GENETIC DIVERGENCE IN *Anthurium andreanum* Linden

By

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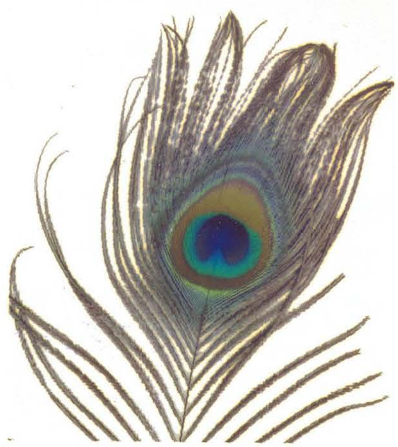

Dedicated

to

"Amma"

DECLARATION

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

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CERTIFICATE

Certified that this thesis entitled **"Genetic divergence in *Anthurium andreanum* Linden"** is a record of research work done independently by **Smt. Mayadevi. P.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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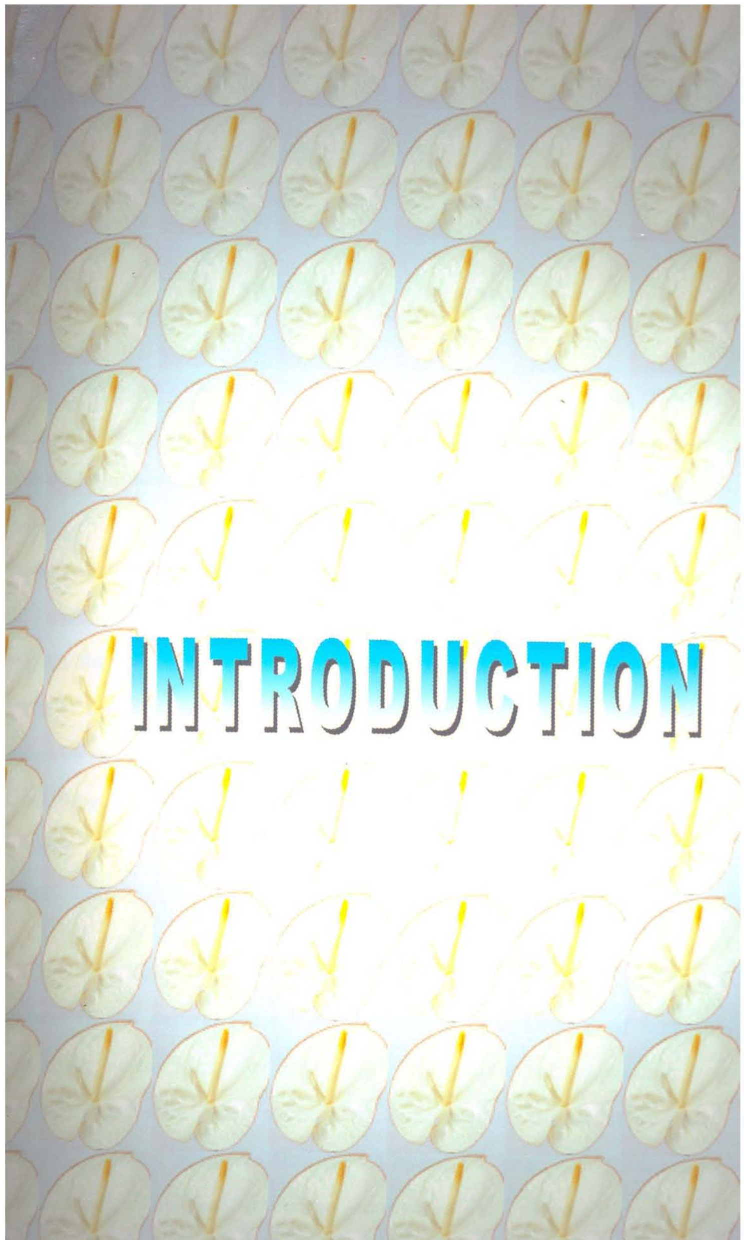
1.	ANOVA	-	Analysis of variance
2.	ANACOVA	-	Analysis of covariance
3.	CD	-	Critical difference
4.	D^2	-	Mahalanobis D^2
5.	EH	-	Economic Heterosis
6.	GA	-	Genetic Advance
7.	GCV	-	Genetic coefficient of variation
8.	gca	-	general combining ability
9.	H^2	-	Heritability (Broad sense)
10.	PCV	-	Phenotypic coefficient of variation
11.	sca	-	Specific combining ability
12.	SE	-	Standard error
13.	t_α	-	Critical value of t at α (5%) level of significance for a given degrees of freedom


INTRODUCTION

1. INTRODUCTION

Anthuriums are cultivated for their colourful long-lasting 'flowers' and handsome foliage. They are gaining popularity as one of the most important commercial ornamental crops of the world. Anthuriums belong to the monocot family Araceae and are native of tropical zones of the central and South America. Of the 700 species reported so far under this genus, only two species are cultivated as popular flowering types. They are *Anthurium andreanum* Linden originated in Columbia ('Oil cloth flower', 'tail flower', 'Palette flower') and *A. scherzerianum* Schott originated in Costa Rica and grown in the tropic and semi-tropic regions for cut flowers ('flamingo flower' or 'flame plant') or as pot plants mainly in Europe. The popular anthurium 'flower' is actually a compound inflorescence called a spadix.

Anthuriums are perennial terrestrial herbs growing as epiphytic climbers in the natural state. *A. andreanum* is somewhat of creeping habit using aerial roots for anchorage, whereas *A. scherzerianum* is a low-growing herbaceous plant. *A. andreanum*, the most common cultivated species, produces flowers all round the year, one flower from each leaf axil. This free flowering sequence of leaf, flower and new leaf is maintained throughout the life of the plant. The domesticated plant is erect with large to small sized ever green leaves. The valuable part of the plant is its showy cordate blistered and glossy spathe which is a modified leaf subtending the fleshy inflorescence bearing small sessile or bisexual flowers called spadix.

A. andreanum is a native of South-West Columbia which was brought to Europe in 1876. From Europe, the species spread to Brazil and Hawaii. Anthurium was introduced to India via England by coffee and tea planters who wanted showy exotic plants for their big bungalows. Even now some of the old tea and coffee plantations in Assam, Darjeeling and Coorg have beautiful and exotic anthurium specimens. Towards the middle of the last centuary, some varieties from Hawaii reached Kalympong of West Bengal the derivatives of which are now known as Kalympong varieties.

A. andreanum is grown exclusively for cut flower production. Major production areas are Hawaii, Netherlands and Mauritius. Anthurium ranks eleventh among cut flowers. The export of anthurium from Mauritius (where it is the national flower) has risen from thirty thousand rupees in 1968 to thirty million rupees in 1990 and the trade is improving due to new market prospects and low cost of cultivation as compared to those in Holland and Hawaii.

Anthurium cut flower production in India is still in its infancy, due to lack of good, elite planting material at reasonable prices and standard cultural practices. It is only very recently that anthurium flowers are seen in the Indian florist shops and a few growers in Salem, Yercaud, Thiruvananthapuram, Kochi, Mercara and Kalympong have started growing Anthurium on large scale for cut flower production (Singh, 1987, 1992).

A. andreanum is an outbreeding species with protogynous flowers. Protogyny is a mechanism to prevent self fertilisation, as the stigmatic surface becomes receptive about 7-10 days before pollen is shed. Cross pollination among selected plants is preferred in commercial seed production. The time required from pollination to the maturity of the seeds is about 4½ to 7½ months.

The present-day flowering anthuriums are mostly hybrids of different varieties involving the two species *A. andreanum* x *A. scherzerianum*. Karyotype analysis and meiotic abnormalities have revealed that there is abundance of genetic variability present in the genus *Anthurium*. This genetic variability presents great scope for achieving crop improvement through controlled hybridisation and selection.

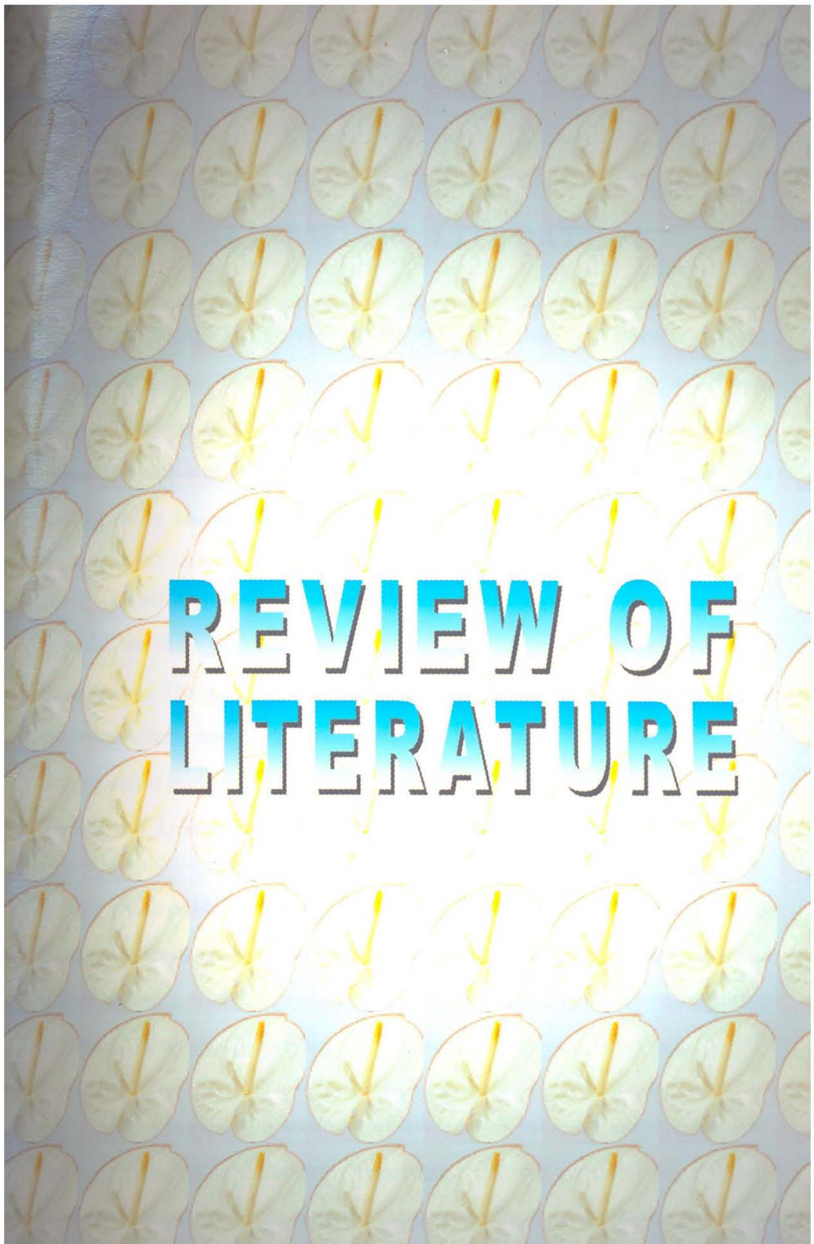
As an export oriented cut flower crop, *Anthurium andreanum* has recently come into economic prominence in Kerala. The warm humid tropical climate of the state can be easily adapted for its wide spread cultivation using green house technology. At present commercial cultivation of anthurium is a field in its infancy in Kerala. Serious constraints such as the lack of suitably adapted good quality planting material at reasonable rates and absence of a steady market are confronting the prospective growers.

A solution to this would be the production of our own indigenous anthurium hybrids with commercial qualities through a vigorous long term breeding programmes.

Hybridisation and selection is the most common and proven method used for improving anthuriums (Kamemoto and Nakasone, 1955). Hybridisation between selected varieties with good combining ability can be used for evolving valuable anthurium hybrids with desirable plant characters such as compact plant type, medium sized leaves, heart shaped spathe, wrinkled spathe texture, slender, short, downward curving candles and straight, long inflorescence axis (Mercy and Dale, 1994).

Cross compatibility in different commercially important varieties of *A. andreanum* by intervarietal hybridisation has been reported by several workers (Sheffer and Kamemoto, 1976; Sindhu, 1995 and Renu, 2000). A pioneering attempt along this line has been initiated in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani some years back which has produced a large number of indigenous anthurium hybrids.

The present study is undertaken with the aim of studying the divergence of 100 genotypes (selected from the above programme) based on multiple characters through clustering by the application of D^2 statistic for selection. As the genus *Anthurium* has a long history of hybridisation in its background, the 20 varieties and their hybrids taken as the experimental materials were all highly heterozygous. The gene action, combining ability analysis and heterosis of five selected parents and their hybrids were also worked out.


REVIEW OF
LITERATURE

2. REVIEW OF LITERATURE

Anthurium is the latest sensation of the Indian floriculture scene and it had gained wide acceptance among the growers, traders and flower lovers. The only species of commercial value in the tropics is *A. andreanum* which is a native of Columbia. The warm humid tropical climate of Kerala can be easily adapted for its widespread cultivation.

Genetic variability and divergence are of great interest to the plant breeder as they play a vital role in framing a successful breeding programme. The genetically diverse parents are likely to produce high heterotic effects and desirable segregates. The multivariate analysis (D^2) is a powerful tool to measure genetic divergence within a set of genotypes (Murty and Arunachalam, 1966).

Since published work on *A. andreanum* is scanty, the present study has been undertaken with hundred anthurium genotypes to understand the nature and magnitude of genetic divergence and the characters contributing to genetic diversity in the species by using the D^2 statistic.

The concept of a measure of divergence between populations was first introduced and further developed on the theoretical side by Mahalanobis (1925). A measure of group distance based on multiple characters was given by Mahalanobis (1928). In 1936, Mahalanobis suggested the generalized distance which has become the standard measure of distance between two populations when all the observed characters are quantitative.

D^2 analysis has also been effectively employed for identification of traits contributing to genetic divergence and grouping of cultivars in vegetatively propagated crops like banana (Valsalakumari *et al.*, 1985; Mercy and George, 1987, 1988) and sugarcane (Punia *et al.*, 1983; Santhi, 1989).

No work has been reported so far in anthurium on this aspect. A review of few works relevant to this crop is attempted here.

2.1. Cultivation aspects

Anthuriums requires a warm green house with 75 per cent shading from direct sunlight and an atmospheric humidity 70-80 per cent humid condition. The temperature range is between 25 and 28°C during the day and 18 and 22°C during the night with optimum being 22° to 25°C. The relative humidity is also very important for growth and development of anthurium, the optimum being around 75 per cent. The morphological characters, flower production and quality of flowers are affected by the intensity of light. The optimum shade requirement is 75 per cent (Mercy and Dale, 1994).

Anthurium needs a light, well drained medium rich in organic matter and with good aeration and water holding capacity. They are usually grown in a medium consisting of sand, cowdung, brick pieces, charcoal and coconut husk in Kerala which can provide 100 per cent drainage (Mercy and Dale, 1994).

2.2. Nutrition

According to Steen and Vijverberg (1973), neither nitrogen or potash had any significant effect on flower yield in the Netherlands. The plants were fertilized with nitrate of lime and or potassium sulphate immediately after planting and five months later, or else, were left unfertilized and all the plants grew equally well.

Colour break down of spathe tissue of anthurium is a typical symptom of Ca deficiency. Calcium application significantly reduced this disorder (Higaki *et al.*, 1980).

A. andreanum cv. 'Lady Jane' was grown with a weekly application of 20:20:20 NPK fertilizer at 200, 400, 600 and 800 mg/litre, and the plant growth was best at the lower two fertilizer levels. Higher levels were found to be detrimental (Henny and Fooshee, 1988).

Higaki *et al.* (1992) and Holley *et al.* (1994) reported that the maximum flower yield in anthurium was obtained when leaf tissue level was 1.87 per cent for N, 0.17 per cent for P and 2.07 per cent of K. Stem length and flower size were maximum with leaf N at 1.59 per cent and K at 1.67 per cent. However, no relationship was observed between the P content in leaves and flower size or stem length.

Studies in the Kerala Agricultural University (Salvi, 1997) revealed that application of NPK fertilizer complex of 17:17:17 @ 1 per cent at weekly intervals produced the maximum height and increased other biometrical characters in *A. andreanum* cv. 'Hawaiian Red'.

2.3. Growth regulators

Nakasone and Kamemoto (1962) reported that light intensity and GA_3 concentration are important factors in regulating flower production in anthurium.

Application of GA, BA and Ethephon at 750 and 1500 ppm was tried in *A. andreanum* cv. 'Hawaiian Red' (Salvi, 1997). BA 750 ppm at monthly interval period produced more plant height, leaf length, breadth and petiole length. GA performed better than BA and Ethephon.

2.4. Plant height

Tisdale *et al.*, (1985) reported that plant height can be used as an index of plant growth.

Higaki and Imamura (1988) found that the height of plants gradually decreased with increasing pH upto 8.0.

According to Bindu and Mercy (1994), the five varieties of the genus *Anthurium* studied by them showed significant variation in plant height, ranging from 45 cm in the var. 'Lady Jane' to 85 cm in the var. 'Pink'.

Sindhu (1995) recorded the height of six varieties of *A. andreanum* which ranged from 43 cm to 70 cm.

In a study on the anthurium cv. 'Hawaiian Red', Salvi (1997) observed that the plant height was superior under 70 per cent shade + 750 ppm BA. In another study on the same variety Abdussammed (1999) concluded that nutrients significantly influenced plant height, both in ground as well as in pot planting.

Renu (2000) recorded significant variation in plant height ranging from 29.7 cm in the var. 'Midori Green' to 70.9 cm in 'Pompon Red'. The varieties 'Liver Red' and 'Mauritius Orange' also were tall, with heights almost on par with that of 'Pompon Red'.

2.5. Number of leaves / spadices per year

Morphological studies conducted by Christensen (1971) showed that *A. andreanum* had a long juvenile phase of vegetative growth followed by a generative phase in which flower buds were produced.

Steen and Vigverberg (1973) on comparing the productivity and inflorescence quality of 120 individual anthurium plants found that their productivity was highly variable ranging from four to sixteen flowers over two years. Leffering (1975) observed that in plants that received 45 per cent of available light, productivity increased from 5 to 12 flowers per plant per year.

On the basis of a study conducted on a variety 'Ozaki', Higaki and Poole (1978) it was concluded that flower production increased with age of the plant.

Higaki and Rasmussen (1979) found that anthuriums are slow-growing producing only six to eight new leaves and vegetative buds on a stem axis per year.

Gajek and Schwarz (1980) are of opinion that there is a close correlation between the number of leaves and number of flowers.

Klapwijk and Spek (1984) studied the monthly pattern of leaf formation for four years in some *A. andreanum* cultivars. The average leaf number / m^2 of glass house space rose from 1.5 in March to 5.0 in June, decling thereafter until the following March.

Singh (1987) observed that the most commonly cultivated varieties produced flower all round the year at the rate of one flower from each leaf axil. The sequence of leaf, flower and new leaf was maintained throughout the life of the plant.

Criley (1989) reported that anthurium grows slowly, producing only six to eight new leaves and vegetative buds on a stem axis per year.

Ray (1990) observed that a switch over from monopodial to homeophyllus sympodial growth was common in the genus *Anthurium*. In homeophyllus sympodial growth each renewal shoot produced a fixed number of leaves.

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

Sindhu (1995) has recorded that the number of spadices produced annually by an anthurium plant varied from four to eight.

Abdussammed (1999) revealed that the effects of nutrients and growth regulators on interval of flower production was not significant.

In a recent study on ten varieties of *A. andreanum*, Renu (2000) showed that one spadix each was produced from the axil of each leaf so that the number of leaves and number of spadices produced annually per plant was the same. The annual production of leaves or spadices was the highest in 'Lady Jane Red' (7.6) followed by 'Liver Red' and 'Pompon Red'.

2.6. Spathe size

The spathe is the most attractive and valuable part of the flower.

The size of spathe is a commercially important trait of anthurium flowers. Criley (1989) recorded that the spathe size could be derived as a measure of length x width (cm).

In a study conducted on the effect of different media and fertilizer levels on *A. andreanum* cv. 'Ozaki Red', Higaki and Poole (1978) noticed that flower size increased with age of the plant.

Based on the United States Department of Agriculture Standards, Singh (1987) proposed 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).

In a study of five varieties of *A. andreanum*, Bindu and Mercy (1994) observed the largest spathe size for 'Pink' (10.4 + 9.7 cm) and the smallest for 'Lady Jane' (6.5 + 3.5 cm). In a similar study Sindhu (1995) found that the varieties 'Pink' and 'Kalympong Red' produced super large flowers and the smallest were produced in the variety 'Miniature White'.

The variety 'Ruth Morat' syn. 'Lady Ruth' had spathes larger than those of variety 'Lady Jane', with a mean width and length of 5.01 and 7.68 cm respectively (Oglesby Plant Laboratory Inc., 1996). Henny (1999) recorded that the new variety *Anthurium andreanum* Red Hot had spathes six to seven cm long and four to five cm wide.

2.7. Suckering ability

Suckering is the natural method of vegetative propagation in anthurium and the ability to produce suckers is a very desirable attribute for commercial varieties.

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

Mercy and Dale (1994) reported that propagation of anthurium using suckers was a very slow and undependable process because most of the good commercial and hybrid varieties were very shy suckering or did not sucker at all. 'Pink' is a profusely suckering variety but the variety is not valuable commercially. Foliar spraying with Gibbberellic acid (GA) or Benzyl adenine (BA) (500-1000 ppm) was found to increase sucker production. Sindhu (1995) noticed maximum number of suckers in the variety 'Pink' and the least in 'Kalympong Red'.

Salvi (1997) inferred that a treatment combination of 80 per cent shade and 750 ppm BA was the best for maximising sucker production. Abdussammed (1999) observed that nutrients failed to make any significant influence on the number of suckers produced per plant, but application of growth regulators significantly increased the sucker production in *A. andreanum*. The highest values were recorded for GA 1000 ppm which was on par with a combination of BA and GA, at 250 ppm each.

Among the ten varieties of anthurium studied by Renu (2000), it was seen that sucker producing ability is an important trait considered in the selection of superior types. It was very high for varieties 'Liver Red', 'Lady Jane' and 'Ceylon Red', medium for varieties 'Midori Green', 'Mauritius Orange' and 'Nitta Orange', low for varieties 'Merengue White' and 'Dragon's Tongue Red' and very low for varieties 'Pompon Red' and 'Tropical Red'.

2.8. Leaf size

Medium sized leaf is considered best for an ideal commercial anthurium plant type as plants with medium leaves are more compact and occupy less green house space than those with large spready leaves.

Sheffer and Kamemoto (1978) made crosses between *Anthurium scherzerianum* and *A. wendlingerri* to produce a hybrid and they observed the leaf size of parents and hybrids for comparison and found that the length and position of the leaf blade were intermediate between the highly contrasting characters of the parental species.

Among the five varieties of *A. andreanum* studied by Bindu (1992), the length of leaves ranged from 13.5 cm to 26 cm and width from 8.7 cm to 23 cm. Leaf size was maximum for 'Pink' and minimum for 'Lady Jane' and 'Chilli Red'.

Mercy and Dale (1994) were of opinion that the leaves of commercially valuable floral anthuriums should be small to medium sized, narrow and elongated. Large and exuberantly growing leaves indicated primitiveness and were undesirable.

Sindhu (1995) observed that 'Pink' variety produced bigger sized leaves where as 'White' and 'Chilli Red' produced smaller sized leaves. The latter two varieties are commercially more valuable than 'Pink'.

Salvi (1997) in *Anthurium andreanum* var. 'Hawaiian Red' reported that the leaf length and breadth were significantly influenced by shade and growth regulators. The treatment combination 60 per cent shade + Hoagland solution + 750 ppm BA produced the longest leaves (10.50 cm) while 60 per cent shade + fertilizer complex + 750 ppm BA produced the broadest leaves (8.00 cm).

Abdussammed (1999) reported that the leaf length, breadth and leaf area were not influenced significantly by the nutrients either in ground or pot planting.

2.9. Spathe colour

Spathe colour varies from pure white to deep maroon among the popular commercial varieties of anthurium. Pastal shades such as white, light pink, coral, light orange etc. are preferred in countries like China, Japan and Korea while darker shades are preferred in the middle east, USA, Singapore and Malaysia. The presence of 3-cyanidin glycoside and 1-pelargonidin glycoside in the spathes of *A. andreanum* was identified by Forsyth and Simmonds, 1954, while the major spathe colours reported by them were red, orange, pink, green and white.

Birdsey (1956) described the spathe of native *A. andreanum* from Columbia as orange scarlet or vermilion whereas the commercial varieties showed a complete colour range from white to dark red. According to Lowry (1972), spathes of all the cultivars of anthurium contained both pelargonidin and cyanidin 3-rutinoside pigments.

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

The presence of anthocyanins in the spathes of *A. andreanum* cultivars was reported by Iwata *et al.* (1979) who identified the pigments to be cyanidin 3-rhamnosyl glucoside and pelargonidin 3-rhamnosyl-glucoside. They also analysed the genetics of spathe colour and found that both the pigments were present in the red cultivars 'Ozaki', 'Kaumana', 'Kozohara', 'Kansako No. 1' and 'Nakazawa' and in the pink cultivar, 'Marian Seefurth'. The orange and coral coloured spathes contained only pelargonidin 3-rhamnosyl glucoside. In white varieties either pelargonidin pigment or both cyanidin and pelargonidin pigments are absent.

Maurer (1979) while describing the techniques of cross pollinating in *A. scherzerianum*, discussed the presence of recessive characters ie., A = with anthocyanin and a = without anthocyanin, B = whole spathe coloured and b = spotted spathe. When the parents were Aa / Bb, the descendants were 9 red (AB), 3 red spots on white (Abb-) and 4 white (aaB- and aabb).

Iwata *et al.* (1985) inferred that the spathe colour in anthurium was determined by the relative concentrations of anthocyanins : a pre dominance of cyanidin 3 - rhamnosyl glucoside resulted in pink to red colours, whereas a predominance of pelargonidin 3-rhamnosyl glucoside resulted in coral to orange. Another pigment flavone present in large and variable amounts was characterized; but not demonstrated to have a modifying effect on cyanic shades.

Henny *et al.* (1988) reported that the hybrid 'Southern Blush' produced through interspecific hybridization, had a medium pink spathe and with a slight lavender tint.

Based on detailed analysis on the genetics of spathe colours in anthuriums, Kamemoto *et al.* (1988) concluded that two major genes, M and O were responsible for the five major colours in *A. andreanum* : red, orange, pink, coral and white. The dosages of M and O genes affect colours. The gene M was found to control the production of cyanidin 3-rutinoside and gene O controlled that of pelargonidin 3-rutinoside. Red and pink resulted when both M and O genes are present with pink being the double heterozygote and orange and coral resulted when only 0 gene was present. The double recessive mmoo produced white. The recessive oo is epistatic to M, and therefore white resulted when both were recessive (mMoo) or M was in combination with recessive oo (MMoo, Mmoo). Orange and white were found to be true breeding. The incremental effects of M was greater than that of O, and therefore the intensity of colours decreased from MMOO, MMOo, MmOO to MmOo. Orange is mmOO and coral is mmOo.

Criley (1989) classified the colours of the important cultivars and new introductions in Hawaii according to the Royal Horticultural Society colour chart.

Wannakrairoj and Kamemoto (1990) in their study on the inheritance of purple spathe in anthurium, proposed a scheme for the genetic control of purple spathe colour. A recessive allele 'p' modified the colour of anthocyanins controlled by M and O loci *ie.*, recessive epistasis. They found that a spathe was purple when the genotype was M-O-pp. If the P locus was dominant, M-O-PP was red, while mmOO-PP was orange and mm O-PP was coral. The P allele has no effect on the white genotypes whether it is dominant or recessive.

Mercy and Dale (1994) reported that the colour of spathe fades gradually as flowers get older. After fertilization of candle, the spathe becomes gradually green and photosynthetic. They also reported that spathe colours varied from white to pink to coral to orange to brown to red to crimson to deep maroon and some varieties had spathes of two or more colours.

Sindhu (1995) observed that the dark and brightly coloured flowers, which are commercially important, were produced by the varieties 'Chilli Red' and 'Kalympong Red'.

Abdussammed (1999) found that the anthocyanin content of *Anthurium* cv. 'Hawaiian Red' was significantly altered under different levels of growth regulator and nutrient treatments. The highest values for anthocyanin content in ground and pot for nutrient were 85.07 mg/g and 93.9 mg/g respectively, while for growth regulator, the corresponding values were 67.88 mg/g and 84.18 mg/g respectively.

Henny (1999) described that the new anthurium hybrid 'Red Hot' had spathes that were medium red at anthesis, which changed to a lighter red prior to senescence.

Spathe colour of ten varieties studied by Renu (2000) ranged from deep maroon to dark red, bright red, red, light orange to dark orange, light green and white.

2.10. Spathe texture

A blistered crickled spathe texture is commercially preferred over a smooth spathe as the former is much more visually attractive.

According to Birdsey (1956), Linden described the spathe of *A. andreanum* and its varying degrees of smoothness and blistering.

Arndt (1991) described the spathe of *A. scherzerianum* variety 'Arabella' as, broad with free lobes and a shallow sinus. Mercy and Dale (1994) suggested that the spathe in floral anthuriums may be smooth, thick and glossy without prominent veins or it may be thinner, deeply veined and blistered.

Sindhu (1995) noticed that the variety 'Honeymoon Red' had smooth, thick and glossy spathes without prominent veins while 'Pink' and 'White' had smooth, thin and lightly veined spathes. 'Kalympong Red', 'Kalympong Orange' and 'Chilli Red' showed intermediate spathe texture and deep to shallow blisters.

Renu (2000) described the spathe texture in ten varieties of anthurium as thick smooth glossy, thin smooth glossy, thin shallowly blistered glossy, medium - thick shallowly blistered glossy, thick medium blistered, glossy and thick deeply blistered glossy.

2.11. Candle length

The candle (spadix) is the inflorescence proper, bearing small bisexual flowers embedded in slanting rows in an acropetal succession. The larger the candle, the more the number of flowers. Commercially, slender and short candles are preferred over long thick candles.

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

2.12. Candle colour

In non-commercial and semi-commercial varieties like 'Honeymoon Red', 'Pink', 'White' etc. candles of single solid colours are usually seen. However most of the new hybrid varieties have double coloured candles.

Gajek and Schwarz (1980) identified the anthurium variety 'Iga-Gold' with Shiny red spathe and a white candle with yellow tip and variety 'Ellrina' with light salmon spathe and sulphur yellow spadix to be the best suited for green house cultivation.

Arndt (1991) reported that *A. scherzerianum* variety 'Arabella' as having red spathe and candle. Observations by Mercy and Dale (1994) revealed that the candle had a single colour red, pink or green in ordinary anthurium varieties and hybrids had candles with yellow, white, pink or red colours in two or more bands.

While studying six varieties of *A. andreanum* Sindhu (1995) observed that the candle had either a single colour or two bands of colours. The new anthurium hybrid 'Red Hot' is reported to have a candle which is orange-red apically, blending to red basally (Henny, 1999).

Renu (2000) in her study on ten varieties of *A. andreanum* observed that the candle had a single colour of pink, light pink, yellow, light yellow, green, light green and pink.

2.13. Inclination of candle

A downward curving candle is an extremely desirable character for commercial anthurium varieties and this helps in packing a larger number of inflorescence in a box during transportation.

Arndt (1991) described the *A. scherzerianum* hybrid 'Arabella' as having red spathe with recurving spadix.

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

In an investigation by Sindhu (1995) the maximum angle of 75° between the base of candle to the plane of spathe was observed in the var. 'Honeymoon Red', which was not desirable. The ideal anthurium spadix with an angle less than 45° were found in varieties 'Chilli Red', 'Kalympong Orange' and 'Kalympong Red'.

2.14. Number of flowers per candle

The larger the candle, the more the number of flowers per candle. Though varieties like 'Honeymoon Red' and 'Pink' have large candles with flowers up to 400 or more, they are not preferred and these varieties are non-commercial. Ideal commercial varieties have smaller candles with a lesser number of flowers.

Watson and Shirakawa (1967) observed that the anthurium flower consisted of a modified leaf, the spathe and a flower, bear spadix with over 300 spirally attached minute flowers. Croat and Bunting (1978) reported that the flower of anthurium were bisexual and was closely congested on cylindrical spikes and arranged in a series of spirals on the spadix.

Singh (1987) reported that the structure which is commonly called the anthurium flower is a combination of colourful modified leaf (spathe) and hundreds of small flowers on the pencil - like protrusion (spadix), the flowers are arranged in a series of spirals, both spadix and spathe are borne on a leafless stalk or peduncle.

According to Bindu and Mercy (1994), anthurium 'flower' had a candle bearing about 50-150 sessile flowers. Mercy and Dale (1994) reported that anthurium 'flower' was actually an inflorescence termed 'spadix' which is racemose with a slender floral axis (candle) bearing 150 to 350 bisexual sessile flowers in acropetal succession.

Sindhu (1995) observed that the average number of flowers produced was maximum in 'Pink' and 'Honeymoon Red' varieties (325 flowers) and the lowest in 'Chilli Red' (175 flowers).

In a study of ten varieties of *A. andreanum*, Renu (2000) observed that the number of flowers per candle varied from variety to variety. It ranged from 254 in 'Tropical Red' to 450 in 'Lady Jane Red'.

2.15. Life of spadix

Paull (1982) recorded the visible changes accompanying the senescence of anthurium flowers as spathe - gloss loss, necrosis of spadix and greening of spathe and spadix. These changes were non reversible processes leading to the death of spadix.

Mercy and Dale (1994) reported that the life of an unfertilized spadix was about two months while that of a fertilized inflorescence was about 4-7 months. Senescence was marked by yellowing of peduncle followed by withering of spathe and candle.

The life of unfertilized spadix was observed by Sindhu (1995) and it ranged from one and a half months in 'Kalympong Orange' to three and a half months in 'Honeymoon Red'. For fertilized spadices, this period ranged from four and a half to eight months.

According to Salvi (1997) among different growth regulators, BA-1500 ppm gave maximum longevity to spadix ie., 152.81 days in the variety 'Hawaiian Red'.

In *Anthurium andreanum* cv. 'Agnihotri', the longevity of spadix was maximum with 1000 ppm GA which was on par with 1500 ppm GA (Valsalakumari *et al.*, 1998). Abdussammed (1999) observed that combined application of BA + GA - 250 ppm recorded the highest longevity of spadix.

Among the ten *A. andreanum* varieties studied by Renu (2000), the time span from emergence of a spathe to its senescence varied from 2.5 months in 'Nitta Orange' to 3.7 months in 'Ceylon Red', in the case of unfertilized spadices. For fertilized spadices, the life span was found to be higher, ranging from about 3.8 to 7.5 months.

2.16. Days to initiation of female phase

Croat (1980) reported that in *Anthurium* species, maturation of flowers was intiated generally from the basal portion of the spadix (candle) and the development proceeds acropetally towards the apex. However *A. andreanum* was not included among the protogynous species of anthurium listed by him.

In 1994, Mercy and Dale reported that the flowers of *A. andreanum* are protogynous and the female reproductive structure or gynoecium reached receptivity about 4-7 days after the opening of the spathe.

In the six varieties studied by Sindhu (1995), the days to initiation of female phase occurred within a period upto 10 days, after opening of spathe, with the variety 'Honeymoon Red' showing the longest period for female phase intiation.

In a study of ten varieties of *A. andreanum*, Renu (2000) observed that the mean number of days to initiation of female phase ranged from 3.6 in variety 'Lady Jane Red' to 6.8 in variety 'Mauritius Orange'.

2.17. Number of days of female phase

Daumann (1921) showed that pistillate phase can be discerned by stigmatic droplets which were formed as the stigma becomes receptive.

Croat (1980) observed that the duration of female phase in *Anthurium* species may range from as short as half a day in *A. ravenii* to 28 days in *A. caperatum* and *A. luteynii*.

Mercy and Dale (1994) reported that receptive female phase can be detected easily by an experienced eye, as a viscous, sticky-to-touch and colourless exudate is secreted by receptive stigmas at this time. Some insect activity also may be seen at this time. The receptive female phase lasted for three to seven days in different varieties.

According to Bindu and Mercy (1994) the female phase varied from three to twelve days in the five varieties of *A. andreanum* studied by them.

Sindhu (1995) noticed that the duration of female phase ranged from 5 to 25 days with the variety 'Chilli Red' showing the shortest period. The Kalympong varieties remained in female phase for longer periods.

The duration of female phase in the ten varieties studied by Renu (2000) varied from 6.4 in variety 'Lady Jane Red' to 16.4 days in variety 'Mauritius Orange'. But there were individual flowers in which the female phase lasted upto 21 days and this was observed in variety 'Mauritius Orange'.

2.18. Duration of male phase

Croat (1980) observed that the initiation of stamen emergence appeared to be equal from all parts of the spadix or intial maturation and staminal exertion appeared for many flowers in the basal fourth, basal third or basal half of the candle and further development proceeded in a systematic manner from base to tip.

Bindu and Mercy (1994) reported that the duration of male phase ranged from 3 to 7 days in the five *A. andreanum* varieties studied by them. They also noticed that the anther exertion started from the base and proceeded regularly towards the apex in all the varieties studied. They also found that during rainy season the male phase may sometimes be completely suppressed.

According to Mercy and Dale (1994), all the anthers on a candle emerged in about 4-8 days. They also noted that the male phase may be suppressed for long or short periods and that anther emergence is comparatively less during the months of March to July.

Sindhu (1995) concluded that the male phase may range from 3-8 days depending on the variety. She also noticed irregular appearance of stamens on the candle.

Among the ten varieties studied by Renu (2000), the average number of days for which the candles remained in male phase ranged from 5.4 days in variety 'Mauritius Orange' to 10.4 days in variety 'Tropical Red'. Scattered anther emergence on the candle was observed in the variety 'Mauritius Orange'.

2.19. Days of interphase

The interval period between female and male was several days in most *Anthurium* species, whereas in a few of them the time lag was so short that it was not certain whether the species involved were homogamous or protogynous (Croat, 1980).

Bindu and Mercy (1994) observed that stigmatic droplets dry up before any stamens emerged out. The interphase of five varieties studied by them ranged from four to seven days. They also found that during rainy season, the interphase is prolonged.

In a study by Sindhu (1995) the interphase in *A. andreanum* ranged from four to ten days. Prolonged interphase with the suppression of male phase was observed from March to August in several varieties.

Renu (2000) recorded that the interphase between the female and male phase was marked by the drying up of stigmatic droplets. Observations from the seven varieties studied showed that the interphase may range from 4.8 to 10.2 days. The variety 'Liver Red' had the longest interphase period while variety 'Merengue White' the shortest. Days of interphase and male phase could not be recorded for the varieties 'Pompon Red', 'Nitta Orange' and 'Midori Green' in which no pollen production was observed during the period of the study.

2.20. Pollen fertility

Stanley and Linskens (1974) observed that the appearance of the pollen alone, even at collection time is not always a good index of viability. So pollen fertility is tested either by using specific stains or by *in vitro* growth studies for correct assessment of pollen fertility and viability.

Mitu and Acatrinei (1974) reported that germination of pollen grain was proportional to pollen grain stainability.

