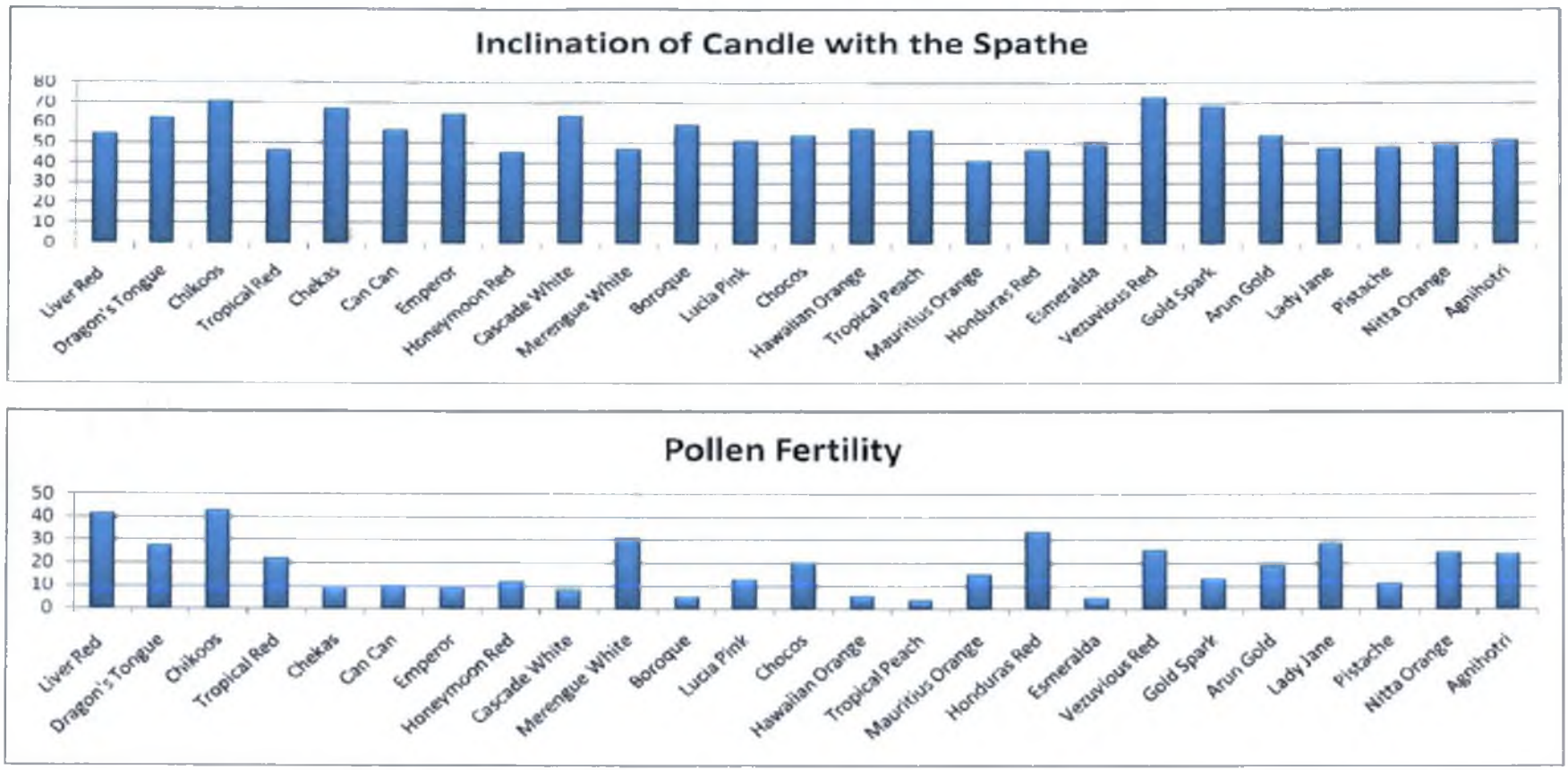
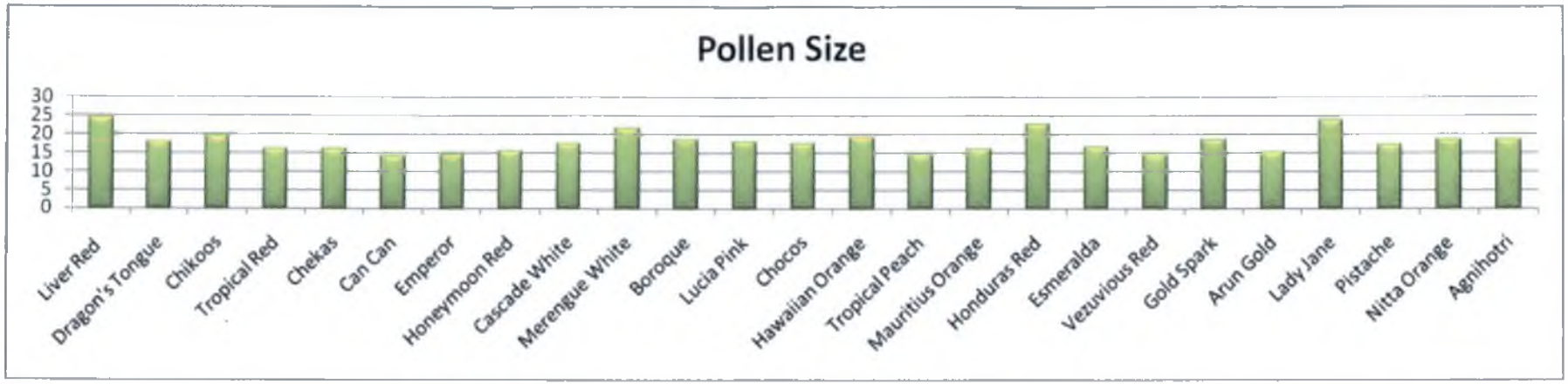


Fig. 1j. Mean performance of twenty five genotypes of *Anthurium andreanum* genotypes



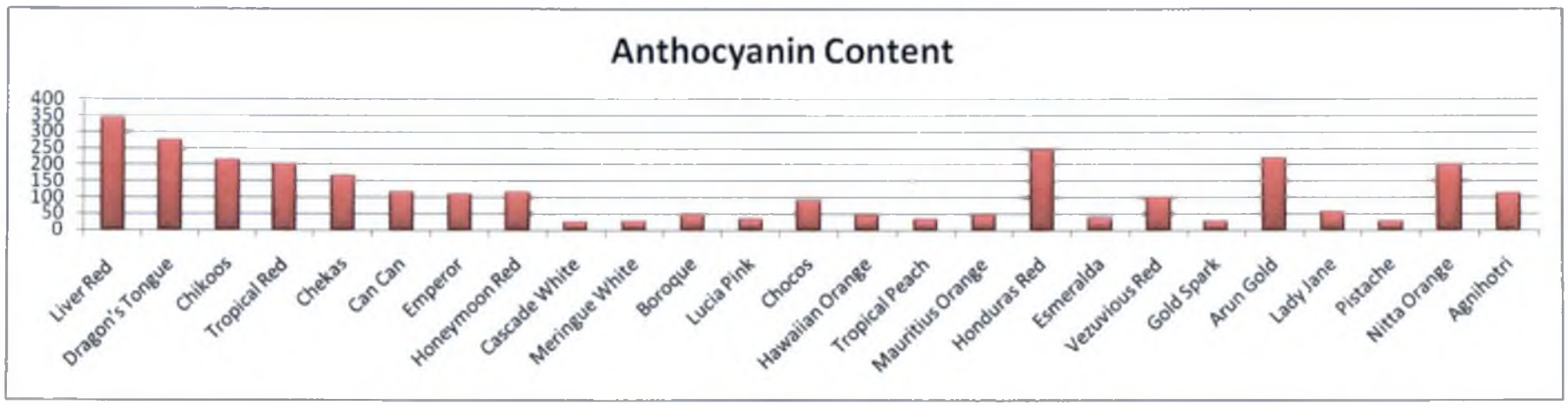


Fig.1k. Mean performance of twenty five genotypes of *Anthurium andreanum* genotypes

4.1.1.2.1.3 Spadix Length (cm)

The highest mean value for spadix was exhibited by the cultivar Chikoos (8.76 cm) followed by Cascade White (7.18 cm) and the lowest mean value was shown by the cultivar Honeymoon Red (2.2 cm) followed by Pistache (3.98 cm).

4.1.1.2.1.4 Number of Flowers Spadix^{-1}

The genotype Chikoos had the maximum number of flowers spadix^{-1} (452.2) which was on par with Dragon's Tongue (446.6) and Arun Gold (414.8). The lowest number of flowers was noticed in the variety Esmeralda (246.2) which was on par with Chekas (251.6), Pistache (251.8) and Gold Spark (252).

4.1.1.2.1.5 Life of Spadix (days)

Life of spadix was the maximum in Tropical Red (91.2 days) which was on par with Liver Red (88.4 days) and the lowest was in Vezuvious Red (48.2 days).

4.1.1.2.1.6 Days to Initiation of Female Phase

The maximum number days for female phase was noticed in the cultivar Boroque (10.8 days) followed by Merengue White (8.8 days) and Hawaiian Orange (8.2 days). The minimum number of days was observed in the cultivar Pistache which was on par with Vezuvious Red (4.2 days)

4.1.1.2.1.7 Duration of Female Phase

The genotype Liver Red (9.4 days) exhibited the maximum duration for female phase followed by Cascade White (8.2 days) and the minimum number of days for the genotype Boroque (5.6 days).

4.1.1.2.1.8 Duration of Interphase

Duration of interphase was high in the variety Liver Red (9.6 days) followed by Chikoos (8 days). The lowest number of days was noticed in Vezuvious Red (3.4 days) which was on par with the following varieties like Pistache (4 days), Gold Spark (4 days), Tropical Peach, Cascade White and Can Can (4.2 days).

4.1.1.2.1.9 Duration of Male Phase

Duration of male phase was the high in Arun Gold (9.8 days) which was on par with Chekas (9.2 days), Honduras Red (9.2 days), Dragon's Tongue (9 days), Cascade White (9 days), Emperor and Chocos (8.8 days). The duration was the lowest in Esmeralda (4.4 days) which was on par with the following varieties like Boroque (5.2 days) and Pistache (5.23 days).

4.1.1.2.1.10 Inclination of Candle with Spathe (degrees)

The maximum value of 72.6 exhibited by the genotype Vezuvious Red which was on par with Chikoos (70.4) and Gold Spark (67.8). The minimum value for inclination of candle with the spathe was noted in the variety Mauritius Orange which was on par with the following varieties like Honeymoon Red (44.8), Tropical Red (46) and Honduras Red (46.2).

4.1.1.2.1.11 Anthocyanin Content (mg g^{-1})

Anthocyanin content was the highest in the cultivar Liver Red (339.52 mg g^{-1}) followed by Dragon's Tongue (273.172 mg g^{-1}) and Honduras Red (242.44 mg g^{-1}). The lowest value of anthocyanin was observed in the cultivar Cascade White (24.01 mg g^{-1}) which was on par with Merengue White (24.78 mg g^{-1}), Pistache (26.23 mg g^{-1}), Gold Spark (26.48 mg g^{-1}) and Lucia Pink (32.67 mg g^{-1}).

4.1.1.2.1.12 Pollen Fertility (per cent)

The highest pollen fertility per cent of 42.58 per cent was exhibited by the genotype Chikoos followed by Liver Red (41.18 per cent) and the lowest pollen fertility per cent of 3.63 was shown by the genotype Tropical Peach which was on par with Esmeralda (4.14 per cent), Boroque (4.96 per cent) and Hawaiian Orange (5.34).

4.1.1.2.1.13 Pollen Size

The variety Liver Red (24.42μ) had the highest pollen size which was on par with Lady Jane (23.90μ). The lowest pollen size was shown by Can Can (14.03μ) which was on par with Vezuvious Red (14.32μ) and Tropical Peach (14.49μ).

4.1.1.2.1.14 Number of Flowers Year^{-1}

The variety Hawaiian Orange produced the maximum number of flowers (5) which was on par with Lady Jane (4.8) and Cascade White (4.8). The variety Mauritius Orange and Lucia pink produced the minimum number of flowers (1.2) which was on par with Agnihotri (1.6), Honeymoon Red (1.8), Tropical Peach (2), Merengue White (2.2) and Nitta Orange (2.4).

4.1.1.2.2 Floral Qualitative Characters

4.1.1.2.2.1 Spathe Colour

The colour of the spathe ranged from deep maroon, dark red, bright red, red, bright orange, orange, pink, peach, green and chocolate brown among the twenty five anthurium genotypes.

4.1.1.2.2.2 Spadix Colour

Significant variation in spadix colour was found among twenty five genotypes of anthurium. The different colours were listed in Table 6.

4.1.1.2.2.3 Type of Inflorescence Axis

Type of inflorescence axis varied from thick straight, long thick curved, long thin curved, short thick straight, medium thick straight, medium thin curved. The ideal, straight long inflorescence axis was found in the genotypes such as Liver Red, Tropical Red, Tropical Peach, Mauritius Orange, Honduras Red and Lady Jane.

4.1.1.2.2.4 Pollen Emergence Pattern

High emergence was noticed in November to February and low pollen emergence was noticed during March to June. The low pollen emergence was may be due to increase in temperature during these summer months.

4.1.1.2.2.5 Pollen Shape and Pollen Colour

Pollen shape varied from round to oval among the twenty five genotypes studied and the pollen colour ranged from cream to white.

4.1.2 Estimation of Genetic Parameters

The extent of variation, estimates of heritability and expected genetic advance in respect of yield and yield contributing traits are the basic requirements for a successful crop improvement programme.

4.1.2.1 Estimation of Variability

The magnitude of phenotypic coefficient of variability (PCV) was higher magnitude than the genotypic coefficient of variability (GCV) for all the observed characters (Table.4). This indicated larger influence of environment for the expression of these characters.

The number of suckers of suckers plant^{-1} exhibited high GCV (80.83 per cent) and PCV (118.10 per cent) followed by anthocyanin content (GCV 79.29 per cent, PCV 79.38 per cent), pollen fertility (GCV 32.90 per cent, PCV 35.59 per cent), number of flowers year^{-1} (GCV 32.90 per cent, PCV 35.59 per cent) and leaf area (PCV 30.55 per cent, GCV 25.77 per cent). High values of GCV suggest better scope of improvement for these traits by selection.

The characters like plant height (GCV 22.77 per cent, PCV 24.75 per cent), number of leaves spadices^{-1} plant^{-1} year^{-1} (GCV 22.28 per cent, PCV 26.67 per cent), spadix length (GCV 24.40 per cent, PCV 25.49 per cent), days to initiation of female phase (GCV 22.31 per cent, PCV 22.96 per cent) and duration of interphase (GCV 26.40 per cent, PCV 26.99 per cent) exhibited moderate value for PCV and GCV.