According to Lalithambika (1978) the pollen sterility of different species of *Anthurium* varied from 63.0 per cent (*A. cordatum*) to 96.5 per cent (*A. veitchii*). She noticed a pollen sterility of 70-75 per cent for *A. andreanum*. Satyadas (1985) also noticed that the pollen sterility varied from 67 per cent (*A. warocqueanum*) to 80 per cent (*A. ornatum*).

Bindu and Mercy (1994) in a study of five varieties of *A. andreanum* noticed that the pollen fertility ranged from 20.4 per cent in 'Honeymoon Red' to 28.8 per cent in 'Pink', using the acetocarmine staining method. Pollen fertility assessed using in vitro pollen germination method varied from 9.7 per cent in variety 'Lady Jane' (pink) to 17.9 per cent in variety 'Pink'. They inferred that the high pollen sterility in *A. andreanum* may be due to its hybrid nature. They concluded that the low fertility can also be due to the high degree of meiotic abnormalities like clumping, lagging of chromosomes at anaphase, unequal segregation, chromosome elimination through micronuclei etc. found in *A. andreanum*.

Renu (2000) estimated the pollen fertility of ten varieties of anthurium using acetocarmine method. The results revealed that variety 'Liver Red' had the highest pollen fertility of 42 per cent followed by varieties 'Tropical Red' (29 per cent) and 'Dragon's Tongue Red' (28 per cent). The lowest values were recorded for varieties 'Lady Jane Red' (14 per cent) and 'Mauritius Orange' (13.7 per cent).

2.21. Pollen emergence pattern

Sindhu (1995) observed that the interphase was prolonged with the suppression of male phase from March to August. In *A. andreanum* anthesis occurs on sunny days between 8 to 10 am and on cloudy and rainy days anther dehiscence is delayed (Mercy and Dale, 1994).

Renu (2000) revealed that anther dehiscence occurred in the early morning hours between 8 and 10 am. Pollen emergence pattern during the period of one year from August, 1998 to July, 1999 was analysed using Cochrans Q test for equality of proportion. The value of Q was found to be significant which showed that there was significant difference among the varieties with respect to pollen emergence pattern. No pollen emergence was recorded for the varieties 'Pompon Red', 'Nitta Orange' and 'Midori Green' during that year. Also the emergence of pollen was found to follow a regular pattern in all the varieties except 'Merengue White'. In all the varieties, the pollen emergence was low in the months from March to June, during which the average maximum and minimum temperatures were higher than the rest of the months. Pollen emergence was highest during October-November-December months.

2.22. Stage of harvest

The 'flowers' are harvested after the unfolding of the spathe is complete. The appearance of female phase on the spadix is also used as a criterion for harvesting the inflorescence.

According to Kamemoto (1962) 'flowers' are cut at the leaf axil when one third to three quarters of the bisexual flowers embedded in the fleshy spadix are open.

Antoine (1994) opined that the 'flowers' are harvested in the morning with their long stalks and most blooms are harvested at about three quarters maturity because at this time it is believed that they have the longest shelf life as cut flowers.

The spadices are cut for sale along with their long stalks when the spathes are fully opened and the candles show about one-third to two thirds, female phase maturity, mostly around 7-10 days after spathe opening (Mercy and Dale, 1994).

According to Prasad *et al.* (1996) anthurium 'flowers' are harvested when the spathe completely unfurls and the spadix is well developed. When one-third of the true flowers on the spadix mature, a change of colour can be observed that moves from base to tip of the spadix and at that stage, the flowers are harvested. Singh (1998) had specified that anthurium flowers are harvested when three quarters of the stigmas along the spadix have become receptive.

Salvi (1997) reported that in inflorescence having 1/3rd flowers opened on spadix, the spathe blueing and gloss loss were late (20.0 and 22.3 days, respectively) and it also had the longest vase life (23.33 days).

2.23. Compatibility studies

Kamemoto and Nakasone (1955) reported that hybridization and selection were the common methods for improving anthuriums. They identified that character to be selected were flower productivity, spathe colour, shape and texture, short internodes and suckering ability. Controlled hybridization indicated that neither white nor red flower colour exhibited dominance and pink was an intermediate heterozygous condition.

Spathe colour inheritance in *A. andreanum* was studied by several workers based on intraspecific and interspecific hybridization (Kamemoto and Nakasone, 1955, 1963, Kamemoto *et al.*, 1969; Sheffer and Kamemoto, 1977).

Birdsey (1956) attributed much of the variation in blistering patterns of spathes of *A. andreanum* to hybridization of this species with *A. lindenianum*, *A. ornatum* and *A. nymphaefolium* and suggested the name *A. cultorum* to highlight the hybrid character.

Selection has been widely used as a method to develop suitable cultivars in the major anthurium producing countries. Of 113 clones evaluated by Kamemoto and Nakasone (1963), 13 were recommended for commercial cut flower production. Two cultivars ie., ''Uniwai' (an exceptionally high yielding white) and 'Marian Seefurth' with a rose coloured spathe were evolved by clonal selection. They also postulated that the inheritance of spathe colour was under the control of multiple alleles and modifying genes. The presence of both the orange and magenta pigments in the pink cultivar, 'Marian Seefurth' which arose from nine crosses between a white clone and a pink clone, substantiates the hypothesis that separate genes designated as M and O are responsible for the production of magenta and orange pigments respectively.

Two seedling selections, 'Anuenue' and 'Chameleon' for cut flower production and a compact clone Red Elf suitable for pot growing were described by Kamemoto *et al.* (1969).

Sheffer and Kamemoto (1976) evaluated the interspecific cross compatibilities among 56 species of *Anthurium* and they concluded that interspecific hybrids with *A. andreanum* and *A. scherzerianum* were not readily obtainable. But they got hybrids of *A. andreanum* with six other closely related species.

Sheffer and Kamemoto (1977) observed good cross compatibility among *A. andreanum*, *A. nymphaefolium* and *A. pinchinchae*. Using this, they developed some cultivars, all of which successfully flowered.

Kaneko and Kamemoto (1978) reported the chromosome numbers 2n = 30 for *A. andreanum* Linden 'Kaumana' and 2n = 30+2B for *A. uniwai*. Meiotic configurations in pollen mother cells were similar for both, with exception of 2B chromosomes in the latter. They concluded that meiotic irregularities suggested a hybrid origin for cultivated anthuriums.

Kamemoto and Sheffer (1978) developed a new species hybrid, with a greyish - orange spathe from the cross *A. scherzerianum* x *A. wendlingerii*. Characteristics such as the length and coil of the spadix and the position of the leaf blade were intermediate between the highly contrasting characteristics of the two parental species. Fertility in the hybrid was good, indicating the relatively close taxonomic relationship of the two species.

Kaneko and Kamemoto (1979) found that chromosome of *Anthurium* sp. was 2n = 30+2B. They inferred that the appearance of off springs with 2, 3 and 4B chromosomes, on self pollination, indicated the transmission of B chromosomes through both pollen and egg.

Based on an evaluation trial, Leeuwen (1984) identified the anthurium cultivars 'Avo-nette', 'Avo-tineko', 'Favoriet', 'Germa', 'Avo-claudia', 'Avo-Ingrid', 'Nova-Aurora', 'Avo-Jose', 'Jamaica', 'Hoenette', 'Sarina' and 'Avo-Anueke' to be the best.

Zimmer (1986) while reviewing the problems in the development of anthurium cultivars, observed that in *A. scherzerianum*, first inflorescence appeared 12-15 months after sowing, but began flowering regularly only after 18-24 months. The spadix seldom had full fruit set. Berries contained 2-3 seeds and ripening took 5-12 months. The species was highly variable and cultivar selection was made from F_1 plants. Tissue culture from selected genotypes took 4-5 months to form plantlets. He added that the selection of a promising genotype took 10-12 years.

Henny *et al.* (1988) obtained 'Southern Blush', a hybrid for foliage producers through interspecific hybridization of a large pink - flowered *A. andreanum* with *A. amnicola* (a dwarf species collected from Costa Rica, which is very floriferous but bears small lavender spathes (nearly more than 2cm long). 'Southern Blush' was intermediate in size between its parents, spathes were about 7.0 cm long and 5.0 cm wide and were medium pink with a slight lavender tint.

Kamemoto *et al.* (1988) described that the major spathe colours in *A. andreanum* red, orange, pink, coral and white, were controlled by two major genes M and O. They found that crosses between two pink produced offspring in the ratio of 9 red to pink : 3 orange to coral : 4 white. They concluded that coral was heterozygous for O and recessive for m. Crosses between two corals gave 3 orange to coral : 1 white. Pink crossed to a coral can be expected to give a ratio of 3 red to pink : 3 orange to coral : 2 white. Pink crossed to a double recessive white gave 1 pink : 1 coral : 2 white. Based on these observations they gave the genotypes of major colours as MMOO, MMOo, and MmOO for red, MmOo for pink, mmOO for orange, mmOo for coral and MMoo, Mmoo and mmoo for white. So orange and white types breed true.

Marutani *et al.* (1993) conducted detailed cytological analysis of *A. andreanum*, its related taxa and their hybrids. They concluded that regular bivalent formation at prometaphase I of meiosis in pollen mother cells of species hybrids suggested close genomic relationships among parental taxa. On the other hand, reduction in pollen fertility estimated by the pollen stainability in those hybrids suggested genetic divergence of the species.

Mercy and Dale (1994) suggested that hybridization between selected varieties with good combining ability can produce novel and valuable anthurium hybrids. They added that a commercial variety should have small to medium sized leaves, extensive root system, short internodes, strong and straight inflorescence axis, medium size spathe with deep wrinkles and short, thin and downward curving candles.

All the five commercial varieties studied by Bindu and Mercy (1994) showed a somatic chromosome number of 30+2B. The B chromosomes are either acentric or telecentric. The karyotype of all the five varieties was analysed and recorded.

Kuehnle *et al.* (1994) produced F_1 hybrids of *A. andreanum* and *A. antioquiense* resistant to bacterial pathogens. They concluded that production of superior cultivars will take many years as it is a perennial crop.

Compatibility analysis by Sindhu (1995) using varieties viz., 'Honeymoon Red' (HR), 'Chilli Red' (CR), 'Kalympong Red' (KR), 'Kalympong Orange' (KO), 'Pink' (P) and 'White' (W) showed that a large number of combinations were incompatible. The maximum percentage of fruits (52.3) was harvested from the cross P x HR. Among the 24 combinations obtained, HR x P and P x HR were found to show the highest compatibility. The duration of fruit maturity ranged from 4.5 to 8.0 months.

Oglesby Plant Laboratory Inc. (1996) described an anthurium variety 'Ruth Morat' syn. 'Lady Ruth' as a derivative from the cross *A. antioquiense* x *A. rotolante* 1. This hybrid had spathes larger than those of variety 'Lady Jane' with a mean width and length of 50.1 and 76.8 mm respectively.

Anthura company (1997) submitted for registration, an anthurium variety 'Champion', derived from *A. andreanum* hybrids. This variety had small leaves and flowers with cupped white spathe held above the canopy and red spadix.

Henny (1999) explained the new interspecific anthurium hybrid 'Red Hot' as highly suitable for pot planting because of its compact growth, freely branching growth habit and production of numerous showy red spathes. The variety 'Red Hot' originated from hybridisation of *A. amnicola* Dressler, a dwarf species with small lavender spathes and a naturally clumping growth habit, with an unnamed selection of *A. andreanum* (accession code G-79) that had pink spathes. One of the F_1 hybrids that resulted was designated as the female parent and crossed with anthurium variety 'Lady Jane' to produce the progeny, from which 'Red Hot' was selected.

Renu (2000) studied the cross compatibility between ten varieties based on the percentage of candles bearing fruits, fruit set and seed germination. The percentages of fruit bearing candles were highest for variety 'Nitta Orange' (51.93) and lowest for variety 'Mauritius Orange' (9.51). The percentage of fruit set was below 50 for all the crosses except for 'Pompon Red' x 'Liver Red'. The cross involving variety 'Pompon Red' as female had the highest percentage of fruit set. Seed germination was highest (87.5 per cent) for the cross 'Dragons tongue' x 'Merengue White'. Scoring of the compatibility reactions based on fruiting candles, fruit set and seed germination, on a scale ranging from 0 to 9, showed the highest compatibility score for PR x LR and 'Ceylon Red' x 'Merengue White' (CR x MW) crosses. The best female parents were found to be varieties 'Nitta Orange', 'Liver Red' and 'Pompon Red'. Varieties 'Ceylon Red', 'Merengue White' and 'Liver Red' performed well as pollen parents. The varieties 'Ceylon Red' and 'Liver Red' performed well both as female and male parent.

Compatibility was estimated using the data on percentage of candles bearing fruits, fruit set/candle and germination of seeds.

a. Percentage of candles bearing fruits

The 1592 pollinations done by Sheffer and Kamemoto (1976) included 20 selfs, 19 intraspecific cross combinations, 315 intragroup interspecific cross combinations (including reciprocals) and 29 different intragroup cross combinations (including reciprocals). The species were divided into six distinct morphological groups on the basis of important Englerian characters of the number of ovules per locule, colour and shape of the berry, shape of inflorescence, shape and texture of the leaf. Group I and II were separated on the basis of the number of ovules per locule. Group III and IV were Engler's sections Pachynerium and Schizoplacium respectively. The remaining species were included under groups V and VI and were organised into two groups on the basis of leaf texture, berry shape and colour. Intra and intergroup pollinations were done, fruits harvested and germinating seeds obtained.

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

Group II, III and V gave higher percentage of fruiting spadices and flowering hybrids than group 1, probably due to the range of chromosome numbers found in the species included in this group. The presence of B-chromosomes also affected the viability (Bhattaglia, 1964, Sheffer and Kamemoto, 1976).

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

All the six varieties of *A. andreanum* evaluated by Sindhu (1995) viz., 'Honeymoon Red', 'Chilli Red', 'Kalympong Orange', 'Kalympong Red', 'Pink' and 'White', showed good percentages of candle bearing fruits. This percentage was maximum (93) for the variety 'White' and lowest (50) for the variety 'Kalympong Red'.

Based on the results of intervarietal hybridisation done using ten varieties of *A. andreanum*, Renu (2000) observed that the percentage of fruit bearing candles was highest (51.93) for 'Nitta Orange' and lowest (9.51) for 'Mauritius Orange'. The only two selfings that produced fruiting candles were for varieties 'Liver Red' and 'Dragon's Tongue'.

b. Number of fruits / candle

Zimmer (1986) studied the problem in the development of anthurium cultivars and identified the absence of full fruit set in spadix as a major one. He added that the period of 5-12 months taken for fruit ripening also was an impediment.

Mercy and Dale (1994) observed that in a well fertilized candle, about 100-200 or more berries developed. A candle with developing fruits could be visually identified from the second month of fertilization, as it became swollen and fleshy with developing fruits embedded in it. In about eight weeks, the tip of the berries started projecting out like small pin heads.

Among the varieties studied by Sindhu (1995), the maximum average number of fruits was produced in the 'Pink' followed by 'Honeymoon Red'. The lowest number of fruits was obtained from Kalympong Red. The maximum number of fruits (170) was harvested from the cross 'Pink' x 'Honeymoon Red' and the lowest number (2) from 'Kalympong Red' x 'Kalympong Red'.

Based on cross compatibility studies using ten varieties, Renu (2000) observed that the number of fruits per candle ranged from five to 183. The variety 'Pompon Red' had the highest average number of fruits per candle and it was lowest for 'Lady Jane'.

c. Percentage of fruit set / candle

Among the six varieties studied by Sindhu (1995), recorded that the maximum percentage fruit set (52.3) was observed for the cross 'Pink' x 'Honeymoon Red' followed by its reciprocal (44.3). The lowest percentage of fruit set (0.4) was observed in the selfing of 'Kalympong Red'.

Renu (2000) observed that the percentage of fruit set was below 50 per cent for all the crosses involving 10 varieties of *A. andreanum* except Pompon Red x Liver Red. The crosses involving Pompon Red as female parent had the highest percentage of fruit set.

2.24. Number of seeds / berry

In anthurium the spadix seldom had full fruit set. Berries contained usually one or two or rarely three seeds and for ripening it took 5-12 months (Zimmer, 1986).

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

Mercy and Dale (1994) reported that in the commercial varieties of *A. andreanum*, each berry contained one or two seeds and the seeds matured in about 4-7½ months. Seeds remain enclosed within the thin fruit wall in a gelatinous pulp and if not harvested will remain attached to the candle for a few days more before they dry up and fall off the candle.

Among the six varieties of *A. andreanum* studied by Sindhu (1994), the percentage of single seeds produced was more than the double seeds except in the cross involving varieties 'Kalympong Red' x

'Honeymoon Red', where the percentage of double seed was 63. The percentage of single seeds ranged from 37 to 100.

2.25. Percentage germination of seeds

Szendel *et al.* (1992) found that the seeds of *Anthurium andreanum* harvested at three maturity stages and those of *A. scherzerianum* at one maturity stage (light orange) were allowed to germinate on 3 substrates, at pH ranging from 4 to 8 in light or darkness and at temperatures of 18, 24 and 28°C. In *A. andreanum* the best germination was obtained on a high peat substrate, at pH 4-5 in light at 28°C using seeds harvested at an early maturity stage (yellow-green to light orange).

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

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

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

Among the six varieties of *A. andreanum* studied by Sindhu (1995), the maximum average seed germination was observed in combinations with the variety 'White' as the female parent (63.4 per cent) and the lowest germination in the variety Kalympong Orange. Highest germination percentage (78.0) among the crosses was recorded for the cross between varieties 'Honeymoon Red' x 'Chilli Red'.

In the compatibility study using ten varieties of *A. andreanum* by Renu (2000), the seed germination was highest (87.5 per cent) in 'Dragon's Tongue' x 'Merengue White'. Among the varieties, seed germination percentage varied from 69.0 in 'Tropical Red' to 2.3 in 'Midori Green'.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study was under taken to estimate the divergence of hundred genotypes of anthurium based on multiple characters (morphological and floral) through clustering the genotypes and applying D^2 analysis for selection. Effects of heterosis, gene action and combining ability were also estimated through a 5 x 5 diallel cross, involving 5 parents and 10 F_1 hybrids. The name of the plant was given in *italics* starting with a capital letter in all scientific context. It is given in ordinary letters starting with a capital letter at the beginning of a sentence or with a small letter inside the sentence wherever it is used as a local name. The investigation was carried out in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, during 1997-1999.

3.1 Experiment No. I : Genetic divergence analysis

3.1.1 Materials

The following twenty varieties and eighty different hybrid genotypes belonging to 22 cross combination of anthurium showing variations in spathe colour, shape and size and other commercially valuable morphological characters, generated through hybridization in an NARP (SR) Project available in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, were utilised for the study.

Varieties

1. Chilli Red (CR)
2. Liver Red (LR)
3. Kalympong Red (KR)
4. Honeymoon Red (HR)
5. Pink (P)
6. Pompon Red (PR)
7. Dragon's Tongue Red (DT)
8. Geisha White (GW)
9. Orange Glory (OG)
10. Lady Jane Red (LJ)
11. Ceylon Red
12. Mauritius Orange (MO)
13. Kalympong Orange (KO)
14. Ordinary Orange (OO)
15. Nitta Orange (NO)
16. Johnson's Pink (JP)
17. Merengue White (MW)
18. Midori Green (MG)
19. Tropical Red (TR)
20. White (W)

Hybrids

21. W x LJ (1)
22. W x LJ (2)
23. W x LJ (3)
24. W x LJ (4)
25. W x LJ (5)
26. W x LJ (6)
27. W x LJ (7)
28. W x KR (1)
29. W x KR (2)
30. KR x HR (1)
31. W x OO (1)
32. W x OO (2)
33. W x OO (3)
34. OO x LR (1)
35. HR x LJ (1)
36. HR x LJ (2)
37. HR x LJ (3)
38. LJ x KR (1)
39. LR x P (1)
40. LR x P (2)
41. LR x P (3)
42. LR x P (4)
43. LR x P (5)
44. KO x P (1)
45. KO x P (2)
46. W x P (1)
47. W x P (2)
48. HR x P (1)
49. HR x P (2)
50. HR x P (3)

51. HR x CR (1)
52. HR x CR (2)
53. HR x CR (3)
54. HR x CR (4)
55. HR x CR (5)
56. HR x CR (6)
57. HR x W (1)
58. OO x HR (1)
59. OO x HR (2)
60. OO x HR (3)
61. OO x HR (4)
62. OO x HR (5)
63. OO x KR (1)
64. OO x KR (2)
65. OO x KR (3)
66. OO x KR (4)
67. OO x KR (5)
68. OO x KR (6)
69. OO x KR (7)
70. OO x KR (8)
71. OO x KR (9)
72. OO x KR (10)
73. HR x KR (1)
74. HR x KR (2)
75. HR x KR (3)
76. HR x KR (4)
77. KR x P (1)
78. KR x P (2)
79. KR x P (3)
80. KR x P (4)
81. KR x P (5)
82. KR x P (6)
83. KR x P (7)
84. KR x P (8)
85. KR x P (9)
86. P x CR (1)
87. P x CR (2)
88. P x CR (3)
89. P x CR (4)
90. P x CR (5)
91. P x CR (6)
92. CR x W (1)
93. CR x W (2)
94. CR x W (3)
95. W x HR (1)
96. W x HR (2)
97. W x HR (3)
98. OO x P (1)
99. OO x P (2)
100. CR x KR (1)

Depending on the availability, 1 to 10 hybrids were selected from each combination.

3.1.2 Methods

The selected plants were raised in pot culture experiment under completely randomised design with three replications. The bottom one-third of each pot was filled with broken bricks and the middle one third portion was filled with a mixture of coarse sand, broken bricks, dried coconut husk pieces and charcoal mixed in 7:1:1:1 ratio, respectively. The plants with well developed roots were placed over this and the plants anchored with more potting mixture. Coarse sand was used in the potting medium and the method of planting ensured 100 per cent drainage.

Artificial shade of 75 per cent was provided with black polypropylene agro-shade netting. Mist irrigation was provided two to three times each day depending on temperature conditions.

Regular applications of fertilizers were given at weekly intervals. NPK mixture 17:17:17 was applied at a strength of 5 g/l as aqueous solution once in a month. Additional nutrients like diluted cowdung water and fermented and diluted ground nut-neem cake mixture were given once a month. For preparing the latter, 2 kg of ground nut cake and 4 kg neem cake were fermented in 5 litres of water for two days. The mixture was then diluted by adding 245 litres of very dilute cowdung water. About 200 ml of the sieved fertilizer solution was then applied to each pot.

Plant Protection

1. For the control of blight / anthracnose caused by *Colletotrichum gleosporioides* regular applications of the following chemicals were undertaken.

   a. Bavistin 50 % wp @ 2g/litre or

   b. Indofil M-45 @ 2g/litre

2. Need based applications of streptocycline @ 0.05 g/litre were given to control the bacterial blight caused by *Xanthomonas axonopodis* pv. *dieffenbachiae.*

3. Dusting of BHC 50 % WP was adopted against termites and ants.

4. Need based applications of Metacid (2g/l) or Nuvacron (2g/l) were given to control leaf feeding caterpillars and grass hoppers. Mites were controlled using Kelthane (2ml/l).

5. Snails and slugs were controlled by picking by hand and also by the application of Furadan 3 G @ 2-3 g/pot.

3.1.2.1. Morphological studies

Uniform plant materials with stabilised vegetative and floral characters of age between 4½ to 5 years were used for taking all observations. Observations on the following ten characters (vegetative and floral characters) were recorded and their mean values were taken.

1. Plant height

Plant height in centimeters was recorded from the base of the plant to the top of the top most leaf.

2. Spathe length

Spathe length in centimeters was measured from the joint of the peduncle to the tip of the spathe.

3. Width of spathe

The maximum width of the spathe was recorded in centimeters.

4. Number of suckers / plant / year

Number of suckers produced from the base of the plant for a period for one year was recorded.

5. Length of leaf blade

The length of leaf blade was measured in centimetres from the base to the tip of the leaf.

6. Width of leaf blade

Maximum width of leaf blade was measured in centimeters.

7. Candle length

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

8. Inclination of the candle

The angle between the base of the candle to the plane of the subtending spathe was taken with the help of a protractor.

9. Number of spadices / plant / year

The number of spadices produced during one year period was observed and recorded.

10. Leaf area

The maximum length and breadth of the third leaf were used for the estimation of leaf area. The third leaf was chosen as this would be the leaf which will be fully unfurled and has achieved its full growth and spread of the leaf blade. The leaf area of hundred genotypes was measured using LI-COR-3100 Conveyor belt automatic leaf area meter. It was tried to relate the leaf area (y) with the maximum length and maximum breadth of leaf using linear regression technique. ie., $y = a + bx$ (Snedecor and Cochran, 1967) where x = maximum length x maximum breadth. b is the regression coefficient which measures the rate of change in y for unit change in x and a is the y-intercept which the line makes with x-axis. The coefficient of determination which is equal to the square of the correlation coefficient between x and y measures the fraction of variation in y explained by the regression relationship.

3.1.2.2 STATISTICAL ANALYSIS

Biometrical techniques applied

Mean, variance, standard error, and co-efficient of variation were the basic parameters estimated. The significance of the genotypic differences was tested through analysis of variance technique. The character associations were estimated through correlation coefficients using analysis of covariance technique. Heritability co-efficient and genetic advance were estimated. The methodology in the estimation of the parameters are given below. With two characters X and Y measured on 'g' genotypes raised in completely randomised design with 'r' replications, the variance co-variance analysis (ANACOVA) is as follows:

Analysis of variance / co-variance

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}

Estimates of components of variance and co-variance

	Genotype	Environment	Phenotype
X	$\sigma^2_{gx} = \frac{Gxx - Exx}{r}$	$\sigma^2_{ex} = E_{xx}$	$\sigma^2_{px} = \sigma^2_{gx} + \sigma^2_{ex}$
Y	$\sigma^2_{gy} = \frac{Gyy - Eyy}{r}$	$\sigma^2_{ey} = E_{yy}$	$\sigma^2_{py} = \sigma^2_{gy} + \sigma^2_{ey}$
XY	$\sigma_{gxy} = \frac{Gxy - Exy}{r}$	$\sigma_{exy} = E_{xy}$	$\sigma_{pxy} = \sigma_{gxy} + \sigma_{exy}$

Co-efficient of variation

Phenotypic and genotypic coefficients of variation (PCV and GCV) for a trait X were estimated as :

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

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

where,

σ_{gx} = Genotypic standard deviation

σ_{px} = phenotypic standard deviation

$\bar{x}$ = Mean of the character under study

Heritability coefficient and genetic advance

Heritability (H^2) in broad sense was estimated as the proportion of heritable component of variation.

$$\text{Heritability coefficient } H^2 = \frac{\sigma_{gx}^2}{\sigma_{px}^2} \times 100 \text{ (Jain, 1982)}$$

$$\text{Genetic advance as percentage of mean (GA)} : \frac{kH^2\sigma_{px}}{\bar{x}} \times 100$$

where k is the selection differential whose value = 2.06 if five per cent selection is to be practised (Miller *et al.*, 1958).

Estimation of components of covariance

Correlation analysis

The correlation coefficients (phenotypic, genotypic and environmental) were worked out as :

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

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

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

Mahalanobis (D^2) analysis

Mahalanobis D^2 (1936) was applied for classificatory studies by Murty and Arunachalam (1966) in crop plants. The same methodology was applied to cluster the hundred genotypes of anthurium in Experiment 1. For i^{th} and j^{th} genotypes, the D^2 value is computed as

$D^2 = \sum_{l=1}^{k} (x_{il} - x_{jl})^2$ where k is the number of characters.

The genotypes were grouped into several clusters based on these D^2 values by Tocher's method of clustering (Rao, 1952).

3.2 Experiment No. II : Estimation of heterosis and gene action

3.2.1 Materials

All the hundred genotypes were crossed among themselves and five parents were found to produce compatible crosses. These parents and their crosses were the materials used to study gene action through combining ability analysis and also heterosis.

Honey moon Red, Pink, Liver Red, Kalympong Red and Chilli Red were the five parents.

Crosses

1. HR x P
2. HR x LR
3. HR x KR
4. HR x CR
5. P x LR
6. P x KR
7. P x CR
8. LR x KR
9. LR x CR
10. KR x CR

3.2.2 Methods

The methods used were the same as that in Experiment 1. The plants were raised in pots under completely randomised design with five replications. Data were recorded from five hybrids from each cross (replications).

3.2.2.1 Morphological studies

The plant materials used were of the same age (4½ - 5 years) as that of the Experiment No. I. Observations on the following twenty eight characters (vegetative and floral) were recorded and their mean values were taken.

a. VEGETATIVE CHARACTERS

1. Plant height

Plant height in centimeters were measured from the base of the plant to the top of the top most leaf.

2. Internode length

The distance between two nodes was measured from the base of the plant and recorded in centimeters.

3. Days from emergence to maturity of leaves

Days from the emergence of the leaf to the maturity of leaves were recorded.

4. Number of leaves

The number of leaves produced during the one year period was observed and recorded.

5. Length of leaf blade

Length of leaf was measured from the base to the tip of the leaf and expressed in centimeters.

6. Width of leaf blade

Maximum width of leaf was measured and recorded in centimeters.

7. Leaf area

Leaf area in sq.cm was estimated by applying linear regression $y = 9.53 + 0.64\ x$ derived from Experiment I.

x = max. leaf length x max. leaf breadth

8. Suckering ability

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

b. FLORAL CHARACTERS

Quantitative characters

Following quantitative characters were measured and statistically analysed :

9. Time taken for first flowering

The time taken from seed germination to first flowering was recorded in months.

10. Days from emergence to maturity of infloresence

The time taken from the emergence of infloresence to its full maturity was recorded.

11. Length of spathe

Spathe length in centimeters was measured from the joint of the peduncle of the spathe to the tip.

12. Width of spathe

Maximum width of spathe was recorded in centimeters.

13. Number of spadices / plant / year

The number of spadices produced during the one year period was noted and recorded.

14. Candle length

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

15. Inclination of candle

The angle between the base of the candle to the plane of the subtending spathe was taken with the help of a protractor.

16. Number of flowers / candle

The total number of flowers arranged spirally on the candle from the base to the tip was counted and recorded.

17. Life of spadix / longevity of spadix

The period between the first day of emergence of inflorescence upto to the time of its yellowing, withering of spathe and shrivelling of candle was recorded as the life of spadix or longevity of spadix.

18. Days for initiation of female phase

The number of days from the emergence of the spathe to the first emergence of mature stigmas of the basal flowers, identified by the presence of honey dew or stigmatic droplets was recorded as the days to initiation of female phase.

19. Duration of female phase

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

20. Days of interphase

The duration between the end of female phase and the emergence of anthers from the basal flowers, indicating the start of malephase, was recorded as the days of interphase.

21. Duration of male phase

The period in days for the emergence of the first anthers in the spadix to the emergence of its last anthers was recorded.

22. Pollen fertility

Pollen fertility was assessed using acetocarmine staining method. Pollen grains were collected during the male phase from all the parents and hybrids and stained with 1:1 glycerine - acetocarmine stain (2 per cent). Five slides were made for each variety and from each slide, ten microscopic fields were scored and the data recorded. Unstained, undersized, partially stained and shrivelled pollen grains were scored as sterile and the uniformly stained, properly filled pollen as fertile. Fertility of each variety was estimated as percentage of the number of fertile pollen grains to the total number of pollen grains scored.

The pollen fertility was calculated as,

$$\text{Pollen fertility} = \frac{\text{No. of well filled and uniformly stained pollen grains}}{\text{Total number of pollen grains}} \times 100$$

23. Estimation of total anthocyanin

Estimation of anthocyanin was done as per the method described by Rangana (1977). The initial step was alcoholic extraction of the plant material (spathe). One gram of the spathe sample from each treatment was extracted with ethanolic hydrochloric acid, filtered through a Buchner funnel using Whatman No. 1 filter paper and the filtrate was then diluted with ethanolic hydrochloric acid to 50 ml to yield optical density values within the optimum range of the spectrophotometer (535 nm). The anthocyanin content was then calculated using the following relationship and the quantity was expressed as mg per 100 gm of the sample.

Total OD per 100 g of sample (x) = [(Absorbance at 535nm) x (Volume made up of the extract used for colour development) x (Total volume) x 100] ÷ [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,

$$\text{Total anthocyanin in mg per 100 g of the sample} = \frac{x}{98.2}$$

24. Estimation of carotenoids

Carotenoids present in spathe were extracted using acetone and the optical density (OD) was measured at 450 nm.

Procedure

Fresh spathe (200 mg of each treatment) was cut into small pieces and homogenised in a blender. The homogenate was then transferred into a volumetric flask, made upto 100 ml and kept overnight in dark. The OD was measured at 450 nm (Jensen, 1978). The carotenoids present in the extract was calculated using the formula.

$$C = \frac{D \times V \times f \times 10}{2500}$$

C = Total amount of carotenoids in mg
D = Absorbance at 450 nm
V = Volume of the original extract in ml
f = Dilution factor
2500 = Average extinction coefficient of the pigments

c. QUALITATIVE CHARACTERS

Following qualitative characters were recorded visually.

25. Type of inflorescence axis

Length, nature and strength of inflorescence axis in each variety were observed and recorded.

26. Spathe colour

The spathe colour of each variety was recorded by visual observation.

27. Spathe texture

The degree of blistering, thickness of spathe, presence of veins and the glossiness of spathe were recorded to differentiate the spathe texture of each variety.

28. Candle colour

Visual observation was used to record the candle colours.

3.2.2.2 STATISTICAL ANALYSIS

The data collected from the parents and hybrids were initially subjected to analysis of variance for each character so as to detect the genotypic differences. The characters for which genotypic differences detected, were further subjected to diallel analysis to estimate the additive components of heritable variation. The following analysis were done.

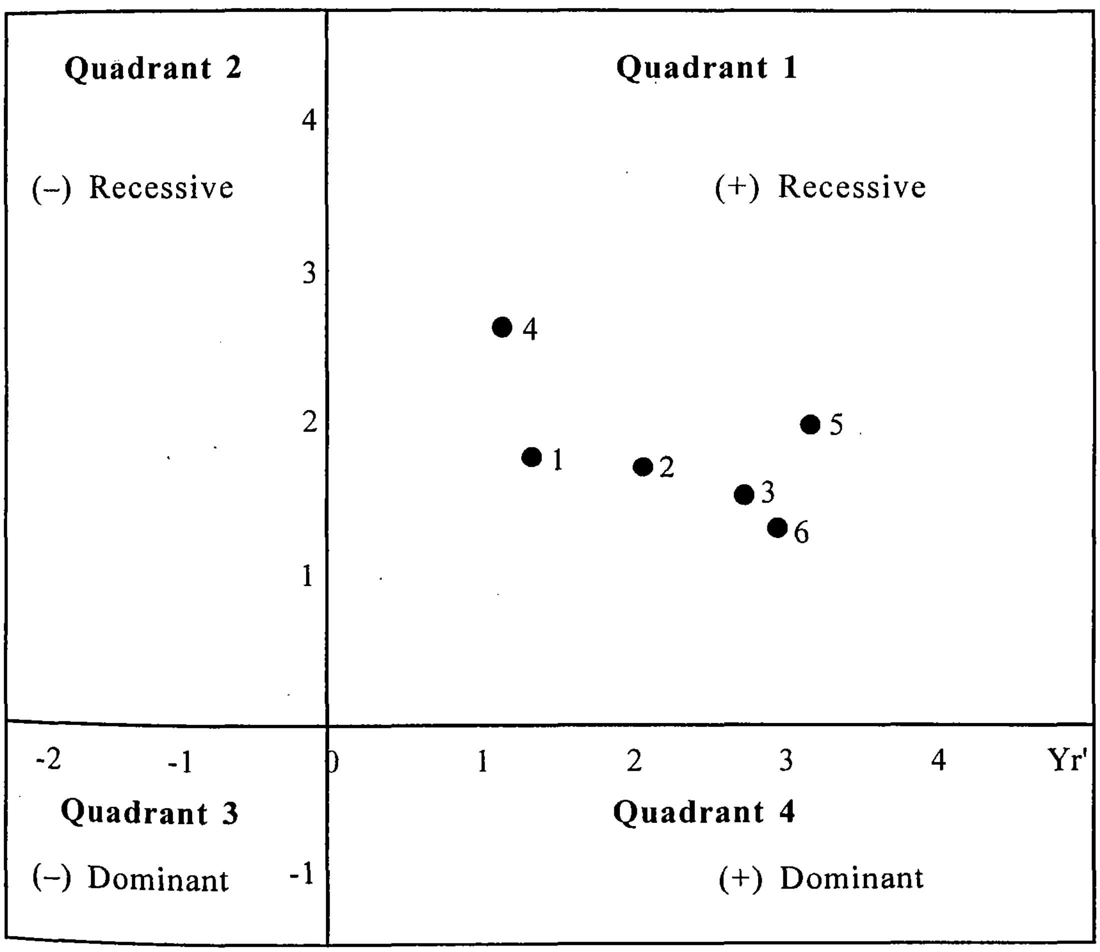
1. Graphical analysis of diallel cross as suggested by Hayman (1954)
2. Combining ability through Griffing's Approach
   - General combining ability
   - Specific combining ability
3. Heterosis

Hayman's Graphical Approach

The experimental material involved heterozygous parents. Most of the information obtained from a diallel cross with homozygous parents can also be extracted if the parental lines are heterozygous (Oakes, 1967).

The linear regression line of array co-variance (Wr) on array variance (Vr) and the distribution of parental arrays along the regression lines will provide information on the gene action involved in the expression of character (Jinks and Hayman, 1953; Hayman, 1954; Dickinson and Jinks, 1956).

The standardised Yr' – $(W_r + V_r)'$ graph (Johnson and Askel, 1959) provides information on the relative distribution of parents and helps to detect parents containing dominant and recessive alleles as given below.



The standardised Yr' – $(W_r + V_r)'$ graph

The statistics computed under this approach are

1. M_{L0} = Parental mean
2. M_{L1} = Offpsring mean (F_1 mean)
3. Y_r = mean value for r^{th} parent
4. $\overline{Y_r}$ = mean of Y_r
5. V_p = Parental variance
6. V_r = Variance of all the progenies in r^{th} parental array (an array is a group of crosses involving a particular parents)
7. W_r = Covariance between parents and their offsprings and their offsprings r^{th} each array
8. $\overline{V}_r$ = Mean of V_r
9. $\overline{V}_{Wr}$ = Mean of W_r
10. $V_{\bar{r}}$ = Variance of array means
11. Yr' = Standardised $Y_r = \dfrac{Y_r - \overline{Y}_r}{SE\,(Y_r)}$
12. $(W_r + V_r)'$ = Standardised $(W_r + V_r)$ values
13. r = correlation coefficient between mean for each parent (Y_r) and parental order of dominance ($W_r + V_r$)
14. b = regression coefficient between W_r and V_r
15. Dominance relationship = $(M_{L1} - M_{L0})^2$

The overall difference between the means of F_1s and parents expresses dominance relationship.