The lowest value of (GCV 5.63 per cent, PCV 6.14 per cent) were noticed in the character days from emergence to maturity of inflorescence followed by days from emergence to maturity of leaves (GCV 6.96 per cent, PCV 6.43 per cent) and duration of female phase (GCV 9.96 per cent, PCV 11.12 per cent).

The difference between the genotypic and phenotypic coefficients of variation was highest for the characters like number of suckers plant^{-1}, leaf area, plant height, number of leaves spadices^{-1} plant^{-1} year^{-1} and internode length. It depicts the influence of environment on these characters. The characters like anthocyanin content, pollen size, pollen fertility, inclination of candle with the spathe, life of spadix and spathe size showed very low

Table 4: Components of total variance for 20 different characters in *Anthurium andreanum*

Sl. No	Characters	Vg	Ve	Vp	PCV	GCV
1	Plant height	57.170	52.000	67.570	24.750	22.770
2	Leaf size or leaf area	4234.120	8575.210	5949.160	30.550	25.770
3	Internodal length	0.019	0.041	0.027	17.230	14.440
4	Number of leaves spadices^{-1} plant^{-1} year^{-1}	I.740	3.760	2.493	26.670	22.280
5	Number of suckers plant^{-1}	0.077	0.438	0.165	118.100	80.830
6	Days from emergence to maturity of leaves	3.376	2.890	3.954	6.960	6.430
7	Days from emergence to maturity of inflorescence	3.030	2.870	3.600	6.140	5.630
8	Number of flowers year^{-1}	1.275	1.085	1.492	35.590	32.900
9	Spathe size	132.010	18.520	135.720	15.320	15.110
10	Spadix length	1.780	0.810	1.950	25.490	24.400
11	Number of flowers spadix^{-1}	1094.720	3908.230	4127.180	20.470	19.920
12	Life of spadix	70.020	6.580	71.330	11.450	11.350
13	Days to initiation of female phase	2.070	0.061	2.190	22.960	22.310
14	Duration of female phase	0.510	0.620	0.630	11.120	9.960
15	Duration of interphase	2.110	0.474	2.200	26.990	26.400
16	Duration of male phase	1.920	0.690	2.060	19.180	18.520
17	Inclination of candle with the spathe	71.340	18.460	75.040	15.710	15.320
18	Anthocyanin content	8318.870	95.050	8337.880	79.380	79.290
19	Pollen fertility	129.190	4.370	130.060	63.010	62.800
20	Pollen size	1.810	7.920	8.280	16.160	15.800

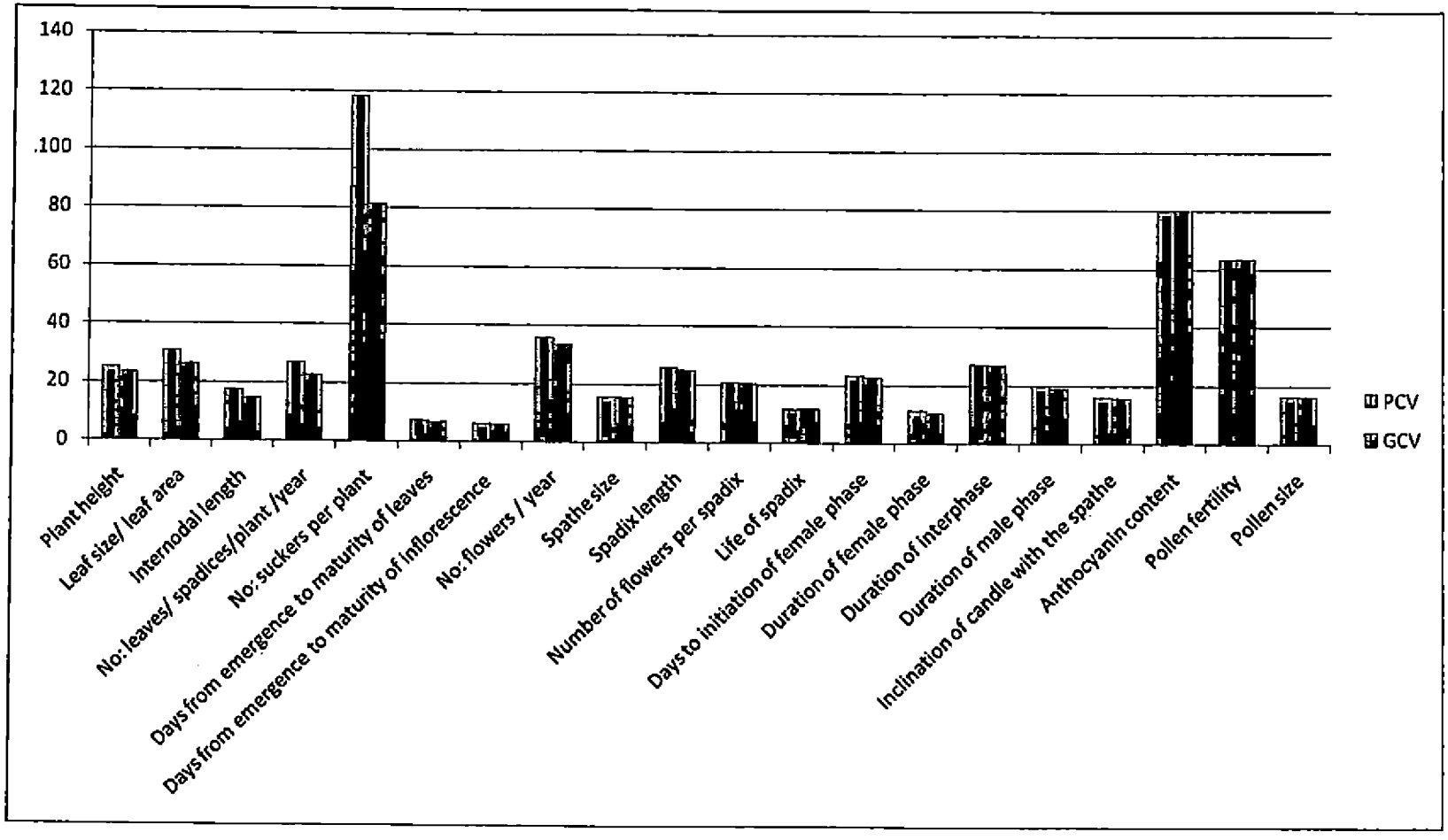


Fig .2 PCV and GCV for the 20 characters in *Anthurium andreanum*

Table 5: Heritability and Genetic advance in 20 different characters of *Anthurium andreanum*

SL. No	Characters	Heritability (Per cent)	Genetic advance as percentage of mean
1	Plant height	84.61	43.15
2	Leaf size or leaf area	71.17	44.79
3	Internode length	70.23	24.93
4	Number of leaves spadices^{-1} plant $^{-1}$year^{-1}	69.83	38.37
5	Number of suckers plant^{-1}	46.85	113.98
6	Days from emergence to maturity of leaves	85.38	12.24
7	Days from emergence to maturity of inflorescence	84.04	10.64
8	Number of flowers year^{-1}	85.45	62.65
9	Spathe size	97.27	30.7
10	Spadix length	91.6	48.12
11	Number of flowers per spadix	94.7	39.94
12	Life of spadix	98.16	23.17
13	Days to initiation of female phase	94.27	44.64
14	Duration of female phase	80.29	36.83
15	Duration of interphase	95.7	53.21
16	Duration of male phase	93.24	36.83
17	Inclination of candle with the spathe	95.08	30.78
18	Anthocyanin content	99.77	163.16
19	Pollen fertility	99.33	128.93
20	Pollen size	95.63	31.84

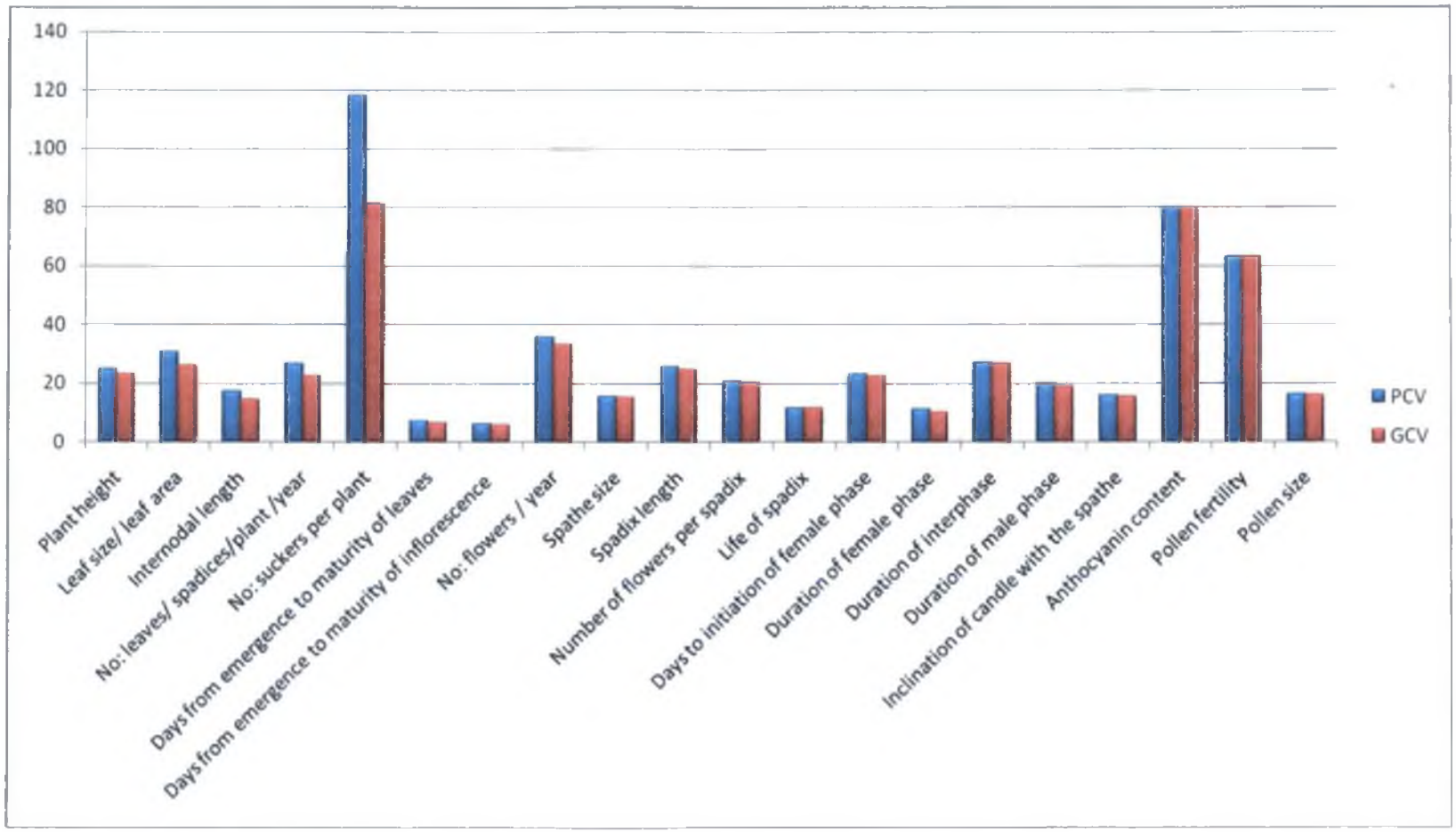


Fig .2 PCV and GCV for the 20 characters in *Anthurium andreanum*

Table 5: Heritability and Genetic advance in 20 different characters of *Anthurium andreanum*

SL. No	Characters	Heritability (Per cent)	Genetic advance as percentage of mean
1	Plant height	84.61	43.15
2	Leaf size or leaf area	71.17	44.79
3	Internode length	70.23	24.93
4	Number of leaves spadices^{-1} plant $^{-1}$year^{-1}	69.83	38.37
5	Number of suckers plant^{-1}	46.85	113.98
6	Days from emergence to maturity of leaves	85.38	12.24
7	Days from emergence to maturity of inflorescence	84.04	10.64
8	Number of flowers year^{-1}	85.45	62.65
9	Spathe size	97.27	30.7
10	Spadix length	91.6	48.12
11	Number of flowers per spadix	94.7	39.94
12	Life of spadix	98.16	23.17
13	Days to initiation of female phase	94.27	44.64
14	Duration of female phase	80.29	36.83
15	Duration of interphase	95.7	53.21
16	Duration of male phase	93.24	36.83
17	Inclination of candle with the spathe	95.08	30.78
18	Anthocyanin content	99.77	163.16
19	Pollen fertility	99.33	128.93
20	Pollen size	95.63	31.84

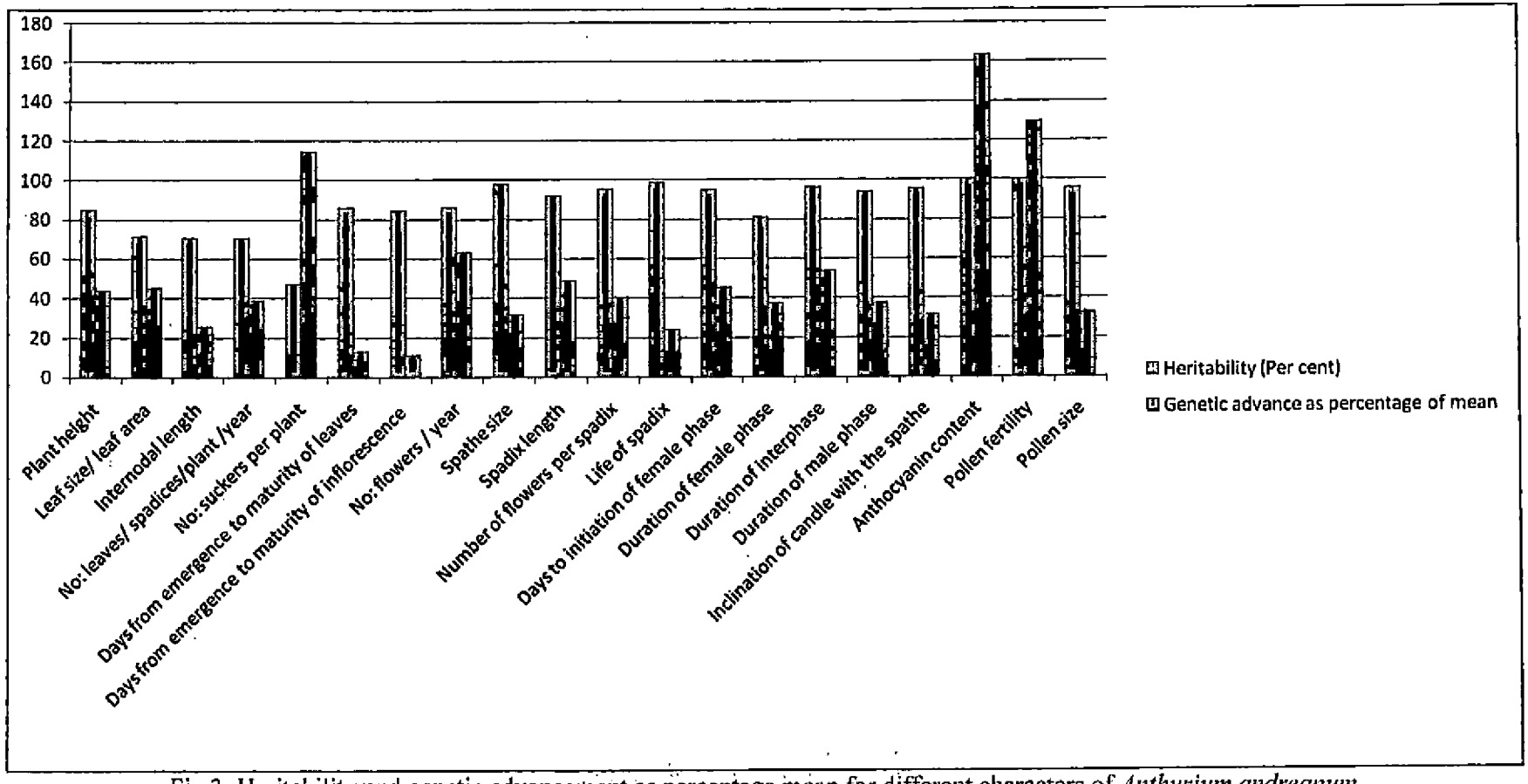


Fig.3. Heritability and genetic advancement as percentage mean for different characters of *Anthurium andreanum*