The $W_r - V_r$ graph was drawn using a regression relationship between W_r and V_r where W_r is the covariance between the parents and offsprings in the r^{th} array and V_r is the variance of the r^{th} array. A parabola was constructed with V_r and $\sqrt{W_r^2}$ values.

In the linear regression of $W_r = a+bV_r$, b is the regression coefficient of W_r on V_r and a, the constant term which is taken as an indication of the type of gene action governing the characters.

If the regression line passes through the origin ie., (a = 0) it can be taken as indication of complete dominance. But if it passes above the origin ie., (a > 0) it can be taken as an indication of absence of dominance ie., partial dominance while the line passing above the origin ie., (a < 0) indicates the presence of over dominance.

Combining ability

Griffing's model I and method II (1956) of combining ability analysis are applied to study the contribution of the parents ie., the general combining effects (gca) of parents and the excess over and above the sum of two GCA effects. ie., the specific combining ability (sca) of crosses. The variation among the genotypes was split into components as follows:

With 'n' parents and nc_2 F_1s raised in CRD with 'r' replications (Dabbolkar, 1992), the ANOVA for combining ability is given as follows.

Analysis of variance - combining ability

Source	Degrees of freedom	Mean square	Expected Mean squares E(MS)
Genotypes	$n + nc_2 - 1$	M_c	$\sigma^2_e + \sigma^2_g$
gca	n-1	M_g	$\sigma^2_e + \sigma^2_{sca} + (n+2)\,\sigma^2_{gca}$
sca	nc_2	M_s	$\sigma^2_e + \sigma^2_{sca}$
Error	$(n+nc_2)\,(r-1)$	M_e	σ^2_e

Mg, Ms and Me are the estimates of mean squares for gca, sca and experimental error. The estimates of variance components are given below:

$$\text{Error mean square} = \hat{\sigma}^2_e = M_s$$

$$\text{gca variance} = \sigma^2_{gca} = \frac{Mg - Ms}{(n+2)}$$

$$\text{sca variance} = \hat{\sigma}^2_{sca} = (M_s - M_e)$$

The additive (σ^2_a) and dominant (σ^2_d) components of variance were estimated as

$$\sigma^2_a = 2\,\sigma^2_{gca}$$

$$\sigma^2_d = \sigma^2_{sca}$$

If significant differences among gca and sca were obtained, their effects were estimated as follows:

General combining ability effect (gi) = $\frac{1}{(n+2)}\left[\sum(Y_{i.}+Y_{ii})-\frac{2Y_{..}}{n}\right]$

Specific combining ability effect of i x j^{th} cross

$$(s_{ij}) = Y_{ij} - \frac{(Y_{i.}+Y_{ii}+Y_{j.}+Y_{jj})}{(n+2)} + \frac{2Y_{..}}{(n+1)(n+2)}$$

where, Y_{ij} = Mean value for P_i x P_j

Y_{ii} = Mean value for selfing P_i ie. for P_i x P_i

$Y_{i.}$ = Total for i^{th} parental array

$Y_{..}$ = Grand total of all the crosses

The standard error (SE) of the combining ability effects and also for their difference are given below:

Effect	Standard error
g_i	$\sqrt{\frac{(n-1)}{n(n+2)}\sigma_e^2}$
g_i - g_j	$\sqrt{\frac{2}{(n+2)}\sigma_e^2}$
s_{ij}	$\sqrt{\frac{(n^2+n+2)}{(n+1)(n+2)}\sigma_e^2}$

$s_{ij} - s_{ik}$ $\sqrt{\frac{2(n+1)}{(n+2)}\sigma_e^2}$

(one parent in common)

$s_{ij} - s_{kl}$ $\sqrt{\frac{2n}{(n+2)}\sigma_e^2}$

(different parents)

The significance of g_i and s_{ij} were tested by applying student's t-test.

$$gca : \frac{g_i}{SE(g_i)}$$

$$sca : \frac{s_{ij}}{SE(s_{ij})}$$

The gca effects of parents and the sca effects of crosses were compared with the critical difference (CD) value, where

$CD = t_\alpha \times SE_d$, SE_d = SE of the difference of effects.

Economic or useful heterosis

Ornamental plants have much commercial value and hence commercial usefulness of a hybrid primarily depends on its performance in comparison with the best available commercial variety. One of the parents considered in the experiment is Liver Red which is the best semicommercial variety. Hence, heterosis is estimated in relation to this best semicommercial variety and this heterosis is generally referred to as economic or useful heterosis (Singh, 1983).

It is the difference in the mean of the hybrid from the mean of the standard variety expressed as a percentage.

$$\frac{\overline{F_1}-\overline{SP}}{\overline{SP}} \times 100$$

$\overline{SP}$ = mean of the standard variety

$\overline{F_1}$ = mean of the hybrid

The significance of the heterosis is tested by student t-test and the comparison among the hybrids and also between $\overline{F_1}$ and $\overline{SP}$ and is done by the critical difference where

$$CD = t_\alpha \sqrt{\frac{2MSE}{r}}$$

where t_α = table value of t with respect to error degrees of freedom.

RESULTS

4. RESULTS

The results of the present investigation on genetic divergence of *Anthurium andreanum* Linden are presented under two major experiments.

1. Experiment No. I : Genetic divergence analysis
2. Experiment No. II : Estimation of heterosis and gene action

4.1 Experiment No. I

One hundred genotypes of *Anthurium andreanum* were evaluated in green house, each genotype being replicated thrice. The data were subjected to statistical analysis and the results are presented in the following sub heads.

4.1.1 Evaluation of genotypes for mean performance

4.1.2 Estimation of variability components

4.1.3 Estimation of heritability and genetic advance

4.1.4 Correlation among different characters

4.1.5 Genetic divergence analysis

4.1.1 Evaluation of genotypes for mean performance

Analysis of variance revealed significant genotypic differences for all characters and is presented in Table 4.1.1(a) and the mean performance among the genotypes along with the CD values are presented in Table 4.1.1 (b). For simplicity of summerisation the genotypes have been categorised independently with respect to each character as low, medium and high based on the area property of normal distribution as follows.

Category	Criterion
Low	$< \bar{x} - 1.96\ \sigma_{n-1}$
Medium	Between $\bar{x} \pm 1.96\ \sigma_{n-1}$
High	$> \bar{x} + 1.96\ \sigma_{n-1}$

where x is the mean and σ_{n-1} is the standard error of the mean.

The distribution of hundred genotypes as per this category is given in Table 4.1.1(c) and Fig. 1.

1. Plant height

The average height of plant was observed as 61.02 cm with a range of 37 cm to 96.67 cm and a co-efficient of variation of 11.74 per cent. Most of the genotypes (52 per cent) had medium height between 52.91 cm to 69.12 cm. Some genotypes (24 per cent) had low height ie., less than 52.91 cm and the remaining 24 per cent had height greater than 69.12 cm.

Table 4.1.1 (a). Analysis of variance of 10 characters in 100 *Anthurium andreanum* genotypes

Sl. No.	Characters	Mean square: Genotypes	Mean square: Error
	DF	99	200
1.	Plant height (cm)	408.44**	51.29
2.	Spathe length (cm)	19.29**	0.78
3.	Spathe width (cm)	11.80**	0.36
4.	No. of suckers per plant	2.47**	0.26
5.	Length of leaf blade (cm)	100.33**	5.53
6.	Width of leaf blade (cm)	50.25**	3.53
7.	Candle length (cm)	9.59**	0.32
8.	Inclination of candle (degrees)	640.52**	4.25
9.	No. of spadices / plant / year	1.71**	0.48
10.	Leaf area (cm^2)	58520.12**	3136.60

** Significant at 1 per cent level
DF = Degree of freedom

Table 4.1.1 (b). Genotypic differences among different varieties on various characters in *Anthurium andreanum*

Genotypes		Plant height (cm)	Length of spathe (cm)	Width of spathe (cm)	Suckering ability	Length of leaf blade (cm)	Width of leaf blade (cm)	Candle length (cm)	Inclination of candle (degrees)	No. of spadices/ plant/year	Leaf area (cm^2)
1.	Chilli Red	61.00	11.97	9.30	3.00	35.50	17.33	7.57	23.33	6.67	403.34
2.	Liver Red	80.33	11.17	7.07	3.67	39.17	19.00	7.17	61.00	7.00	487.29
3.	Kalympong Red	74.33	12.73	9.87	1.67	44.67	17.33	8.33	24.33	6.67	508.07
4.	Honeymoon Red	56.33	13.87	9.30	3.33	44.17	28.33	9.37	75.00	7.33	817.34
5.	Pink	69.33	13.67	12.00	4.00	47.67	26.80	10.83	71.67	6.67	827.88
6.	Pompon Red	89.67	10.00	7.13	2.67	36.33	16.33	6.00	30.33	7.00	389.05
7.	Dragon's tongue Red	78.33	19.17	12.97	2.33	37.00	19.67	7.83	68.33	7.00	472.06
8.	Geisha White	53.00	6.97	6.17	1.33	23.33	13.83	4.70	50.00	5.33	217.80
9.	Orange Glory	67.00	9.17	6.60	2.67	28.50	12.17	5.00	41.33	8.00	264.62
10.	Lady Jane Red	43.83	8.10	5.73	4.00	23.83	11.33	5.90	69.67	8.00	182.86
11.	Ceylon Red	70.67	10.93	8.93	2.67	28.67	12.00	7.00	40.00	6.67	230.54
12.	Mauritius Orange	75.67	11.90	7.70	1.33	26.83	15.33	4.63	32.67	6.33	273.10
13.	Kalympong Orange	87.00	10.93	8.80	3.33	35.17	19.00	13.70	39.67	7.33	436.68
14.	Ordinary Orange	62.67	11.33	9.63	1.00	24.67	13.00	6.43	39.67	6.67	214.86

Table 4.1.1 (b). (Contd...)

Genotypes	Plant height (cm)	Length of spathe (cm)	Width of spathe (cm)	Suckering ability	Length of leaf blade (cm)	Width of leaf blade (cm)	Candle length (cm)	Inclination of candle (degrees)	No. of spadices/ plant/year	Leaf area (cm^2)
15. Nitta Orange	63.67	11.80	9.90	0.67	27.83	12.83	5.10	43.00	6.00	243.77
16. Johnson's Pink	71.83	10.63	9.83	1.33	30.67	16.33	7.57	46.67	6.00	335.72
17. Merengue White	60.83	11.83	9.33	0.67	29.67	15.67	7.13	45.67	4.67	311.72
18. Midori Green	42.50	14.67	11.77	1.00	22.00	12.17	6.03	44.00	6.33	180.21
19. Tropical Red	45.67	10.50	7.00	0.67	18.17	11.83	7.37	38.33	5.67	154.06
20. White	96.67	7.50	5.83	1.33	37.00	24.67	6.57	57.67	7.33	593.42
21. W x LJ(1)	60.00	6.83	5.00	3.67	26.67	15.33	4.67	76.33	6.67	272.78
22. W x LJ(2)	58.67	10.17	6.83	3.00	22.33	14.83	7.27	69.00	6.33	221.80
23. W x LJ(3)	62.33	9.33	5.50	3.67	22.33	14.33	6.80	56.00	5.33	214.44
24. W x LJ(4)	59.33	8.83	5.67	3.33	20.83	12.50	4.30	56.67	5.33	168.68
25. W x LJ(5)	60.00	11.17	6.33	2.67	30.33	20.00	6.83	60.67	6.00	398.65
26. W x LJ(6)	59.00	9.83	6.33	2.67	29.33	17.83	8.17	67.67	5.67	351.18
27. W x LJ(7)	55.33	7.67	5.17	2.67	26.33	14.67	5.00	72.67	5.67	257.21
28. W x KR(1)	49.67	9.50	8.17	2.33	28.17	15.50	5.50	79.00	5.33	289.96
29. W x KR(2)	52.67	9.07	8.27	2.67	27.00	13.83	6.17	69.33	5.00	249.85

Table 4.1.1 (b). (Contd...)

Genotypes	Plant height (cm)	Length of spathe (cm)	Width of spathe (cm)	Suckering ability	Length of leaf blade (cm)	Width of leaf blade (cm)	Candle length (cm)	Inclination of candle (degrees)	No. of spadices/ plant/year	Leaf area (cm^2)
30. KR x HR(1)	61.67	10.33	7.77	2.00	32.67	15.50	6.80	57.67	6.33	334.44
31. W x OO(1)	71.00	13.67	8.00	1.67	31.33	21.17	9.20	76.67	7.33	438.01
32. W x OO(2)	82.33	8.83	6.83	1.33	32.33	20.33	6.17	68.33	6.67	431.72
33. W x OO(3)	65.00	14.17	13.00	1.00	40.33	22.33	7.63	49.00	7.00	588.09
34. OO x LR(1)	54.67	14.50	11.83	1.00	29.67	20.33	10.17	69.67	6.67	442.60
35. HR x LJ(1)	83.00	13.03	10.97	2.67	41.00	25.00	8.50	65.33	7.33	665.74
36. HR x LJ(2)	79.33	12.33	7.83	2.67	35.00	24.67	8.63	53.33	6.67	563.34
37. HR x LJ(3)	76.00	10.83	7.30	2.67	33.00	26.33	10.63	58.00	7.00	565.48
38. LJ x KR(1)	68.67	13.13	7.97	2.67	28.00	14.83	7.57	60.00	6.00	275.13
39. LR x P(1)	71.67	12.33	9.50	2.67	31.33	12.67	7.00	65.00	7.33	306.92
40. LR x P(2)	56.00	11.33	8.17	0.67	28.33	15.67	7.63	65.67	6.67	239.08
41. LR x P(3)	45.67	11.87	7.67	2.67	26.33	14.67	11.43	41.67	6.00	257.00
42. LR x P(4)	63.00	9.73	8.10	1.33	27.00	16.67	6.90	73.33	6.33	298.60
43. LR x P(5)	59.33	8.93	7.07	2.67	27.00	17.00	6.23	70.00	5.67	304.57
44. KO x P(1)	77.33	13.50	8.70	1.00	37.33	24.67	8.43	75.33	7.00	603.02

Table 4.1.1 (b). (Contd...)

Genotypes	Plant height (cm)	Length of spathe (cm)	Width of spathe (cm)	Suckering ability	Length of leaf blade (cm)	Width of leaf blade (cm)	Candle length (cm)	Inclination of candle (degrees)	No. of spadices/ plant/year	Leaf area (cm^2)
45. KO x P(2)	70.00	12.83	10.37	1.00	33.33	20.17	9.50	71.67	7.33	440.46
46. W x P(1)	51.00	12.83	7.20	1.33	21.33	12.00	5.53	46.00	6.33	173.58
47. W x P(2)	76.67	12.53	7.53	1.00	34.00	20.67	11.33	76.67	5.67	459.24
48. HR x P(1)	75.00	11.77	8.00	1.67	33.33	19.00	9.90	71.67	6.00	173.58
49. HR x P(2)	60.33	11.83	7.57	2.33	30.00	21.33	10.03	47.67	5.33	435.77
50. HR x P(3)	50.33	14.27	8.07	2.33	29.33	14.00	6.83	74.33	5.67	272.25
51. HR x CR(1)	50.33	12.33	6.93	2.67	32.00	15.17	9.23	45.67	5.67	317.48
52. HR x CR(2)	54.67	11.23	8.20	2.33	28.00	11.67	8.40	45.00	6.33	245.05
53. HR x CR(3)	45.00	13.00	7.07	2.67	24.33	13.33	6.60	33.00	6.00	217.32
54. HR x CR(4)	53.00	10.40	6.90	2.67	25.00	13.33	9.67	31.67	7.33	222.65
55. HR x CR(5)	56.33	9.40	7.30	2.33	32.17	19.50	7.27	28.33	6.00	410.81
56. HR x CR(6)	53.33	10.30	7.80	2.33	28.83	15.83	9.60	52.67	5.67	301.80
57. HR x W(1)	66.00	14.00	9.23	2.00	30.67	16.50	7.60	58.33	6.33	332.94
58. OO x HR(1)	58.33	11.00	8.17	1.67	36.33	22.67	7.97	56.67	5.67	535.82
59. OO x HR(2)	56.00	11.27	8.43	2.67	34.33	24.67	8.00	44.67	5.00	549.48

Table 4.1.1 (b). (Contd...)

Genotypes	Plant height (cm)	Length of spathe (cm)	Width of spathe (cm)	Suckering ability	Length of leaf blade (cm)	Width of leaf blade (cm)	Candle length (cm)	Inclination of candle (degrees)	No. of spadices/ plant/year	Leaf area (cm^2)
60. OO x HR(3)	42.33	9.00	7.17	3.33	18.00	11.33	7.20	30.33	5.67	140.52
61. OO x HR(4)	64.67	13.67	11.50	2.67	34.33	24.33	9.10	61.67	5.67	542.65
62. OO x HR(5)	65.67	14.83	11.33	2.33	34.33	17.00	8.50	54.67	5.67	381.58
63. OO x KR(1)	54.67	9.00	6.80	3.33	25.83	14.33	6.40	41.67	7.00	245.05
64. OO x KR(2)	45.00	6.50	4.83	3.00	21.00	10.50	4.97	32.33	6.67	151.45
65. OO x KR(3)	46.00	7.33	5.50	3.33	22.33	12.67	6.83	30.00	6.67	191.27
66. OO x KR(4)	47.67	9.00	6.47	3.33	23.67	12.33	6.57	21.67	6.67	292.67
67. OO x KR(5)	53.67	7.73	6.37	1.33	23.70	12.67	6.00	51.33	6.33	201.10
68. OO x KR(6)	63.00	15.83	12.67	1.00	33.67	18.17	8.83	41.67	6.33	401.30
69. OO x KR(7)	55.33	10.00	6.90	1.00	28.50	11.83	6.30	47.67	5.67	225.16
70. OO x KR(8)	37.00	9.00	6.10	3.00	17.00	9.83	5.80	45.00	6.33	116.62
71. OO x KR(9)	47.33	10.30	7.47	2.33	28.00	17.00	6.83	40.00	6.33	314.17
72. OO x KR(10)	53.33	12.17	6.23	1.00	32.00	12.67	6.93	44.00	6.00	268.30
73. HR x KR(1)	53.33	9.37	7.23	1.33	28.17	17.17	7.13	60.67	5.67	319.61
74. HR x KR(2)	65.67	10.30	6.73	1.33	33.00	20.33	8.83	53.67	5.00	438.97

Table 4.1.1 (b). (Contd...)

Genotypes	Plant height (cm)	Length of spathe (cm)	Width of spathe (cm)	Suckering ability	Length of leaf blade (cm)	Width of leaf blade (cm)	Candle length (cm)	Inclination of candle (degrees)	No. of spadices/ plant/year	Leaf area (cm^2)
75. HR x KR(3)	62.33	10.03	7.13	1.33	32.67	18.00	7.50	65.33	5.33	385.85
76. HR x KR(4)	48.00	9.00	6.93	2.67	24.83	12.00	5.83	39.33	7.00	200.14
77. KR x P(1)	71.33	8.03	6.47	2.67	30.70	18.27	6.07	53.67	6.33	370.70
78. KR x P(2)	50.00	7.10	4.83	2.67	27.03	15.33	8.00	48.00	6.00	274.06
79. KR x P(3)	68.67	9.50	8.00	0.67	32.33	16.67	8.00	54.33	6.00	355.34
80. KR x P(4)	50.33	9.13	6.67	2.33	29.00	14.17	9.70	77.67	5.00	411.50
81. KR x P(5)	65.00	10.40	6.53	2.33	27.00	14.67	7.17	47.67	6.67	260.20
82. KR x P(6)	58.00	10.77	7.83	0.67	26.33	15.33	7.80	37.00	5.67	268.20
83. KR x P(7)	52.33	10.00	7.47	2.33	27.67	13.33	6.67	28.33	5.67	245.26
84. KR x P(8)	60.00	7.33	5.60	2.33	27.00	16.67	5.83	49.33	6.33	297.32
85. KR x P(9)	51.00	6.50	4.83	2.33	25.00	12.67	4.83	39.33	5.67	211.77
86. P x CR(1)	64.33	13.33	11.43	2.67	33.33	14.83	11.43	44.00	5.00	326.01
87. P x CR(2)	45.67	7.53	6.37	1.67	19.33	12.33	5.43	50.67	4.67	162.49
88. P x CR(3)	59.00	9.17	5.67	1.00	29.33	12.50	7.87	57.67	5.33	243.24
89. P x CR(4)	59.00	8.00	5.93	1.00	35.67	15.83	4.93	50.33	5.33	370.06

Table 4.1.1 (b). (Contd...)

Genotypes	Plant height (cm)	Length of spathe (cm)	Width of spathe (cm)	Suckering ability	Length of leaf blade (cm)	Width of leaf blade (cm)	Candle length (cm)	Inclination of candle (degrees)	No. of spadices/ plant/year	Leaf area (cm^2)
90. P x CR(5)	70.67	21.33	12.50	1.00	34.33	17.83	5.67	53.33	5.67	401.64
91. P x CR(6)	85.00	10.50	9.17	1.00	36.67	21.33	9.53	61.33	5.33	510.22
92. CR x W(1)	57.33	10.30	7.93	1.00	34.67	15.67	7.33	64.67	4.67	356.41
93. CR x W(2)	66.00	12.30	6.73	1.00	33.00	20.00	11.33	66.67	5.33	432.25
94. CR x W(3)	71.33	11.40	7.13	1.00	33.33	21.83	8.77	70.33	5.33	474.70
95. W x HR(1)	57.33	7.90	4.90	2.00	23.00	14.00	6.13	57.00	5.67	215.08
96. W x HR(2)	66.33	10.10	4.27	1.00	30.33	15.50	9.17	73.33	5.67	310.01
97. W x HR(3)	61.00	9.93	6.37	0.67	30.00	18.17	8.03	48.00	5.33	358.42
98. OO x P(1)	55.67	11.00	9.10	2.00	27.00	16.00	7.80	47.00	4.67	286.54
99. OO x P(2)	45.33	6.33	5.33	2.67	21.83	12.00	6.60	33.67	6.33	177.74
100. CR x KR(1)	48.00	10.70	5.83	1.00	31.00	14.67	7.93	42.67	5.67	300.73
$F_{99, 299}$	7.96**	24.78**	33.02**	9.63**	18.16**	14.25**	30.04**	150.59**	3.59**	18.686**
SE_m	4.135	0.509	0.345	0.292	1.357	1.08	0.326	1.19	0.399	32.310
CD	11.461	1.412	0.957	0.811	3.762	3.00	0.904	3.30	1.104	89.558

* Significant at 5% level ** Significant at 1% level

Table 4.1.1 (c). Classification of genotypes

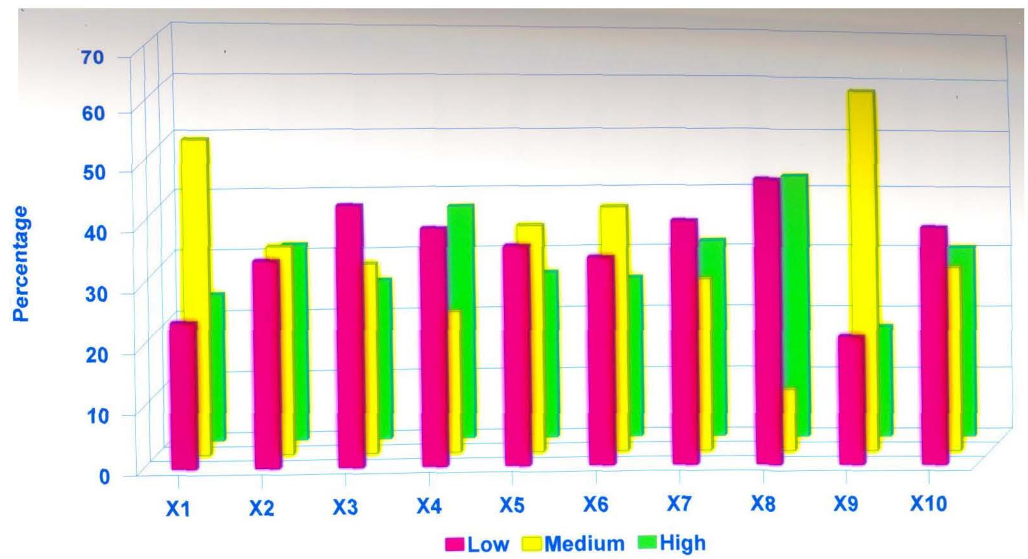
Sl. No.	Character	Mean, Range & CV	Limits ($\bar{x} \pm \sigma_{n-1}$)	Sl. No. and number of genotypes in different classes		
				Low $<\bar{x} - 1.96\ \sigma_{n-1}$	Medium Between $\bar{x} \pm 1.96\ \sigma_{n-1}$	High $> \bar{x} \pm 1.96\ \sigma_{n-1}$
1	Plant height (cm) Mean Range CV(%)	 61.02 37 - 96.67 11.74	(52.91, 69.12)	10, 18, 19, 28, 29, 41, 46, 50, 51, 53, 60, 64, 65, 66, 70, 71, 76, 78, 80, 83, 85, 87, 99, 100 **(24 %)**	1, 14, 15, 17,21, 22, 23, 24, 25, 26, 30, 33, 42, 43, 49, 58, 61, 68, 75, 82, 84, 86, 88, 89, 92, 95, 97, 55, 56, 59, 63, 4, 8, 27, 34, 40, 52, 54, 9, 38, 57, 62, 74, 79, 81, 93, 96, 67, 69, 72, 73, 98 **(52 %)**	3, 6, 7, 11, 12, 13, 16, 20, 31, 32, 35, 36, 37, 39, 44, 45, 47, 48, 77, 90, 91, 94 **(24 %)**
2	Spathe length (cm) Mean Range CV(%)	 10.80 6.33 - 21.33 8.17	(9.80, 11.80)	8, 9, 10, 20, 21, 23, 24, 27, 28, 29, 32, 42, 43, 55, 60, 63, 64, 65, 66, 67, 70, 73, 76, 77, 78,79,80, 84, 85, 87, 88, 89, 95, 99 **(34 %)**	2, 6, 11, 13, 16, 19, 22, 25, 30, 37, 56, 58, 59, 71, 74, 81, 82, 91, 92, 98, 100, 94, 96, 97, 83, 69, 75, 48, 52, 54, 40, 15, 26, 14 **(34 %)**	1, 3, 4, 5, 7, 17, 18, 31, 33, 34, 35, 36, 38, 39, 41, 44, 45, 46, 47, 49, 50, 51, 53, 57, 61, 62, 68, 72, 86, 90, 93, 12 **(32 %)**
3	Spathe width (cm) Mean Range CV(%)	 7.76 4.27 - 13.0 7.73	(7.08, 8.44)	2, 8, 9, 10, 19, 20, 21, 22, 23, 24, 25, 26, 27, 32, 43, 51, 53, 54, 63, 64, 65, 66, 67, 69, 70, 72, 74, 76, 77, 78, 80, 81, 84, 85, 87, 88, 89, 93, 95, 96, 97, 99, 100 **(43 %)**	12, 30, 31, 36, 38, 41, 42, 47, 48, 49, 50, 56, 71, 79, 82, 83, 92, 13, 6, 28, 29, 40, 37, 46, 55, 60, 58, 59, 73, 75, 94 **(31 %)**	1, 3, 4, 5, 7, 11, 14, 15, 16, 17, 18, 33, 34, 35, 39, 44, 45, 52, 57, 61, 62, 68, 86, 90, 98, 91 **(26 %)**

Table 4.1.1. (c) (Contd...)

4	Suckering ability Mean Range CV(%)	 2.06 0.67 - 4.00 24.79	(1.49, 2.63)	3, 8, 12, 14, 15, 16, 17, 18, 19, 20, 32, 33, 34, 40, 42, 44, 45, 46, 47, 67, 68, 69, 72, 73, 74, 75, 77, 79, 82, 88, 89, 90, 91, 92, 93, 94, 96, 97, 100 **(39 %)**	7, 28, 30, 49, 50, 52, 55, 56, 57, 62, 71, 80, 81, 83, 84, 85, 98, 31, 43, 48, 58, 87 **(23 %)**	1, 2, 4, 5, 6, 9, 10, 11, 13, 21, 22, 23, 24, 25, 26, 27, 29, 35, 36, 37, 38, 39, 41, 51, 53, 54, 59, 60, 61, 63, 64, 65, 66, 70, 76, 78, 86, 99 **(38 %)**
5	Length of leaf blade (cm) Mean Range CV(%)	 21.74 17.0 - 47.67 7.91	(27.08, 32.40)	8, 10, 12, 14, 18, 19, 22, 23, 24, 27, 29, 46, 53, 54, 63, 64, 65, 66, 67, 70, 76, 78, 81, 82, 83, 84, 85, 87, 88, 89, 90, 91, 92, 95, 98, 99 **(36 %)**	9, 11, 16, 17, 25, 26, 34, 40, 41, 42, 43, 49, 50, 56, 57, 69, 77, 80, 96, 97, 100, 15, 21, 28, 31, 32, 39, 38, 51, 55, 60, 52, 71, 73, 68, 72, 75 **(37 %)**	1, 2, 3, 4, 5, 6, 7, 13 ,20, 30, 33, 35, 36, 37, 44, 45, 47, 48, 58, 59, 61, 62, 74, 79, 86, 93, 94 **(27 %)**
6	Width of leaf blade (cm) Mean Range CV(%)	 16.57 9.83 - 28.33 11.34	(14.45, 18.69)	8, 9, 10, 11, 15, 18, 19, 23, 24, 25, 28, 30, 39, 46, 50, 52, 53, 54, 60, 63, 64, 65, 66, 67, 69, 70, 72, 76, 83, 84, 85, 87, 95, 99 **(34 %)**	3, 6, 14, 16, 17, 29, 31, 40, 42, 43, 56, 57, 62, 71, 73, 77, 80, 88, 96, 98 1, 7, 12, 21, 22, 27, 26, 38, 41, 51, 68, 75, 90, 78, 81, 82, 86, 100, 97, 79 **(40 %)**	2, 4, 5, 13, 20, 32, 33, 34, 35, 36, 37, 44, 45, 47, 48, 49, 55, 58, 59, 61, 74, 89, 91, 92, 93, 94 **(26 %)**
7	Candle length (cm) Mean Range CV(%)	 7.51 4.30 - 13.70 7.53	(6.87, 8.15)	6, 8, 9, 10, 12, 14, 15, 18, 20, 21, 23, 24, 25, 27, 28, 29, 30, 32, 43, 46, 50, 53, 63, 64, 65, 66, 67, 69, 70, 71, 76, 77, 83, 84, 85, 87, 89, 90, 95, 99 **(40 %)**	1, 7, 11, 16, 19, 22, 33, 38, 40, 55, 57, 73, 75, 78, 79, 82, 88, 92, 98, 97, 100, 2, 17, 39, 42, 58, 72, 81 **(28 %)**	3, 4, 5, 13, 26, 31, 34, 35, 36, 37, 41, 44, 45, 47, 48, 49, 51, 52, 54, 56, 59, 60, 61, 62, 68, 74, 80, 86, 91, 93, 94, 96 **(32 %)**

Table 4.1.1. (c) (Contd...)

8	Inclination of candle (degrees) Mean Range CV(%)	 53.00 21.67 - 79.0 3.8	(50.67, 55.33)	1, 3, 6, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 33, 41, 46, 49, 51, 52, 53, 54, 55, 59, 60, 64, 65, 66, 68, 69, 70, 71, 72, 76, 78, 81, 82, 83, 84, 85, 86, 89, 97, 98, 99, 100, 63 **(47 %)**	56, 74, 75, 77, 90, 36, 62, 67, 79, 87 **(10 %)**	2, 4, 5, 7, 10, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 34, 35, 37, 38, 39, 40, 42, 43, 44, 45, 47, 48, 50, 57, 58, 61, 73, 80, 88, 91, 92, 93, 94, 96, 95 **(43 %)**
9	Number of spadices/plant/ year Mean Range CV(%)	 6.12 4.67 - 8.00 11.33	(5.34, 6.90)	8, 17, 23, 24, 28, 29, 49, 59, 74, 75, 80, 86, 87, 88, 90, 91, 92, 93, 94, 97, 98, 89 **(22 %)**	1, 12, 15, 16, 18, 22, 25, 38, 41, 42, 46, 48, 52, 53, 55, 57, 67, 68, 70, 71, 72, 77, 78, 79, 84, 99, 3, 6, 11, 14, 19, 26, 27, 21, 43, 30, 32, 34, 36, 40, 47, 50, 51, 56, 58, 60, 61, 62, 64, 65, 66, 69, 73, 81, 96, 100, 82, 83, 85, 90, 95 **(61 %)**	2, 4, 5, 7, 9, 10, 13, 20, 31, 33, 35, 37, 39, 44, 45, 54, 63 **(17 %)**
10	Leaf area (cm^2) Mean Range CV(%)	 338.07 116.62 - 827.88 16.52	(274.75, 401.40)	8, 9, 10, 11, 12, 14, 15, 18, 19, 29, 35, 36, 40, 41, 46, 48, 50, 52, 53, 54, 58, 60, 63, 64, 65, 67, 69, 70, 72, 75, 81, 82, 83, 85, 87, 88, 95 ,99, 100 **(39 %)**	16, 17, 30, 34, 39, 51, 56, 57, 71, 73, 78, 79, 86, 89, 92, 96, 97, 6, 25, 27, 38, 42, 43, 62, 66, 68, 77, 90, 84, 98 **(30 %)**	1, 2, 3, 4, 5, 7, 13, 20, 21, 22, 23, 24, 26, 28, 31, 32, 33, 37, 44, 45, 47, 49, 55, 59, 61, 74, 76, 80, 91, 93, 94 **(31 %)**



X1 - Plant height
X2 - Spathe length
X3 - Spathe width
X4 - Number of suckers/plant
X5 - Length of leaf blade
X6 - Width of leaf blade
X7 - Candle length
X8 - Inclination of candle
X9 - Number of spadices/plant/year
X10 - Leaf area

Fig. 1. Percentage distribution of hundred genotypes with low, medium and high groups

Table 4.1.1 (d). Percentage distribution of hundred genotypes into low, medium and high groups

Sl. No.	Characters	Low	Medium	High
1.	Plant height	24	52	24
2.	Spathe length	34	34	32
3.	Spathe width	43	31	26
4.	Suckering ability	39	23	38
5.	Length of leaf blade	36	37	27
6.	Width of the leaf blade	34	40	26
7.	Candle length	40	28	32
8.	Inclination of candle	47	10	43
9.	Number of spadices/plant/year	21	61	18
10.	Leaf area	39	30	31

2. Spathe length

The average spathe length was observed to be 10.80 cm with a range of 6.33 cm to 21.33 cm and a co-efficient of variation of 8.17 per cent. An equal distribution of genotypes was noted in all the three categories.

3. Spathe width

The width of the spathe had an average of 7.76 cm. The width ranged from 4.27 cm to 13 cm with a co-efficient of variation of 7.73 per cent. Most of the plants (43 per cent) had a spathe width less than 7.08 cm. The spathe widths of the medium (7.08 - 8.44 cm) and high (> 8.44 cm) categories of genotypes were 31 per cent and 26 per cent respectively.

4. Suckering ability

The average number of suckers was 2.06 with a range of 0.67 - 4.00 and having a co-efficient of variation of 24.79 per cent. This character was found to be more variable among the genotypes. Many genotypes (39 per cent) had suckers less than 1.49 while 23 per cent of genotypes had medium number of suckers (1.49 to 2.63) while 38 per cent having high number of suckers (above 2.63).

5. Length of leaf blade

The length of leaf blade ranged from 17 cm to 47.67 cm with an average of 21.74 cm and a co-efficient of variation of 7.91 per cent.

Some genotypes (36 per cent) registered a length of less than 27.08 cm while 37 per cent of genotypes had medium length for its leaf blade ie., between 27.08 and 32.40 cm while 27 per cent of the genotypes had a length greater than 32.40 cm.

6. Width of leaf blade

The average width of leaf blade was 16.57 cm with a co-efficient of variation of 11.34 per cent. The genotypes differed in their width by 9.83 cm to 28.33 cm. Some (40 per cent) had medium leaf width (range between 14.45 cm to 18.69 cm) while 34 per cent of the genotypes had width of leaf blade of less than 14.45 cm and 26 per cent of genotypes registered a leaf width of more than 18.69 cm.

7. Candle length

The average candle length was observed to be 7.51 cm with a range of 4.30 cm to 13.70 cm and a co-efficient of variation of 7.53 per cent. Most of the plants (40 per cent) had a candle length less than 6.87 cm. But some genotypes (28 per cent) had a candle length of 6.87 cm - 8.15 cm while 32 per cent had a length greater than 8.15 cm.

8. Inclination of candle

The inclination of the candle was 53 degrees on an average with a co-efficient of variation of 3.89 per cent. The inclination of the candle ranged from 21.67 - 79.00 degrees. Many genotypes (47 per cent) had an inclination of the candle less than 50.67 degrees. Some genotypes

(10 per cent) had an inclination of candle between 50.67 - 55.33 degrees while 43 per cent of the genotypes had an inclination of more than 55.33 degrees.

9. Number of spadices / plant / year

The average number of spadices per plant per year was 6.12. The number of spadices per plant ranged from 4.67 to 8.00 with a co-efficient of variation of 11.33 per cent. Most of the genotypes (61 per cent) had medium number of spadices/plant/year (5.34 - 6.90). But a few genotypes (22 per cent) had spadices less than 5.34 and 17 per cent of the genotypes had a higher number of spadices/plant/year ie., more than 6.90.

10. Leaf area

The average leaf area was 338.07 cm^2 with a co-efficient of variation of 16.52 per cent. The genotypes differed in their leaf area by 116.62 cm^2 to 827.88 cm^2. Some genotypes (39 per cent) had a low leaf area of less than 274.75 cm^2. An equal distribution of genotypes was observed in the medium (274.75 to 401.40) and high (more than 401.40) categories.

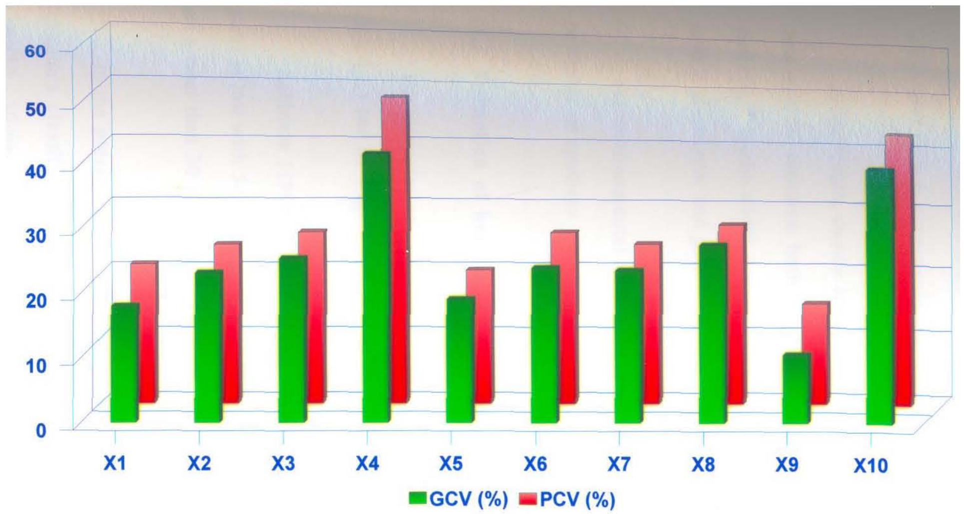
4.1.2 Estimation of variability components

The genotypic and environmental components of phenotypic variance are presented in Table 4.1.2 and Fig. 2 along with the co-efficient of variation (CV) which being a relative measure of variation is used for comparison among characters measured in different units.