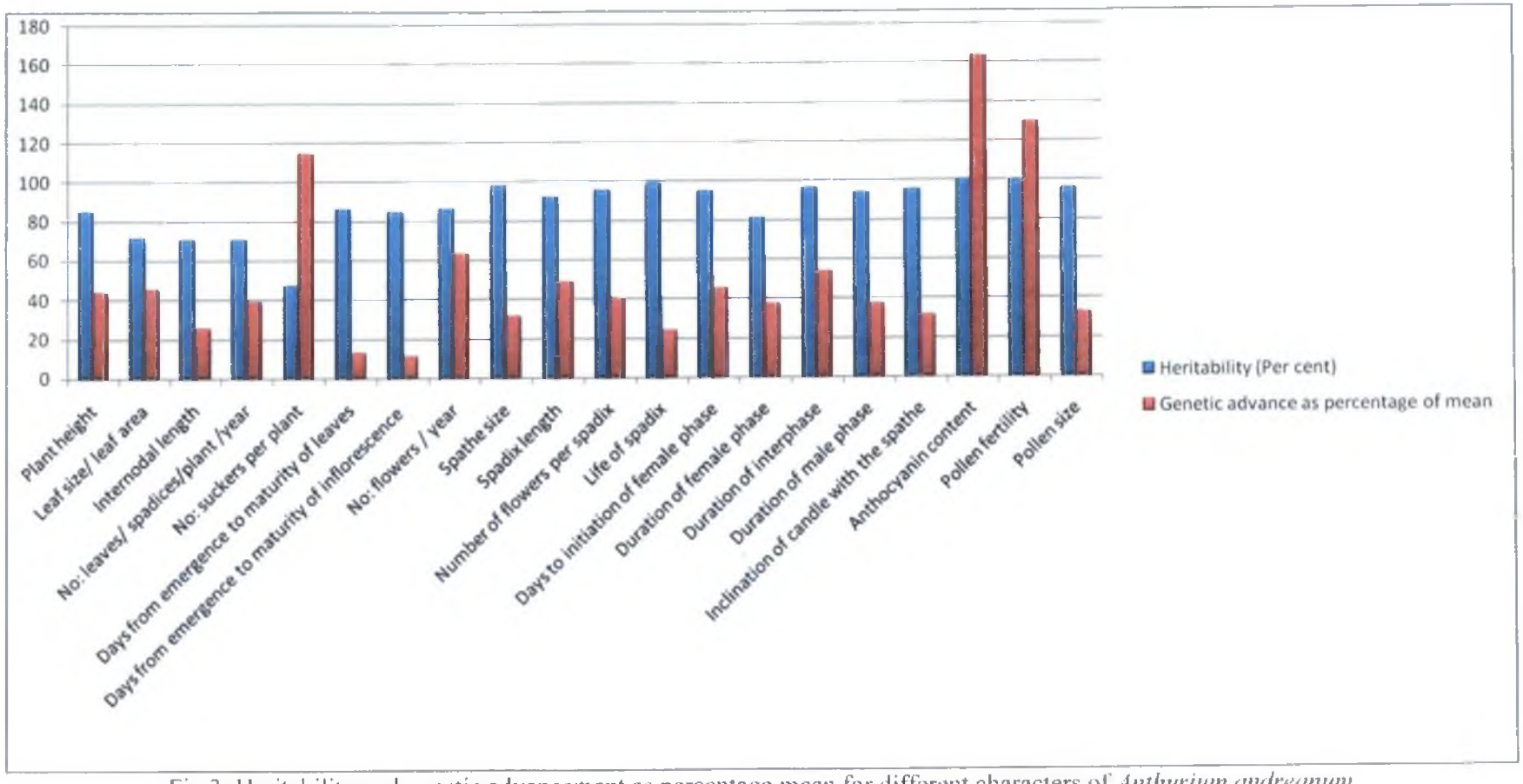


Fig.3. Heritability and genetic advancement as percentage mean for different characters of *Anthurium andreanum*

difference between PCV and GCV. The variation found in these characters may be due to genetic factors and the effect of environmental factors was negligible.

4.1.2.2 Heritability and Genetic Advance

High heritability estimates of a character provide a measure of the effectiveness of selection on phenotypic basis for that particular character. All the characters studied showed very high heritability except number of suckers plant-^{1}. The estimated results were presented in Table 5.

High heritability was noticed in characters like anthocyanin content (99.77 per cent) followed by pollen fertility (99.33 per cent), life of spadix (98.16 per cent), pollen size (95.63 per cent), spathe size (97.27 per cent), duration of inter phase (95.70 per cent), inclination of candle with the spathe (95.08 per cent), number of flowers spadix^{-1} (94.70 per cent), days to initiation of female phase (94.37 per cent), duration of male phase (93.24 per cent) and spadix length (91.64 per cent) and the least value of 46.85 per cent heritability was noticed in the character number of suckers plant^{-1}.

According to Robinson *et al.* (1949), genetic advance of less than 20 per cent is low and if it is more than 20 per cent, high genetic advance is ensured. High genetic advance is observed in characters like number of suckers plant^{-1}, anthocyanin content, pollen fertility, number of flowers year^{-1}, duration of interphase, spadix length, days from initiation of female phase, leaf area, plant height, number of flowers spadix^{-1}, number of leaves spadices^{-1} plant^{-1}year^{-1}, pollen size, spathe size, duration of male phase, inclination of candle with the spathe, internode length. Low genetic advance was recorded in characters like days from emergence to maturity of inflorescence, days from emergence to maturity of leaves and duration of female phase.

Johnson *et al.* (1955) have suggested that heritability along with genetic advance expressed in percentage of mean furnish a better picture than heritability alone. This was observed in almost all the characters studied except days from emergence to maturity of leaves, days from emergence to maturity of inflorescence, number of suckers plant^{-1} and duration of female phase.

High heritability coupled with high genetic advance indicate additive gene effect and improvement could be made for that character by simple selection based on the phenotypic performance.

4.1.3 Correlation Studies

Selection for specific character is known to result in correlated response in certain other characters. Generally, plant breeders make selection for one or two attributes at a time. The three correlations are furnished in Table 6.

4.1.3.1 Phenotypic Correlation

The plant height showed significant positive association with characters like leaf area (0.8481), number of suckers plant^{-1} (0.2537), spathe size (0.3855), number of flowers spadix^{-1} (0.3325), life of spadix (0.4689) and days to initiation of female phase (0.3866).

Leaf area found to have positive correlation with plant height (0.8481), number of suckers plant^{-1} (0.2356), spathe size (0.5423), spadix length (0.3717), number of flowers spadix^{-1} (0.4055), life of spadix (0.4890), days from initiation of female phase (0.3932), inclination of candle with the spathe (0.2796) and number of flowers year^{-1} (0.2367).

Internode length showed significant positive association with plant height (0.1520) and days from initiation of female phase (0.3022). Days from emergence to maturity of leaves found to have significant positive association with duration of female phase (0.3228).

Days from emergence to maturity of inflorescence significantly and positively correlated with number of leaves spadices^{-1} plant^{-1} (0.4371). Number of leaves spadices^{-1} plant^{-1} year^{-1} was highly correlated with days from emergence to maturity of inflorescence (0.4371) and number of suckers plant^{-1} (0.2811). Number of suckers plant^{-1} showed significant positive correlation with characters like plant height (0.2537), leaf area (0.2356), number of leaves spadices^{-1} plant^{-1} year^{-1} (0.2811) and duration of male phase (0.2436).

Spathe size found to have significant positive correlation with plant height (0.3855), leaf area (0.5423), spadix length (0.2396), number of flowers spadix^{-1} (0.3588), life of spadix (0.3367), days from initiation of female phase (0.3956) and inclination of candle with the spathe (0.3165).

Spadix length showed positive significant correlation with leaf area (0.3717), spathe size (0.2396), number of flowers spadix^{-1} (0.3989), life of spadix (0.3530), days from initiation of female phase (0.2993), duration of female phase (0.3687), duration of interphase (0.4119), inclination of candle with the spathe (0.3485) and pollen size (0.2466).

Table 6 a: Phenotypic correlation coefficient among 20 characters of *Anthurium andreanum*

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}
X_1	1	0.8481**	0.1520	0.2257*	-0.2468**	-0.1496	0.2537**	0.3855**	0.2190*	0.3325**	0.4689**	0.3866**	0.1797**	-0.0244	0.1495	0.2102*	0.0324	0.1686	-0.0525	0.0937
X2		1	-0.025	-0.057	-0.2803**	-0.1607	0.2356**	0.5423**	0.3717**	0.4055**	0.4890**	0.3932**	0.1070	-0.0628	0.2271*	0.2796*	0.0068	0.0796	0.0012	0.2367**
X_3			1	0.2139*	-0.0613	0.0948	0.0542	0.1351	0.0069	0.0308	0.0938	0.3022**	0.1189	-0.2108*	-0.2262*	-0.2267*	-0.2706**	0.0192	-0.3818**	-0.1239
X_4				1	0.1075	0.0529	0.1017	-0.1992*	-0.1735	0.1198	0.1419	-0.2416**	0.3228**	0.0693	0.1084	0.0149	0.2023*	0.0265	-0.3828**	-0.0426
X_5					1	0.4371**	-0.2353**	-0.4113**	-0.1531	-0.3132**	-0.5441**	-0.3611**	-0.2281**	0.0181	-0.2899**	0.0931	0.0831	0.2032**	-0.3387**	0.0634
X_6						1	0.2811**	-0.3751**	-0.5222**	-0.1723	-0.5192**	-0.3760**	-0.1994*	-0.0119	-0.2819**	-0.0911	-0.0521	-0.0303	-0.1473	-0.0582
X_7							1	-0.1571	-0.3049**	0.0736	0.0154	-0.0527	0.1435	0.2436**	-0.0038	0.0653	-0.1015	-0.1262	0.1277	0.0541
X_8								1	0.2396**	0.3588**	0.3367**	0.3956**	-0.1847*	-0.0314	-0.0426	0.3165**	-0.2531**	-0.2922**	-0.0781	-0.0278
X_9									1	0.3989**	0.3530**	0.2993**	0.3687**	0.0533	0.4119**	0.3485**	0.1932*	0.2466**	0.1304	0.4903**
X_{10}										1	0.4996**	0.1834*	0.3936**	0.3961**	0.5194**	0.1477	0.4937**	0.1506	0.4680**	0.0025
X_{11}											1	0.3261**	0.4577**	0.0083	0.5388**	-0.1109	0.1458	0.1580	0.4042**	0.0388
X_{12}												1	-0.0351	-0.2716**	0.1213	-0.0522	-0.2519**	0.0711	-0.1600	-0.1096
X_{13}													1	0.1017	0.5813**	-0.1433	0.3697**	0.4061**	0.3135**	0.0559
X_{14}														1	0.0505	0.3701**	0.3217**	-0.0678	0.4479**	0.0229
X_{15}															1	-0.1222	0.5632**	0.4292**	0.6893**	-0.0497
X_{16}																1	-0.0202	-0.2334**	0.0775	0.5766**
X_{17}																	1	0.6355**	0.6546**	-0.0073
X_{18}																		1	0.2509**	0.0962
X_{19}																			1	0.0759
X_{20}																				1

X_1 - Plant height, X_2 - Leaf area, X_3 - Internode length, X_4 -Days from emergence to maturity of leaves, X_5 - Days from emergence to maturity of inflorescence, X_6 - Number of leaves spadices^{-1} plant^{-1}year^{-1}, X_7 - Number of suckers plant-^{1}, X_8 - Spathe size, X_9 - Spadix length, X_{10} - Number of flowers spadix^{-1}, X_{11} - Life of spadix, X_{12} - Days to initiation of female phase, X_{13} - Duration of female phase, X_{14} - Duration of male phase, X_{15} - Duration of interphase, X_{16} - Inclination of candle with the spathe, X_{17} - Pollen fertility, X_{18} - Pollen Size, X_{19} -Anthocyanin Content, X_{20} - Number of flowers year^{-1}

** Significance at 1 per cent level * Significance at 5 per cent level

Number of flowers spadix^{-1} showed positive significant correlation with plant height (0.3325), leaf area (0.4055), spathe size (0.3588), spadix length (0.3989), life of spadix (0.4996), duration of female phase (0.3936), duration of male phase (0.3961), duration of inter phase (0.5194), pollen fertility (0.4937) and anthocyanin content (0.4680).

Life of spadix found to have positive association with characters like plant height (0.4689), leaf area (0.4890), spathe size (0.3367), spadix length (0.3530), number of flowers spadix^{-1} (0.4996), days from initiation of female phase (0.3261), duration of female phase (0.4577), duration of interphase (0.5388) and anthocyanin content (0.4042).

Days from initiation of female phase showed positive significant correlation with plant height (0.3866), leaf area (0.3932), internode length (0.3022), spathe size (0.3956), spadix length (0.2993) and life of spadix (0.3261).

Duration of female phase is highly correlated with days from emergence to maturity of inflorescence (0.3228), spadix length (0.3687), number of flowers spadix^{-1} (0.3936), life of spadix (0.4577), duration of interphase (0.5813), pollen fertility (0.3697), pollen size (0.4061) and anthocyanin content (0.3135).

Duration of male phase found to have significant positive association with number of suckers plant^{-1} (0.2436), number of flowers spadix^{-1} (0.3961), inclination of candle with the spathe (0.3701), pollen fertility (0.3217) and anthocyanin content (0.4479).

Duration of interphase showed significant positive correlation with spadix length (0.4119), number of flowers spadix^{-1} (0.5194), life of spadix (0.5388), duration of female phase (0.5813), pollen fertility (0.5632), pollen size (0.4292) and anthocyanin content (0.6893).