Table 4.1.2 Components of total variance for the ten traits in *A. andreanum*

Sl. No.	Characters	σp^2	σg^2	σe^2	PCV (%)	GCV (%)
1.	Plant height (cm)	170.34	119.05	51.29	21.38	17.88
2.	Spathe length (cm)	6.95	6.17	0.78	24.41	23.00
3.	Spathe width (cm)	4.17	3.82	0.36	26.32	25.19
4.	Number of suckers/plant	1.00	0.74	0.26	48.64	41.84
5.	Length of leaf blade (cm)	37.13	31.60	5.53	20.49	18.96
6.	Width of leaf blade (cm)	19.10	15.57	3.53	26.38	23.81
7.	Candle length (cm)	3.41	3.09	0.32	24.59	23.41
8.	Inclination of candle (degrees)	216.35	212.09	4.25	27.75	27.48
9.	No. of spadices / plant / year	0.89	0.41	0.48	15.42	10.46
10.	Leaf area (cm^2)	21594.55	18462.79	6387.56	43.47	40.19

PCV - Phenotypic coefficient of variation
GCV - Genotypic coefficient of variation
σp^2 - Phenotypic variance
σg^2 - Genotypic variance
σe^2 - Environmental variance



X1 - Plant height
X5 - Length of leaf blade
X9 - Number of spadices/plant/year
X2 - Spathe length
X6 - Width of leaf blade
X10 - Leaf area
X3 - Spathe width
X7 - Candle length
X4 - Number of suckers/plant
X8 - Inclination of candle

Fig. 2. GCV and PCV for the ten traits of *A. andreanum*

Maximum variability both at phenotypic (48.64 per cent) and genotypic (41.84 per cent) levels was observed for number of suckers/ plant and the minimum was recorded for number of spadices/plant/year (PCV 15.42 per cent and GCV 10.46 per cent). Leaf area also registered a high value both at phenotypic and genotypic levels.

Spathe length, candle length and inclination of candle were in the same order of variation both at phenotypic and genotypic levels. But plant height, spathe width, length and width of leaf blade differed in their ranks at phenotypic and genotypic levels (Table 4.1.2).

The environmental influence was less for all characters except for number of spadices per plant per year.

4.1.3 Estimation of heritability and genetic advance

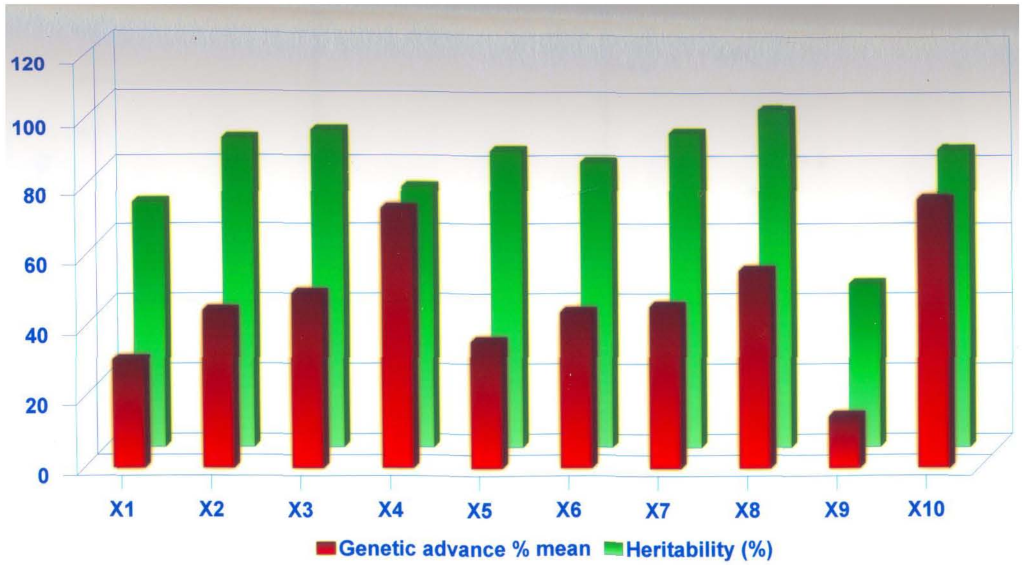
The estimates of heritability and genetic advance are presented in Table 4.1.3 and in Fig. 3 and Fig. 4.

Robinson (1965) classified the heritability estimates in cultivated plants as low with 5-10 per cent heritability, medium with 10-30 per cent and greater than 30 per cent as high.

In the present study, the heritability estimates were high as per Robinson's classification. Allard's (1960) classification of heritability [Low (10 - 30 per cent), medium (30 - 60 per cent) and high (above 60 per cent)] also revealed high heritability estimates for all characters,

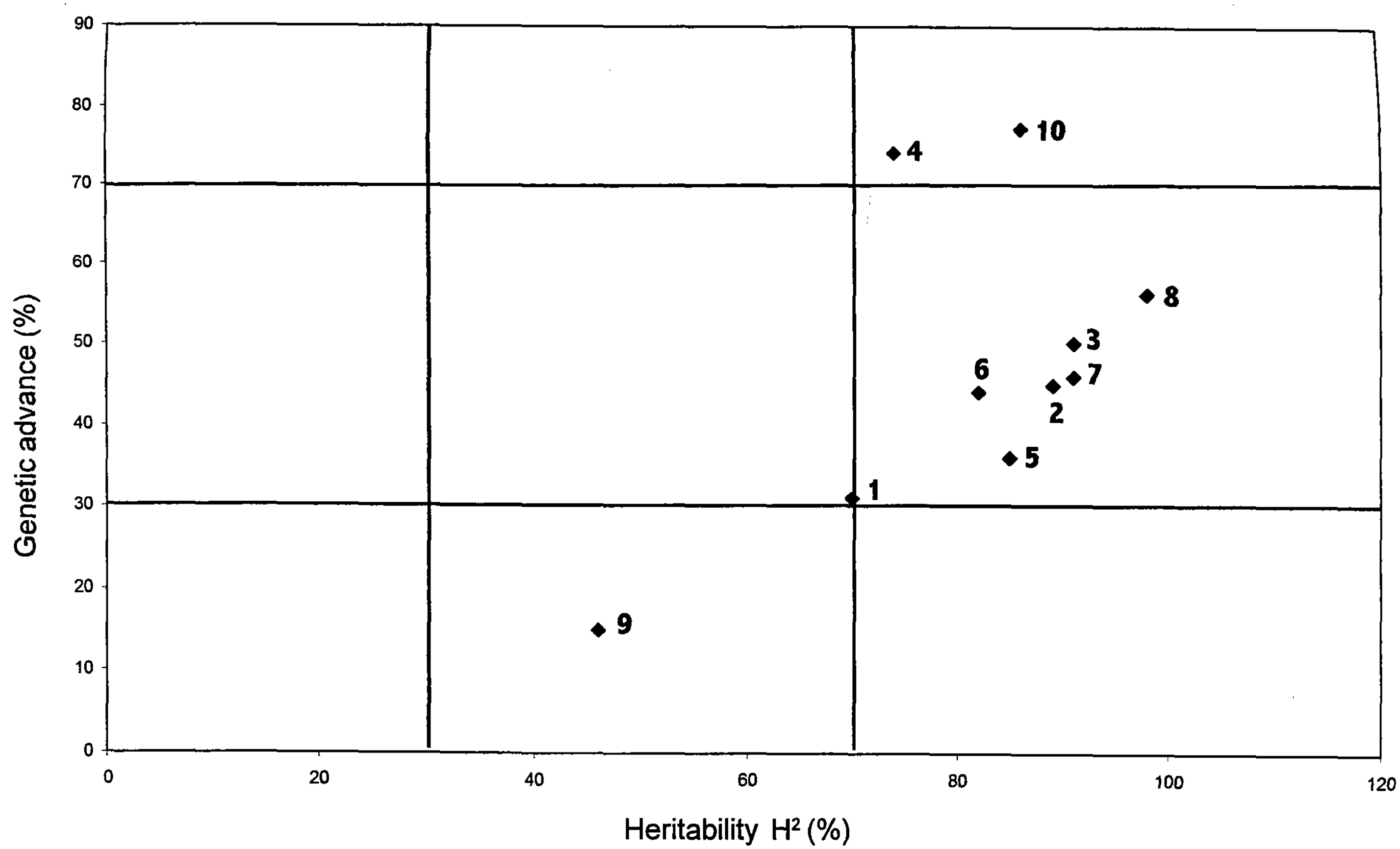
Table 4.1.3 Heritability and genetic advance for the ten traits in *A. andreanum*

Sl. No.	Characters	Heritability (%)	Genetic advance (at 5 %)	Genetic advance (as % of mean)
1.	Plant height (cm)	69.90	18.79	30.79
2.	Spathe length (cm)	88.80	4.83	44.71
3.	Spathe width (cm)	91.40	3.85	49.63
4.	No. of suckers per plant	74.21	1.52	73.93
5.	Length of leaf blade (cm)	85.12	10.68	35.91
6.	Width of leaf blade (cm)	81.54	7.34	44.29
7.	Candle length (cm)	90.64	3.45	45.94
8.	Inclination of candle (degrees)	98.03	29.70	56.04
9.	No. of spadices / plant / year	46.37	0.90	14.72
10.	Leaf area (cm^2)	85.50	258.82	76.56



X1 - Plant height
X5 - Length of leaf blade
X9 - Number of spadices/plant/year
X2 - Spathe length
X6 - Width of leaf blade
X10 - Leaf area
X3 - Spathe width
X7 - Candle length
X4 - Number of suckers/plant
X8 - Inclination of candle

Fig. 3. Heritability and genetic advance for the ten traits of *A. andreanum*



1. Plant height
2. Spathe length
3. Spathe width
4. Number of suckers/plant
5. Length of leaf blade
6. Width of leaf blade
7. Candle length
8. Inclination of candle
9. Number of spadices/plant/year
10. Leaf area

Fig. 4. Character distribution in terms of heritability and genetic advance

except number of spadices per plant per year which comes under the medium heritability category. Genetic advance as percentage of mean is independent of the unit of measurement and hence is used for comparison among characters. Maximum genetic advance was obtained for leaf area (76.56 per cent) followed by number of suckers / plant (73.93 per cent) and least genetic advance was obtained for number of spadices/ plant / year (14.72 per cent) at five per cent selection.

4.1.4 Correlation among different characters

The phenotypic, genotypic and environmental correlations among the various characters were estimated and the results are presented in Tables 4.1.4 (a, b & c) and Fig. 5, 6 and 7. The significance of both phenotypic and environmental correlations were tested. However no test is available to detect the genotypic correlation co-efficients.

4.1.4 (a) Phenotypic correlation

Plant height was found to have significant positive correlation with spathe length, spathe width, length and width of leaf blade, candle length, inclination of candle and leaf area. But no correlation was observed for this character with suckering ability and number of spadices/plant/year.

Spathe length had positive significant correlation with plant height, spathe width, length and width of leaf blade, candle length and leaf area and a significant negative correlation with suckering ability. Spathe length was not correlated with inclination of candle and number of spadices/plant/year.

Table 4.1.4 (a). Phenotypic correlation coefficients among the ten traits in Anthurium

Characters		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
Plant height (cm)	X_1										
Spathe length (cm)	X_2	0.2617**									
Spathe width (cm)	X_3	0.2642**	0.8031**								
Suckering ability	X_4	-0.1280	-0.1960*	-0.1688							
Length of leaf blade (cm)	X5	0.5756**	0.4493**	0.4636**	-0.1040						
Width of leaf blade (cm)	X6	0.5274**	0.3429**	0.3473**	-0.0477	0.7242**					
Candle length (cm)	X_7	0.2487*	0.3937**	0.3411**	-0.0346	0.4571**	0.4810**				
Inclination of candle (degrees)	X_8	0.2345*	0.1418	0.0687	-0.0766	0.2582**	0.3791**	0.1825			
No. of spadices / plant / year	X_9	0.1918	0.0771	0.1005	0.2256*	0.1321	0.0805	-0.0004	-0.0355		
Leaf area (cm^2)	X_{10}	0.5255**	0.3915**	0.4184**	-0.0194	0.8682**	0.9165**	0.4795**	0.3204**	0.1403	

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

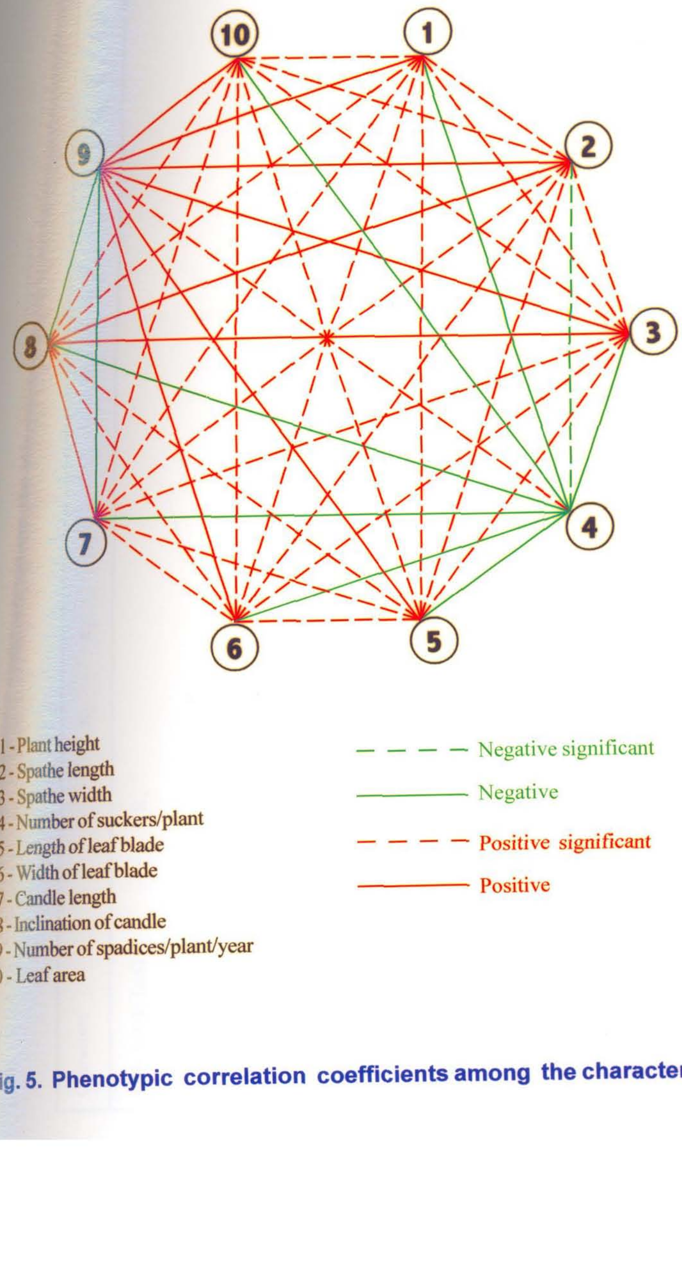
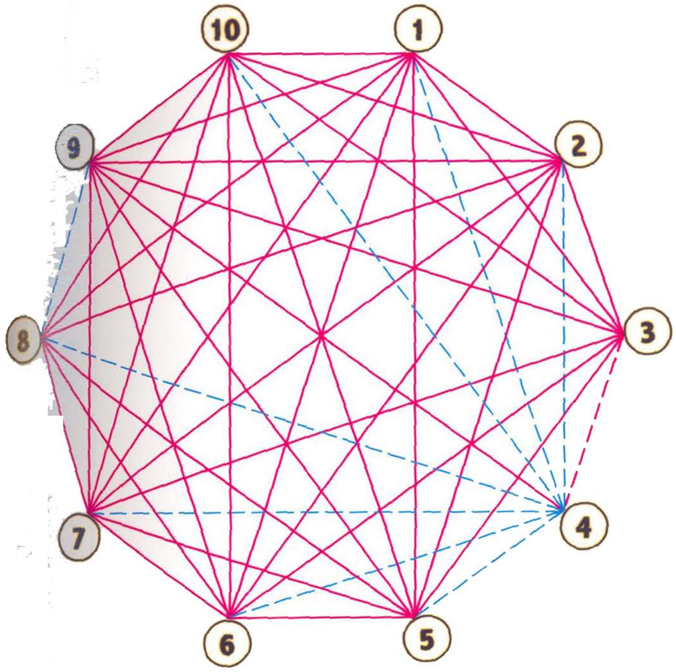


Fig. 5. Phenotypic correlation coefficients among the characters

Table 4.1.4 (b). Genotypic correlation coefficients among the ten traits in Anthurium

Characters		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
Plant height (cm)	X_1										
Spathe length (cm)	X_2	0.3180									
Spathe width (cm)	X_3	0.3292	0.8201								
Suckering ability	X_4	-0.1515	-0.2222	-0.1935							
Length of leaf blade (cm)	X_5	0.7257	0.5018	0.5290	-0.0957						
Width of leaf blade (cm)	X_6	0.6486	0.3992	0.4063	-0.0615	0.8072					
Candle length (cm)	X_7	0.3187	0.4018	0.3517	-0.0324	0.4881	0.5349				
Inclination of candle (degrees)	X_8	0.2812	0.1521	0.0714	-0.0850	0.2851	0.4276	0.1912			
No. of spadices / plant / year	X_9	0.3765	0.1298	0.1618	0.3725	0.2159	0.1745	0.0069	-0.0705		
Leaf area (cm^2)	X_{10}	0.6399	0.4415	0.4822	-0.0053	0.8984	0.9359	0.5119	0.3550	0.2401	



1 - Plant height
2 - Spathe length
3 - Spathe width
4 - Number of suckers/plant
5 - Length of leaf blade
6 - Width of leaf blade
7 - Candle length
8 - Inclination of candle
9 - Number of spadices/plant/year
10 - Leaf area

– – – – Negative
———— Positive

Fig. 6. Genotypic correlation coefficients among the characters

Table 4.1.4 (c). Environment correlation coefficients among the ten traits in Anthurium

Characters		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
Plant height (cm)	X_1										
Spathe length (cm)	X_2	0.0612									
Spathe width (cm)	X_3	0.0062	0.6551**								
Suckering ability	X_4	-0.0678	-0.0921	-0.0633							
Length of leaf blade (cm)	X_5	0.0748	0.1011	-0.0268	-0.1423						
Width of leaf blade (cm)	X_6	0.1602	0.0226	-0.0283	0.0009	0.3117**					
Candle length (cm)	X_7	-0.0294	0.3241**	0.2339*	-0.0518	0.2401*	0.1609				
Inclination of candle (degrees)	X_8	0.0220	-0.0020	0.0262	-0.0574	*-0.0424	-0.0542	0.0528			
No. of spadices / plant / year	X_9	-0.0561	-0.0254	-0.0226	0.0191	-0.0127	-0.0851	-0.0219	0.1171		
Leaf area (cm^2)	X_{10}	0.1476	0.0536	-0.0712	-0.0787	0.6929**	0.8252**	0.2480*	-0.0870	-0.0391	

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

Spathe width showed significant positive correlation with spathe length, plant height, length and width of leaf blade, candle length and leaf area and was uncorrelated with suckering ability, inclination of candle and number of spadices/plant/year.

Suckering ability showed significant positive correlation only with number of spadices/plant/year and significant negative correlation with spathe length.

Length of leaf blade had significant positive correlation with plant height, spathe length, spathe width, candle length, width of leaf blade, inclination of candle and leaf area and uncorrelated with suckering ability and number of spadices per plant per year.

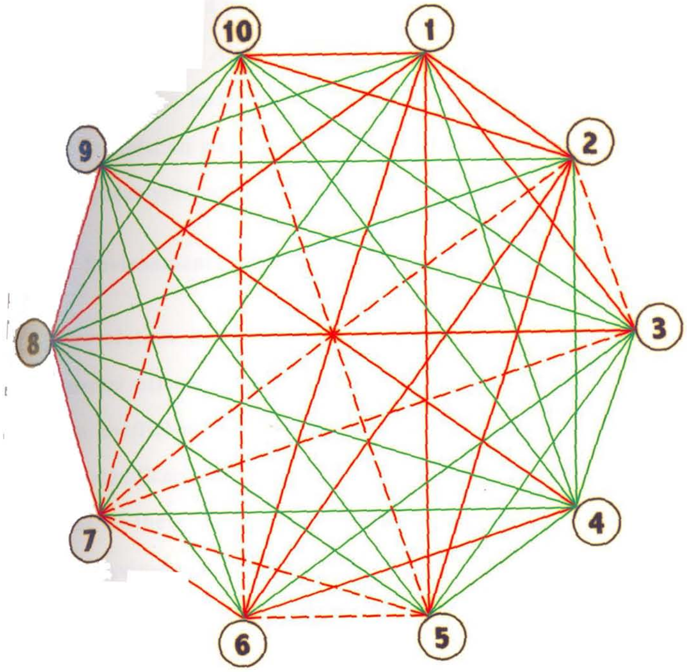
Width of leaf blade showed significant positive correlation for all the characters except for number of spadices/plant and suckering ability.

Candle length recorded significant positive correlation with plant height, spathe length and width, length and width of leaf blade and leaf area.

Inclination of candle had significant positive correlation with plant height, length and width of leaf blade and leaf area.

Number of spadices/plant/year had significant positive correlation with suckering ability and leaf area alone.

Leaf area was significantly correlated with all the characters except suckering ability and number of spadices/plant/year.



1 - Plant height
2 - Spathe length
3 - Spathe width
4 - Number of suckers/plant
5 - Length of leaf blade
6 - Width of leaf blade
7 - Candle length
8 - Inclination of candle
9 - Number of spadices/plant/year
10 - Leaf area

- – – – Negative significant
- —— Negative
- – – – Positive significant
- —— Positive

Fig. 7. Environment correlation coefficients among the characters

4.1.4(b) Genotypic correlation

Plant height had positive correlation for all the characters except for suckering ability. All the estimates of correlation of this character with other characters had higher values than phenotypic correlations. The pattern of correlation was similar with respect to all the characters just as that of phenotypic correlation.

4.1.4(c) Environmental correlation

Correlation between two characters may also arise from environmental effects. Most of the estimates of the environmental correlation coefficients for the characters under the present study are low and insignificant indicating the least effect of environment in the expression of these characters. However even with the carefully controlled environmental conditions, spathe length was found to be significant and positively correlated with spathe width and candle length. Likewise spathe width showed significant positive correlation with spathe length and candle length.

Length of leaf blade showed positive and significant correlation with width of leaf blade, candle length and leaf area whereas the width of leaf blade showed significant positive correlation with length of leaf blade and leaf area.

Candle length was significant and positively correlated with length and width of spathe, length of leaf blade and leaf area. Leaf area had significant positive correlation with length and width of leaf blade and candle length.

4.1.5 Cluster analysis through Mahalanobis D^2 - statistic

The 100 genotypes of *Anthurium* were subjected to Mahalanobis D^2 analysis based on the 10 characters *viz.,* plant height, spathe length, spathe width, suckering ability, length of leaf blade, width of leaf blade, candle length, inclination of candle, number of spadices/plant/year and leaf area. Hundred C_2 D^2 values were estimated, the range of these D^2 values being 37.06 (between G_{23} and G_{95}) to 1655120.00 (between G_1 and G_5) [Appendix I]. The significance of D^2 values was tested by applying Chi-square test of significance because each D^2 is distributed as a Chi-square. Ten characters were considered for D^2 so thus the Chi-square has got 10 degrees of freedom whose critical value is 18.07 and 23.21 respectively at five per cent and one per cent levels of significance. All the D^2 values were significant.

Tocher's method was applied to cluster the genotypes based on their pair-wise D^2 values and as such, 17 clusters were formed. The group constellation of these 17 clusters are presented in Table 4.1.5 (a) and Plates (1 to 9).

Three genotypes could not be included in any of the clusters and were kept as independent.

The average intra and inter cluster D^2 values and distances are presented in Tables 4.1.5 (b) and 4.1.5 (c) and in Chapter 5. The mean performance of a cluster with respect to individual characters is presented in Table 4.1.5 (d). The co-efficients of variation for each trait at genotypic and inter-cluster level are presented in Table 4.1.5 (e).

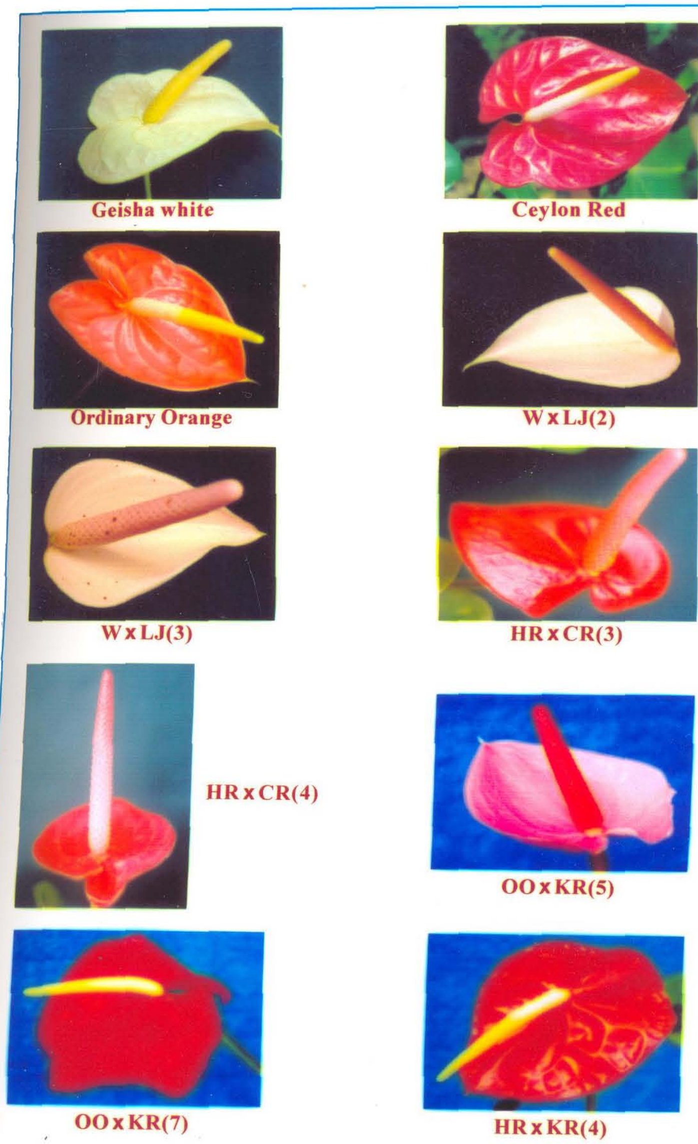


Plate 1. Experiment I - Cluster 1

Table 4.1.5 (a). Group constellations in 100 genotypes of *Anthurium andreanum*

Cluster	No. of genotypes	Genotypes
C_1	12	Geisha White, Ceylon Red, Ordinary Orange, WxLJ(2), WxLJ(3), HRxCR(3), HRxCR(4), OOxKR(5), OOxKR(7), HRxKR(4), KRxP(9), WxHR(1)
C_2	13	Orange Glory, Nitta Orange, WxLJ(7), WxKR(2), LRxP(2), LRxP(3), HRxCR(2), OOxKR(1), OOxKR(10), KRxP(5), KRxP(6), KRxP(7), PxCR(3)
C_3	15	Johnsons Pink, Merengue White, KRxHR(1), LRxP(1), LRxP(4), LRxP(5), HRxCR(1), HRxCR(6), HRxW(1), OOxKR(9), HRxKR(1), KRxP(8), PxCR(1), WxHR(2), CRxKR(1)
C_4	5	HRxLJ(2), HRxLJ(3), OOxHR(1), OOxHR(2), OOxHR(4)
C_5	9	Kalympong Orange, WxOO(1), WxOO(2), OOxLR(1), KOxP(2), HRxP(2), HRxKR(2), KRxP(4), CRxW(2)
C_6	9	Midori Green, Tropical Red, WxLJ(4), WxP(1), HRxP(1), OOxHR(3), OOxKR(2), PxCR(2), OOxP(2)
C_7	6	Mauritius Orange, WxLJ(1), WxKR(1), LJxKR(1), HRxP(3), KRxP(2)
C_8	7	WxLJ(6), OOxHR(5), KRxP(1), KRxP(3), PxCR(4), CRxW(1), WxHR(3)

Contd...

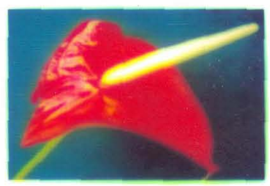
Orange glory

Nitta Orange

W x LJ(7)

W x KR(2)

LR x P(2)



HR x CR(2)

OO x KR(1)

KR x P(5)

KR x P(7)

KR x P(6)

P x CR(3)

Plate 2. Experiment I - Cluster 2

Plate 3. Experiment I - Cluster 3

Table 4.1.5 (a). (Contd...)

Cluster	No. of genotypes	Genotypes
C_9	4	Liver Red, Dragon's tongue Red, WxP(2), CRxW(3)
C_{10}	7	Chilli Red, Pompon Red, WxLJ(5), HRxCR(5), OOxKR(6), HRxKR(3), PxCR(5)
C_{11}	2	Honeymoon Red, Pink
C_{12}	3	White, WxOO(3), KOxP(1)
C_{13}	2	Kalympong Red, PxCR(6)
C_{14}	3	Lady Jane Red, OOxKR(4), OOxP(1)
C_{15}	1	HRxLJ(1)
C_{16}	1	OOxKR(3)
C_{17}	1	OOxKR(8)

Plate 4. Experiment I - Cluster 4 & Cluster 5

Table 4.1.5 (b). Average intra and inter cluster distance (D^2)

Cluster Number																
C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17
9801	23409	87616	1008016	426409	25921	34225	194481	570025	271441	3330625	1249924	734449	38025	1760929	6724	85264
	14641	38025	802816	299209	202500	7225	110889	439569	190969	2948089	1054729	586756	24336	1540081	29241	160801
		24025	511225	133956	202500	19600	24025	225625	65536	2350089	712336	330625	55225	1119364	142884	341056
			6400	123904	1343281	660969	320356	57121	214369	677329	9409	19321	810000	121104	1164241	1397124
				7225	644809	226576	48400	27556	21609	1371241	232324	48400	312481	483025	532900	894916
					14641	114244	350464	855625	487204	3920400	1664100	1056784	98596	2262016	8281	19321
						4900	68644	349281	133956	469225	859329	481636	29584	1368900	66564	190096
							6724	108241	12996	1920996	509796	206116	128164	829921	265225	532900
								3721	56644	1115136	135424	42436	490000	651249	383161	790321
									6561	1646089	352836	110224	178084	337561	570025	1125721
										576	477481	692224	2937796	226576	3610000	4473225
											2116	70225	1058841	758641	1464100	2033476
												900	594441	137641	898704	1354896
													1296	1542564	60516	189225
														0	2027776	2689600
															0	47089
																0

Bold figures in diagonals are the intra-cluster distances.

Midori Green

W x LJ(4)

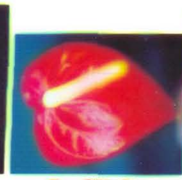
Tropical Red

HR x P(1)

Cluster 6

OO x HR(3)

OO x KR(2)



P x CR(2)

OO x P(2)

Mauritius Orange

W x LJ(1)

W x KR(1)

Cluster 7

LJ x KR(1)

HR x P(3)

KR x P(2)

Plate 5. Experiment I - Cluster 6 & Cluster 7

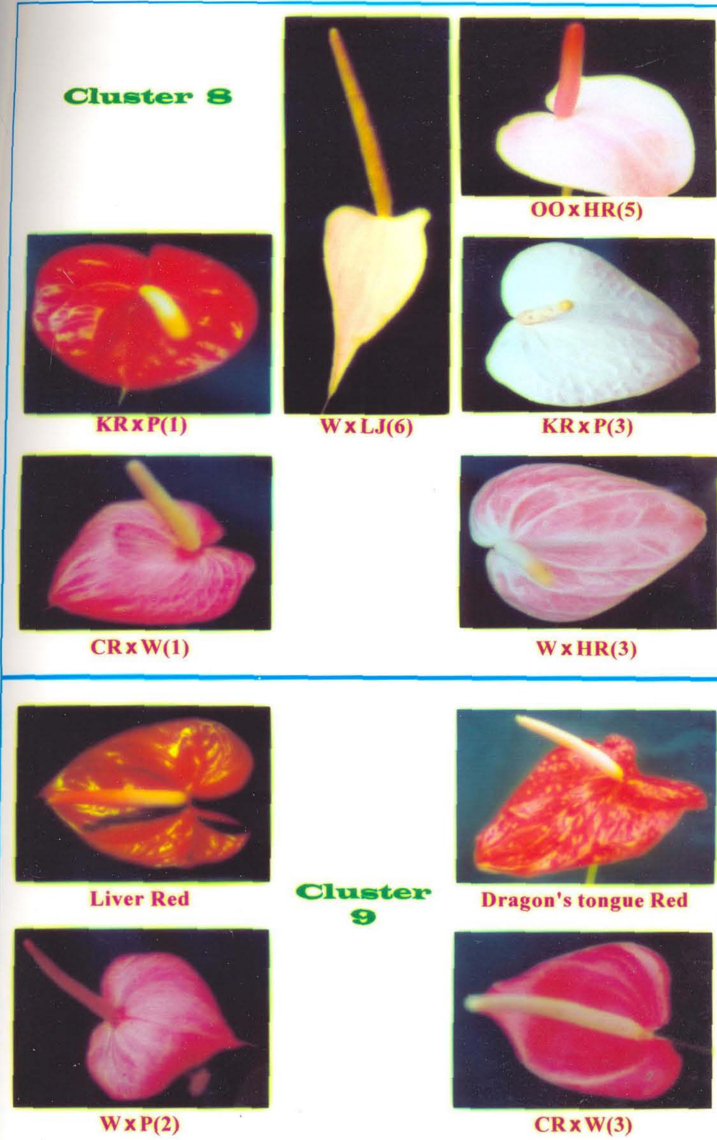


Plate 6. Experiment I - Cluster 8 & Cluster 9

Table 4.1.5 (c). Average intra and inter cluster distance ($\sqrt{D^2}$)

Cluster Number																
C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17
99	153	296	1004	653	161	185	441	755	521	1825	1118	857	195	1327	82	292
	121	195	896	547	450	85	333	663	437	1717	1027	766	156	1241	171	401
		155	715	366	450	140	155	475	256	1533	844	575	235	1058	378	584
			80	352	1159	813	566	239	463	823	97	139	900	348	1079	1182
				85	803	476	220	166	147	1171	482	220	559	695	730	946
					121	338	592	925	698	1980	1290	1028	314	1504	91	139
						70	262	591	366	685	927	694	172	1170	258	436
							82	329	114	1386	714	454	358	911	515	730
								61	238	1056	368	206	700	807	619	889
									81	1283	594	332	422	581	755	1061
										24	691	832	1714	476	1900	2115
											46	265	1029	871	1210	1426
												30	771	371	948	1164
													36	1242	246	435
														0	1424	1640
															0	217
																0

Bold figures in diagonals are the intra-cluster distances.