Inclination of candle with the spathe had positive significant association with leaf area (0.2796), spathe size (0.3165), spadix length (0.3485) and duration of male phase (0.3701).

Pollen fertility showed significant positive association with no of flowers spadix^{-1} (0.4937), duration of female phase (0.3697), duration of male phase (0.3217), duration of interphase (0.5632), pollen size (0.6355) and anthocyanin content (0.6546).

Pollen size had positive significant correlation with spadix length (0.2466), duration of female phase (0.4061), duration of interphase (0.4292) and pollen fertility (0.2509).

Anthocyanin content found to have positive significant correlation with number of flowers spadix^{-1} (0.4680), life of spadix (0.4042), duration of female phase (0.3135), duration of male phase (0.4479), duration of interphase (0.6893), pollen fertility (0.6546) and pollen size (0.2509).

4.1.3.2 Genotypic Correlation

Plant height was found to have significant positive association was found in most of the characters except pollen fertility (0.0299).

Leaf area showed significant positive correlation with characters such as plant height (0.6112), number of suckers plant^{-1} (0.3462), spathe size (0.6500), spadix length (0.4473), number of flowers spadix^{-1} (0.5147), life of spadix (0.5941), days from initiation of female phase (0.4775), duration of interphase (0.2544) and inclination of candle with the spathe (0.3468).

Internode length was found to have significant positive association with plant height (0.2051), days from emergence to maturity of leaves (0.2563), number of suckers plant^{-1} (0.2382) and days from initiation of female phase (0.3794).

Days from emergence to maturity of leaves had significant positive correlation with characters like plant height (0.2610), internode length (0.2563), number of suckers plant^{-1} (0.1853), duration of female phase (0.3891) and pollen fertility (0.2168).

Days from emergence to maturity of inflorescence was found to have significant positive correlation with number of leaves spadices^{-1} plant^{-1} year^{-1} (0.5839) and pollen size (0.2320).

Number of leaves spadices^{-1} plant^{-1} year^{-1} exhibited positive significant association with days from emergence to maturity of leaves (0.5839) and number of suckers plant^{-1} (0.4419).

Number of suckers plant^{-1} showed positive association with almost all the character studied and significant positive association was found in characters like plant height (0.4147), leaf area (0.3462), internode length (0.2382), days from emergence to maturity of leaves (0.1853), duration of female phase (0.1930), duration of male phase (0.3717) and anthocyanin content (0.1805). Significant negative association was found in characters like

Table 6 b: Genotypic correlation coefficient among 20 characters of *Anthurium andreanum*

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}
X_1	1	0.6112**	0.2051*	0.2610**	-0.2850**	-0.2172*	0.4147**	0.4281**	0.2344**	0.3573**	0.5093**	0.4355**	0.1894*	-0.012	0.1825*	0.2394**	0.0299	0.1855*	-0.0626	0.1235
X2		1	-0.0394	-0.1114	-0.4020**	-0.2934**	0.3462**	0.6500**	0.4473**	0.5147**	0.5941**	0.4775**	0.1231	-0.0724	0.2544**	0.3468**	0.0103	0.0517	0.002	0.2421**
X_3			1	0.2563**	-0.1343	0.0371	0.2382**	0.1345	-0.0134	0.0583	0.1241	0.3794**	0.0985	-0.2552**	-0.2972**	-0.2823**	-0.3215**	-0.0006	-0.4561**	-0.1493
X_4				1	0.1326	0.0596	0.1853*	-0.2174*	-0.1946*	0.1168	0.163	-0.2699**	0.3891**	0.0806	0.1273	0.0036	0.2168*	0.0224	0.1572	-0.0751
X_5					1	0.5839**	-0.341**	-0.4552**	-0.1918*	-0.3511**	-0.5957	-0.4125**	-0.2942**	0.0023	-0.3286**	0.0994	0.0905	0.2320**	-0.3702**	0.0817
X_6						1	0.4419**	-0.4879**	-0.6549**	-0.1807*	-0.6226**	0.4312**	-0.2957**	0.0445	-0.3371**	-0.0745	-0.0574	-0.0531	-0.178	-0.0896
X_7							1	-0.2291*	-0.4539**	0.113	0.0001	-0.0643	0.1930*	0.3717**	0.0029	0.1017	-0.1521	-0.2142**	0.1805*	0.0905
X_8								1	0.2513**	0.3814**	0.3525**	0.4113**	-0.2113*	-0.0281	-0.0441	0.3295**	-0.2565**	-0.3089**	-0.0776	-0.0255
X_9									1	0.4357**	0.3752**	0.3277**	0.4243**	0.054	0.4441**	0.3646**	0.2009*	0.2633**	0.1359	0.5585**
X_{10}										1	0.5167**	0.1987*	0.4622**	0.4188**	0.5580**	0.1576	0.5047**	0.1644	0.4805**	0.0157
X_{11}											1	0.3447**	0.5164**	0.003	0.5563**	-0.1151	0.1465	0.1718	0.4077**	0.0384
X_{12}												1	-0.0236	-0.2848**	0.119	-0.0563	-0.2593**	0.0755	-0.1640	-0.1037
X_{13}													1	0.1172	0.6550**	-0.1569	0.4154**	0.4593**	0.3479**	-0.1021
X_{14}														1	0.0434	0.3843**	0.3343**	-0.0602	0.4647**	0.0383
X_{15}															1	-0.1274	0.5813**	0.4371**	0.7057**	-0.0625
X_{16}																1	-0.0193	-0.2448**	0.0802	0.6285**
X_{17}																	1	0.6534**	0.6574**	-0.0035
X_{18}																		1	0.2587**	0.0832
X_{19}																			1	0.0845
X_{20}																				1

X_1 - Plant height, X_2 - Leaf area, X_3 - Internode length, X_4 -Days from emergence to maturity of leaves, X_5 - Days from emergence to maturity of inflorescence, X_6 - Number of leaves spadices^{-1} plant^{-1}year^{-1}, X_7 - Number of suckers plant-^{1}, X_8 - Spathe size, X_9 - Spadix length, X_{10} - Number of flowers spadix^{-1}, X_{11} - Life of spadix, X_{12} - Days to initiation of female phase, X_{13} - Duration of female phase, X_{14} - Duration of male phase, X_{15} - Duration of interphase, X_{16} - Inclination of candle with the spathe, X_{17} - Pollen fertility, X_{18} - Pollen Size, X_{19} -Anthocyanin Content, X_{20} - Number of flowers year^{-1}

** Significance at 1 per cent level * Significance at 5 per cent level

days from emergence to maturity of inflorescence (-0.3410), spathe size (-0.2291), spadix length (-0.4539) and pollen size (-0.2142).

Spathe size was found to have positive significant correlation with plant height (0.4281), leaf area (0.6500), spadix length (0.2513), number of flowes spadix^{-1} (0.3814), life of spadix (0.3525), days from initiation of female phase (0.4113) and inclination of candle with the spathe (0.3295).

Spadix length had significant positive correlation with characters such as plant height (0.2344), leaf area (0.4473), spathe size (0.2513), number of flowers spadix^{-1} (0.4357), life of spadix (0.3752), days from initiation of female phase (0.3277), duration of female phase (0.4243), duration of interphase (0.4441), inclination of candle with the spathe (0.3646), pollen fertility (0.2009) and pollen size (0.2633).

Number of flowers spadix^{-1} was found to have negative association with days from emergence to maturity of inflorescence (-0.3511) and number of leaves spadices^{-1} plant $^{-1}$ year^{-1} (-0.1807) and the remaining characters showed significant positive association except internode length (0.0583), days from emergence to maturity of leaves (0.1168), number of suckers plant^{-1} (0.1130), inclination of candle with the spathe (0.1576) and pollen size (0.1644).

Life of spadix showed significant negative correlation with days from emergence to maturity of inflorescence (-0.5957) and number of leaves spadices^{-1} plant^{-1} year^{-1}. Significant positive correlation found in characters like plant height (0.5093), leaf area (0.5941), spathe size (0.3525), spadix length (0.3752), number of flowers spadix^{-1} (0.5167), days from initiation of female phase (0.3447), duration of female phase (0.5164), duration of interphase (0.5563) and pollen size (0.1718).

Days from initiation of female phase showed positive association with plant height (0.4355), leaf area (0.4775), internode length (0.3794), spathe size (0.4113), spadix length (0.3277), number of flowers spadix^{-1} (0.1987) and life of spadix (0.3447).

Duration of female phase had significant negative association with days from emergence to maturity of leaves (-0.2942), number of leaves (-0.2957), spathe size (-0.2113.) and significant positive association with plant height (0.1897), days from emergence to maturity of leaves (0.3891), number of suckers plant^{-1} (0.1930), spadix length (0.4243),

Table 6 c: Environmental correlation coefficient among 20 characters of *Anthurium andreanum*

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}
X_1	1	-0.0899	-0.0287	-0.026	-0.0412	0.0805	-0.026	-0.447	-0.1107	0.1406	0.0907	-0.0221	0.0641	0.1713	-0.0519	0.1548	0.0208	0.1658	0.2662**	0.1234
X2		1	0.0098	0.1453	0.1426	0.1565	0.0913	0.0167	0.0167	-0.1381	-0.1036	-0.0296	0.0461	0.1542	-0.0471	-0.0428	0.0345	-0.8953	-0.1648	0.006
X_3			1	0.074	0.1621	0.0808	-0.2071	0.1546	0.1114	-0.1334	0.1248	-0.115	0.1655	0.154	-0.0331	-0.0483	0.1724	-0.0495	-0.0865	0.0453
X_4				1	-0.0312	0.0325	-0.0553	-0.018	-0.0128	0.1681	-0.1401	-0.0026	0.0229	-0.0842	0.1374	0.0874	0.0588	-0.0219	0.1156	0.1112
X_5					1	-0.0469	-0.0732	0.0043	0.1313	0.0001	-0.508	-0.0097	0.0224	0.058	0.0476	0.013	-0.0756	-0.0024	0.0027	0.0677
X_6						1	0.0707	0.1675	0.0108	0.1561	-0.506	0.1456	-0.0549	0.0558	-0.0249	0.0956	0.1345	0.0903	-0.1643	0.1342
X_7							1	-0.0194	-0.0356	-0.01	0.1547	-0.008	0.0094	-0.0376	-0.0159	0.0378	0.1149	0.1711	-0.0136	0.0432
X_8								1	0.0504	-0.1918	0.1345	0.0415	0.0502	-0.0034	-0.0107	-0.0725	0.1126	0.0352	-0.1394	0.1235
X_9									1	-0.1055	0.008	-0.097	-0.0005	-0.067	-0.1299	0.0615	0.1654	0.0342	-0.1226	0.0123
X_{10}										1	0.1543	-0.132	-0.0652	0.0151	0.009	0.106	-0.0123	0.0395	0.0218	0.1342
X_{11}											1	0.1362	-0.742	0.168	0.0223	-0.023	-0.0296	0.1328	-0.1275	0.1296
X_{12}												1	0.1544	0.1139	0.0573	0.0215	0.0044	-0.0322	0.0054	0.0126
X_{13}													1	0.1756	0.1416	0.0009	0.0141	-0.0167	0.0222	0.0034
X_{14}														1	-0.0135	0.1723	0.0015	-0.0313	0.0235	0.0007
X_{15}															1	0.1334	0.1342	-0.1223	-0.0684	0.2347
X_{16}																1	0.1344	0.1243	0.02	0.0345
X_{17}																	1	0.1324	-0.1317	0.0213
X_{18}																		1	-0.0215	0.1134
X_{19}																			1	0.1454
X_{20}																				1

X_1 - Plant height, X_2 - Leaf area, X_3 - Internode length, X_4 -Days from emergence to maturity of leaves, X_5 - Days from emergence to maturity of inflorescence, X_6 - Number of leaves spadices^{-1} plant^{-1}year^{-1}, X_7 - Number of suckers plant-^{1}, X_8 - Spathe size, X_9 - Spadix length, X_{10} - Number of flowers spadix^{-1}, X_{11} - Life of spadix, X_{12} . Days to initiation of female phase, X_{13} - Duration of female phase, X_{14} - Duration of male phase, X_{15}. Duration of interphase, X_{16} - Inclination of candle with the spathe, X_{17} - Pollen fertility, X_{18} - Pollen Size, X_{19} -Anthocyanin Content, X_{20} - Number of flowers year^{-1}

** Significance at 1 per cent level * Significance at 5 per cent level

number of flowers spadix^{-1} (0.4622), life of spadix (0.5164), duration of interphase (0.6550), pollen fertility (0.4154), pollen size (0.4593) and anthocyanin content (0.3479).

Duration of male phase showed significant positive association with number of suckers plant^{-1} (0.3717), number of flowers spadix^{-1} (0.4188), inclination of candle with the spathe (0.3843), pollen fertility (0.3343) and anthocyanin content (0.4647).

Duration of interphase found to have significant positive correlation with plant height (0.1825), leaf area (0.2544), spadix length (0.4441), number of flowers spadix^{-1} (0.5580), life of spadix (0.5563), duration of female phase (0.6550), pollen fertility (0.5813), pollen size (0.4371) and anthocyanin content (0.7057).

Inclination of candle with the spathe was positively associated with plant height (0.2394), leaf area (0.3468), spathe size (0.3295), spadix length (0.3646) and duration of male phase (0.3843).

Pollen fertility showed significant positive association with days from emergence to maturity of leaves (0.2168), spadix length (0.2009), number of flowers spadix^{-1} (0.5047), duration of female phase (0.4154), duration of male phase (0.3343), duration of interphase (0.5813), pollen size (0.6534) and anthocyanin content (0.6574).

Pollen size found to have positive significant correlation with plant height (0.1855), days from emergence to maturity of inflorescence (0.2320), spadix length (0.2633), duration of female phase (0.4593), duration of interphase (0.4371), inclination of candle with the spathe (0.6534) and anthocyanin content (0.2587).

Anthocyanin content showed positive significant correlation with number of suckers per plant (0.1805), number of flowers per spadix (0.4805), life of spadix (0.4077), duration of female phase (0.3479), duration of male phase (0.4647), duration of interphase (0.7057) and pollen fertility (0.6574).

Number of flowers year^{-1} found to have positive significant association with leaf area (0.2367), spadix length (0.4903) and inclination of candle with the spathe (0.5766).

4.1.3.3 Environmental Correlation

Plant height was found to have significant positive correlation with anthocyanin content (0.2662). Environmental correlation between other characters was not significant.

Table 7: List of genotypes selected for hybridization

Sl. No	Genotype
1	Liver Red
2	Dragon's Tongue
3	Chikoos
4	Chekas
5	Honduras Red
6	Esmeralda
7	Hawaiian Orange
8	Chocos
9	Boroque
10	Pistache
11	Tropical Peach
12	Lucia Pink
13	Cascade White
14	Merengue White
15	Vezuvious Red

Table 8: Matrix showing the number of pollinations done in each combination among the genotypes of *Anthurium andreanum*

	LR	DT	C	CK	HR	E	HO	CS	B	P	TP	LP	CW	MW	VR
LR		1	-	-	-	-	-								
DT	2		1	1				1							
C	2	1										1			
CK	1	1	1		1		1	1	1	1		1	1	1	
HR	2	2										2			
E	1	1	1	1	1		1		1		1		1	1	1
HO	2	1	1									1	1	1	
CS			1									1			
B			2												
P			1												
TP			1												
LP		1	1												
CW		2	2												
MW				1											
VR		1	1												

Self ing is not included in the study

4.2 COMPATIBILITY STUDIES

4.2.1 Percentage of Candle Bearing Berries

The percentage of candle bearing fruits is furnished in the Table 9.

4.2.1.1 Liver Red

Only one cross was attempted and it was successful (Liver Red x Dragon's Tongue) and showed 100 per cent berries in this combination.

4.2.1.2 Dragon's Tongue

Out of the five crosses only three got successful. The average percentage of candles in this genotype was 30 per cent. Percentage of candle bearing berries was the highest for the combination (100 per cent) Dragon's Tongue x Chikoos and Dragon's Tongue x Chekas..

4.2.1.3 Chikoos

Among the three successful crosses two crosses having 100 per cent berries Chikoos x Dragon's Tongue, Chikoos x Lucia Pink and the cross, Chikoos x Liver Red found to have 50 per cent berries.

4.2.1.4 Chekas

Only one cross combination got successful out of the 11 cross combinations attempted. The cross, Chekas x Dragon's Tongue was with 100 per cent berries.

4.2.1.5 Pistache

Only one cross combination (Pistache x Chikoos) was attempted that was successful with 100 per cent berries per spadix.

4.2.1.6 Honduras Red

Among the six cross combinations, three got successful with 50 per cent spadix bearing berries. The crosses were Honduras Red x Liver Red, Honduras Red x Dragon's Tongue and Honduras Red x Lucia Pink.

Table 9: Matrix showing candle bearing fruits in each combination

	LR	DT	C	CK	HR	E	HO	C	B	P	TP	LP	CW	MW	VR	Average
LR		100	-	-	-	-	-									100
DT	50		100	100				0								30
C	50	100										100				62.5
CK	0	100	0		0		0	0	0	0		0	0	0		9.09
HR	50	50										50				25
E	100	100	0	0	0		0		0		0		0	0	0	18.18
HO	50	100	100									100	100	100		78.57
C			0									100				50
B			50													25
P			100													100
TP			100													100
LP		0	0													0
CW		50	50													25
MW				0												0
VR		100	0													50

Self ing is not included in the study 0 – Crosses attempted but not successful Total crosses -62 Successful -26

LR x DT

DT x LR

Plate : 6 Spadix with fruit set in different crosses

TP x C

HO x C

Plate: 6 (Continued) Spadix with fruit set in different crosses

HR x LR

CW x C

Plate : 6 (Continued) Spadix with fruit set in different crosses

DT x C

C x DT

Plate : 6 (Continued) Spadix with fruit set in different crosses

B x C

HO x LP

Plate : 6 (Continued) Spadix with fruit set in different crosses

CK x DT

HO x CW

Plate : 6 (Continued) Spadix with fruit set in different crosses

C x LR

CW x DT

Plate : 6 (Continued) Spadix with fruit set in different crosses

4.2.1.7 Esmeralda

Among the two successful cross combinations, out of the 11 cross combination attempted. The cross Esmeralda x Liver Red and Esmeralda x Dragon's Tongue had 100 per cent spadix bearing berries.

4.2.1.8 Hawaiian Orange

Out of the six successful candles bearing fruits, the highest percentage of berries (100 per cent) were obtained in the entire cross except Hawaiian Orange x Liver Red.

4.2.1.9 Chocos

The only one successful cross, Chocos x Lucia Pink had 4 berries per spadix .

4.2.1.10 Boroque

Out of the two crosses attempted, the successful cross of Boroque x Chikoos found to have 50 per cent spadix bearing berries.

4.2.1.11 Vezuvious Red

Only one cross was successful out of the two cross combination attempted. The cross, Vezuvious Red x Dragon's Tongue had 100 per cent berries per spadix.

4.2.1.12 Tropical Peach

The only cross combination of this genotype, Tropical Peach x Chikoos found to have 100 per cent spadix bearing berries.

4.2.1.13 Cascade White

Out of the two successful cross combinations, Cascade White x Dragon's Tongue and Cascade White x Chikoos had 50 per cent of the berries bearing spadices.

4.2.1.14 Merengue White

Out of the two cross combination attempted, none was found to have candle bearing berries.

4.2.1.15 Lucia Pink

None of the cross found to have candle bearing berries in this genotype.

4.2.2 Number of Berries Spadix^{-1}

The number of berries spadix^{-1} for the successful crosses are presented in the Table. 10.

4.2.2.1 Liver Red

The maximum number of berries obtained in the cross, Liver Red x Dragon's Tongue was 60. This was the only one cross attempted in this parent.

4.2.2.2 Dragon's Tongue

Among the three successful crosses the highest number of berries obtained in the cross Dragon's Tongue x Chikoos (65) followed by Dragon's Tongue x Chekas (13) and the lowest number of berries obtained in the cross Dragon's Tongue x Liver Red (6).

4.2.2.3 Chikoos

Out of the three successful candle bearing berries the maximum number of berries were found in the cross, Chikoos x Liver Red (16) followed by Chikoos x Lucia Pink (12). The minimum number of berries were obtained in the cross Chikoos x Dragon's Tongue.

4.2.2.4 Chekas

The number of berries spadix^{-1} was very low for the cross, Chekas x Dragon's Tongue (3) which was the only successful cross combination in Chekas.

4.2.2.5 Pistache

The cross, Pistache x Chikoos found to have five berries in the spadix.

4.2.2.6 Honduras Red

The number berries spadix^{-1} was highest in the combination Honduras Red x Lucia Pink (21) followed by Honduras Red x Liver Red (20). Out of the three successful cross combinations lowest number of berries of 18 were obtained in the cross Honduras Red x Dragon's Tongue.

Table 10: Matrix showing average number of berries per spadix

	LR	DT	C	CK	HR	E	HO	C	B	PI	TP	LP	CW	MW	VR	Average
LR		60														60
DT	6	65		13												28
C	16	5										12				11
Ck		3														3
HR	20	18										21				19.66
E	24	22														23
HO	18	13	23									16	15	10		15.83
C												4				4
B			45													45
P			5													5
TP			5													5
LP																0
CW		7	15													11
MW																0
VR		3														3

*Selfing is not included in the study

4.2.2.7 Esmeralda

Among the two successful cross combinations, the cross Esmeralda x Liver Red (24) had the highest number of berries spadix^{-1} followed by Esmeralda x Dragon's Tongue (22).

4.2.2.8 Hawaiian Orange

Out of the six successful candles bearing fruits, the highest numbers of berries were obtained in the cross, Hawaiian Orange x Chikoos (23), Hawaiian Orange x Liver Red (18), Hawaiian Orange x Lucia Pink (16), Hawaiian Orange x Cascade White (15) and Hawaiian Orange x Dragon's Tongue (13). The lowest number of berries were found in the cross Hawaiian Orange x Merengue White (10).

4.2.2.9 Chocos

The only one successful cross, Chocos x Lucia Pink had 4 berries per spadix.

4.2.2.10 Boroque

From the cross, Boroque x Chikoos, 45 berries were obtained.

4.2.2.11 Vezuvious Red

The cross, Vezuvious Red x Dragon's Tongue exhibited the lowest number of berries of three among all the other combinations of genotypes.

4.2.2.12 Tropical Peach

The only cross combination of this genotype, Tropical Peach x Chikoos yield five berries per spadix.

4.2.2.13 Cascade White

Out of the two successful cross combinations, Cascade White x Dragon's Tongue had the highest number of berries (15) and Cascade White x Dragon's tongue had only few (7)

4.2.3 Percentage of Fruit Set Candle^{-1}

The percentage of fruit set candle^{-1} for the successful crosses are presented in the Table. 11.

4.2.3.1 Liver Red

The cross Liver Red x Dragon's Tongue had 52.63 per cent fruit set candle^{-1}.

4.2.3.2 Dragon's Tongue

Among the three successful crosses, the highest percentage of fruit set candle^{-1} (48.15 per cent) obtained in the cross, Dragon's Tongue x Chikoos followed by Dragon's Tongue x Chekas (9.58 per cent) and the lowest per cent of fruit set candle^{-1} obtained in the cross Dragon's Tongue x Liver Red (4.4 per cent).

4.2.3.3 Chikoos

Out of the three successful candle bearing berries crosses the maximum per cent of fruit set were found in the cross Chikoos x Lucia Pink (9.58) followed by Chikoos x DT (3.73). The minimum per cent of fruit set was obtained in the cross Chikoos x Dragon's Tongue (1.17).

4.2.3.4 Chekas

The per cent of fruit set for the cross Chekas x Dragon's Tongue (1.19) was very low.

4.2.3.5 Pistache

The only one cross of Pistache x Chikoos which found to 1.98 per cent fruit set candle^{-1}.

4.2.3.6 Honduras Red

The highest per cent of fruit set candle^{-1} found in the combination Honduras Red x Lucia Pink (6.93 per cent) followed by Honduras Red x Dragon's Tongue (6.23 per cent). Out of the three successful cross combinations lowest per cent of fruit set candle^{-1} (1.98 per cent) were obtained in the cross Honduras Red x Liver Red.

Table 11: Matrix showing average percentage of fruit set in each combination

	LR	DT	C	CK	HR	E	HO	C	B	P	TP	LP	CW	MW	VR	Average
LR		52.63														52.63
DT	4.4		48.15	9.58												20.71
C	1.17	3.13										9.58				4.62
CK		1.19														1.19
HR	1.98	6.23										6.93				5.04
E	32.5	29.81														31.15
HO	21	15.56	27.53									19.15	17.95	11.97		18.86
C												3.24				3.24
B			52.44													52.44
P			1.98													1.98
TP			4.29													4.29
LP																0
CW		6.68	14.31													10.49
MW																0
VR		3.6														3.6

*Self ing is not included in the study

4.2.3.7 Esmeralda

Among the two successful cross combinations, the cross Esmeralda x Liver Red (32.5 per cent) had the highest percentage of fruit set spadix^{-1} followed by Esmeralda x Dragon's Tongue (29.81 per cent).

4.2.3.8 Hawaiian Orange

Among the six successful crosses, the highest per cent of fruit set candle^{-1} found in the cross, Hawaiian Orange x Chikoos (27.5 per cent), Hawaiian Orange x Liver Red (21 per cent), Hawaiian Orange x Lucia Pink (19.15 per cent), Hawaiian Orange x Cascade White (17.95 per cent) and Hawaiian Orange x Dragon's Tongue (15.56 per cent). The lowest per cent of fruit set candle^{-1} were found in the cross Hawaiian Orange x Merengue White (11.97 per cent).

4.2.3.9 Chocos

The cross, Chocos x Lucia Pink showed 3.24 per cent fruit set candle^{-1}.

4.2.3.10 Boroque

The cross, Boroque x Chikoos found to have 52.44 per cent fruit candle^{-1}, this was the only cross in the variety Boroque.

4.2.3.11 Vezuvious Red

The cross, Vezuvious Red x Dragon's Tongue had 3.6 per cent fruit set candle^{-1}.

4.2.3.12 Tropical Peach

The cross, Tropical Peach x Chikoos found to have 4.29 per cent fruit set candle^{-1}.

4.2.3.13 Cascade White

Out of the two successful cross combinations, Cascade White x Dragon's Tongue had the highest per cent of fruit set candle^{-1} (14.31 per cent) and Cascade White x Dragon's tongue had 6.68 percentage of fruit set candle^{-1}.

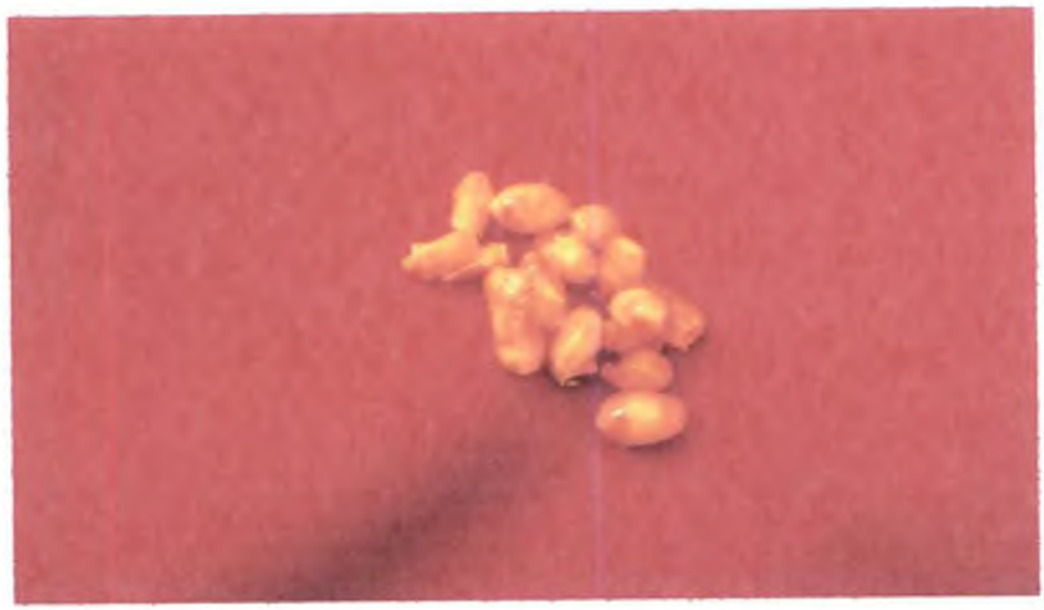


Plate 7: Ripe berries

4.2.4 Number of Seeds^{-1} Berry

Berries took 4 to 7 months to mature and it varies according to varieties. The number of berries in each successful combination is furnished in the Table.12.

4.2.4.1 Liver Red

The percentage of single seeded berries was 75 per cent in the cross, Liver Red x Dragon's Tongue and the percentage of double seeded varieties found to be 25 per cent. This was the only one cross attempted in this parent.

4.2.4.2 Dragon's Tongue

Among the three successful crosses the highest per cent of single seeded berries obtained in the cross, Dragon's Tongue x Chekas (92.30) followed by Dragon's Tongue x Chikoos (76 per cent) and the lowest per cent of single seeded berries obtained in the cross Dragon's Tongue x Liver Red (66.66 per cent). In the case of double seeded berries, the highest per cent was obtained in the cross, Dragon's Tongue x Liver Red (33.33 per cent) followed by Dragon's Tongue x Chikoos (23.07 per cent) and Dragon's Tongue x Chekas (7.6 per cent).