Chilli Red


W x LJ(5)


Pompon Red


HR x CR(5)

Cluster 10


OO x KR(6)


HR x KR(3)


P x CR(5)


Honeymoon Red

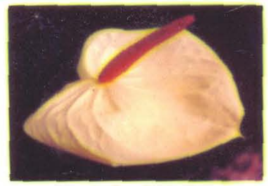
Cluster 11


Pink

Plate 7. Experiment I - Cluster 10 & Cluster 11

Cluster 12

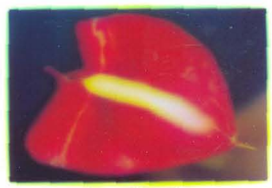
White



KO x P(1)

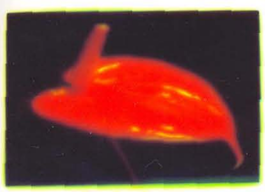
Cluster 13

Kalympong Red

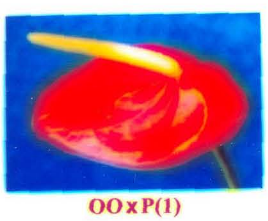


P x CR(6)

Cluster 14



Lady Jane



OO x P(1)

OO x KR(4)

Plate 8. Experiment I - Clusters 12, 13 & 14

Table 4.1.5 (d). Cluster means of the ten characters

Sl. No.	Characters	Clusters																
		C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}
1.	Plant height (cm)	55.89	56.72	59.62	66.87	67.48	50.20	50.06	63.14	76.67	66.14	62.83	79.67	79.67	49.06	83.00	46.00	37.00
2.	Spathe length (cm)	9.44	10.00	10.76	11.81	11.59	9.77	10.46	10.06	13.57	12.82	13.73	11.72	11.62	9.36	13.03	7.33	9.00
3.	Spathe width (cm)	6.75	7.27	7.83	8.65	8.17	7.04	6.97	7.48	8.68	8.91	10.65	9.18	9.52	7.10	10.97	5.50	6.10
4.	Suckering ability	2.20	1.92	1.87	2.47	1.70	2.07	2.50	1.33	2.00	2.00	3.67	1.11	1.34	3.11	2.67	3.33	3.00
5.	Length of leaf blade (cm)	24.64	27.73	29.84	36.20	31.87	23.33	27.67	32.43	35.88	33.57	45.92	38.22	40.67	24.56	41.00	22.33	17.00
6.	Width of leaf blade (cm)	13.15	13.81	15.81	24.53	19.65	12.87	15.05	17.06	20.29	18.17	27.57	23.89	19.33	13.22	25.00	12.67	9.83
7.	Candle length (cm)	6.46	7.04	7.30	8.87	9.85	6.58	6.20	7.29	8.78	7.79	10.10	3.77	8.93	6.76	8.50	6.83	5.80
8.	Inclination of candle (degrees)	46.17	41.79	55.13	54.87	63.52	44.85	61.72	45.81	69.08	49.19	73.34	60.67	42.83	46.11	65.33	30.00	45.00
9.	No. of leaves or spadices/ plant/year	6.17	6.15	5.91	6.00	6.22	5.88	6.00	5.57	6.25	6.10	7.00	7.11	6.00	6.45	7.33	6.67	6.33
10.	Leaf area (cm^2)	234.54	252.83	314.13	426.38	419.14	164.72	276.21	363.33	473.32	461.35	822.61	594.84	509.15	254.02	665.74	191.27	116.62

Cluster 15
HR x LJ(1)

Cluster 16
OO x KR(3)

Cluster 17
OO x KR(8)

Plate 9. Experiment I - Clusters 15, 16 & 17

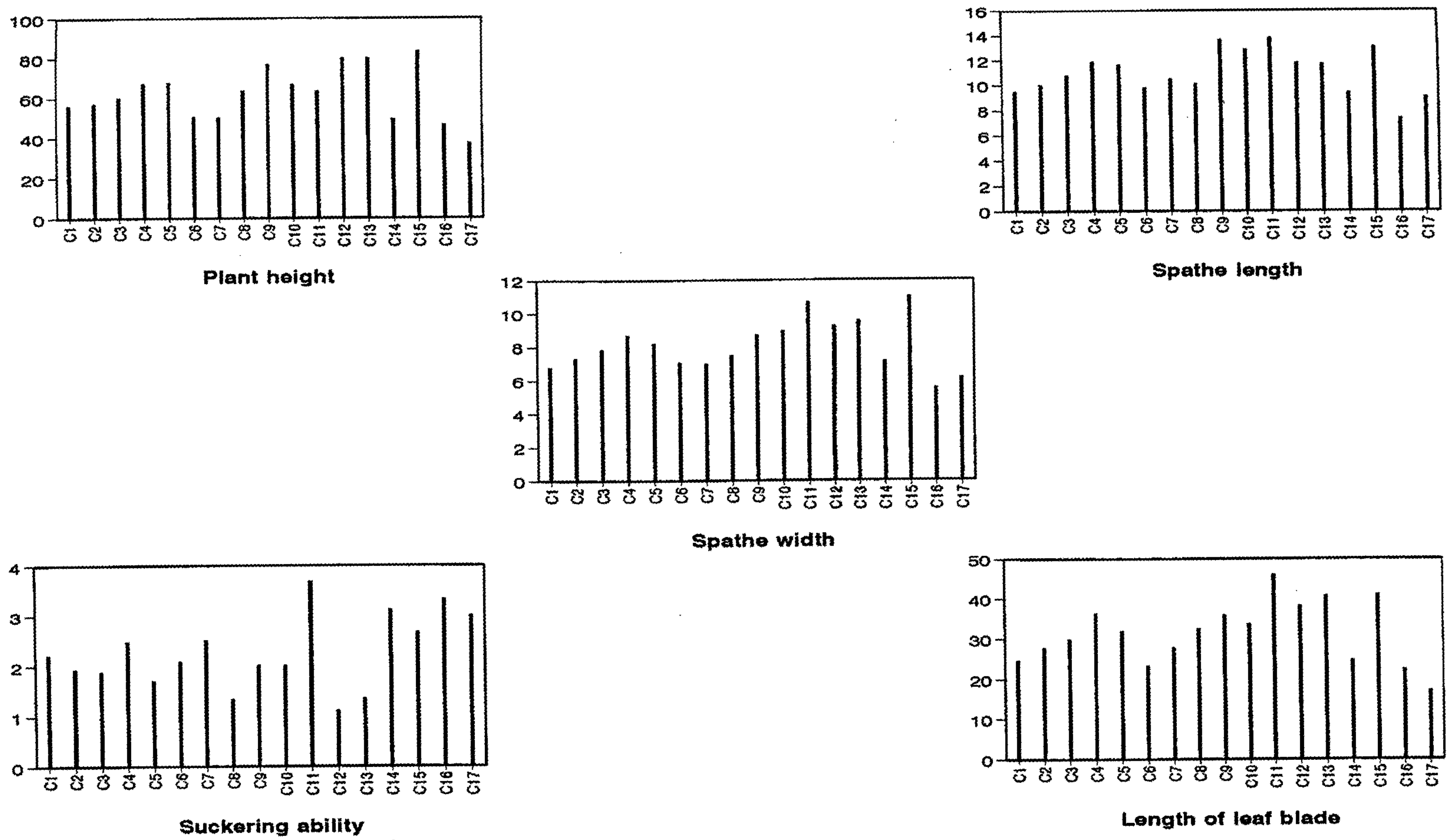


Fig. 8a. Characterwise performance of genotypes within clusters

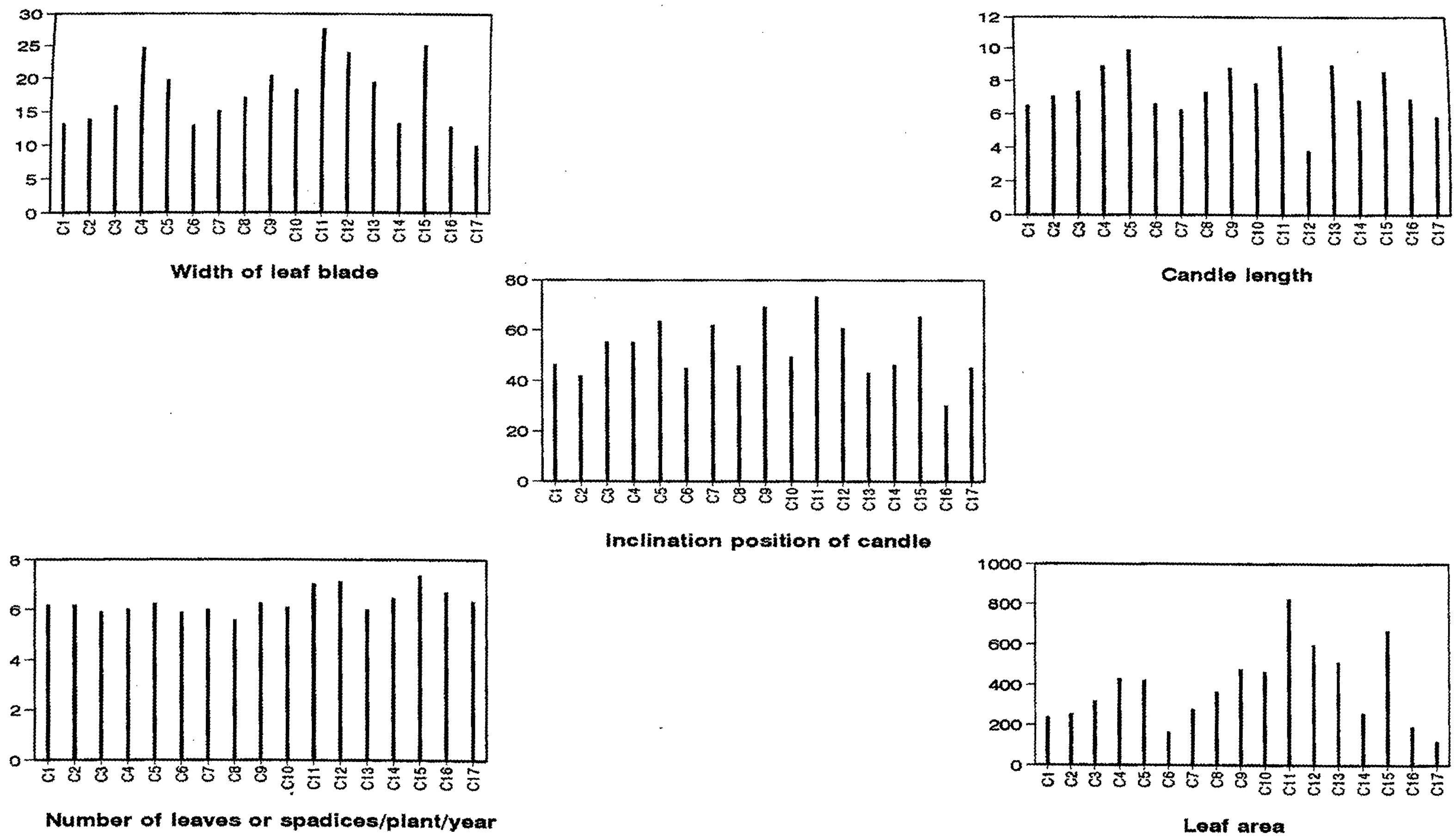


Fig. 8b. Characterwise performance of genotypes within clusters (Contd..)

The inter-cluster D^2 values are expressed as the diversification among the groups of genotypes resembling each other based on the ten characters under study and intra-cluster D^2 values are expressed as the magnitude of divergence between genotypes within a cluster. The intra-cluster D^2 values ranged from 576 (2 genotypes) to 24025 (15 genotypes). The inter-cluster D^2 values ranged from 6724 (between C_1 and C_{16}) to 4473225 (between C_{11} and C_{17}).

The cluster means of the ten characters are presented in Table 4.1.5 (d) and Fig. 8 (a and b). Cluster 11 showed the highest cluster mean for spathe length, suckering ability, length of leaf blade, width of leaf blade, candle length, inclination of candle and leaf area. The highest cluster mean for spathe width and number of spadices / plant / year was registered by Cluster 15. This cluster also recorded the second highest cluster mean for length of leaf blade, width of leaf blade and leaf area.

The co-efficient of variation (CV in percentage) for each trait at genotypic and intercluster levels were estimated and this co-efficient indicates the relative contribution of each trait at these two levels (Fig. 9). At genotypic level X_4 ie., suckering ability registered the maximum co-efficient of variation 24.79 per cent followed by X_{10} ie., leaf area (16.52 per cent). At the intercluster level, leaf area registered the maximum co-efficient of variation (49.44 per cent) followed by suckering ability (32.32 per cent). The order of differentiation is from lowest to highest one presented along with the co-efficient of variation values. Thus at genotypic level suckering ability was the potential trait of differentiation

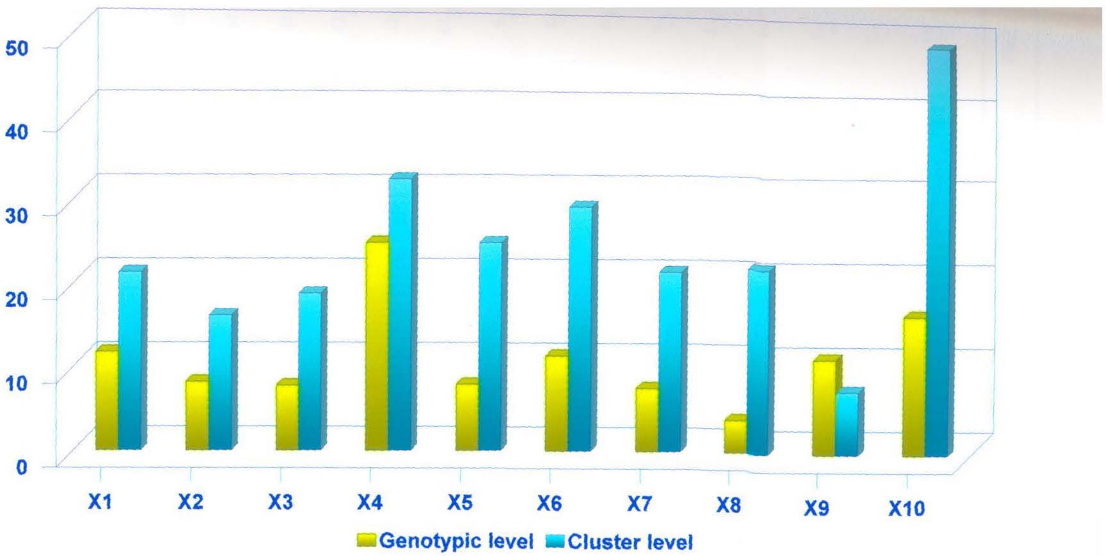
Table 4.1.5 (e). Pattern of variation in terms of CV at genotypic and inter-cluster levels

Sl. No.	Character	CV_G	CV_{IC}
1.	Plant height	11.74 (8)	21.24 (4)
2.	Spathe length	8.17 (5)	16.09 (2)
3.	Spathe width	7.73 (3)	18.71 (3)
4.	Suckering ability	24.79 (10)	32.32 (9)
5.	Length of leaf blade	7.91 (4)	24.74 (7)
6.	Width of leaf blade	11.34 (7)	29.07 (8)
7.	Candle length	7.53 (2)	21.36 (5)
8.	Inclination of candle	3.89 (1)	21.88 (6)
9.	Number of spadices / plant / year	11.33 (6)	7.51 (1)
10.	Leaf area	16.52 (9)	49.44 (10)

CV_G - Genotypic level coefficient of variation

CV_{IC} - Cluster level coefficient of variation

Figures in parenthesis are the rank order of differentiation.



X1 - Plant height
X5 - Length of leaf blade
X9 - Number of spadices/plant/year
X2 - Spathe length
X6 - Width of leaf blade
X10 - Leaf area
X3 - Spathe width
X7 - Candle length
X4 - Suckering ability
X8 - Inclination of candle

Fig. 9. Pattern of variation in terms of cv. at genotypic and inter-cluster level

Table 4.1.5 (f). Maximum and minimum divergence between clusters

Cluster	Maximum		Minimum	
C_1	3330625	[C_{11}]	6724	[C_{16}]
C_2	2948089	[C_{11}]	7225	[C_7]
C_3	2350089	[C_{11}]	19600	[C_7]
C_4	1397124	[C_{17}]	9409	[C_{12}]
C_5	1371241	[C_{11}]	21609	[C_{10}]
C_6	3920400	[C_{11}]	8281	[C_{16}]
C_7	1368900	[C_{15}]	7225	[C_2]
C_8	1920996	[C_{11}]	12996	[C_{10}]
C_9	1115136	[C_{11}]	27556	[C_5]
C_{10}	1646089	[C_{11}]	12996	[C_8]
C_{11}	4473225	[C_{17}]	226576	[C_{15}]
C_{12}	2033476	[C_{17}]	9409	[C_4]
C_{13}	1354896	[C_{17}]	19321	[C_4]
C_{14}	2937796	[C_{11}]	24336	[C_2]
C_{15}	2689600	[C_{17}]	121104	[C_4]
C_{16}	3610000	[C_{11}]	6724	[C_1]
C_{17}	4473225	[C_{11}]	19321	[C_6]

Figures in parenthesis are the cluster numbers.

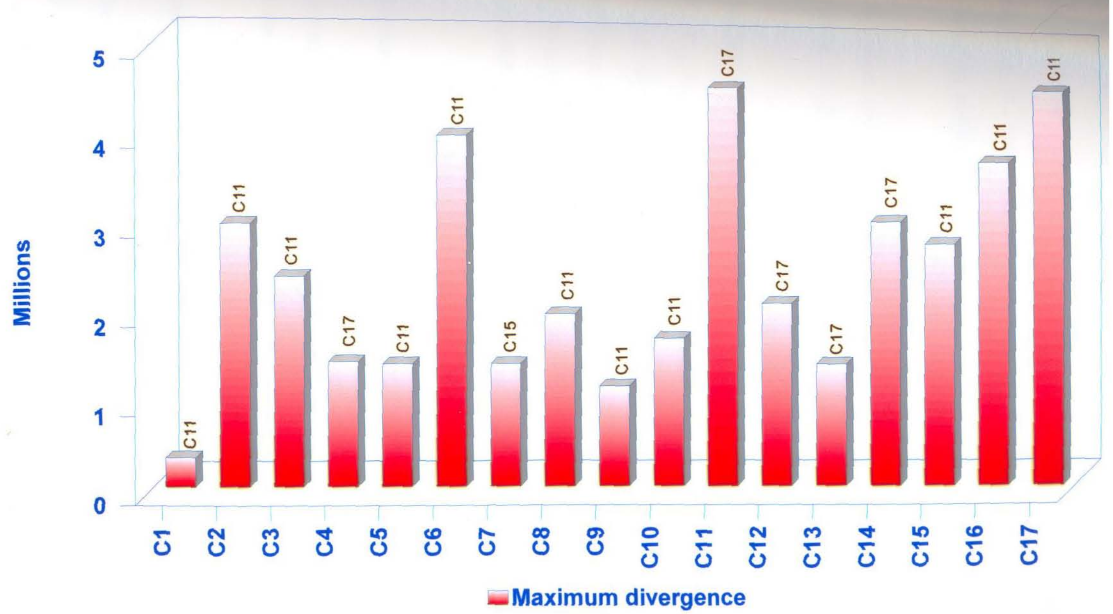


Fig. 10. Maximum divergence between clusters

among the genotypes followed by leaf area. While leaf area was the potential contributor of differentiation at inter-cluster level followed by suckering ability ie., maximum divergence is for X_{10} (leaf area) followed by X_4 (suckering ability).

Maximum and minimum divergences between clusters are listed in the Table 4.1.5 (f) and Fig. 10.

Maximum divergence was observed for C_{11} with C_1, C_2, C_3, C_5, C_6, C_8, C_9, C_{10}, C_{14}, C_{16}, C_{17}. A comparison of the clusters at maximum and minimum level recorded the following results. 'Honeymoon Red' and 'Pink' were the genotypes in C_{11}. So C_{11} is a better combiner in producing hybrids on the basis of the ten multiple characters studied. C_{17} ie., OO x KR (8) had maximum divergence with C_4, C_{11}, C_{12}, C_{13} and C_{15}.

4.2 Experiment No. II : Estimation of heterosis and gene action

Statistical analysis of the data relating to the experiment-II was done and the results are presented below.

4.2.1 Mean performance of parents and hybrids

The mean performances of the five parents and ten hybrids for the twenty nine characters (vegetative, floral and qualitative) are presented in Table 4.2.1 (a) for vegetative characters, 4.2.1 (b) and 4.2.1 (c) for floral and qualitative characters. (Plates 10 and 11)

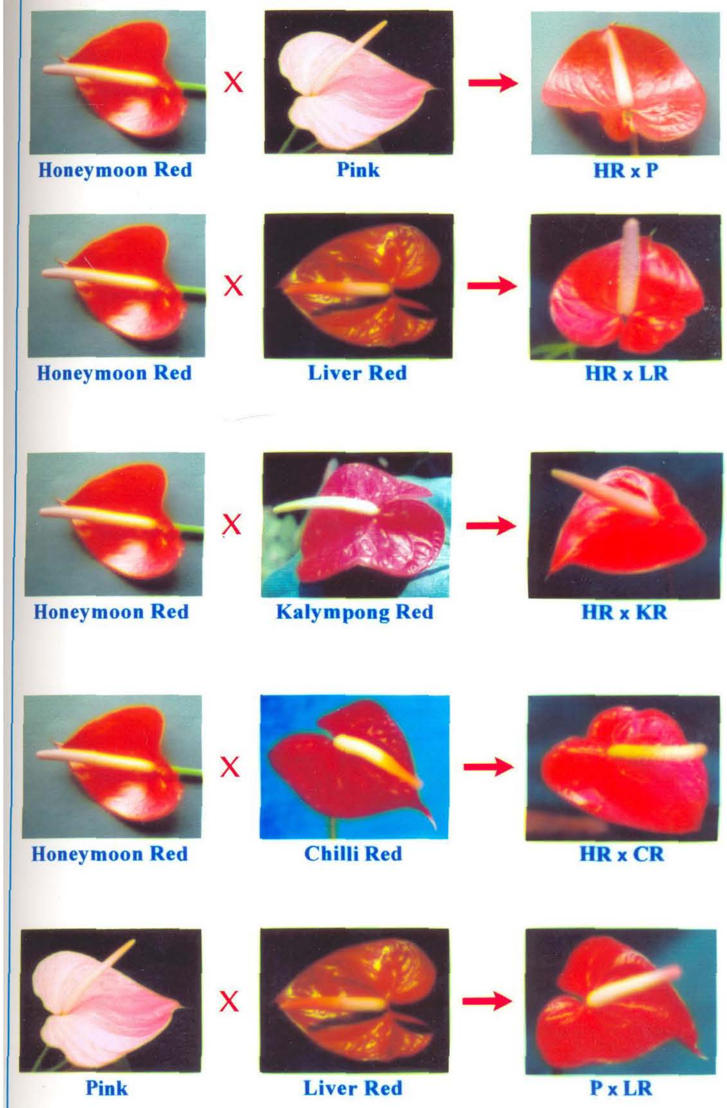


Plate 10. Experiment II

Table 4.2.1 (a). Vegetative character differentiation in parents and F_1 hybrids

Sl. No.	Characters / Treatments	Plant height (cm)	Internode length (cm)	Days from emergence to maturity of leaves	No. of leaves	Length of leaf blade (cm)	Width of leaf blade (cm)	Leaf size / Leaf area (cm^2)	Suckering ability
1.	HR	58.40	1.06	41.40	7.60	47.60	30.76	938.81	3.40
2.	P	68.20	1.00	44.40	7.00	48.16	27.18	847.41	4.00
3.	LR	80.20	1.52	43.80	7.00	40.90	18.40	491.00	3.60
4.	KR	72.08	1.08	43.20	7.20	42.30	16.98	471.82	1.60
5.	CR	58.80	1.44	42.20	7.00	34.40	17.90	403.03	2.80
6.	HR x P	66.00	1.34	44.00	7.20	31.24	21.26	430.15	3.60
7.	HR x LR	53.10	1.20	40.60	6.60	28.42	18.80	351.44	3.40
8.	HR x KR	66.20	1.08	43.40	7.40	30.86	18.64	379.54	2.40
9.	HR x CR	62.50	1.10	41.80	7.40	25.92	13.74	237.42	2.80
10.	P x LR	64.60	1.10	40.40	7.20	36.18	18.48	437.41	3.40
11.	P x KR	69.30	1.24	45.20	7.20	27.04	13.98	251.46	2.80
12.	P x CR	70.80	1.02	38.20	7.60	38.30	20.08	501.85	2.60
13.	LR x KR	53.82	1.14	40.80	7.40	25.22	14.26	248.93	3.40
14.	LR x CR	50.80	1.24	39.00	7.00	30.60	13.96	282.93	3.40
15.	KR x CR	65.50	1.32	41.40	7.40	36.08	15.26	361.88	3.00
	F	3.939**	1.987**	2.097**	1.369	112.835**	137.935**	173.70**	5.277**
	SE	4.013	0.1106	1.391	0.228	0.697	0.413	15.431	0.2607
	CD	11.352	0.313	3.935	0.644	1.973	1.169	43.645	0.737

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

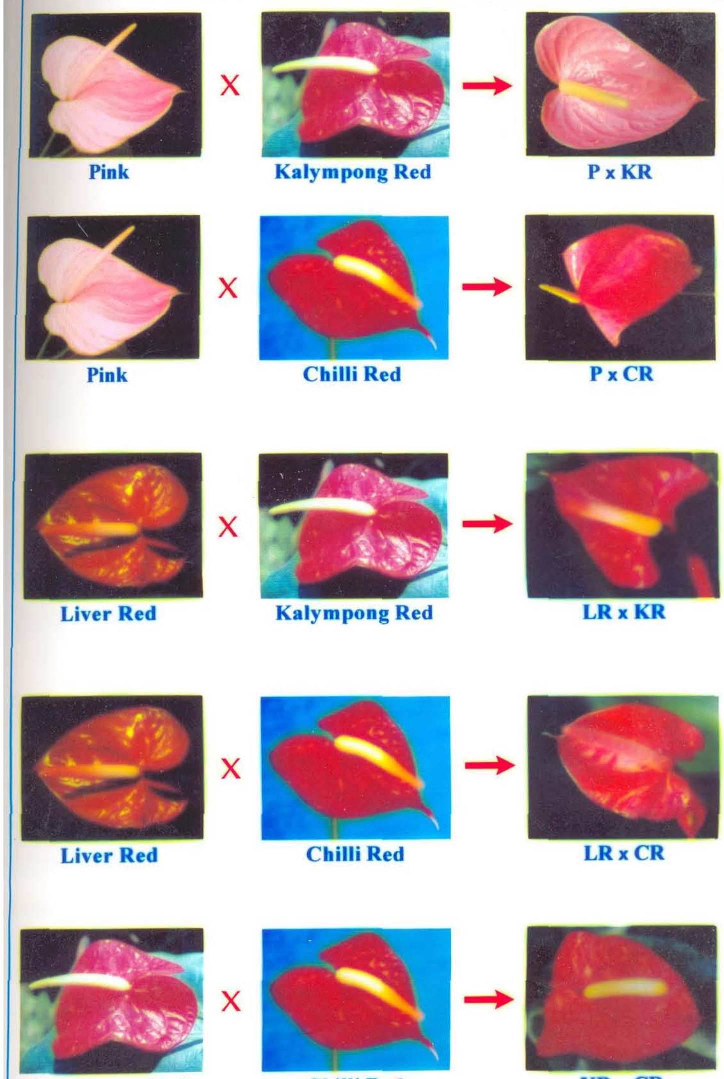


Plate 11. Experiment II

Table 4.2.1 (b). Floral character differentiation in parents and F_1 hybrids

Sl. No.	Characters / Treatments	Time taken for first flowering (months)	Days from emergence to maturity of inflorescence	Length of spathe (cm)	Width of spathe (cm)	No. of spadices per plant	Candle length (cm)	Inclination of candle (degrees)	No. of flowers / candle
1.	HR	36.80	50.60	14.26	10.08	7.60	10.38	78.20	492
2.	P	36.80	48.40	12.80	11.10	6.80	12.72	69.40	600
3.	LR	38.20	48.40	11.60	7.24	7.00	7.18	61.00	400
4.	KR	36.20	47.00	14.14	10.62	6.40	9.30	21.00	445
5.	CR	36.40	44.60	11.94	8.80	6.40	8.84	45.80	372
6.	HR x P	37.00	41.00	11.20	8.10	7.20	7.48	89.60	600
7.	HR x LR	37.40	41.60	14.60	12.20	6.20	10.38	54.40	502
8.	HR x KR	36.80	54.00	11.72	8.36	7.20	9.44	38.80	600
9.	HR x CR	36.80	50.80	12.90	11.30	7.00	7.14	20.80	450
10.	P x LR	36.80	46.60	8.72	7.30	7.00	5.90	34.00	400
11.	P x KR	36.60	52.60	9.60	7.14	7.20	9.06	50.80	600
12.	P x CR	37.40	51.20	9.28	7.28	7.40	7.00	41.20	402
13.	LR x KR	37.20	52.40	11.66	8.72	7.40	9.00	36.40	540
14.	LR x CR	37.20	52.20	7.40	5.90	6.60	7.92	43.40	558
15.	KR x CR	36.80	51.00	13.58	11.40	7.00	6.76	51.80	500
	F	4.104**	5.506**	18.814**	20.660**	3.792**	82.792**	1319.54**	356.318**
	SE	0.2366	1.699	0.4969	0.427	0.209	0.194	0.534	4.396
	CD	0.669	4.805	1.405	1.208	0.593	0.550	1.510	12.436

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

Tabl 4.2.1 (b) (Contd......)

Sl. No.	Characters / Treatments	Life of spadix (days)	Days to initiation of female phase	Duration of female phase	Days of interphase	Duration of male phase	Pollen fertility (%)	Total anthocyanin content (mg/g)	Carotene content (mg/100g)
1.	HR	120.40	6.80	11.20	8.80	7.20	19.70	245.83	7.52
2.	P	105.20	5.20	7.40	11.20	5.20	28.40	121.38	2.10
3.	LR	101.20	6.80	11.00	10.40	5.60	40.90	386.56	7.12
4.	KR	100.00	4.40	13.60	10.80	5.20	25.90	334.42	9.03
5.	CR	98.00	5.20	7.80	7.80	5.00	20.12	323.83	4.96
6.	HR x P	123.60	4.80	11.20	10.20	6.00	24.00	214.26	4.82
7.	HR x LR	120.80	3.80	12.80	10.20	7.20	34.70	146.03	5.02
8.	HR x KR	126.00	3.60	9.60	11.00	8.20	25.52	277.19	2.54
9.	HR x CR	117.80	6.20	11.00	9.39	5.60	30.80	207.54	3.82
10.	P x LR	117.20	4.60	10.60	10.40	5.80	31.14	200.61	1.76
11.	P x KR	116.00	4.80	10.40	10.80	9.66	28.62	207.62	2.34
12.	P x CR	122.00	3.60	12.20	12.60	6.60	23.14	209.17	2.45
13.	LR x KR	110.80	4.00	10.80	10.00	7.80	32.32	319.15	7.62
14.	LR x CR	112.00	5.20	9.60	9.80	8.60	23.64	329.74	2.92
15.	KR x CR	112.60	4.40	9.60	11.60	8.00	23.20	330.95	5.31
	F	3.803**	7.90**	5.13**	4.188**	7.358**	87.15**	11327.14**	23726.96**
	SE	4.592	0.37	0.733	0.561	0.527	0.618	0.722	0.015
	CD	12.988	1.048	2.073	1.586	1.493	1.750	2.042	4.284

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

Table 4.2.1 (c). Variation in qualitative characters among the parents and hybrids

Sl. No. (1)	Parents / Hybrids (2)	Plant type (3)	Spathe colour (4)	Spathe texture (5)	Candle colour (6)	Type of inflorescence axis (7)
1.	HR	Spreading	Red	Thick smooth, glossy	Red	Long, straight and strong
2.	Pink	Spreading	Pink	Medium thick, smooth	Light pink	Long, straight and strong
3.	Liver Red	Compact	Deep maroon	Thick, smooth, glossy	Red	Long, straight and strong
4.	Kalympong Red	Semi spreading	Dark red	Medium, thick, deeply blistered glossy	Yellowish white	Long, thin slightly curved
5.	Chilli Red	Compact	Dark red	Medium, thick, deeply blistered glossy	Light red	Long straight strong
6.	HR x P	Spreading	Dark red	Thick, smooth glossy	Pink	Long straight strong
7.	HR x LR	Semi spreading	Red	Thick, smooth glossy	Light pink	Long straight strong

Table 4.2.1 (c). (Contd...)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
8.	HR x KR	Spreading	Dark red	Thick, smooth glossy	Reddish pink	Long straight, strong
9.	HR x CR	Semi spreading	Red	Medium thick blistered, glossy	Yellowish white	Long straight, strong
10.	P x LR	Spreading	Red	Medium thick blistered, glossy	White	Long, straight, strong
11.	P x KR	Compact	Dark pink	Thick, medium blistered, glossy	Yellow	Long straight, strong
12.	P x CR	Spreading	Dark pink	Thick smooth, glossy	Cream	Long straight, strong
13.	LR x KR	Semi spreading	Deep maroon	Thick, blistered and glossy	Yellow	Long straight, strong
14.	LR x CR	Compact	Deep maroon	Thick, medium blistered, glossy	Yellow	Long straight, strong
15.	KR x CR	Compact	Deep maroon	Thick, smooth, glossy	Yellow	Long, straight, strong

Significant differences were detected among the parents and hybrids with respect to all the characters except in the case of number of leaves.

The mean height of plants of the parents ranged from 58.40 cm (HR) to 80.20 cm (LR) and that of hybrids ranged from 50.80 cm (LR x CR) to 70.80 cm (P x CR).

The mean internode length recorded by the parents ranged from 1.00 cm (P) to 1.52 cm (LR) and in the hybrids it ranged from 1.02 cm in P x CR to 1.34 cm for HR x P.

The days from emergence to maturity of leaves recorded by the parents ranged from 41.40 days in HR to 44.40 days in P. Among the hybrids, it ranged from 38.20 days in P x CR to 45.20 days in P x KR.

The maximum number of leaves was produced by the parent HR (7.60) which was on par with hybrid P x CR and the minimum was recorded by the hybrid HR x LR (6.6). The number of leaves was not significantly different among the parents. But significant differences were observed among the hybrids.

The parents showed significant differences in the mean length of leaf blade ranging from 34.40 cm in CR to 48.16 cm in P. The hybrids also showed significant differences for this character, ranging from 25.22 cm (LR x KR) to 38.30 cm (P x CR).

The width of the leaf blade recorded by the parents ranged from 16.98 cm in KR to 30.76 cm in HR. Among the hybrids, it ranged from 13.74 cm in HR x CR to 21.26 cm in HR x P.

The leaf area recorded by the parents ranged from 403.03 sq.cm in CR to 938.81 sq.cm in HR, whereas it ranged from 237.42 sq.cm to 501.85 sq.cm in the hybrids HR x CR and P x CR respectively.

Suckering ability ranged from 1.6 in KR to 4 in the parent P while the range of this character was from 2.40 (HR x KR) to 3.60 (HR x P) in the hybrids.

The mean time taken for first flowering ranged from 36.20 months in parent KR to 38.20 months in LR, while the range for this character in the hybrids was from 36.60 months (P x KR) to 37.40 months (HR x LR). Maximum time was taken by parent LR which was significantly high compared to other parents. But significant difference was not observed in hybrids.

Days from emergence to maturity of inflorescence recorded by the parents ranged from 44.60 days in CR to 50.60 days in HR while the range of this character in hybrids ranged from 41 days in HR x P to 54 days in HR x KR. Only the parent HR took more days for inflorescence maturity than the parent CR. The crosses HR x P and HR x LR took less number of days compared to parents.

The length of spathe in parents was minimum in LR (11.60 cm) and maximum in HR (14.26 cm). Among the hybrids, the length of spathe ranged from 14.60 cm in HR x LR to 7.40 cm in LR x CR. The spathe length of hybrid HR x LR exceeded the measurements of the better parent HR.

Among the parents, LR produced flowers with a mean spathe width of 7.24 cm, being the minimum value while P had flowers with maximum spathe width of 11.10 cm. Among the hybrids the minimum value was recorded by LR x CR (5.90 cm) and maximum by HR x LR (12.20 cm) which was higher than the maximum value observed among the parents.

The minimum number of spadices per plant/year among the parents was exhibited by KR and CR (6.40) and maximum by HR (7.60) which was on par with the other three parents. The hybrids also showed differences for this character ranging from 6.20 cm (HR x LR) to 7.40 (P x CR and LR x KR).

The mean candle length among the parents ranged from 7.18 cm (LR) to 12.72 cm (P) while in the hybrids it ranged from 5.90 cm (P x LR) to 10.38 cm (HR x LR).

The parents showed significant differences in the inclination of the candle ranging from 21 degrees in KR to 78.2 degrees in HR. The hybrids also showed significant differences in this parameter ranging from 20.80 degrees (HR x CR) to 89.60 degrees (HR x P).

Number of flowers / candle recorded by the parents ranged from about 372 in CR to about 600 in P. Among the hybrids, P x LR had the minimum number of flowers / candle of about 400 while HR x P and P x KR had the maximum number of flowers / candle of about 600.

The life of spadix recorded by the parents ranged from 98 days in CR to 120.40 days in HR. A wide variation of this character was seen among the hybrids with a range of 110.80 days (LR x KR) to 126 days (HR x KR).

The mean days for initiation of female phase among the parents ranged from 4.40 days (KR) to 6.80 days (HR and LR). Among the hybrids, this period ranged from 3.60 days (HR x KR, P x CR) to 6.20 days (HR x CR).

The parents showed a wide range of variability for the duration of female phase ranging 7.40 days in P to 13.60 days in KR. The hybrids also showed a wide range of variability from 9.60 days (LR x CR, KR x CR, HR x KR) to 12.80 days (HR x LR) for this character.

The mean days of interphase was minimum for CR (7.80) and maximum for P (11.20) among the parents. A wide variability for this character was seen among the hybrids with a range of 9.39 days (HR x CR) to 12.60 days (P x CR).

Duration of male phase ranged from 5.00 days in CR to 7.20 days in HR in parents. The duration was maximum in P x KR (9.60 days) and minimum in HR x CR (5.60 days) among the hybrids.

Pollen fertility was minimum in CR (20.12 per cent) and was maximum in LR (40.90 per cent) among the parents, whereas it ranged from 23.14 per cent to 34.70 per cent in the hybrids P x CR and HR x LR respectively.

The mean total anthocyanin content ranged from 121.38 mg/g in P to 386.56 mg/g in LR in the parents while the range of this character was from 146.03 mg/g (HR x LR) to 330.95 mg/g (KR x CR) in the hybrids. Carotene content ranged from 2.10 mg/100g in P to 9.03 mg/100g in KR in the parents while the range of this character was from 1.76 mg/100g (P x LR) to 7.62 mg/100g in the hybrid LR x KR.

In the case of the qualitative character plant type, the parents LR and CR had compact plant type; HR and P had spreading plant type while KR was a semi-spreading type. Among the hybrids, P x KR, LR x CR and KR x CR had compact plant types, while HR x P, HR x KR, P x LR and P x CR had spreading nature.

Spathe colour ranged from deep maroon to light pink. The parent LR had deep maroon coloured spathe. Red coloured varieties showed variation from dark red (CR) and (KR) to red (HR). Among the F_1's also variations from deep maroon to dark red to bright red to red to dark pink were observed.

Thick, smooth and glossy spathe texture was seen for parents LR and HR. Parent P had medium thick, smooth spathes while parents KR and CR produced medium thick, deeply blistered and glossy spathes. Among the crosses, thick, smooth and glossy spathes were observed for HR x P, HR x LR, HR x KR, P x CR and KR x CR, while medium thick blistered and glossy spathes were noticed in HR x CR and P x LR. The hybrids P x KR and LR x CR had thick, medium blistered glossy spathes.

Candle colour varied from light pink in P to red in HR and LR, yellowish white in KR and light red in CR. In the crosses, the candle colour ranged from cream, light pink, pinkish yellow, yellowish pink, reddish pink and red.

The nature of inflorescence axis is an important commercial trait. The inflorescence axis was long, straight and strong for all the hybrids and for the crosses except for KR in which it was long thin and slightly curved.

4.2.2. Hayman's Graphical analysis of diallel crosses

The degree of dominance, parental order of dominance, the relationship between array variance (V_r) and covariance between parents and progeny of the parents in the r^{th} array (W_r) and the relative distribution of the parents with positive and negative effects were studied. The linear regression of parental offspring covariance and parental array variance revealed the following results.

4.2.2.1 Wr-Vr graph

The linear relationship between Wr and Vr is estimated and presented in Table 4.2.2.1 (a), (b), (c) & (d). The equality of the regression co-efficient (b) of Wr and Vr to unity ie., b=1 indicates the absence of epistasis and vice versa. As such, all the characters except for plant height, non-allelic interaction was observed.

The kind of epistasis was also determined from the graphs for the expression of various characters in anthurium presented in pages 127 to 138.

Table 4.2.2.1 (a). Diverse statistics under graphical approach (for vegetative characters)

Parents	Y_r	V_r	W_r	Estimated W_r	W_r+V_r	Dominance order	Yr'	$(W_r+V_r)'$	$\sqrt{Wr^2}$
1. Plant height (cm)									
HR	58.40	30.79	-15.61	-20.33	15.18	2	6.32	0.148	51.25
P	68.20	6.22	-10.80	-40.72	-4.58	1	7.38	-0.045	23.04
LR	80.20	149.59	93.55	78.25	243.14	5	8.68	2.37	112.97
KR	72.08	48.64	-30.47	-5.52	18.77	3	7.80	0.177	64.42
CR	58.80	56.28	-24.18	0.81	32.10	[illegible]	6.36	0.312	69.29
2. Internode length (cm)									
HR	1.06	0.01	-97.59	-97.88	-97.60	2	4.40	-26.74	0.03
P	1.00	0.02	-96.25	-100.50	-96.27	1	4.15	-26.37	0.04
LR	1.52	0.03	-104.65	-102.48	-104.62	5	6.32	-28.67	0.04
KR	1.08	0.01	-98.93	-97.10	-98.92	3	4.48	-27.11	0.03
CR	1.44	0.03	-103.30	-102.77	-103.27	4	5.98	-28.30	0.04
3. Days to emergence to maturity of leaves									
HR	41.40	2.01	-3629.55	-3572.99	-3627.54	3	34.26	-42.87	1.71
P	44.40	9.01	-3646.87	3633.64	-3637.86	4	36.75	-42.99	3.63
LR	43.80	3.09	-3515.97	-3582.39	-3512.88	2	36.25	-41.51	2.12
KR	43.20	3.06	-3677.95	-3582.11	-3674.89	5	35.75	-43.43	2.11
CR	42.20	3.23	-3484.41	-3583.60	-3481.18	1	34.93	-41.14	2.17

Table 4.2.2.1 (a). (Contd...)