4.2.4.3 Chikoos

Out of the three successful crosses, the maximum percentage of single seeded berries were found in the cross, Chikoos x Dragon's Tongue (100 per cent) followed by Chikoos x Lucia Pink (91.6 per cent). The minimum per cent of single seeded berries number of berries were obtained in the cross, Chikoos x Liver Red (60 per cent). Among the double seeded varieties, Chikoos x Liver Red (40 per cent) had the highest per cent of double seeded berries followed by Chikoos x Lucia Pink (8.3 per cent).

4.2.4.4 Chekas

The cross, Chekas x Dragon's Tongue which was the only successful cross combination using Chekas as female parent which was having 100 per cent single seeded berries.

4.2.4.5 Pistache

The only one cross of Pistache x Chikoos which found to have 80 per cent single seeded berries and 20 per cent double seeded berries.

4.2.4.6 Honduras Red

Among the three successful crosses, the percentage of single seeded berries was the highest in the cross, Honduras Red x Dragon's Tongue (94.4 per cent) followed by Honduras Red x Liver Red (90 per cent) and Honduras Red x Lucia Pink (85 per cent). The cross, Honduras Red x Lucia Pink (15 per cent) had the highest per cent of double seeded berries followed by Red x Liver Red (10 per cent) and Honduras Red x Dragon's Tongue (5.5 per cent).

4.2.4.7 Esmeralda

Out of the two successful cross combinations, the cross Esmeralda x Dragon's Tongue (90.9 per cent) had the highest percentage of single seeded berries followed by Esmeralda x Liver Red (70.8 per cent). The maximum percentage of double seeded berries was recorded in the cross, Esmeralda x Liver Red (29.16 per cent). The cross, Esmeralda x Dragon's Tongue had only 9.09 percentage double seeded berries.

4.2.4.8 Hawaiian Orange

Among the six successful crosses, the highest percentage of 88.88 per cent single seeded berries were found in the cross, Hawaiian Orange x Liver Red followed by Hawaiian Orange x Dragon's Tongue (76.92 per cent), Hawaiian Orange x Chikoos (69.56 per cent), Hawaiian Orange x Cascade White (66.66 per cent) and Hawaiian Orange x Lucia Pink (62.5 per cent) and Hawaiian Orange x Merengue White (60 per cent). The cross, Hawaiian Orange x Merengue White (40 per cent) had the highest percentage of double seeded berries followed by Hawaiian Orange x Lucia Pink (37.5 per cent), Hawaiian Orange x Cascade White (33.33 per cent), Hawaiian Orange x Chikoos (30.43 per cent), Hawaiian Orange x Dragon's Tongue (23 per cent) and Hawaiian Orange x Liver Red (12.5 per cent).

4.2.4.9 Chocos

The only one successful cross of Chocos x Lucia Pink had 75 per cent single seeded berries and 25 per cent double seeded berries

Table 12: Number of seeds per berry and seed size among the crosses of *Anthurium andreanum* genotypes

Sl. No	Crosses	Number of seeds per berry (Per cent)		Seed Size (mm)	
		Single Seeded	Double Seeded	Single Seeded	Double Seeded
1	LR x DT	75	25	3.15 x 2.56	2.13 x 1.9
2	DT x LR	66.6	3333	3.00 x 2.30	3.25 x 2.1
3	DT x C	76	24	3.21 x 2.13	2.3 x 1.95
4	DT x Ck	92.3	7.6	3.30 x 2.45	2.13 x 1.8
5	C x DT	100		3.43 x 2.55	2.30 x 2
6	C x LR	60	40	3.14 x 2.20	2.01 x1.5
7	C x LP	91.6	8.3	3.45 x 2.50	2.24 x 2
8	CK x DT	100		2.99 x 1.7	-
9	P x C	80	20	3.25 x 2.34	2.33 x 1.7
10	HR x DT	94.4	5.5	3.17 x 2.33	2.56 x 1.67
11	HR x L R	90	10	3.23 x 2.48	2.37 x 1.7
12	HR x LP	85	15	3.00 x 2.21	2.34 x 2.01
13	E x LR	70.8	29.16	3.23 x 2.41	2.33 x 1.8
14	E x DT	90.9	9.09	2.99 x 2.1	2.3 x 1.7
15	H.O x DT	76.92	23	3.87 x 2.75	2.38 x 1.55
16	HO x C	69.56	30.43	3.76 x 2.52	2.76 x 1.85
17	HO x LR	88.9	12.5	3.43 x 2.67	2.40 x 1.56
18	HO x CW	66.7	33.3	3.2 x 2.33	2.05 x 1.6
19	HO x MW	60	40	3.01 x 2.2	2.14 x 1.9
20	HO x LP	62.5	37.5	3.33 x2.10	2.34 x 1.76
21	CS x LP	75	25	3.60 x 2.43	2.45 x 1.92
22	B x C	82.2	17.8	3.63 x 2.54	2.80 x 2.05
23	VR x DT	100	0	3.42 x 2.44	-
24	TP x C	100	0	2.5 x 1.9	-
25	CW x C	80	20	2.7 x 1.9	2.5 x 1.85
26	CW x DT	14	14	2.78 x 2	2.6 x 1.55

4.2.4.10 Boroque

The cross, Boroque x Chikoos had 82.22 per cent single seeded berries and 17.77 per cent double seeded berries.

4.2.4.11 Vezuvious Red

From the cross, Vezuvious Red x Dragon's Tongue had 100 per cent single seeded berries.

4.2.4.12 Tropical Peach

The only one cross combination of this genotype, Tropical Peach x Chikoos exhibited 100 per cent single seeded berries.

4.2.4. 13 Cascade White

Among the two successful cross combinations, Cascade White x Dragon's Tongue (85 per cent) had the highest per cent of single seeded berries followed by Cascade White x Chikoos (80 per cent). The cross, Cascade White x Chikoos found to have 20 per cent double seeded berries and the cross, Cascade White x Dragon's Tongue had 15 per cent double seeded berries.

4.2.5 Seed Size

Seed size of successful cross combinations are presented in the Table. 12.

4.2.5.1 Liver Red

The cross, Liver Red x Dragon's Tongue had single seeded berries with the seed size (3.15 x 2.56 mm) and double seeded berries having 2.13 x 1.9 mm seed size.

4.2.5.2 Dragon's Tongue

Among the three successful crosses, the maximum seed size for single seeded berries was exhibited by cross Dragon's Tongue x Chekas (3.30 x 2.45mm) followed by Dragon's Tongue x Liver Red (3.00 x 2.30 mm) and Dragon's Tongue x Chikoos (3.21 x 2.13mm). In the case of double seeded berries, the maximum seed size was obtained in the cross Dragon's Tongue x Liver Red (3.25 x 2.1mm) followed by Dragon's Tongue x Chikoos (2.3 x 1.95mm) and Dragon's Tongue x Chekas (2.13 x 1.8mm).

4.2.5.3 Chikoos

Out of the three successful crosses, The lowest seed size of 2.01 x1.5 mm was found double seeded berries of the cross Chikoos x Liver Red followed by Chikoos x Dragon's Tongue (2.24 x 2 mm) and Chikoos x Lucia Pink (2.30 x 2 mm). The size of single seeded berries was high in the cross, Chikoos x Dragon's Tongue (3.43 x 2.55 mm) followed by Chikoos x Lucia Pink (3.45 x 2.50 mm) and Chikoos x Liver Red (3.14 x 2.20 mm).

4.2.5.4 Chekas

The cross, Chekas x Dragon's Tongue had only single seeded berries of size 2.99 x 1.7 mm.

4.2.5.5 Pistache

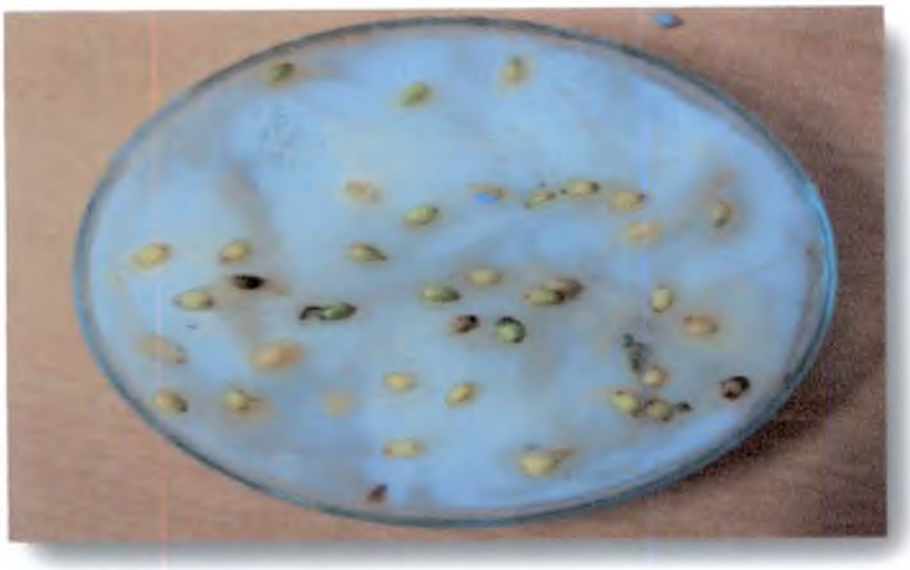
The only one cross of Pistache x Chikoos which was having single seeded as well as double seeded berries. The size of the single seeded berries was 3.25 x 2.34 mm and 2.33 x 1.7 mm for the double seeded berries.

4.2.5.6 Honduras Red

Among the three successful crosses, the maximum seed size of 3.23 x 2.48 mm for single seeded berries was found in the cross, Honduras Red x Liver Red followed by Honduras Red x Dragon's Tongue (3.17 x 2.33 mm) and Honduras Red x Lucia Pink (3.00 x 2.21 mm). In the case of double seeded berries, the largest seed size of 2.34 x 2.01 mm was exhibited by the cross, Honduras Red x Lucia Pink followed by Red x Dragon's Tongue (2.56 x 1.67 mm) and Honduras Red x Liver Red (2.37 x 1.7 mm).

4.2.5.7 Esmeralda

Out of the two successful cross combinations, Esmeralda x Liver Red had double as well as single seeded berries. The double seeded berries had the size of 2.33 x 1.8 mm and 3.23 x 2.41 mm. The cross, Esmeralda x Dragon's Tongue had seed size of 2.99 x 2.1 mm for single seeded berries and 2.33 x 1.8 mm for double seeded berries.



Seed kept for germination

2 month old seedlings

Plate 8: Seed germination

4.2.5.8 Hawaiian Orange

The cross, Hawaiian Orange x Dragon's Tongue had the largest single seed size (3.87 x 2.75 mm) and the smallest size of 3.01 x 2.2 mm was found in the cross Hawaiian Orange x Merengue White. Among double seeded berries, the cross, Hawaiian Orange x Chikoos had the largest seed size of 2.76 x 1.85 mm and the smallest seed size was noticed in the cross Hawaiian Orange x Cascade White (2.05 x 1.6mm).

4.2.5.9 Chocos

The cross, Chocos x Lucia Pink had single seeded berries of size 3.60 x 2.43 mm and double seeded berries of size 2.45 x 1.92 mm.

4.2.5.10 Boroque

The cross, Boroque x Chikoos had single as well as double seeded berries of seed size 3.63 x 2.54 mm and 2.80 x2.05 mm.

4.2.5.11 Vezuvious Red

The cross, Vezuvious Red x Dragon's Tongue had only single seeded berries of size 3.42 x 2.44 mm.

4.2.5.12 Tropical Peach

The cross, Tropical Peach x Chikoos had 100 per cent single seeded berries with seed size 3.24 x 2.15 mm.

4.2.2.13 Cascade White

Among the two successful cross combinations, Cascade White x Dragon's Tongue (2.78 x 2 mm) had the largest single seeded berries. Cascade White x Chikoos had the largest double seeded berries of size (2.45 x 1.85 mm).

4.2.6 Seed Germination

The matured berries were harvested and it's squeezed to given out the seeds. Then the pulp around the seed was removed and it was placed on a petridish containing wet cotton. The number of days for germination varied from 4 to 9 days according to the genotype. An

Table 13: Matrix showing seed germination in each combination

	LR	DT	C	CK	HR	E	HO	CS	B	P	TP	LP	CW	MW	VR	Average
LR		51.6														51.6
DT	66.60		23.07	53.8												47.5
C	40	50										50				46.66
CK		33.33														33.33
HR	45	66.66										55				55.53
E	64.51	45.45														54.98
HO	55.5	46.15	69.56									50	26.66	40		47.97
CS												25				25
B			28.88													28.88
P			20													20
TP			40													40
LP																
CW		37	44													
MW																40.5
VR		66.51														66.5

*Self ing is not included in the study

2 month old seedlings in pots

4-5 month old seedling

Plate: 9 Seedlings at different stages

increase in temperature reduces the percentage of germination. The seed germination percentage of each successful cross is furnished in the Table.13.

4.2.6.1 Liver Red

The only successful cross Liver Red x Dragon's Tongue had 51.2 per cent seed germination.

4.2.6.2 Dragon's Tongue

Among the three successful crosses, the maximum percentage of seed germination was found in the cross Dragon's Tongue x Liver Red (66.66 per cent) followed by Dragon's Tongue x Chekas (53.8 per cent) and Dragon's Tongue x Chikoos (23.07 per cent).

4.2.6.3 Chikoos

Out of the three successful crosses, the lowest percentage of seed germination was found in the cross, Chikoos x Liver Red (40 per cent) followed by Chikoos x Dragon's Tongue (50 per cent) and Chikoos x Lucia Pink (50 per cent).

4.2.6.4 Chekas

The cross, Chekas x Dragon's Tongue had 33.33 per cent germination.

4.2.6.5 Pistache

The only successful cross of Pistache x Chikoos exhibited 20 per cent seed germination.

4.2.6.6 Honduras Red

Among the three successful crosses, the maximum per cent of seed germination was found in the cross, Honduras Red x Dragon's Tongue (66.66 per cent) and the lowest per cent of seed germination was noticed in the cross Honduras Red x Liver Red (45 per cent).

4.2.6.7 Esmeralda

Out of the two successful cross combinations, the cross, Esmeralda x Liver Red had the maximum per cent of germination (64.51 per cent) followed by Esmeralda x Dragon's Tongue (45.45 per cent).

4.2.6.8 Hawaiian Orange

The cross, Hawaiian Orange x Chikoos had the maximum percentage of germination (69.56 per cent) followed by Hawaiian Orange x Liver Red (55.55 per cent). The least per cent of germination was exhibited by the cross Hawaiian Orange x Merengue White (40 per cent) among the six successful cross combinations.

4.2.6.9 Chocos

The cross, Chocos x Lucia Pink exhibited 25 per cent seed germination.

4.2.6.10 Boroque

The only one cross of this genotype, Boroque x Chikoos had 28.88 per cent seed germination.

4.2.6.11 Vezuvious Red

The cross, Vezuvious Red x Dragon's Tongue exhibited 66.51 per cent of seed germination.

4.2.6.12 Tropical Peach

Only 40 per cent of the seeds were germinated in the cross, Tropical Peach x Chikoos.