Parents	Y_r	V_r	W_r	Estimated W_r	$W_r + V_r$	Dominance order	Yr'	$(W_r + V_r)'$	$\sqrt{Wr^2}$
4. Number of leaves									
HR	7.60	0.148	-1011.33	-1001.10	-1011.18	2	29.15	-67.04	0.10
P	7.00	0.048	-1011.40	-1011.92	-1011.35	3	26.84	-67.05	0.06
LR	7.00	0.088	-983.50	-1007.59	-983.41	1	26.84	-65.20	0.08
KR	7.20	0.012	-1022.56	-1015.82	-1022.55	5	27.61	-67.79	0.03
CR	7.00	0.072	-1016.96	-1009.32	-1016.89	4	26.84	-67.42	0.07
5. Length of leaf blade (cm)									
HR	47.60	72.94	-4844.30	-5043.13	-4771.36	3	8.48	-20.29	47.95
P	48.16	63.99	-5371.75	-5006.82	-5307.76	5	8.58	-22.57	44.92
LR	40.90	39.27	-4794.98	-4906.54	-4755.71	1	7.28	-20.22	35.19
KR	42.30	48.54	-4815.83	-4944.15	-4767.29	2	7.53	-20.27	39.12
CR	34.40	23.85	-4917.77	-4843.99	-4893.92	4	6.13	-20.81	27.42
6. Width of leaf blade (cm)									
HR	30.76	39.45	-4134.77	-4265.07	-4095.32	5	4.89	-9.33	39.51
P	27.18	22.88	-4058.45	-3800.99	-4035.57	4	4.32	-9.19	30.09
LR	18.40	5.97	-3378.09	-3327.68	-3372.12	3	2.93	-7.68	15.37
KR	16.98	3.86	-3191.90	-3268.41	-3188.04	1	2.70	-7.26	12.36
CR	17.90	7.47	-3268.64	-3369.68	-3261.17	2	2.85	-7.43	17.19

Table 4.2.2.1 (a). (Contd....)

Parents	Y_r	V_r	W_r	Estimated W_r	W_r+V_r	Dominance order	Yr'	$(W_r+V_r)'$	$\sqrt{Wr^2}$
7. Leaf area (cm)^2									
HR	938.81	74417.97	-52497.88	-62407.45	21920.09	1	3.85	0.54	66610.25
P	847.41	47765.35	-88045.41	-71073.69	40280.06	2	3.47	-0.99	53365.26
LR	491.00	10380.52	-75486.78	-83229.56	65106.26	3	2.01	-1.61	24877.78
KR	471.82	8888.22	-83789.85	-83714.78	74901.63	5	1.93	-1.85	23020.20
CR	403.03	10727.08	-83722.40	-83116.87	72995.36	4	1.65	-1.80	25289.66
8. Suckering ability									
HR	3.40	0.25	-3175.11	-3111.69	-3174.86	3	3.64	-9.98	0.47
P	4.00	0.33	-3337.98	-3026.92	-3337.65	4	4.28	-10.49	0.54
LR	3.60	0.01	-3501.24	-3370.25	-3501.23	5	3.86	-11.01	0.08
KR	1.60	0.47	-2686.54	-2882.21	-2686.07	1	1.71	-8.44	0.64
CR	2.80	0.09	-2972.04	-3281.24	-2971.95	2	2.99	-9.34	0.28

Table 4.2.2.1 (b). Diverse statistics under graphical approach (for floral characters)

Parents	Y_r	V_r	W_r	Estimated W_r	$W_r + V_r$	Dominance order	Yr'	$(W_r + V_r)'$	$\sqrt{Wr^2}$
1. Time taken for first flowering									
HR	36.80	0.068	-37760.33	-37605.22	-37760.26	4	47.04	-157.51	0.20
P	36.80	0.092	-37719.70	-37660.11	-37719.61	3	47.04	-157.34	0.24
LR	38.20	0.268	-38168.85	-38066.81	-38168.58	5	48.83	-159.21	0.41
KR	36.20	0.132	-37515.08	-37752.99	-37514.95	1	46.28	-156.49	0.28
CR	36.40	0.152	-37719.49	-37798.30	-37719.34	2	46.53	-157.34	0.31
2. Days from emergence to maturity of inflorescence									
HR	50.60	34.94	-50828.96	-50115.85	-50794.02	1	23.16	-29.58	12.91
P	48.00	20.63	-51218.25	-52054.13	-51197.62	2	21.97	-29.81	9.92
LR	48.40	19.95	-51517.57	-52146.24	-51497.62	3	22.16	-29.99	9.76
KR	47.00	7.18	-54879.46	-53875.46	-54872.28	4	21.52	-31.95	5.85
CR	44.60	9.27	-53340.05	-53592.62	-53330.78	5	20.42	-31.05	6.65
3. Length of spathe (cm)									
HR	14.26	2.25	-14585.87	-13445.66	-14583.62	5	11.65	-12.08	1.84
P	12.80	2.77	-11635.11	-13324.91	-11632.34	1	10.45	-9.63	2.04
LR	11.60	7.93	-12170.42	-12121.65	-12162.49	2	9.47	-10.07	3.45
KR	14.14	3.23	-13687.61	-13217.13	-13684.38	4	11.55	-11.33	2.20
CR	11.94	6.77	-12422.72	-12392.38	-12415.95	3	9.75	-10.28	3.19

Table 4.2.2.1 (b). (Contd...)

Parents	Y_r	V_r	W_r	Estimated W_r	$W_r + V_r$	Dominance order	Yr'	$(W_r + V_r)'$	$\sqrt{Wr^2}$
4. Width of spathe (cm)									
HR	10.08	3.21	-11448.77	-10371.33	-11445.56	5	6.47	-13.30	2.79
P	11.10	2.80	-9358.47	-10440.56	-9355.67	1	7.12	-10.87	2.61
LR	7.24	5.82	-9459.33	-9930.13	-9453.51	2	4.64	-10.99	3.76
KR	10.62	3.01	-10577.55	-10405.64	-10574.54	4	6.81	-12.29	2.71
CR	8.80	5.91	-10217.94	-9914.40	-10212.03	3	5.64	-11.87	3.79
5. Number of spadices / plant									
HR	7.60	0.27	-8135.75	-8000.16	-8135.48	3	15.26	-59.35	0.26
P	6.80	0.05	-8228.28	-8149.76	-8228.23	5	13.66	-60.02	0.11
LR	7.00	0.21	-7904.83	-8041.71	-7904.62	1	14.06	-57.66	0.23
KR	6.40	0.15	-8135.69	-8083.26	-8135.54	4	12.85	-59.35	0.19
CR	6.40	0.15	-7950.85	-8080.50	-7950.70	2	12.85	-57.99	0.19
6. Candle length (cm)									
HR	10.38	2.40	10437.55	-9688.53	-10434.95	5	5.06	-16.00	3.18
P	12.72	7.04	9811.65	-9947.15	-9804.61	3	6.20	-15.03	5.44
LR	7.18	2.93	9402.86	-9716.08	-9399.93	2	3.50	-14.41	3.51
KR	9.30	1.22	10141.98	-9619.93	-10140.76	4	4.53	-15.55	2.27
CR	8.84	0.72	8769.70	-9591.85	-8768.98	1	4.31	-13.44	1.75

Table 4.2.2.1 (b). (Contd...)

Parents	Y_r	V_r	W_r	Estimated W_r	$W_r + V_r$	Dominance order	Yr'	$(W_r + V_r)'$	$\sqrt{Wr^2}$
7. Inclination of candle (degrees)									
HR	78.20	789.65	-65822.32	-69012.52	-65032.67	4	3.480	-6.95	631.83
P	69.40	508.40	-66761.35	-60891.92	-66252.96	5	3.090	-7.08	566.97
LR	61.00	134.59	-53806.39	-50098.71	-53671.86	3	2.710	-5.74	260.85
KR	21.00	157.75	-46609.14	-50767.40	-46451.39	1	0.934	-4.97	282.40
CR	45.80	138.18	-47973.78	-50202.40	-47835.60	2	2.037	-5.12	264.31
8. No. of flowers / candle									
HR	492.00	4605.19	-654373.80	-625465.70	-649768.60	3	5.49	-1.14	6086.46
P	600.00	11880.81	-640445.60	-628173.00	-652326.50	4	6.69	-1.15	9776.07
LR	400.00	5742.00	-601041.30	-625888.70	-595299.30	2	4.46	-1.05	6796.30
KR	445.00	4445.00	-664827.40	-625406.10	-660382.40	5	4.96	-1.16	5979.67
CR	372.00	5586.80	-570076.50	-625831.00	-564489.70	1	4.15	-0.99	6703.83
9. Life of spadix (days)									
HR	120.40	9.95	-221826.20	-220181.70	-221816.30	5	13.34	-30.03	28.46
P	105.20	52.16	-212840.30	-211225.30	-212788.20	4	11.66	-28.81	65.16
LR	101.20	55.44	-204792.90	-210529.20	-204737.50	1	11.22	-27.72	67.18
KR	100.00	87.99	-206008.80	-203621.50	-205920.80	3	11.08	-27.88	84.64
CR	98.00	88.21	-204938.00	-204848.50	-204849.80	2	10.86	-27.73	84.74

Table 4.2.2.1 (b). (Contd...)

Parents	Y_r	V_r	W_r	Estimated W_r	$W_r + V_r$	Dominance order	Yr'	$(W_r + V_r)'$	$\sqrt{Wr^2}$
10. Days to initiation of female phase									
HR	6.80	2.03	-9845.69	-9992.50	-9843.66	5	6.34	-15.74	1.53
P	5.20	0.36	-8986.56	-8791.01	-8986.20	2	4.85	-14.37	0.64
LR	6.80	1.45	-9533.10	-9577.60	-9531.65	3	6.34	-15.24	1.29
KR	4.40	0.21	-8283.69	-8686.52	-8283.48	1	4.10	-13.24	0.49
CR	5.20	0.95	-9611.03	-9217.44	-9610.08	4	4.85	-15.36	1.05
11. Duration of female phase									
HR	11.20	1.29	-21882.43	-21690.08	-21881.14	5	4.33	-24.43	2.94
P	7.40	3.23	-20311.69	-20139.59	-20308.46	2	2.86	-22.67	4.65
LR	11.00	1.35	-21487.97	-21642.11	-21486.62	4	4.25	-23.98	3.01
KR	13.60	2.72	-21172.58	-20545.59	-21169.86	3	5.25	-23.63	4.27
CR	7.80	2.75	-19685.91	-20523.20	-19683.16	1	3.01	-21.97	4.29
12. Days of interphase									
HR	8.80	0.71	-19575.76	-20645.68	-19575.05	1	6.10	-20.79	1.22
P	11.20	0.91	-21787.66	-20624.73	-21786.75	5	7.77	-23.13	1.37
LR	10.40	0.07	-20050.09	-20714.52	-20050.02	2	7.21	-21.29	0.38
KR	10.80	0.37	-21392.86	-20686.73	-21392.53	4	7.49	-22.72	0.83
CR	7.80	0.57	-20205.69	-20340.40	-20202.12	3	5.41	-21.45	2.73

Table 4.2.2.1 (b). (Contd...)

Parents	Y_r	V_r	W_r	Estimated W_r	W_r+V_r	Dominance order	Yr'	$(W_r+V_r)'$	$\sqrt{Wr^2}$
13. Duration of male phase									
HR	7.20	1.08	-13581.97	-13787.63	-13580.88	3	8.01	-15.39	0.94
P	5.20	2.99	-13185.51	-13993.29	-13182.52	1	5.79	-14.94	1.55
LR	5.60	1.66	-13900.08	-13849.55	-13898.42	4	6.23	-15.75	1.16
KR	5.20	2.55	-15408.89	-13945.67	-15406.34	5	5.79	-17.46	1.44
CR	5.00	2.35	-13423.70	-13924.02	-13421.35	2	5.56	-15.21	1.38
14. Pollen fertility (%)									
HR	19.70	34.55	-53660.00	-58625.86	-53625.45	2	2.29	-0.201	50.65
P	28.40	11.40	-53897.51	-51460.92	-53886.11	3	3.30	-0.202	29.10
LR	40.90	38.94	-64804.40	-59986.21	-647975.50	5	4.75	-2.433	53.77
KR	25.90	12.18	-53999.10	-51700.74	-53986.93	4	3.01	-0.203	30.07
CR	20.12	15.66	-48191.98	-52779.25	-48176.32	1	2.34	-0.181	34.10
15. Total Anthocyanin content (mg/gm)									
HR	245.83	4314.61	-56990.30	-517098.70	-557675.70	4	2.28	-6.38	6700.42
P	121.38	9764.80	-617057.20	-505035.30	-616080.70	5	3.28	-7.05	3187.40
LR	386.56	2751.69	-406559.30	-511450.60	-403807.60	1	1.19	-4.62	5850.95
KR	334.42	2395.27	-443436.34	-510162.60	-441041.10	2	2.41	-5.05	4992.39
CR	323.83	9886.91	-551940.30	-537236.20	-542053.40	3	3.79	-6.20	10142.88

Table 4.2.2.1 (b). (Contd...)

Parents	Y_r	V_r	W_r	Estimated W_r	W_r+V_r	Dominance order	Yr'	$(W_r+V_r)'$	$\sqrt{Wr^2}$
16. Carotene content (mg/100 gm)									
HR	7.52	3.37	-11292.61	-9631.81	-11289.24	3	2.80	-4.51	4.94
P	2.10	1.49	-6466.64	-8425.38	-6405.15	1	0.78	-2.56	3.28
LR	7.12	6.52	-11624.77	-11649.99	-11618.25	4	2.65	-4.65	6.87
KR	9.03	8.91	-12767.94	-13178.69	-12759.03	5	3.36	-5.10	8.03
CR	4.96	1.55	-9257.27	-8463.35	-9255.72	2	1.84	-3.70	3.35

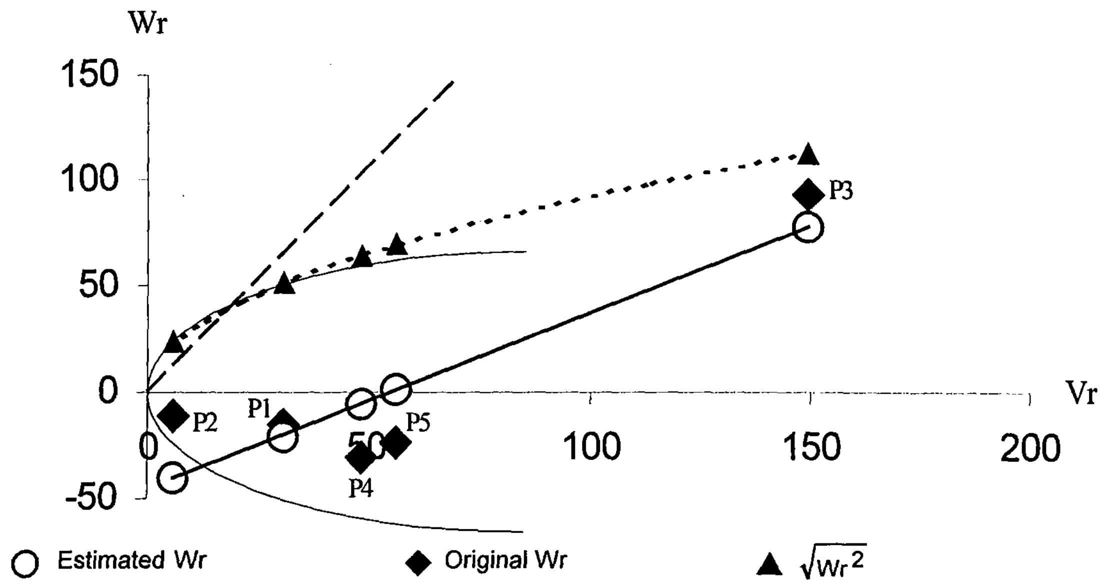
Table 4.2.2.1 (c). Linear regression of Wr on Vr - Vegetative characters

Sl.No.	Character	Regression Wr = a + bVr
1.	Plant height	Wr = -45.89 + 0.83 Vr
2.	Internode length	Wr = -93.42 – 330.95 Vr
3.	Days from emergence to maturity of leaves	Wr = -3555.60 – 8.66 Vr
4.	Number of leaves	Wr = -1017.12 + 108.27 Vr
5.	Length of leaf blade	Wr = -4747.24 – 4.06 Vr
6.	Width of leaf blade	Wr = -3160.38 – 28.00 Vr
7.	Leaf area / Leaf size	Wr = -86604.84 + 33 Vr
8.	Suckering Ability	Wr = -3378.73 – 1059.65 Vr

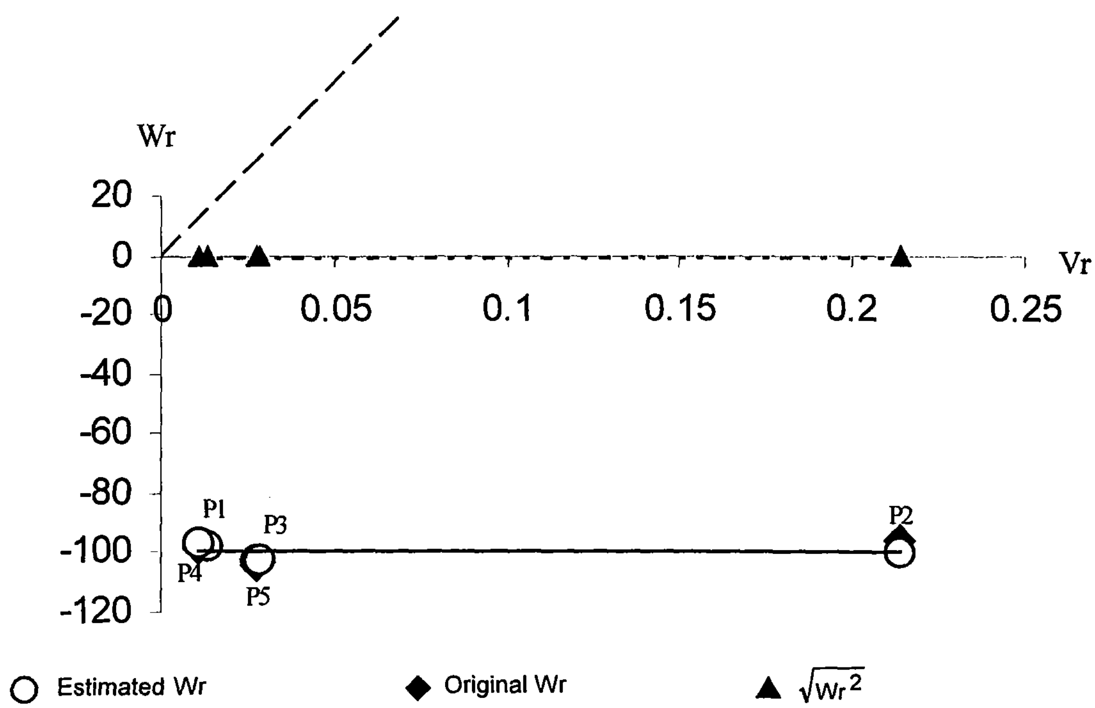
Table 4.2.2.1 (d). Linear regression of Wr on Vr - Floral characters

Sl. No.	Character	Regression Wr = a+bVr
1.	Time taken for first flowering	Wr = -37448.17 – 2305.68 Vr
2.	Days from emergence to maturity of inflorescence	Wr = -54847.85 + 135.43 Vr
3.	Length of spathe	Wr = -13971.72 + 233.40 Vr
4.	Width of spathe	Wr = -10914.26 + 169.20 Vr
5.	Number of spadices/plant	Wr = -8185.77 + 692.60 Vr
6.	Candle length	Wr = -9551.14 – 56.27 Vr
7.	Inclination of candle	Wr = -46212.68 – 28.87 Vr
8.	Number of flowers/candle	Wr = -623752.10 – 0.37 Vr
9.	Life of spadix	Wr = -222293.70 + 212.20 Vr
10.	Days to initiation of female phase	Wr = -8531.69 – 720.32 Vr
11.	Duration of female phase	Wr = -22719.45 + 799.22 Vr
12.	Days to interphase	Wr = -20721.49 + 106.89 Vr
13.	Duration of male phase	Wr = -13669.82 – 108.24 Vr
14.	Pollen fertility	Wr = -47931.76 – 309.54 Vr
15.	Total anthocyanin content	Wr = -501506.40 – 3.61 Vr
16.	Carotene content	Wr = -7472.04 – 640.31 Vr

Wr - Vr graph

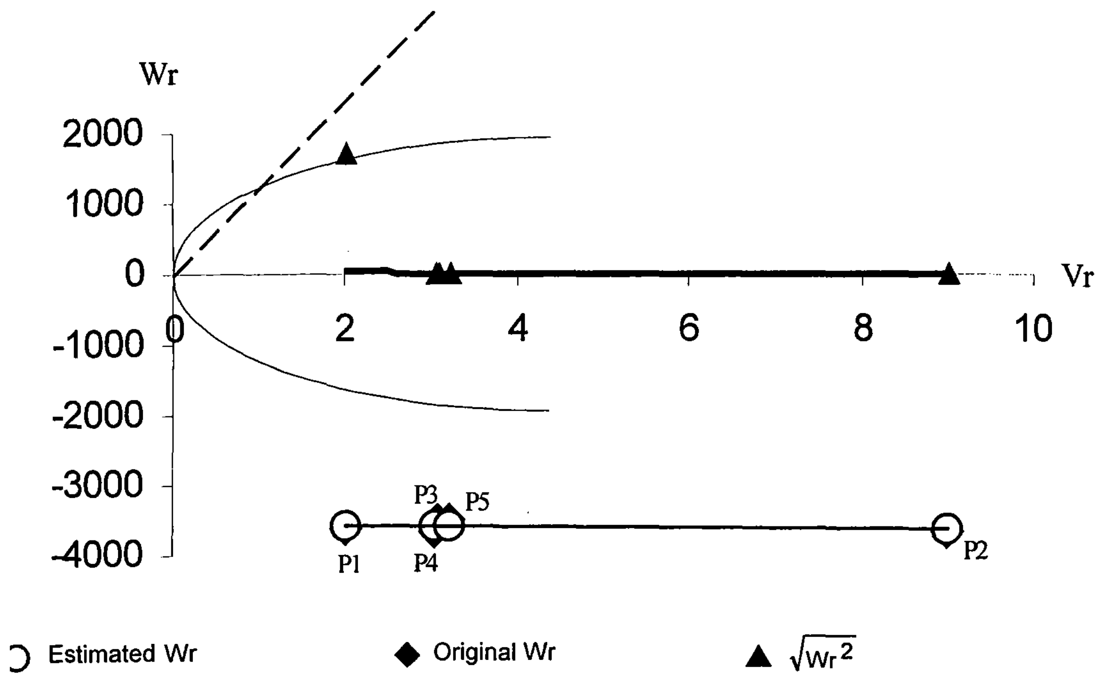


Plant height (cm)

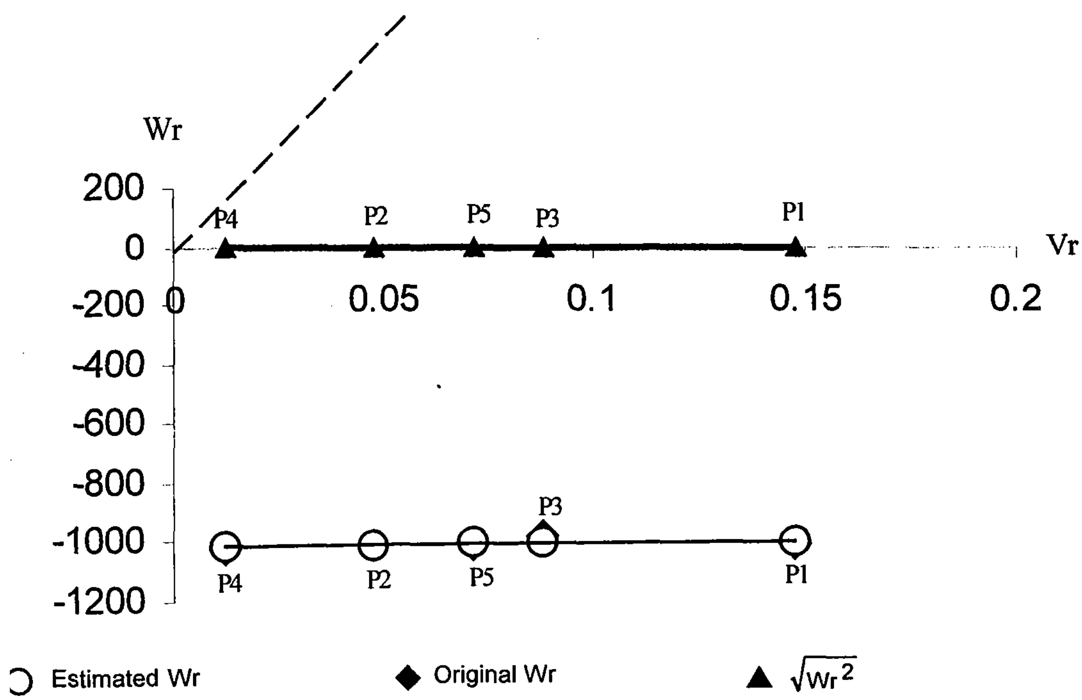


Internode length (cm)

Wr - Vr graph

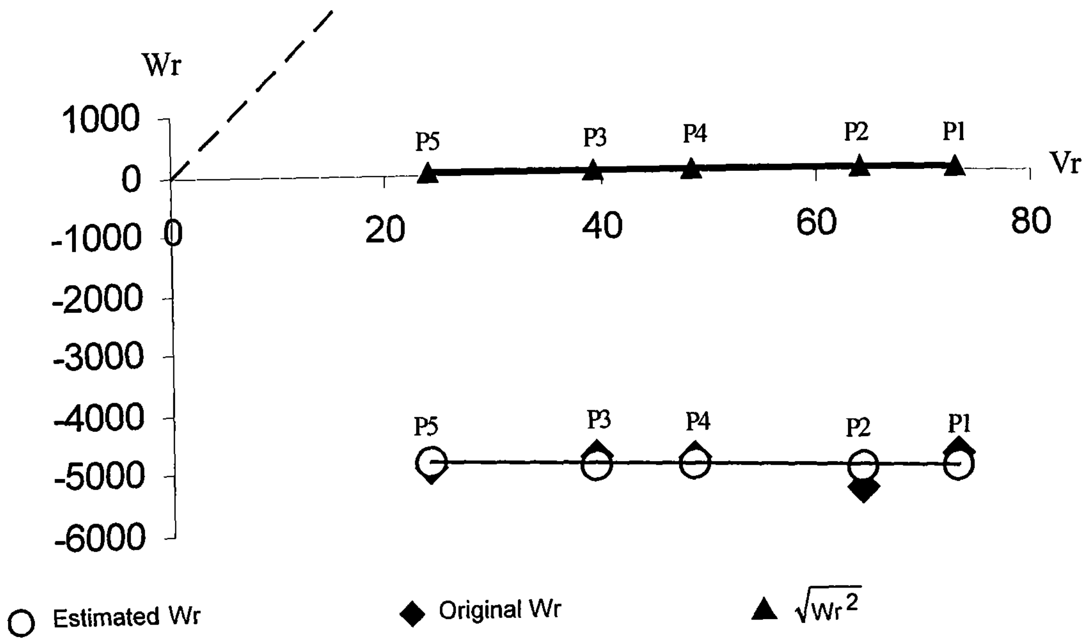


Days from emergence to maturity of leaves

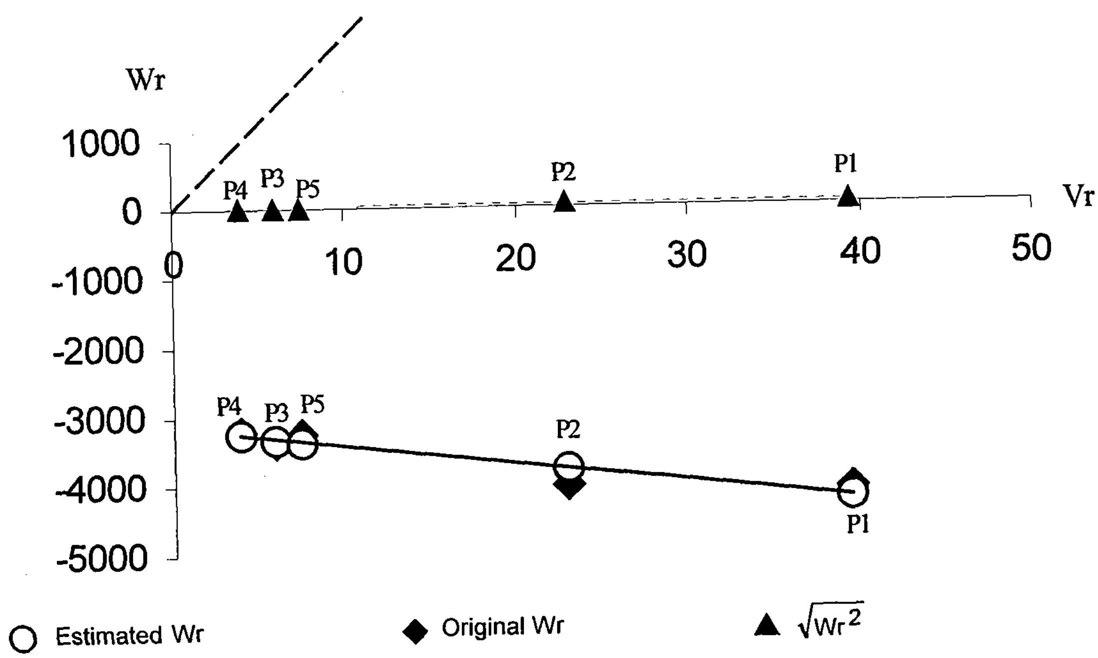


Number of leaves

Wr - Vr graph

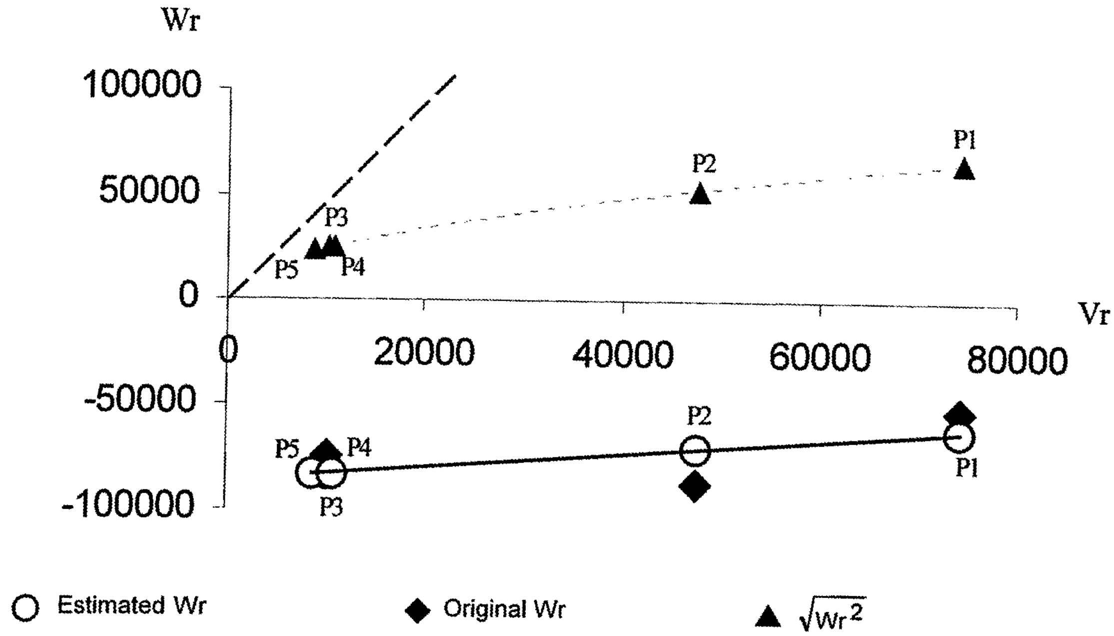


Length of leaf blade (cm)

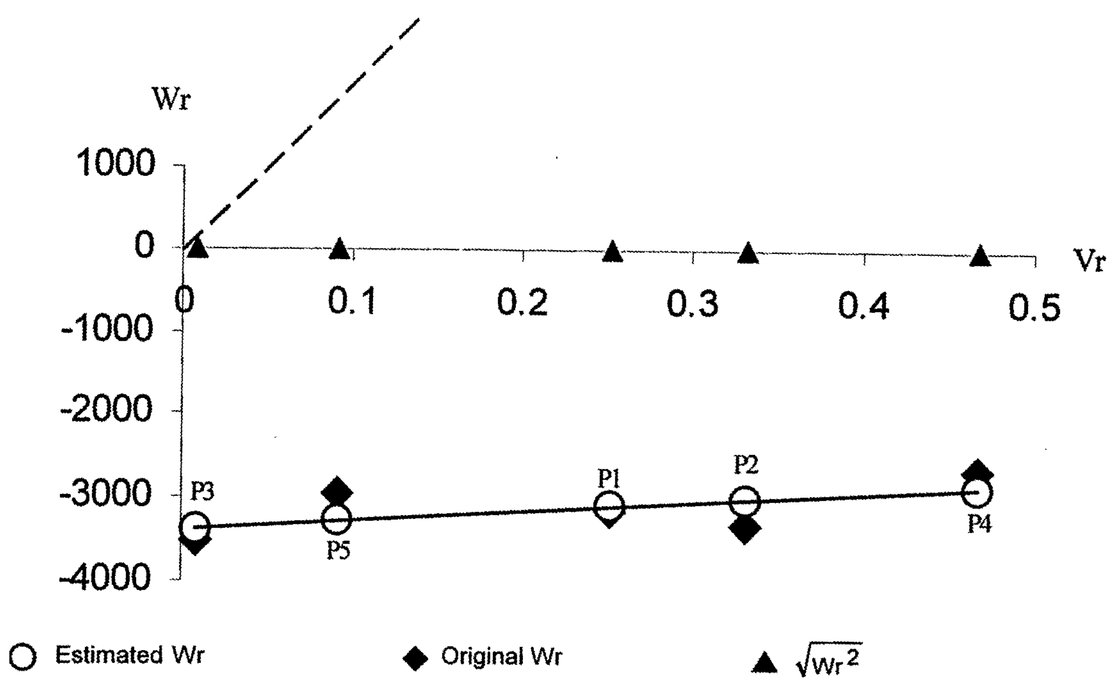


Width of leaf blade (cm)

Wr - Vr graph

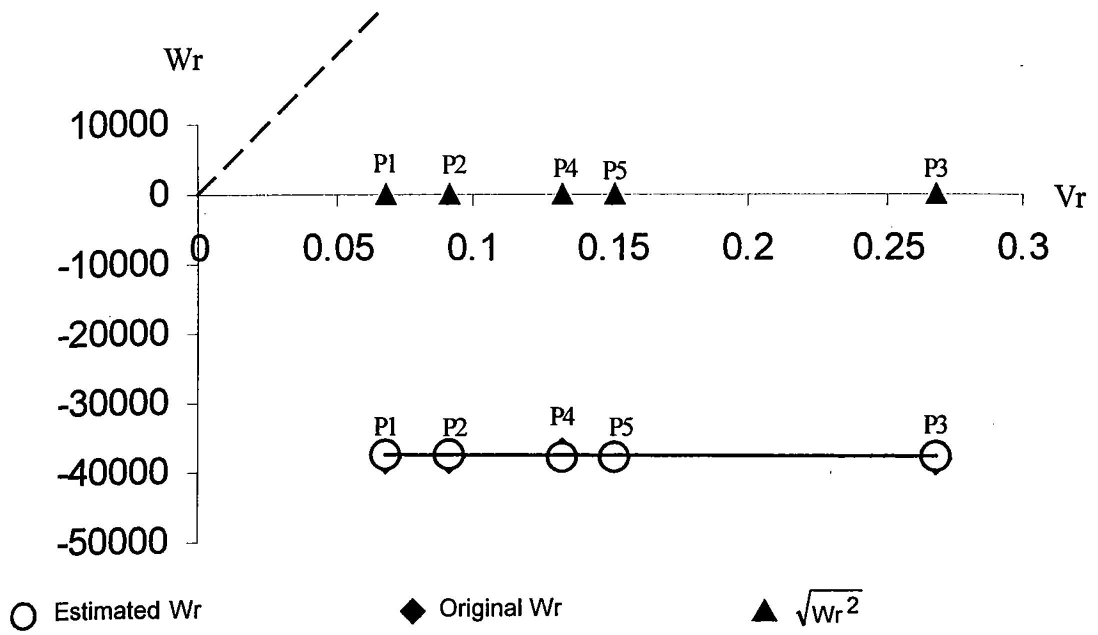


Leaf area (cm²)

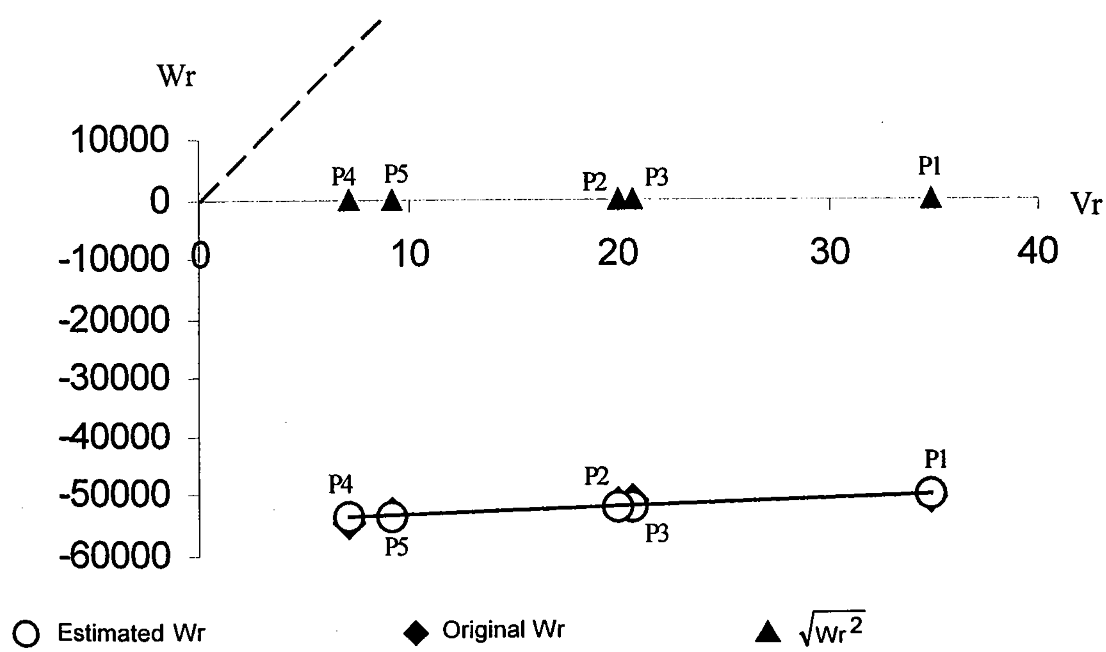


Suckering ability (%)

Wr - Vr graph

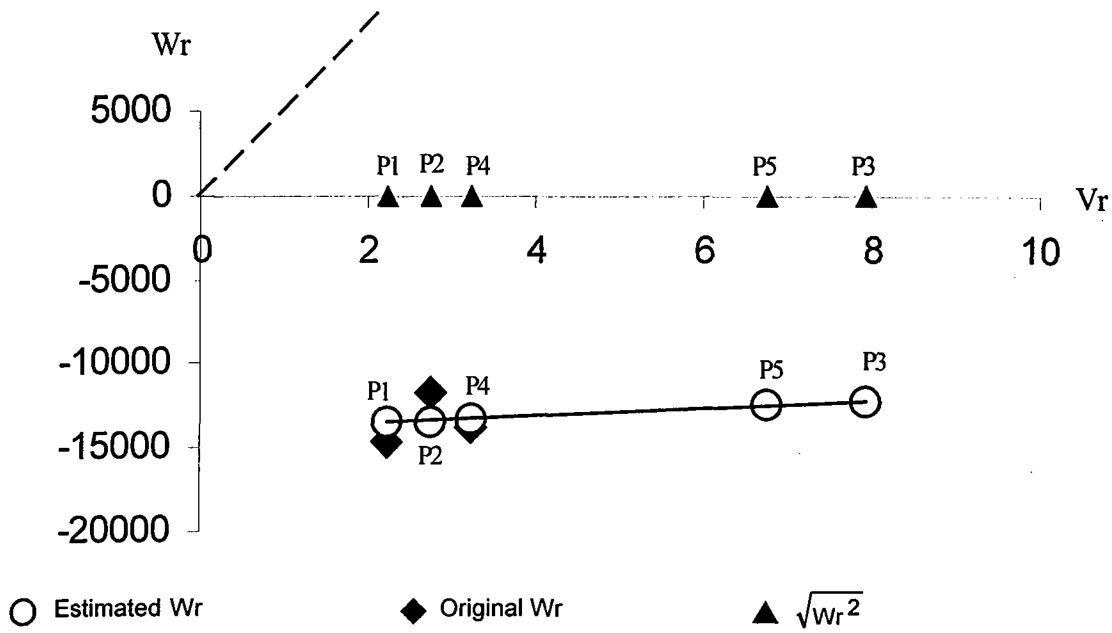


Time taken for first flowering

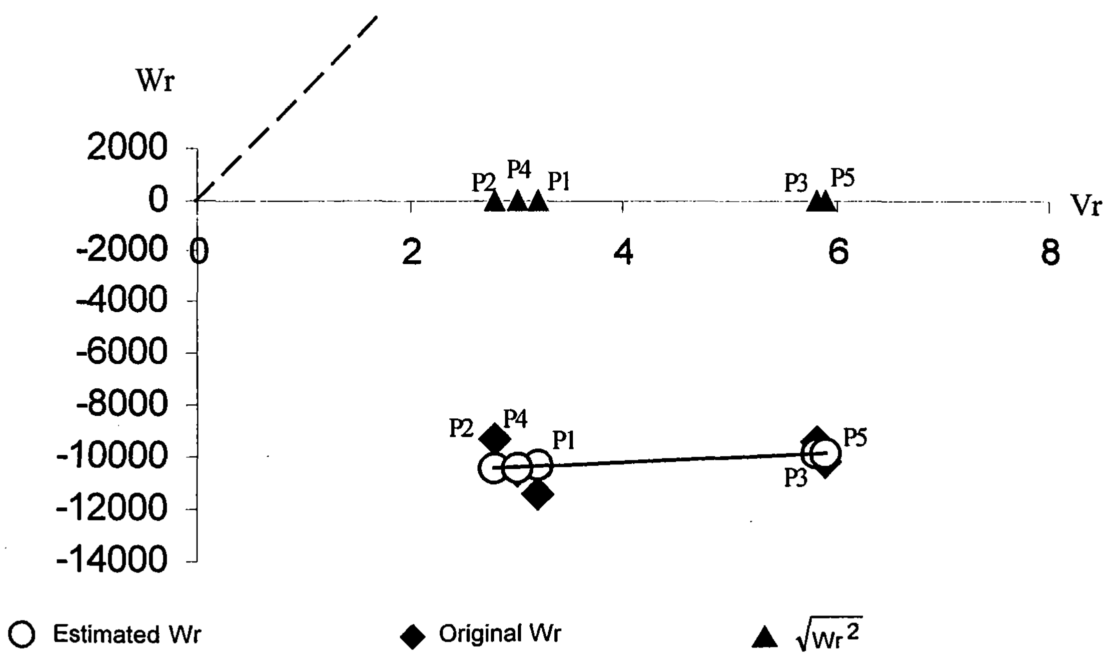


Days from emergence to maturity of inflorescence

Wr - Vr graph

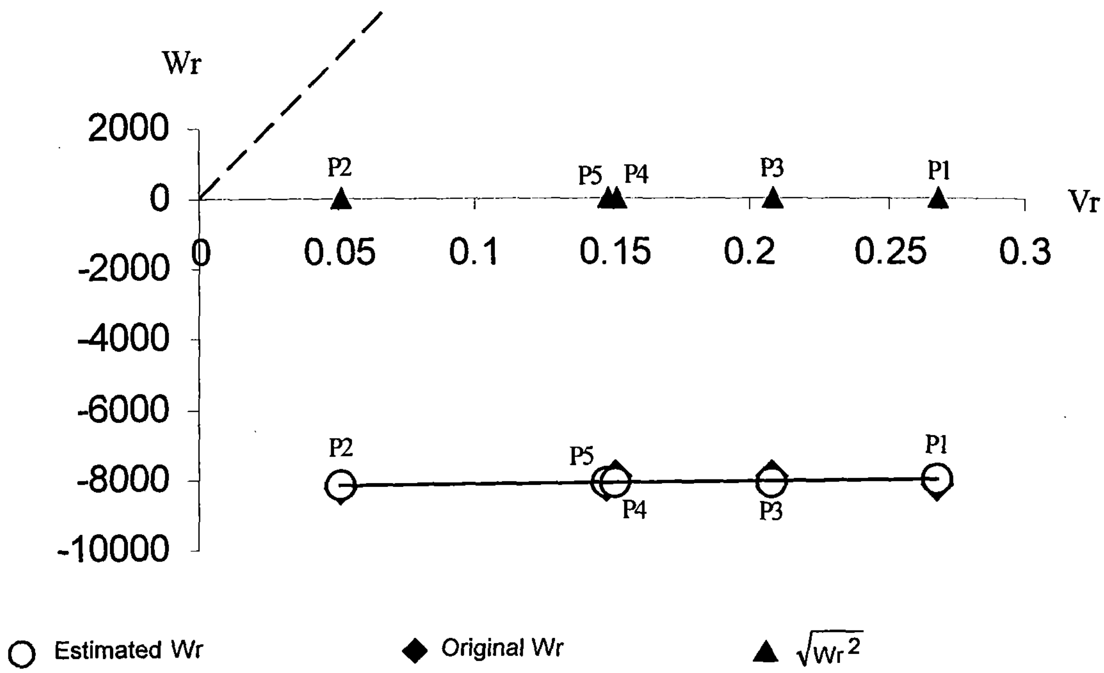


Length of spathe (cm)

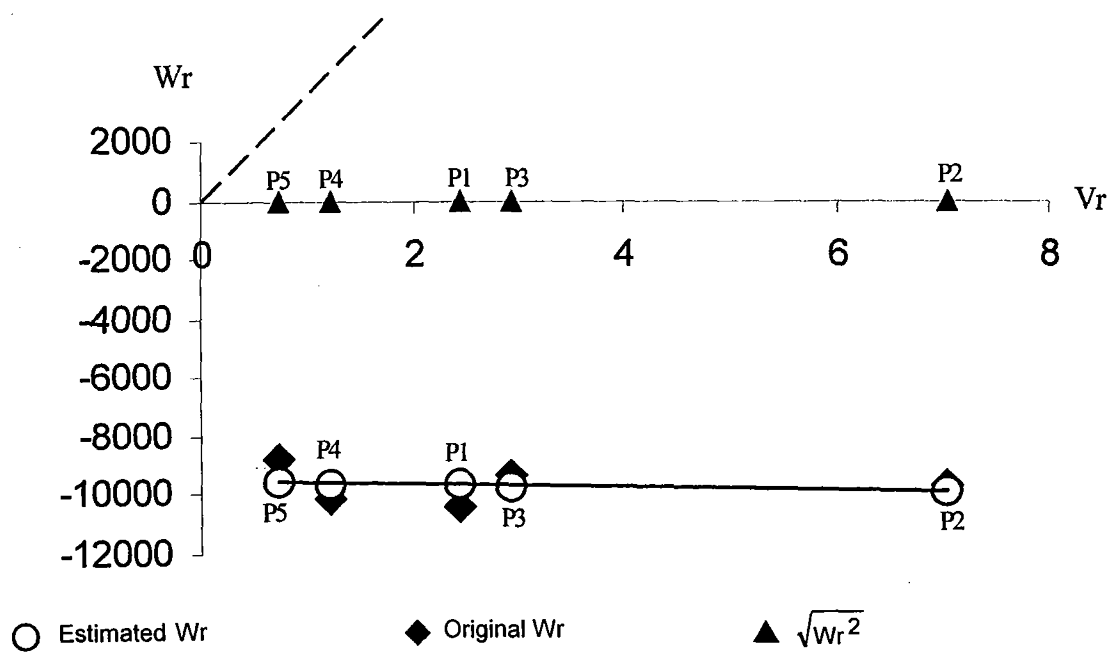


Width of spathe (cm)

Wr - Vr graph

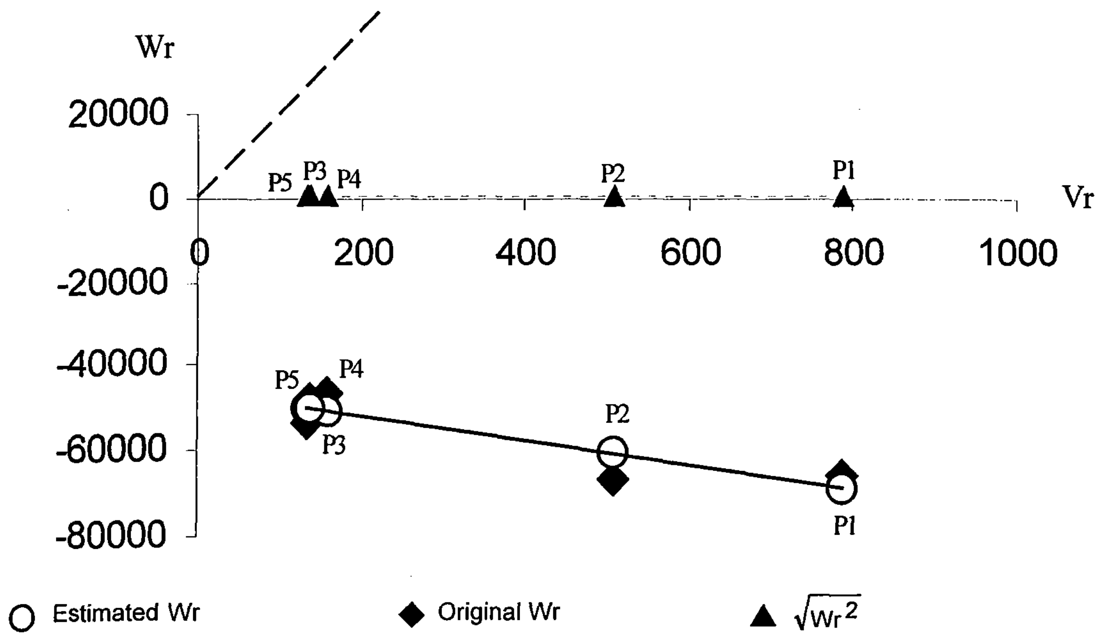


Number of spadices / plant / year

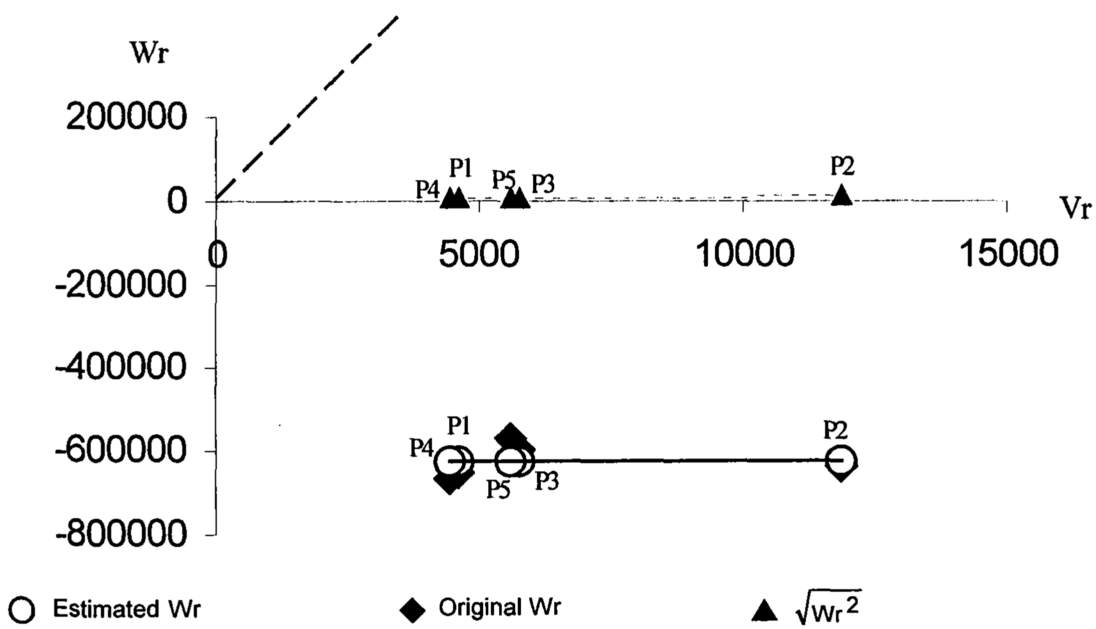


Candle length (cm)

Wr - Vr graph

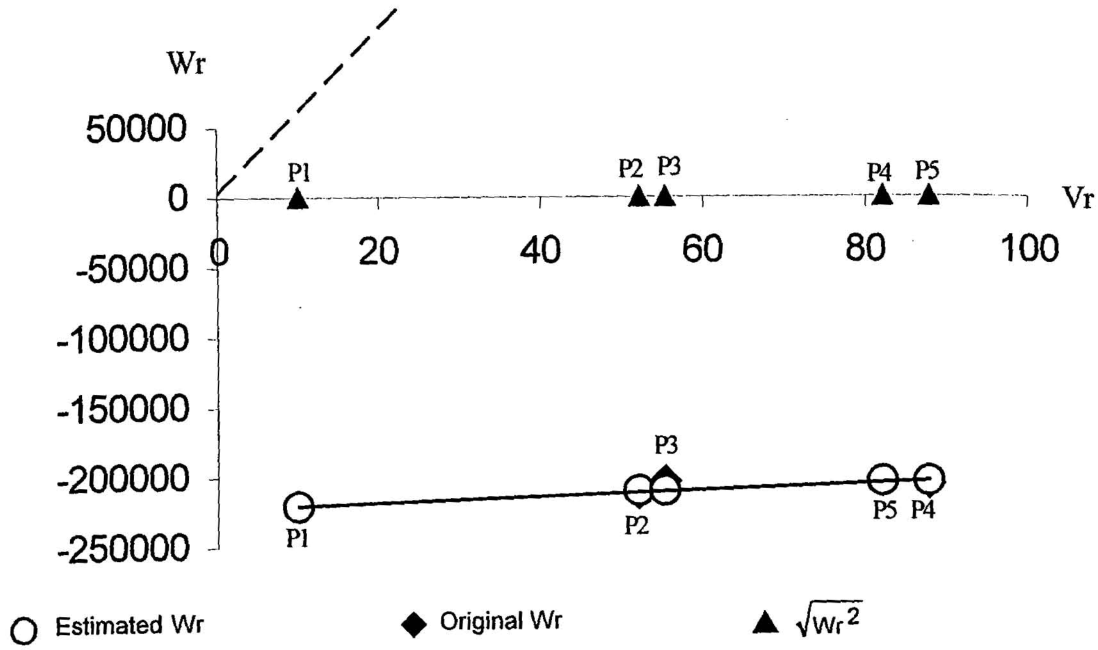


Inclination of candle (degrees)

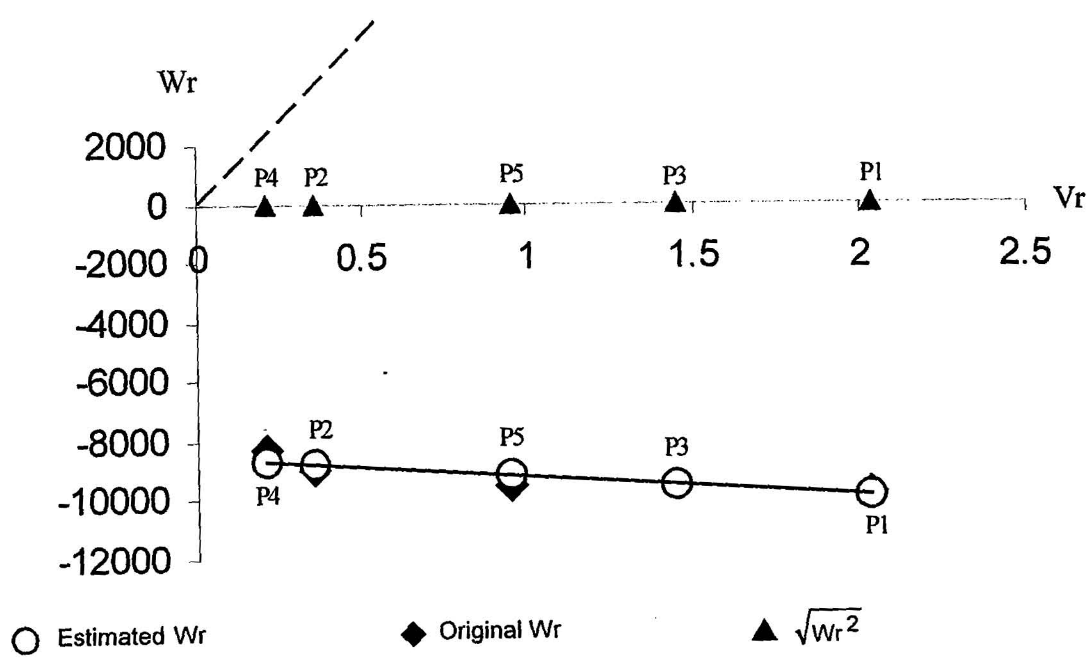


Number of flowers / candle

Wr - Vr graph

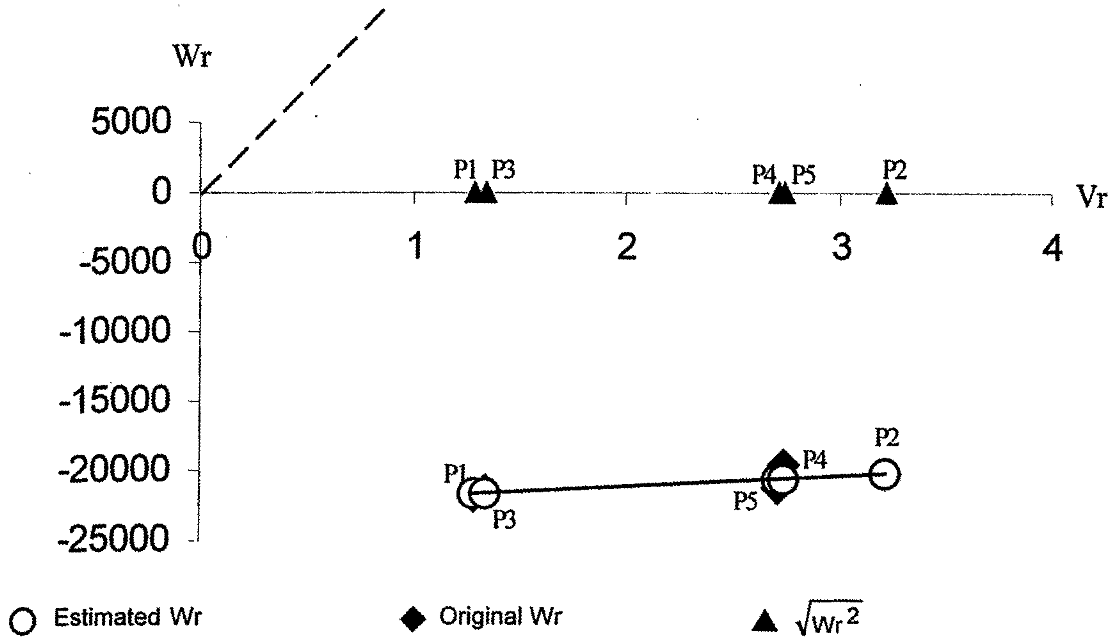


Life of spadix

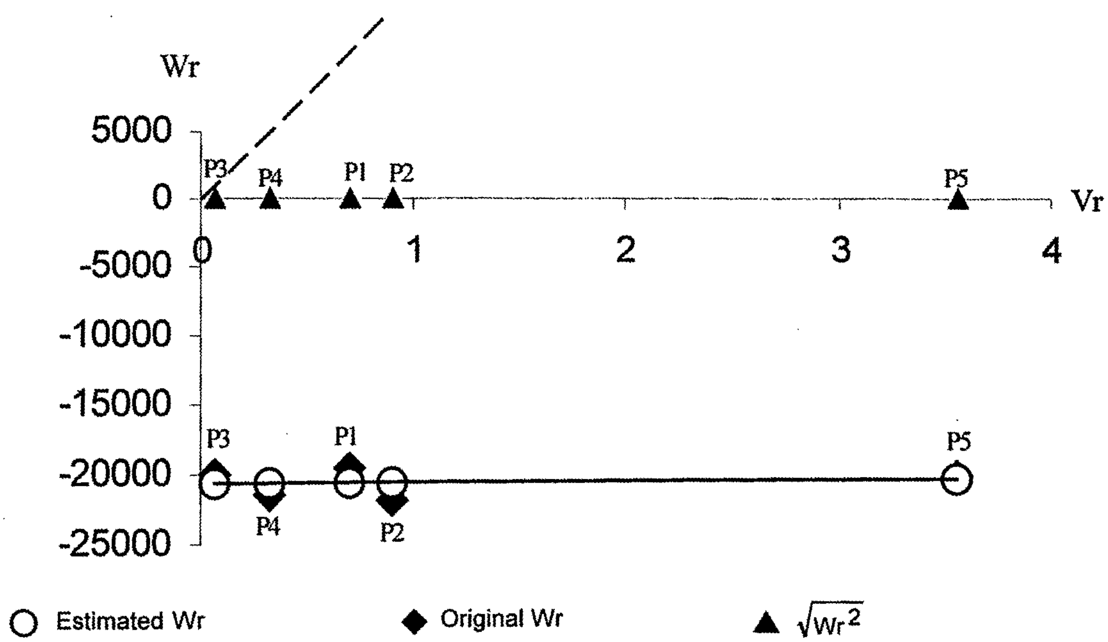


Days to initiation of female phase

Wr - Vr graph

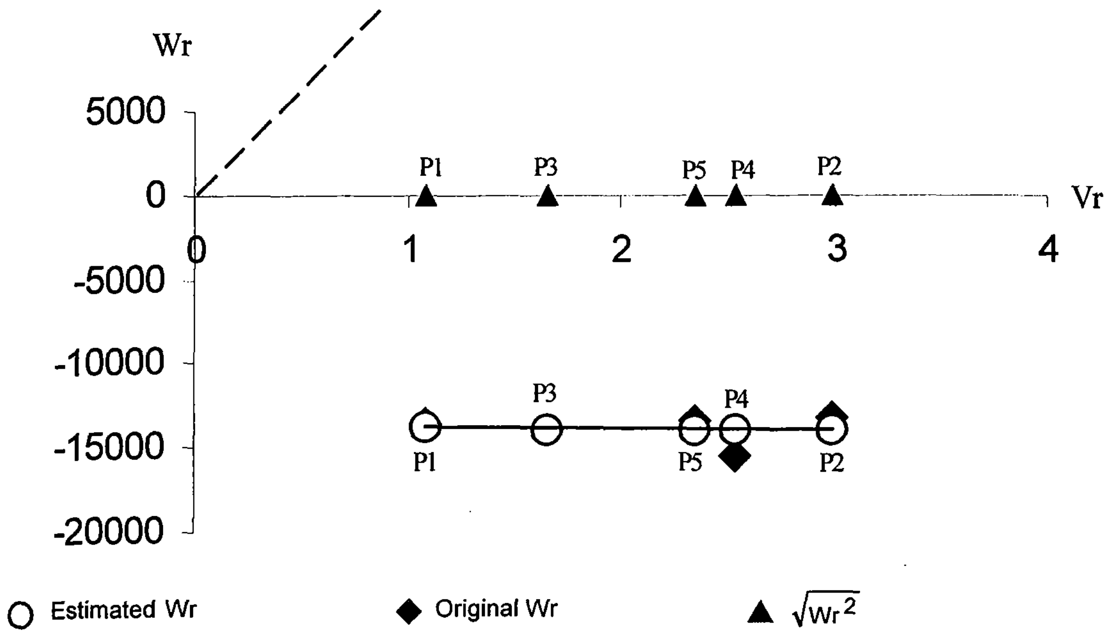


Duration of female phase

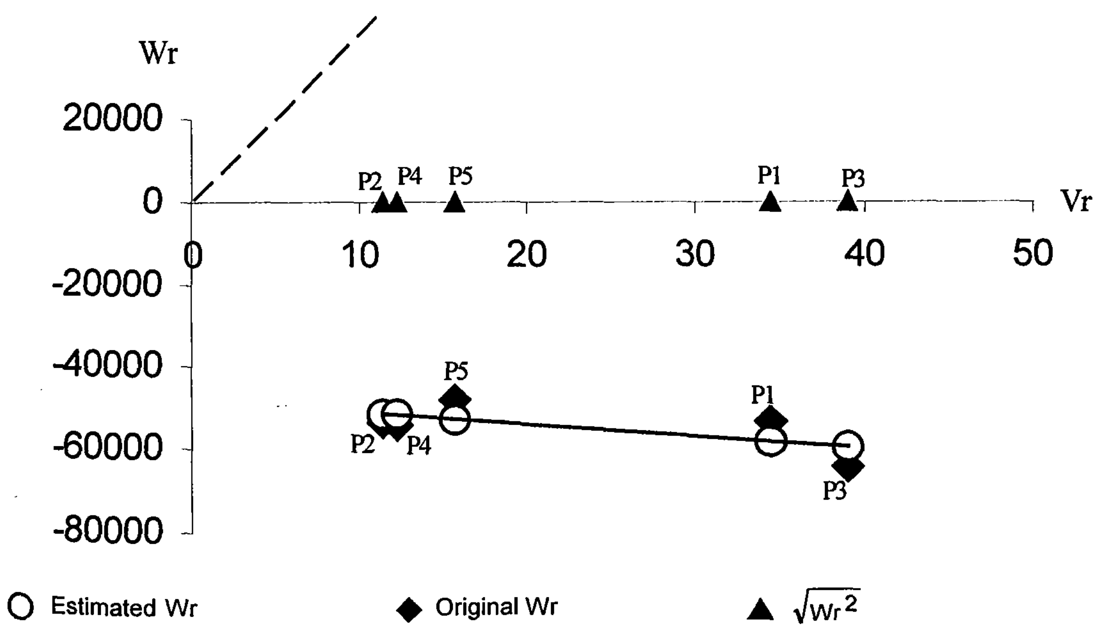


Days of interphase

Wr - Vr graph

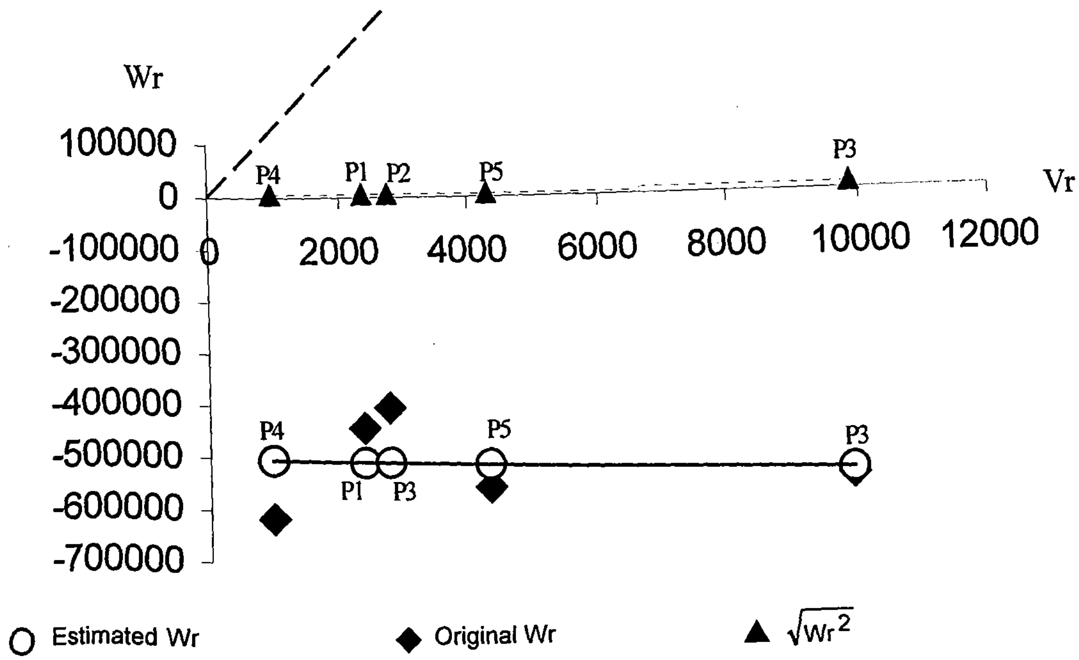


Duration of male phase

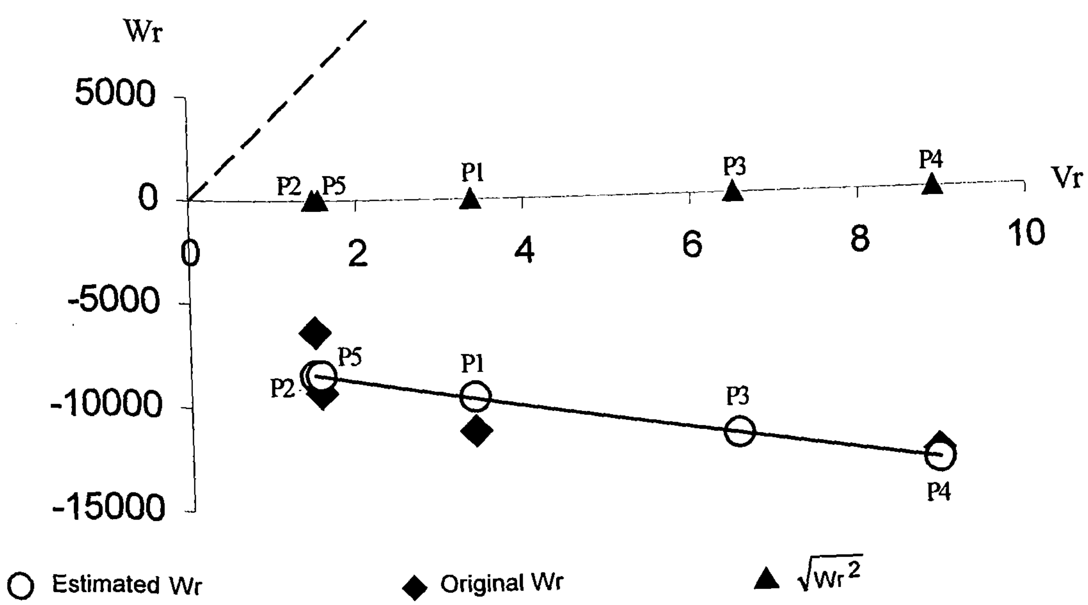


Pollen fertility (%)

Wr - Vr graph



Total Anthocyanin content (mg/g)



Carotene content (mg/100g)

For all the characters the regression line intercepted the W_r-axis below the origin. Here over-dominance was detected in all these cases. Dominant variance was attributed to the character expressions.

A. VEGETATIVE CHARACTERS

1. Plant height

Dominance variance was relatively more important for the expression of the character. Maximum frequency of dominant alleles was shown by P_2, minimum by P_5 and P_3 shows the recessive alleles, others were in the intermediate position.

2. Internode length

The graph showed that parents P_1, P_3, P_4 and P_5 possessed the maximum recessive genes more or less at the same level. P_2 possessed maximum frequency of recessive alleles.

3. Days from emergence to maturity of leaves

Parents were situated far away from the origin. P_1, P_3, P_4, P_5 and P_2 possessed recessive genes, maximum recessive genes for P_2. However, P_1, P_3, P_4 and P_5 possessed recessive genes at more or less at the same level.

4. Number of leaves

Parents P_1 and P_3 possessed most of recessive genes. Maximum is for P1 and minimum for P_4, P_2, P_3 and P_5 occupy the intermediate positions.

5. Length of leaf blade

Maximum recessive genes were observed for P_1 and minimum for P_5 and others were in the intermediate position.

6. Width of leaf blade

Parents P_4, P_3 and P_5 possessed recessive genes more or less at the same level. Maximum recessive genes were possessed by P_1. P_2 was at the intermediate level.

7. Leaf area

Parents P_3, P_4 and P_5 had recessive genes at more or less at the same level. P_1 was having the maximum and P_2 was in the intermediate position.

8. Suckering ability

All the parents possessed recessive genes. Maximum recessive genes were for P_4 and minimum for P_3 and others were in the intermediate positions.

B. FLORAL CHARACTERS

1. Time taken for first flowering

All the parents had recessive genes. P_1 and P_2 were more or less at the same level. P_3 had the maximum recessive genes and others were in the intermediate position.

2. Days from emergence to maturity of inflorescence

All the parents had recessive alleles. Maximum was for P_1, minimum for P_4 and P_5 and others were in intermediate positions.

3. Length of spathe

All the parents had recessive alleles. P_3 had the maximum frequency of recessive alleles. P_1, P_2 and P_4 possessed the minimum frequency and P_5 was in the intermediate position.

4. Width of spathe

P_1, P_2 and P_4 had the minimum frequency of recessive alleles and P_3 and P_5 had the maximum frequency of recessive alleles.

5. Number of spadices / plant / year

All the parents had recessive alleles. P_1 had the maximum frequency of recessive alleles where as P_2 possessed the minimum frequency of recessive alleles. P_4, P_5 and P_3 were in the intermediate positions with P_4 and P_5 more or less at the same level.

6. Candle length

The graph revealed that all the parents possessed recessive genes. Maximum frequency was for P_2 and minimum by P_5 and P_4. P_5 and P_4 were more or less at the same position. P_1 and P_3 were in the intermediate positions.

7. Inclination of candle

All the parents possessed recessive genes. Maximum frequency was exhibited by P_1, minimum by P_3, P_4 and P_5. P_2 was in the intermediate position.

8. Number of flowers/candle

All parents possessed recessive genes. P_2 showed the maximum frequency of recessive alleles and P_4, the minimum frequency.

9. Life of spadix

All parents possessed recessive alleles. P_4 exhibited the maximum frequency of recessive alleles, P_1 the minimum. P_2 and P_3 were in the intermediate position.

10. Days to initiation of female phase

The graph showed that all parents possessed recessive genes. P_1 possessed the maximum frequency of recessive alleles and P_4, the minimum frequency followed by P_2. P_5 and P_3 were in the intermediate positions.

11. Duration of female phase

All the parents possessed recessive genes. P_2 had the maximum frequency and P_1 with minimum frequency followed by P_3. The parents P_5 and P_4 were in the intermediate positions.

12. Days of interphase

Parent P_5 possessed maximum frequency of recessive alleles. P_3 had the minimum frequency followed by P_4, P_1 and P_2.

13. Duration of male phase

P_2 had the maximum frequency of recessive alleles where as P_1 with minimum frequency. P_3, P_5 and P_4 were in the intermediate positions.

14. Pollen fertility

Maximum frequency of recessive alleles were for P_3 and P_1. But P_2, P_4 and P_5 showed the minimum frequency.

15. Total anthocyanin content

All the parents possessed dominant alleles. Maximum was for P_3 and minimum for P_2. The rest of the parents were in the intermediate positions.

16. Carotene content

Maximum frequency of recessive alleles was for P_4 and minimum for P_2 and P_5. P_1 and P_3 were in the intermediate positions.

4.2.2.2 Standardised Yr' - (Wr + Yr)' graph

The means of the common parent of the array Yr and (Wr+Vr) were standardised respectively to Yr' and (Wr+Vr)' and are presented graphically. The intersecting points locate the relative distribution of array points (parents) in the standardised graph having four quarters specified by pre-dominance of dominant / recessive alleles with positive/negative effects. These gene effects can be revealed from graphs (pages 145 to 156).

A. VEGETATIVE CHARACTERS

1. Plant height

Array with common parent P_1, P_3, P_4 and P_5 possesed most of the recessive genes with positive effect, P_3 having the maximum number of genes. P_2 lying near the border line, implied that both dominant and recessive genes with positive effect were attributed in the expression in its array.

2. Internode length

All the (Wr+Vr) values were negative. The position of the parents in the 4th quadrant revealed that these parents possessed most of the dominant genes with positive effect, P_5 and P_3 having the highest frequency of alleles.