4.2.6.13 Cascade White

Out of the two successful cross combinations, the maximum percentage of seed germination was exhibited by the genotype Cascade White x Chikoos (44 per cent) followed by Cascade White x Dragon's Tongue (37 per cent).

DISCUSSION.....

5. DISCUSSION

Cut flowers are gaining importance year by year and the floriculture industry focuses on the quality of the flowers rather than the quantity of flowers. The unavailability of quality planting materials is the major problem faced by the farmers.

The present investigation was to evaluate the parental genotypes and improve them through hybridization. Statistical analyses were carried out on the genetic parameters and also cross compatibility studies were done based on the fruit set and seed germination and the results are discussed below.

5.1 MEAN PERFORMANCE

The vegetative as well as the floral characters showed wide variations among the 25 genotypes studied. The height of the plant ranged from 22 cm in Nitta Orange to 50.6 cm in Cascade White. The mean plant height recorded among the 25 genotypes was 33.20 cm. The genotype Cascade White recorded the highest mean plant height (50.6 cm) which was on par with the genotypes Chikoos (46 cm), Liver Red (44 cm) and Boroque (42 cm). Abdussammed (1999) found that nutrients play significant role in plant height, both in ground as well as pot planting in anthurium. Bindu and Mercy (1994) observed wide variation in plant height while studying the five genotypes of anthurium and reported that plant height can be taken as a varietal trait. This was in accordance with the findings of Renu (2000), Mayadevi (2001), Asish (2002), Premna (2003), Pravin (2004), Madhukumar (2010) and Sheena (2015).

Leaf area showed wide variation among the genotypes according to the size of the leaf as well as the age of the plant. In the present study, the maximum leaf area was exhibited by the cultivar Cascade White (450.276 cm^2) and the minimum leaf area was shown by the variety Nitta Orange (151.044 cm^2). Mercy and Dale (1994) opined that the commercial floral anthurium consists of small to medium sized leaves which should be either narrow or elongated. Similar results

were obtained by Mayadevi (2001), Premna (2003) Pravin (2004), Agasimani *et al.* (2011a), Jacob (2011) and Sheena (2015)

The internode length among the 25 genotypes of anthurium varied from 0.66 cm in Chekas and 1.3 cm in Tropical Peach. Cultivars with short internodes will have compact shape, which is preferred in the world market (Mercy and Dale, 1994). Days from emergence to maturity of leaves showed a wide variation ranging from 24.4 days in Boroque and 32.6 days in Liver Red. Similar results were reported by Mayadevi (2001), Premna (2003), Madhukumar (2010) and Sheena (2015).

The present study revealed that number of leaves spadices^{-1} plant^{-1} year $^{-1}$ was the highest in the variety Honeymoon Red (9) followed by Lady Jane (8.6) and the lowest was noticed in Tropical Red. These results were supported by Asish(2002), Premna (2003), Pravin (2004), Islam *et al.* (2013) and Sheena (2015). Usually hybrid varieties produce less number of suckers compared to ordinary varieties. In the present study, the number of suckers was the highest in the variety Honeymoon Red (1.6) which was on par with Lady Jane (0.8), Emperor (0.8) and Dragon's Tongue. The genotypes like Gold Spark, Nitta Orange, Agnihotri, Pistache, Chocos, Tropical Red, Hawaiian Orange, Mauritius Orange, Honduras Red and Esmeralda did not produce suckers. These findings were supported by Mayadevi (2001), Pravin (2004), Madhukumar (2010) and Sheena, (2015).

The present study revealed that there was significant variation in the number of days from emergence to maturity of inflorescence among the genotypes. The maximum number of days for emergence was noticed in the genotype Agnihotri (34.6) and the minimum was in Can Can (28.4 days). This was in accordance with the findings of Mayadevi (2001), Pravin (2004), Madhukumar (2010) and Sheena (2015).

The present study revealed that the highest number of flowers was produced by the genotypes, Cascade White (4.8) and Lady Jane (4.8) and the

lowest number of flowers was found in Mauritius Orange (1.2) and Lucia Pink (1.2). The flower production usually ranges from 5-8 per plant, but the decrease in flower production during the experimental period was due to increased temperature and the incidence of pest and diseases. Significant variation in flower production was observed by Sindu (1995), Renu (2000), Mayadevi (2001), Madhukumar (2010) and Sheena (2015).

In the present investigation a wide variation in spathe size was recorded among the twenty five genotypes of anthurium and it ranged from 42.88 cm^2 (Lady Jane) to 101 cm^2 (Boroque). Significant variation in spathe size were reported by Mayadevi (2001), Pravin (2004), Madhukumar (2010), Agasimani *et al.* (2011a), Islam *et al.* (2013) and Sheena (2015).

Small sized candles are preferred in the floriculture world. In the present study, the mean of spadix length ranged from 3.2 cm (Honeymoon Red) to 8.76 cm (Chikoos). According to Mercy and Dale (1994), candles of hybrid varieties are shorter and slender compared to ordinary commercial varieties. These results were supported by Srinivasa and Reddy (2005), Madhukumar (2010) and Sheena (2015).

According to the size of the candle the number of flowers also varies. The non commercial varieties which serve as the best female parent have large number of flowers in their candles. The commercial varieties which are cultivated today have small sized candles with less number of flowers. In the present study, the maximum number of flowers $spadix^{-1}$ (452.2) was found in the genotype Chikoos and the minimum number of flowers was expressed by Esmeralda (246.2). Significant variation in number of flowers $spadix^{-1}$ was reported by Sindhu (1995), Mayadevi (2001), Madhukumar (2010) and Sheena (2015).

The present investigation revealed that the life of spadix was the highest in the genotype Tropical Red (91.2 days) and the lowest in Vezuvious Red (48.2 days). Mercy and Dale (1994) reported that the fertilized inflorescence has more

shelf life when compared to unfertilized one. Similar findings were reported by Sindhu (1995), Shiva and Nair (2008), Madhukumar (2010) and Sheena (2015).

Two weeks after the emergence of flowers, the female phase started. The initiation of female phase was identified by white colour secretion on the stigma which was sticky on touch. According to Mercy and Dale (1994), the flowers were arranged on the spadix in acropetal succession; so the flower maturation starts from the base and later it progresses towards the tip. The anthurium flower is protogynous in nature and the number of days from initiation of female phase in the present study ranged from 4.2 (Vezuvious Red) to 10.8 days (Boroque). Similar works were done earlier and reported by Renu (2000), Mayadevi (2001), Pravin (2004), Madhukumar (2010) and Sheena (2015).

The present investigation revealed that the genotype Liver Red exhibited the maximum duration of female phase and the minimum number of days was found in Boroque. Mercy and Dale (1994) noticed that the receptive female phase can be identified by a viscous exudate which was sticky in touch. Several findings in accordance with this result have been reported by Sindhu (1995), Mayadevi (2001), Premna (2003), Madhukumar (2010) and Sheena (2015).

Interphase was identified by the drying up of stigmatic fluid over the candle. Among the 25 genotypes studied, the maximum days for interphase (9.6 days) were found in Liver Red and the minimum was found in the genotype Vezuvious Red (3.4 days). These results were supported by the findings of Renu (2000), Mayadevi (2001), Premna (2003), Pravin (2004), Madhukumar (2010).

The male phase starts, a week after interphase. The present investigation revealed that the duration of male phase ranged from 4.4 days (Esmeralda) to 9.8 days (Arun Gold). Mercy and Dale (1994) found that within 4-8 days, all the anthers on a spadix emerged out. Similar results were obtained by Renu (2000), Pravin (2004), Madhukumar (2010) and Sheena (2015).

An ideal anthurium spadix have angle of inclination less than 45^0 which facilitates it for suitable packing purposes (Mercy and Dale, 1994). In the present study, the maximum value of 72.6^0 exhibited by the genotype Vezuvious Red and the minimum value for inclination of candle with the spathe was noted in the variety Mauritius Orange (41^0). This result was in accordance with the findings of Renu (2000), Mayadevi (2001), Pravin (2004), Madhukumar (2010) and Sheena (2015).

Anthocyanins are the pigments which are responsible for the spathe colour in anthurium. In the present investigation, the anthocyanin content varied from 24.01 mg g^{-1} (Cascade White) to 339.52 mg/g (Liver Red). Similar findings were reported by Asish (2002), Premna (2003), Madhukumar (2010) and Sheena (2015).

Pollen fertility is an important factor that determines the success of hybridization programmes. Among anthurium genotypes pollen sterility is high. The present study revealed that the highest pollen fertility of 42.58 percent was expressed by the genotype Chikoos followed by Liver Red (41.18 per cent) and the lowest pollen fertility per cent of 3.63 was exhibited by the genotype Tropical Peach. The studies of Lalithambika (1978) revealed thatthe pollen sterility of *Anthurium andreanum* is about 70-75 per cent and this confirms with the present study. Mercy and Dale (1994) reported that high pollen sterility in the genotype was an indication of its hybrid nature. Bindu and Mercy (1994) inferred that the high pollen sterility was due to meiotic abnormalities that occur during anaphase. Similar findings were reported by Pravin (2004), Madhukumar (2010) and Sheena (2015).

In the present study low pollen emergence was noticed during March to June and the peak emergence was noticed from November to February. It may be due to the increase in temperature. Similar findings were recorded by Renu (1999), Ravidas (2003), Madhukumar (2010) and Sheena (2015).

The present study revealed that the mean size of pollen ranged from 14.03µ (Can Can) to 24.42µ (Liver Red). Pollen shape ranged from round to oval among the 25 genotypes of anthurium and the pollen colour ranged from cream to white. Significant variation in pollen size was recorded by Premna (2003), Pravin (2004), Madhukumar (2010) and Sheena (2015).

The present investigation found that there was a wide variation among the qualitative characters studied, such as colour of young leaf and petiole, spathe colour, spadix colour and type of inflorescence axis. The colour of young leaves showed variation from green to greenish brown and reddish brown and the colour of young leaves varied from green to light green and to reddish green and also brown to reddish brown. Similar results were obtained by Asish (2002), Madhukumar (2010) and Sheena (2015).

Detailed information about the inheritance of spathe colour was given by Kamemoto *et al.* (1998). The two genes M and O controls the five major colours in anthurium such as red, orange, pink, coral and white. Gene M plays a major role in the production of cyanidin 3-rutinoside and gene O controls the production of pelargonidin 3-rutinoside. If both genes are present in the spathe it may give rise to pink or red spathe. So the varieties which were having red and pink spathe in the present investigation may contain both M and O genes. The variation found in red spathe may be due to the incremental effect of gene M over the gene O. So the intensity of colour can be shown by MMOO < MMOo < MmOO <MmOo. Orange spathe colour was found to be true breeding and the genotype 'mmOO' and the coral colour had a genotype of 'mmOO'. White colour occurs when 'OO' is in combination with M as well as for double recessive 'mmoo'and white breeds true. Pink colour in anthurium was due to recessive epistasis by 'p' allele and the genotype was found to be 'MO pp'. It was found that the dominant P allele had any effect over M and O. In the present study, variation in colour of the spathe ranged from deep maroon, dark red, bright red, red, bright orange, orange, pink, peach, green to chocolate brown. The above data confirms the results reported by

Renu (2000) Premna (2003), Pravin (2004), Madhukumar(2010) and Sheena (2015).

The colour of anthurium candles varied among varieties. Mercy and Dale (1994) reported that the colour variation in anthurium ranged from red, pink and green among ordinary varieties where as in hybrids it ranged from yellow, white, pink or red colours in two or more bands. In the present investigation, the colour of the candle ranged from red, pink, pinkish white, yellow and green and also double colours are noticed in the candle. Significant variation in candle colour was recorded by Mayadevi (2001), Ashish (2002), Premna (2003), Pravin (2004), Madhukumar (2010) and Sheena (2015).

An ideal spadix consists of a straight long inflorescence axis which increases the value of anthurium in the commercial market. In the present study, the type of inflorescence axis showed significant variation among the 25 genotypes of anthurium. It ranged from long thick straight, long thick curved, long thin curved, short thick straight, medium thick straight, medium thin curved. The ideal inflorescence axis was seen in varieties such as Liver Red, Tropical Red, Tropical Peach, Mauritius Orange, Honduras Red and Lady Jane. Similar results were reported by Pravin (2004) and Madhukumar (2010).

5.2 VARIABILITY COMPONENTS

Analysis of variance may not reveal the absolute variability and this could be accessed through standardizing the phenotypic and genotypic variances by obtaining the coefficients of variability. Hence, the components of variation such as genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV) were computed. Further it is essential to separate out the environmental influence from the total variability; for selection. This indicates the accuracy with which a genotype can be identified by its phenotypic performance. The estimates of heritability alone fail to indicate the response to selection. Therefore, the heritability estimates appeared to be more meaningful

when accompanied by estimates of genetic advance. Hence, the genetic advances as per cent mean (GAM) was also estimated.

Variability can be assessed through a simple approach of examining range values. Wide range of variation provides an ample scope for selection of superior and desired genotypes by the plant breeders for further improvement of these characters. The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the traits under study.

The present study, revealed that high PCV and GCV were observed in characters such as number of suckers plant^{-1} followed by anthocyanin content, pollen fertility, number of flowers year^{-1} and leaf area. The variability studies suggest that there is better scope of improvement for these traits by selection. This result was supported by Premna (2003), Pravin (2004), Madhukumar (2010) and Sheena (2015).

The lowest value of PCV and GCV were found in the trait, number of days from emergence to maturity of inflorescence followed by days from emergence to maturity of leaves and duration of female phase. This finding was supported by Ashish (2003), Pravin (2004), Madhukumar (2010) and Sheena (2015).

The difference between the genotypic and phenotypic coefficients of variation was found high for the characters like number of suckers plant^{-1}, leaf area, plant height, number of leaves spadices^{-1} plant^{-1} year^{-1} and internode length. It shows the influence of environment on these characters. The characters like anthocyanin content, pollen size, pollen fertility, inclination of candle with the spathe, life of spadix, spathe size recorded low difference between GCV and PCV and the environmental effect was less on these characters. Similar results were reported by Premna (2003), Pravin (2004) and Madhukumar (2010).

5.3 HERITABILITY AND GENETIC ADVANCE

Estimate of heritability assists breeders to allocate resources necessary to effectively select for desired traits and to achieve maximum genetic gain with little time and resources.

In the present study, high heritability was noticed for characters like anthocyanin content followed by pollen fertility, life of spadix, pollen size, spathe size, duration of inter phase, inclination of candle with the spathe, number of flowers spadix^{-1}, days to initiation of female phase, duration of male phase and spadix length and low heritability was noticed in the character number of suckers plant^{-1}. Similar findings were reported by Premna (2003), Pravin (2004), Madhukumar (2010) and Sheena (2015).

In the present investigation, high genetic advance was found in characters such as number of suckers plant^{-1}, anthocyanin content, pollen fertility, number of flowers year^{-1}, duration of interphase, spadix length, days from initiation of female phase, leaf area, plant height, number of flowers spadix^{-1}, number of leaves spadices^{-1} plant^{-1} year^{-1}, pollen size, spathe size, duration of male phase, inclination of candle with the spathe and internodal length. Low genetic advance was recorded in characters like days from emergence to maturity of inflorescence, days from emergence to maturity of leaves and duration of female phase. These result was in accordance with the results of Mayadevi (2001), Premna (2003), Pravin (2004) and (Sheena, 2015).

Heritability coupled with genetic advance play a vital role in breeding programmes as indicate the additive gene action for selecting the best individuals (Panse and Sukhatme, 1967). In the present study almost all the characters had high heritability and genetic advance except days from emergence to maturity of leaves, days from emergence to maturity of inflorescence, number of suckers plant^{-1} and duration of female phase. Pravin (2004) observed high heritability and high genetic advance in characters such as

pollen fertility, pollen size, number of suckers plant^{-1} and duration of male phase.

5.4 CORRELATION STUDIES

Understanding the interaction of the traits among themselves and with the environment is of great use in plant breeding. Correlation studies provide information on the nature and extent of association between any two quantitative traits. Genetic enhancement of a trait is possible through selection of a correlated trait.

The three types of correlation such as genotypic, phenotypic and environmental correlation among the 20 quantitative characters are discussed here. In the present investigation plant height exhibited significant positive phenotypic correlation with characters like leaf area, number of suckers plant^{-1}, spathe size, number of flowers spadix^{-1}, life of spadix and days to initiation of female phase. If a pair of characters are found to have positive correlation, the improvement in one character will results in the improvement of other character and also vice versa. This was utilized by the plant breeder to select the traits based on correlation, in genetic improvement programmes. Similar finding were reported by Mayadevi (2001), Asish (2002), Premna (2003), Pravin (2004), Madhukumar (2010) and Sheena (2015).

Plant height was found to have positive significant genotypic association with most of the characters except pollen fertility. Life of spadix expressed significant positive correlation with characters like plant height, leaf area, spathe size, spadix length, number of flowers spadix^{-1}, days from initiation of female phase, duration of female phase, duration of interphase and pollen size. Asish (2002) found that the character, life of spadix was positively correlated with leaf area and candle length. Premna (2003) observed significant positive correlation for life of spadix with the characters such as internodal length, leaf area, days from emergence to maturity of inflorescence, candle length and pollen fertility.

Spadix length showed positive significant phenotypic correlation with leaf area, spathe size, number of flowers spadix^{-1}, life of spadix, days from initiation of female phase, duration of female phase, duration of interphase, inclination of candle with the spathe and pollen size. Spadix length had significant positive correlation with characters such as plant height, leaf area, spathe size, number of flowers spadix^{-1}, life of spadix, days from initiation of female phase, duration of female phase, and duration of interphase, inclination of candle with the spathe, pollen fertility and pollen size. Similar results were reported by Renu (2000), Mayadevi (2001), Asish (2002), Pravin (2004) and Madhukumar (2010).

In the present study, plant height was found to have significant positive environmental correlation with anthocyanin content. Environmental correlation between other characters was not significant. This was in agreement with the results of Pravin (2004), Madhukumar (2010) and Sheena (2015).

5.5 COMPATIBILITY STUDIES

The flower of anthurium is protogynous; this makes the crop highly out crossing. The genetic improvement in anthurium can be done by hybridization and selection (Kamemoto and Nakasone, 1955). The new world anthuriums were the results of interspecific hybridization which occurred spontaneously among old species (Kaneko and Kamemoto, 1978). Hybridization between selected parents with good combining ability yields valuable and novel hybrids (Mercy and Dale, 1994).

In the present investigation, the compatibility analysis was carried out on basis of percentage of fruit set and seed germination. Out of the 62 crosses attempted, 26 got successful. Among the successful crosses, 100 percent fruit bearing candle was found in 17 crosses and 50 percent found in 9 crosses. Among the 15 genotypes selected for hybridization, the maximum percentage of candle bearing fruits (100 per cent) was obtained in the genotypes Liver Red, Pistache and Tropical Peach. The minimum zero percentage was exhibited by the genotypes Lucia Pink and Merengue White. Several findings, in accordance with

these results have been reported by Sindhu (1995), Renu (2000), Premna (2003), Pravin (2004), Madhukumar (2010) and Sheena (2015).

The fruit of anthurium is a berry. The fertilized candle could be visually identified from the first month itself. The bulging found in the candle was helpful for easy identification. As the growth of the candle progressed, the candle became swollen and fleshy with the development of berries. In the present study, among the 26 successful cross combination, the highest number of seeds berry^{-1} was found in the cross, (DT x C) and the lowest was found in two crosses such as (CK x DT) and (VR x DT). Mecy and Dale (1994) inferred that a fully fertilized candle consists of 100 to 200 fruits. Similar findings were reported by Renu (2000), Pravin (2004) and Sheena (2015).

One of the major problems in anthurium breeding was the absence of full fruit set among the fertilized candles (Zimmer, 1986). In the present investigation, the percentage of fruit set was below 55 percent for all the successful crosses. The maximum fruit set of 52.63 per cent was expressed by the cross, LR x DT and the minimum of 1.17 percent was found in C x LR. The average percentage of fruit set was the highest in the genotype Liver Red followed by Boroque and the lowest percentage was found in the genotype Chekas. Similar findings were reported by Sindhu (1995), Renu (2000), Premna (2003), Pravin (2004), Madhukumar (2010) and Sheena (2015).

The berries of anthurium were found to have two to three seeds (Zimmer *et al*, 1986). In the present investigation, among the 26 successful cross combinations, almost all the crosses had highest percentage of single seeded berries except (C x DT), (CK x DT), (VR x DT) and (TP x C). Similar results were recorded by Sindhu (1995), Mayadevi (2001), Premna (2003) Pravin (2004), Madhukumar (2010) and Sheena (2015). The present study revealed that the highest germination percentage was in the cross, (HO x C) (69.56 per cent) followed by DT x LR (66.66 per cent) and HR x DT (66.66 per cent) and the lowest was in (P x C) (20 per cent). This results was in accordance with the results of Pravin (2004), Madhukumar (2010) and Sheena (2015).

SUMMARY.....

6. SUMMARY

The present investigation, "Varietal evaluation and genetic improvement of anthurium (*Anthurium andreanum* Linden) through hybridization" was aimed to assess the genetic variability of commercial genotypes of anthurium and to improve them through intervarietal hybridization. The study was carried out at Coconut Research Station, Balaramapuram during 2014 -16. The investigation consisted of two experiments. Experiment I involved the evaluation of twenty five genotypes of anthurium for commercial qualities and selection of fifteen parents suitable for hybridization. Experiment II involved the hybridization and compatibility studies. A brief summary of results was presented below.

Twenty five genotypes of anthurim which comes under the project of State Horticulture Mission at Coconut Research Station, Balaramapuram were utilized for the parental evaluation in experiment I. The plants were raised in pots in a net house. The design used was completely randomized design with five replication. Fifteen parents were selected for hybridization purpose based on vegetative as well as floral characters and crossing was made among them in experiment -II.

Analysis of variance showed that there was wide variation among the twenty five genotypes of anthurium for quantitative characters. The characters includes plant height, leaf size or leaf area, internode length, number of suckers plant^{-1}, number of leaves spadices^{-1} plant^{-1} year^{-1}, days from emergence to maturity of leaves, days from emergence to maturity of inflorescence, number of flowers year^{-1}, spathe size, anthocyanin content, spadix length, inclination of candle with the spathe, number of flowers spadix^{-1}, life of spadix, days to initiation of female phase, duration of female phase, days to inter phase, duration of male phase, pollen fertility and pollen size.

The plant height varied from 22 cm in Nitta Orange to 50.6 cm in Cascade White. The leaf area was the maximum in Cascade White and the minimum in

Nitta Orange. The internode length varied from 1.3 cm in Tropical Peach and 0.66 cm in Chekas. Days from emergence to maturity of leaves were the highest in Liver Red and the lowest in Boroque. Number of leaves spadices $^{-1}$ plant^{-1} year^{-1} was the highest in Honeymoon Red and the lowest was noticed in Tropical Red. Sucker production was the highest in Honeymoon Red.

The number of days for emergence of inflorescence was the maximum in Agnihotri and the minimum in Can Can. The maximum numbers of flowers were produced by Cascade White and Lady Jane and the lowest number of flowers was found in Mauritius Orange and Lucia Pink. The maximum spathe size was noticed for Boroque and the minimum was in Lady Jane. The highest spadix length was exhibited by the variety Chikoos. The maximum number of flowers per spadix exhibited by Chikoos and the minimum number of flowers by Esmeralda. The life of spadix was the maximum in Tropical Red and the minimum in Vezuvious Red.

The number of days for initiation of female phase was the highest in Boroque and the lowest in Vezuvious Red. The duration of female phase was ranged from genotype 9.4 days (Liver Red) to 5.6 days (Boroque). The minimum days for interphase was found in Vezuvious Red. The mean number of days for initiation of female phase ranged from 4.4 to 9.8 days. The ideal inclination of candle with the spathe was exhibited by the variety Mauritius Orange. The anthocyanin content ranged from 24.01 mg/g to 339.52 mg g^{-1} among the twenty five genotypes of anthurium. The highest pollen fertility was noticed in Chikoos followed by Liver Red.

The maximum pollen emergence was found during November to February and the minimum was found from March to June. The pollen size ranged from 14.03μ (Can Can) to 24.42μ (Liver Red). Pollen shape varied from round to oval and the pollen colour ranged from cream to white.

Qualitative characters such as colour of young leaf and petiole, spathe colour, spadix colour and type of inflorescence axis showed a wide variation among the twenty five genotypes of anthurium studied.

Variability studies expressed high GCV and PCV for the characters such as number of suckers plant^{-1}, anthocyanin content, pollen fertility, number of flowers year^{-1} and leaf area. It indicates that improvement in these characters can be done by selection. The lower values of PCV and GCV were found in characters such as days from emergence to maturity of inflorescence, days from emergence to maturity of leaves and duration of female phase.

The characters like number of suckers plant^{-1}, leaf area, plant height, number of leaves spadices^{-1} plant^{-1} year^{-1} and internode length expressed maximum difference between PCV and GCV. This indicates the influence of environment on these characters. High heritability along with high genetic advance was observed in most of the characters studied except days from emergence to maturity of leaves, days from emergence to maturity of inflorescence, number of suckers plant^{-1} and duration of female phase. This indicates the effect of additive gene action. These character can be improved through selection.

Correlation studies showed that plant height had significant positive phenotypic correlation with leaf area, number of suckers plant^{-1}, spathe size, number of flowers spadix^{-1}, life of spadix and days to initiation of female phase. Plant height expressed significant positive genotypic correlation with most of the characters except pollen fertility. The genotypic correlation plays a vital role in breeding programmes. Number of flowers year^{-1} showed positive significant phenotypic correlation with leaf area, spadix length and inclination of candle with the spathe and significant positive genotypic correlation was found with characters such as leaf area and spathe size. Environmental correlation was

absent for most of the characters. But the character plant height was found to have significant positive correlation with anthocyanin content.

Cross compatibility analysis was carried out based on the percentage fruit set and seed germination among the fifteen genotypes of anthurium. Out of the 62 crosses attempted based on the availability of pollen and receptive stigma, 26 crosses got successful. The percentage of fruit bearing candles ranged from 0 to 100 among the fifteen genotypes selected. The maximum percentage of candle bearing fruits was found in the genotypes such as Liver Red, Pistache and Tropical Peach. The maximum number of fruits candle^{-1} was expressed by the cross DT x C (65) and the lowest number was found in CK x DT (3) and VR x DT (3). The average number of fruits candle^{-1} was the highest in the genotype Liver Red (60) and the lowest for Chekas (3) and Vezuvious Red (3). The percentage of fruit set was the highest in LR x DT (52.63 per cent) and it was the lowest in C x LR (1.17 per cent). The berries required 4 to 7 months to mature. The number of days for germination varied from 4 to 9 among the 26 successful crosses of anthurium. Single as well as double seeded berries were noticed in almost all the crosses except C x DT, CK x DT and VR x DT and TP x C. The cross HO x DT exhibited the maximum seed size among the single seeded berries and among the double seeded berries, the cross HO x C was found to have the maximum seed size. The highest percentage of germination was found in the cross H O x C (69.56 per cent) and the lowest for P x C (20 per cent). Among the 26 successful crosses of anthurium, the highest seed germination and medium fruit set were found in the cross HO x C.

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7. REFERENCES

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VARIETAL EVALUATION AND GENETIC IMPROVEMENT IN ANTHURIUM (*Anthurium andreanum* Linden) THROUGH HYBRIDIZATION

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ABSTRACT

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ABSTRACT

The present investigation, "Varietal evaluation and genetic improvement of anthurium (*Anthurium andreanum* Linden) through hybridization" was carried out at Coconut Research Station, Balaramapuram, during 2014 -16, to assess the genetic variability of commercial genotypes of anthurium and improve them through intervarietal hybridization.

Twenty five genotypes of anthurium were evaluated in completely randomized design with five replication to identify suitable parents with commercial qualities.There was wide variation among the qualitative as well as quantitative characters of anthurium. The number of flowers year^{-1} ranged from 1.2 (Lucia Pink, Mauritius Orange) to 4.8 (Cascade White and Lady Jane) and the spathe size ranged from 42.88 cm^2 (Lady Jane) to 101 cm^2 (Boroque).

The number of suckers plant^{-1} exhibited high genotypic coefficient of variation and phenotypic coefficient of variation followed by anthocyanin content, pollen fertility, number of flowers year^{-1} and leaf area. High heritability coupled with high genetic advance found in almost all the characters except days from emergence to maturity of leaves, days from emergence to maturity of inflorescence, number of suckers plant^{-1} and duration of female phase. It indicates additive gene effect and improvement could be made for that character by simple selection based on the phenotypic performance.

The number of flowers year^{-1} showed significant positive phenotypic association with characters like leaf area, spadix length and inclination of candle with the spathe.

Based on the availability of pollen as well as the receptivity of stigma, sixty two crosses were attempted among the fifteen parental genotypes, out of which twenty six were successful.

The percentage of candle bearing berries ranged from 0 to 100. The average number of fruits candle^{-1} was found to be high in the variety Liver Red and it was low in the genotypes, Vezuvious Red and Chekas. The percentage of fruit set was high in Liver Red x Dragon's Tongue and it was low in Chikoos x Liver Red. The cross Hawaiian Orange x Dragon's Tongue exhibited the maximum seed size among the single seeded berries and in double seeded berries, Hawaiian Orange x Chikoos found to had the highest seed size. The percentage of germination was high in Hawaiian Orange x Chikoos and low in Pistache x Chikoos.

The present investigation revealed that there was wide variation in characters among twenty five genotypes of anthurium evaluated. Cross compatibility analysis revealed that the cross Hawaiian Orange x Chikoos have medium fruit set and highest seed germination among all the successful crosses.