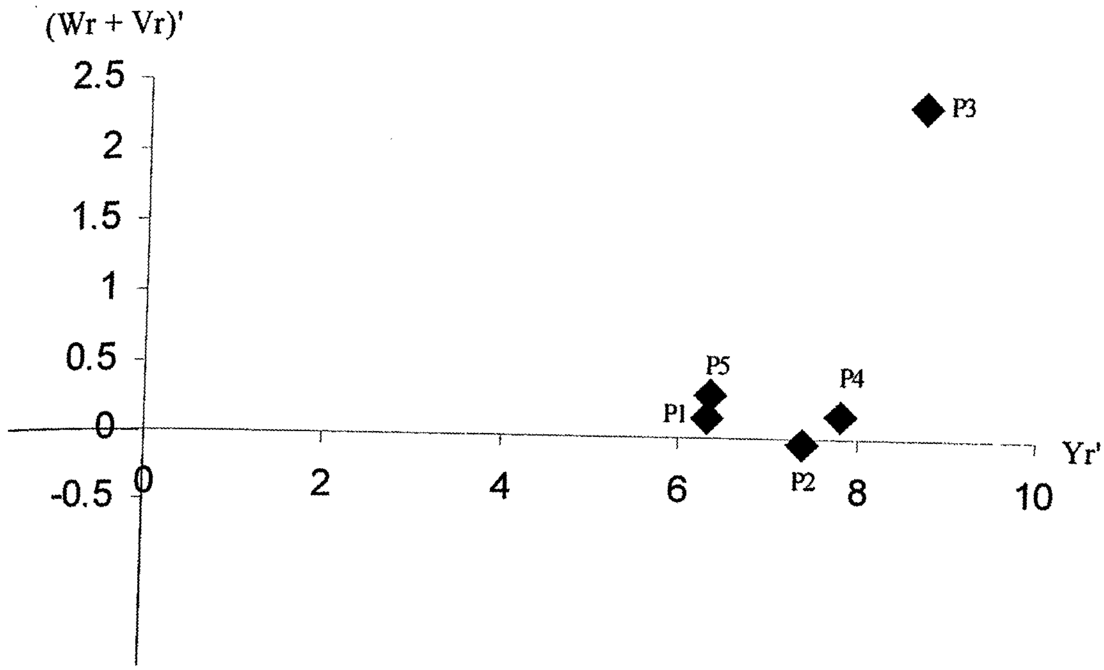
3. Days from emergence to maturity of leaves

All the parents possessed most of the dominant genes with positive effects. P_2 and P_5 were having the highest frequency of alleles.

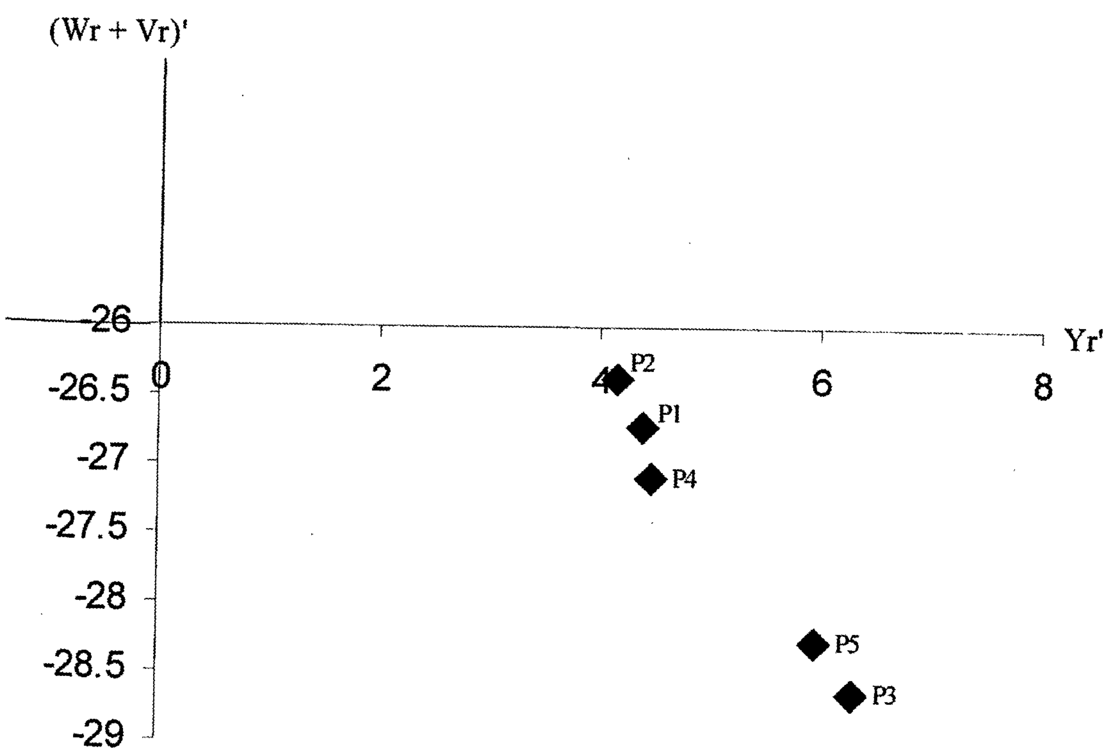
4. Number of leaves

Here also all the parents possessed most of the dominant genes with positive effects. P_4 possessed maximum frequency of alleles.

Standardised Yr - (Wr+Vr) graph

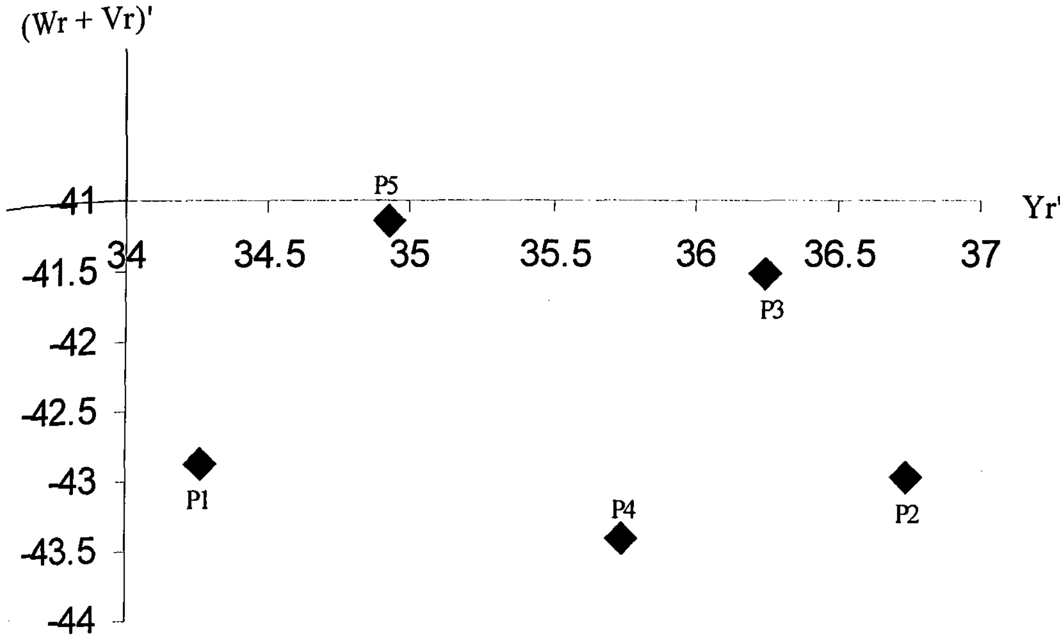


Plant height (cm)

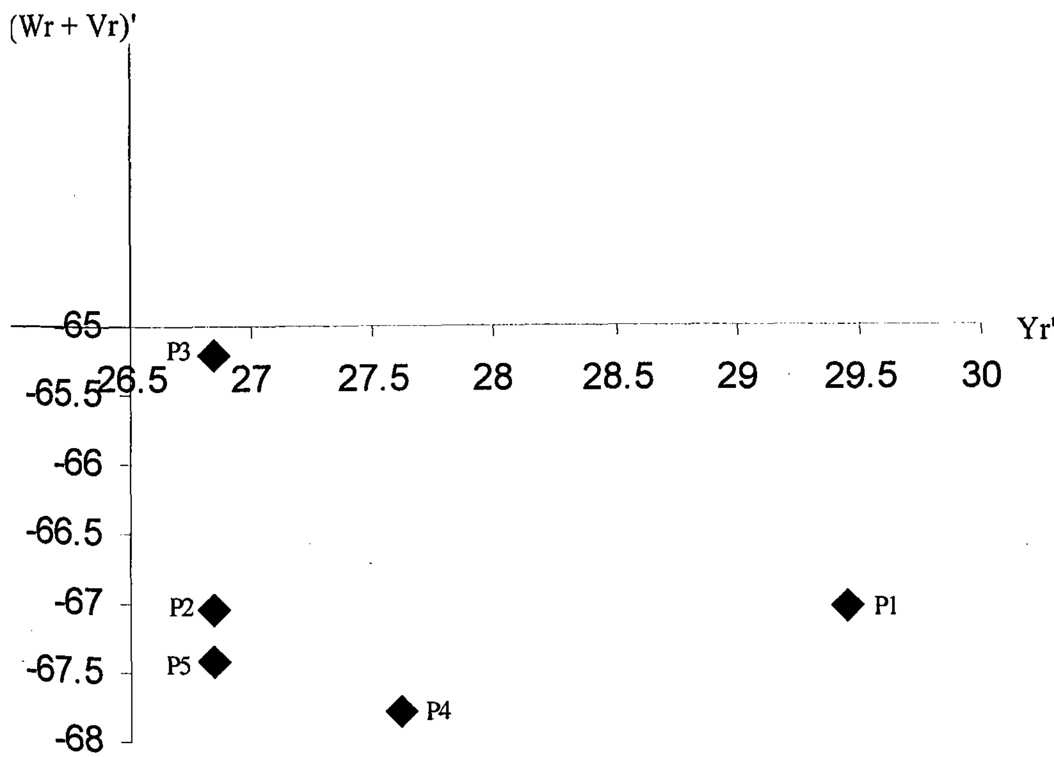


Internode length (cm)

Standardised Yr - (Wr+Vr) graph

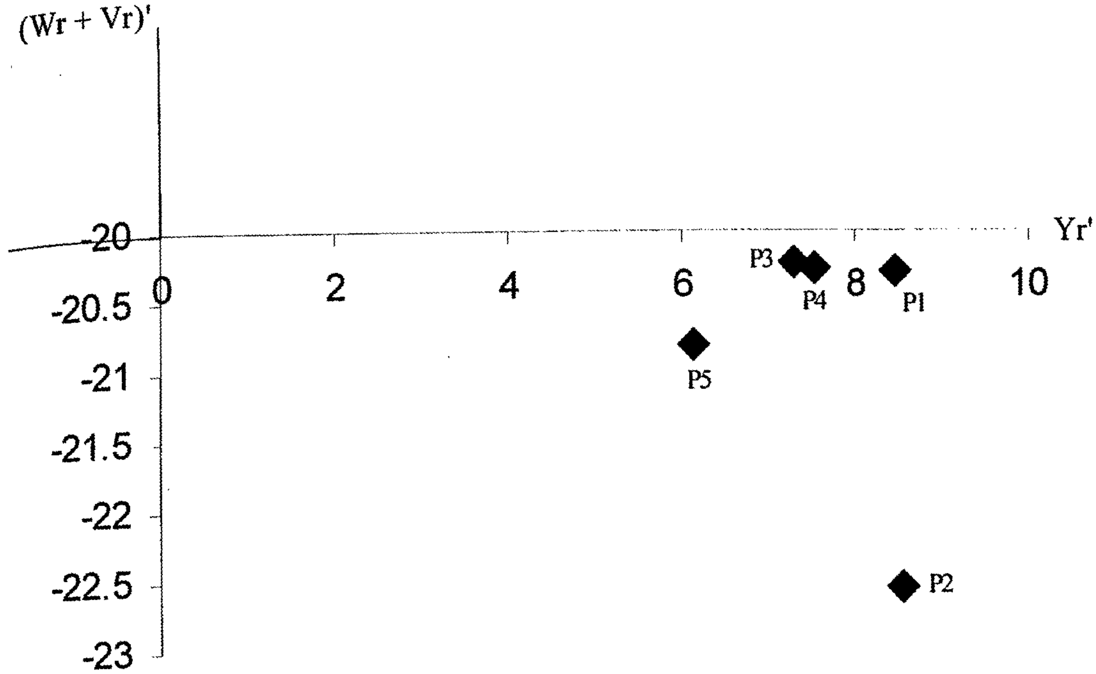


Days from emergence to maturity of leaves

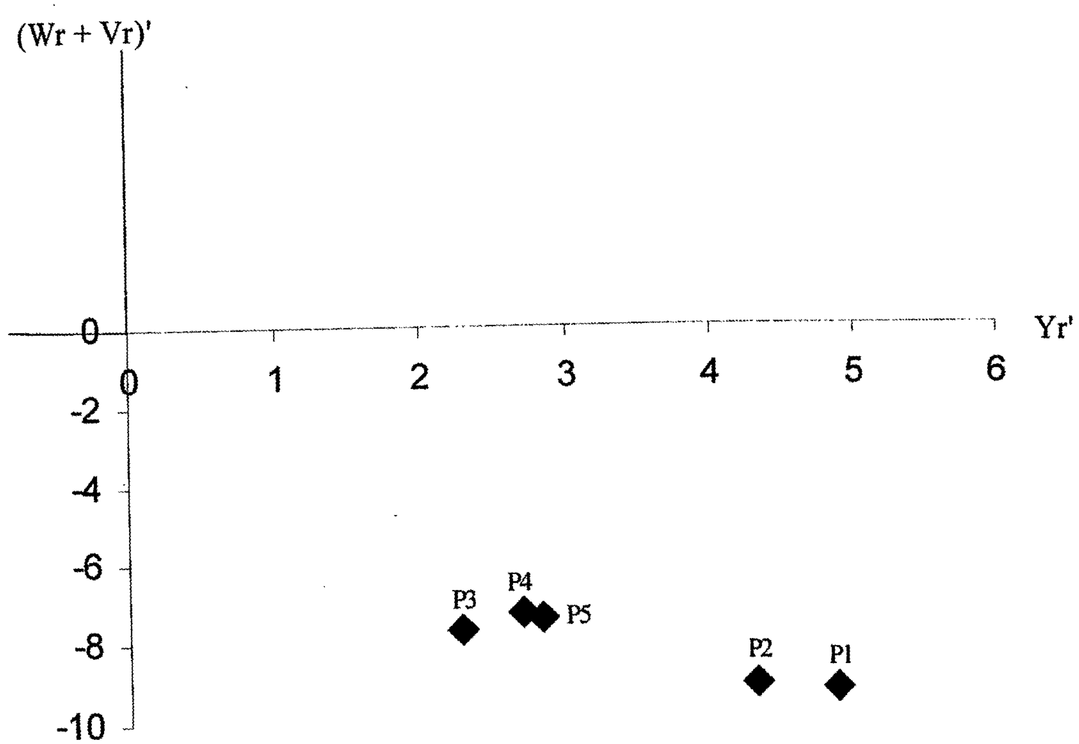


Number of leaves

Standardised Yr - (Wr+Vr) graph

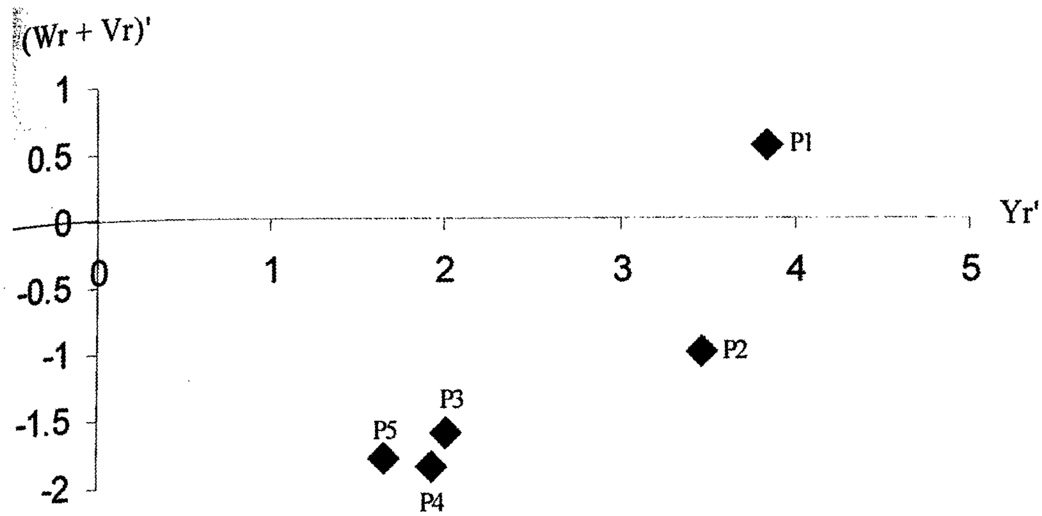


Length of leaf blade (cm)

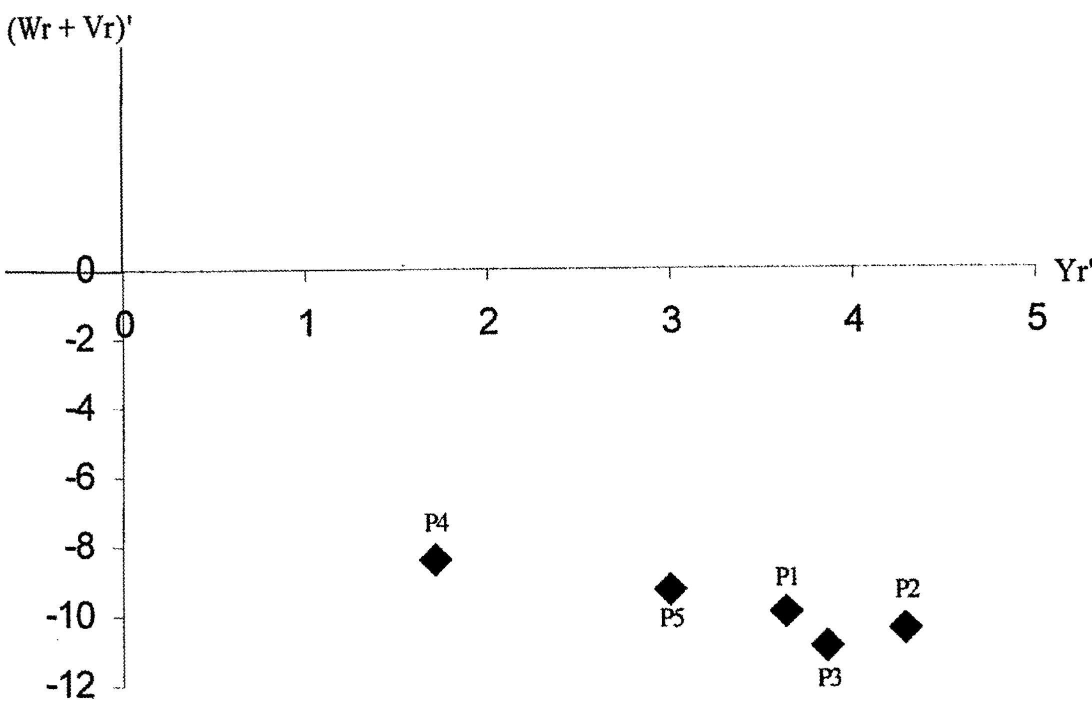


Width of leaf blade (cm)

Standardised Yr - (Wr+Vr) graph

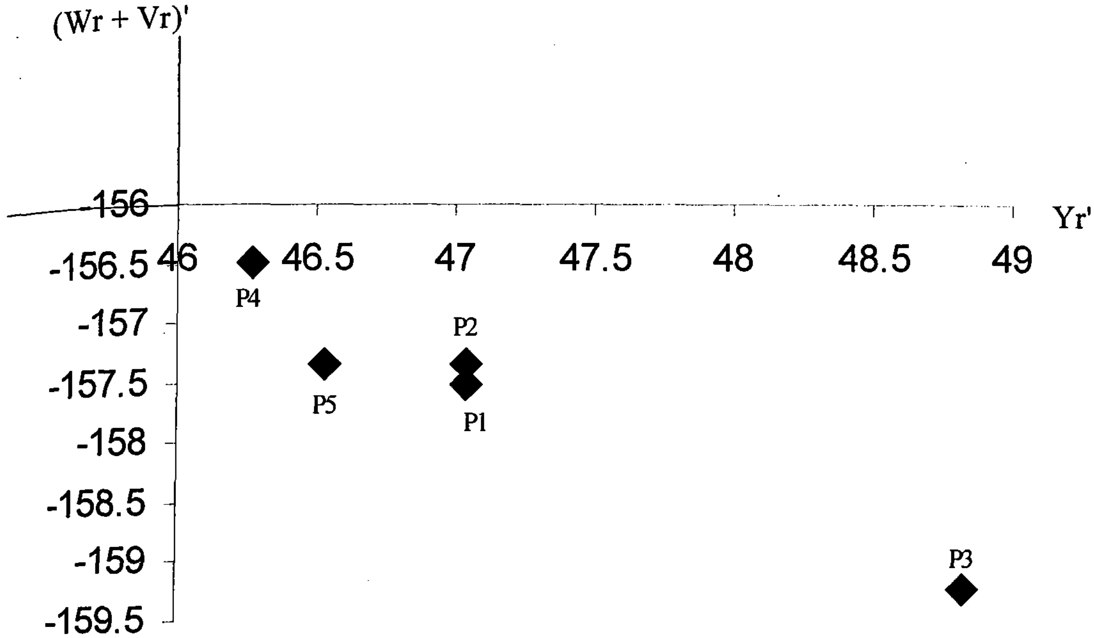


Leaf area (cm²)

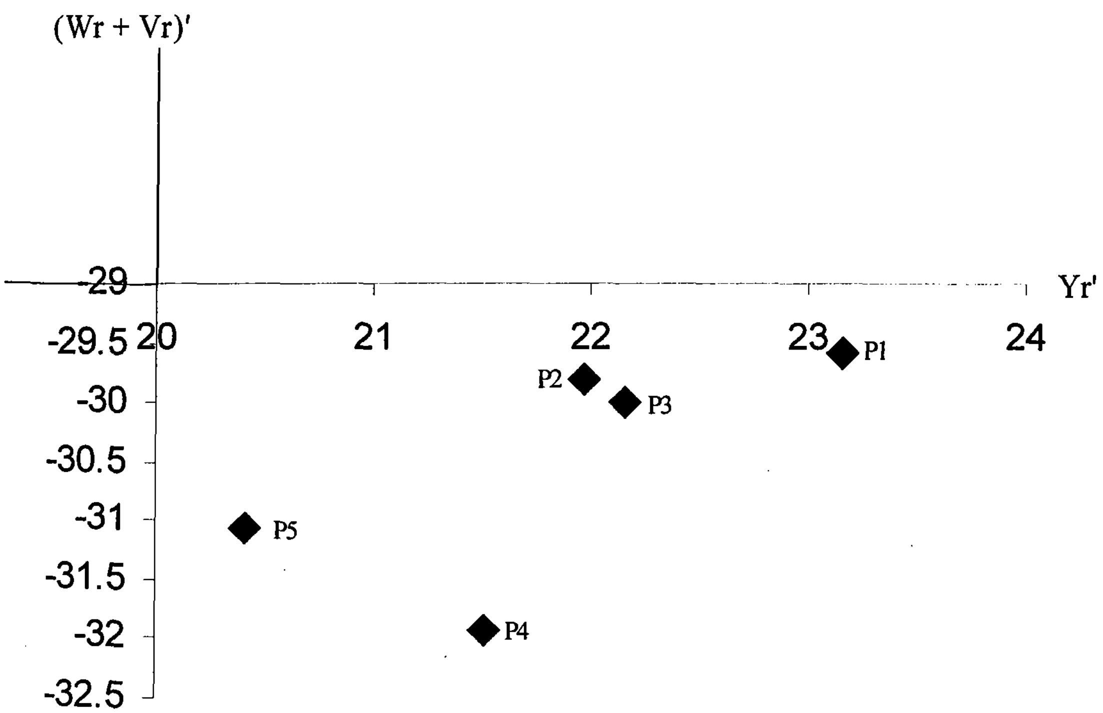


Suckering ability (%)

Standardised Yr - (Wr+Vr) graph

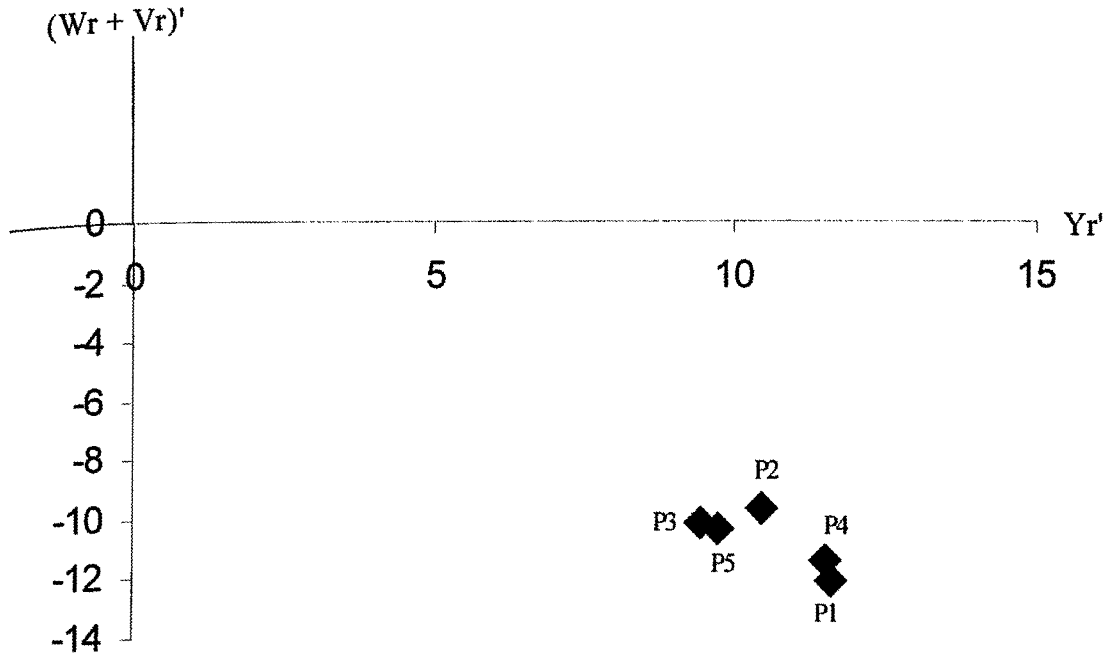


Time taken for first flowering

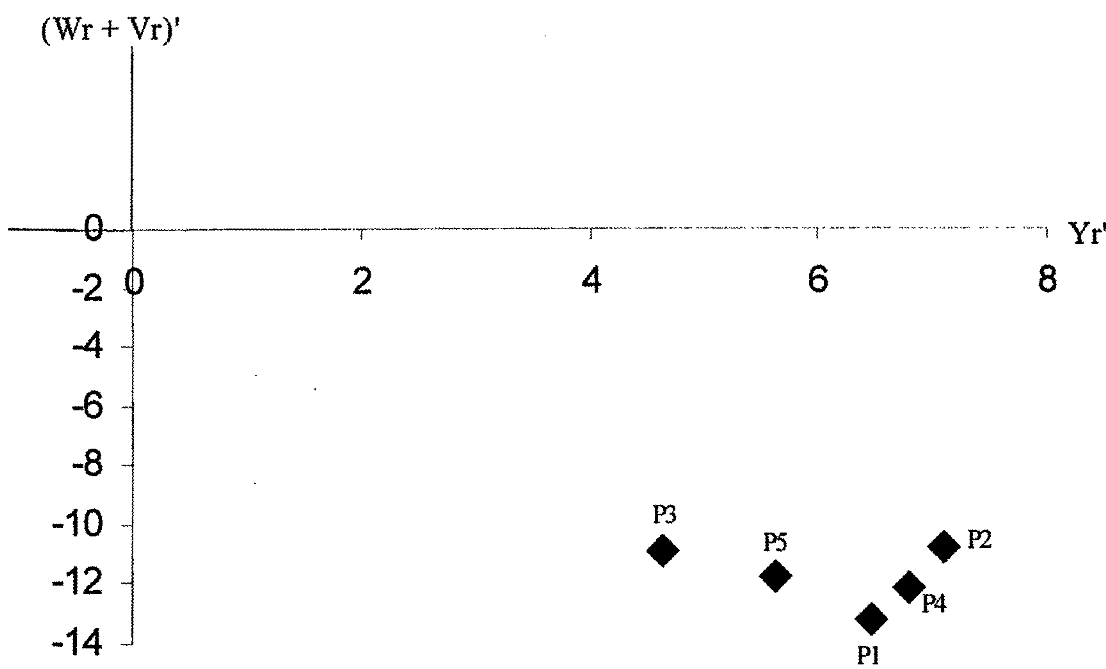


Days from emergence to maturity of inflorescence

Standardised Yr - (Wr+Vr) graph

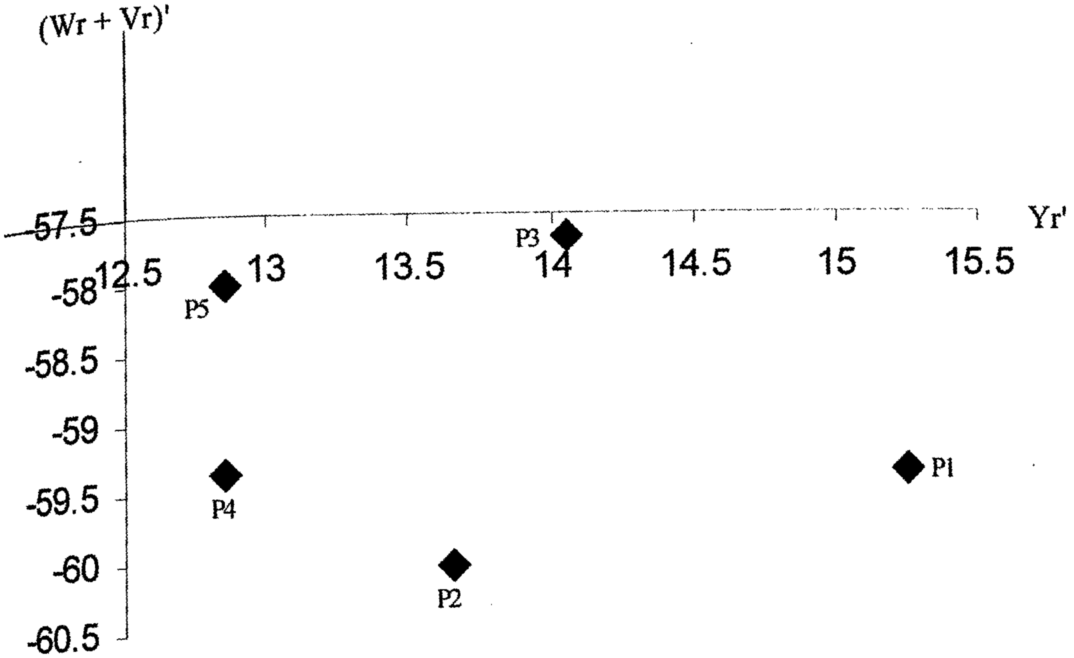


Length of spathe (cm)

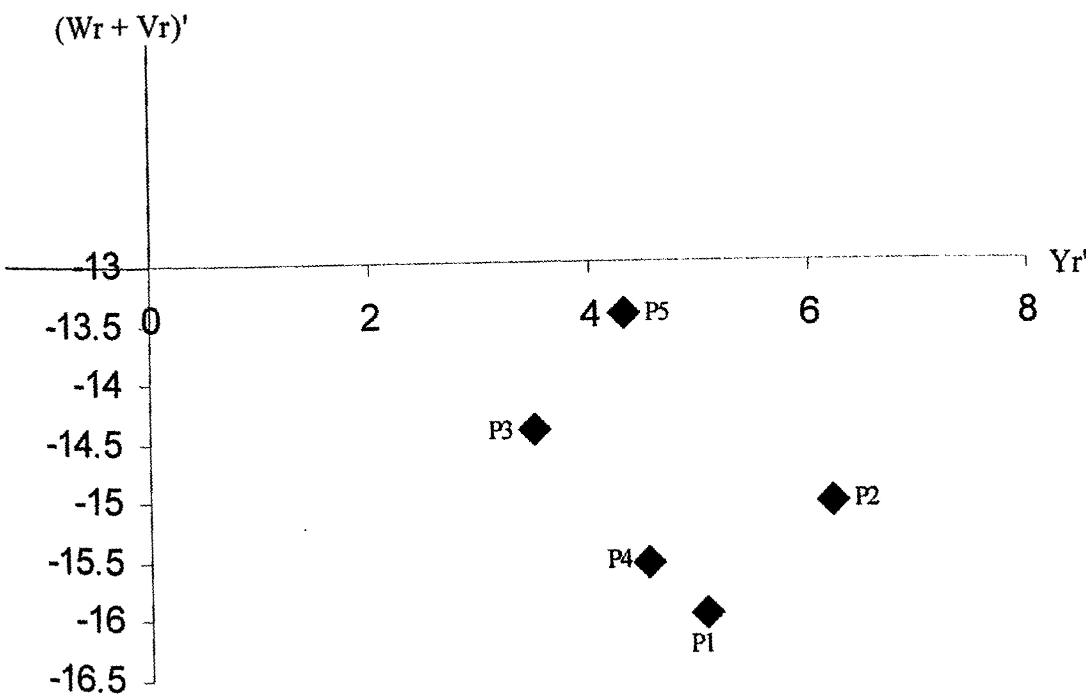


Width of spathe (cm)

Standardised Yr - (Wr+Vr) graph

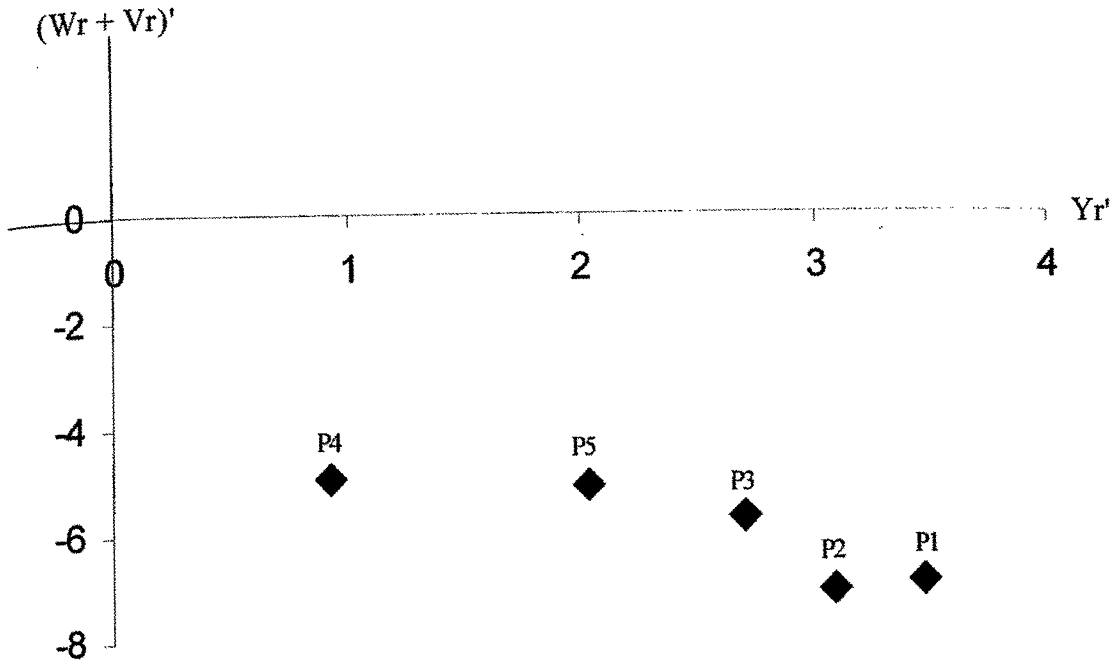


Number of spadices / plant / year

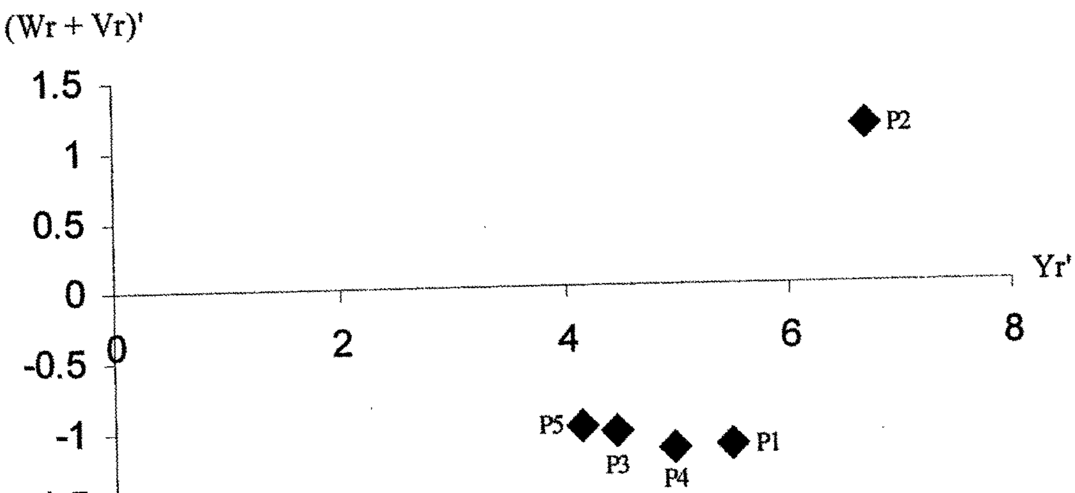


Candle length (cm)

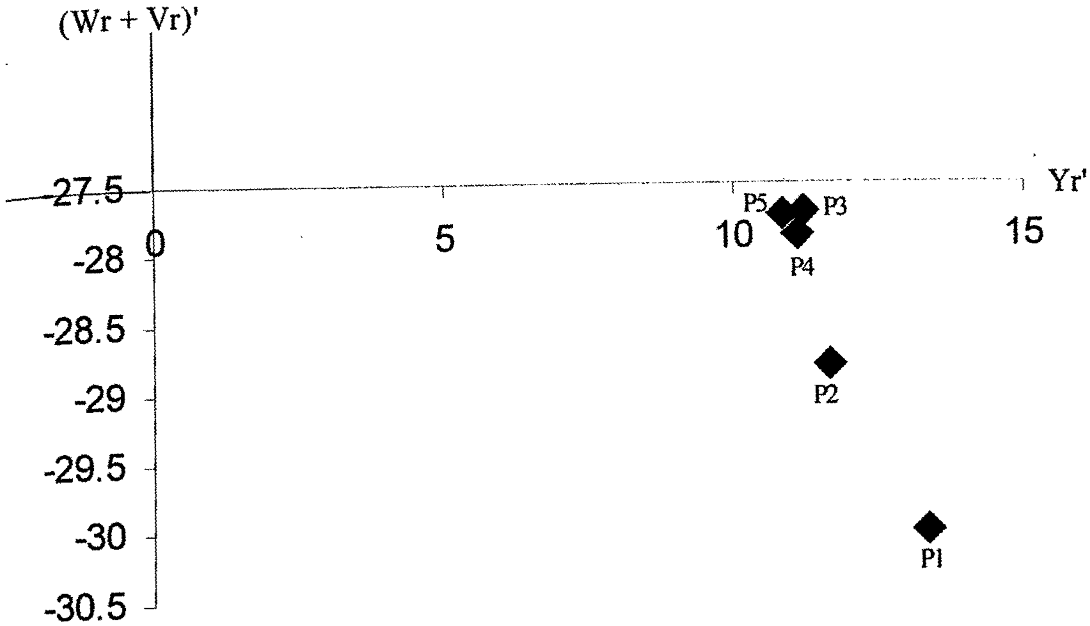
Standardised Yr - (Wr+Vr) graph



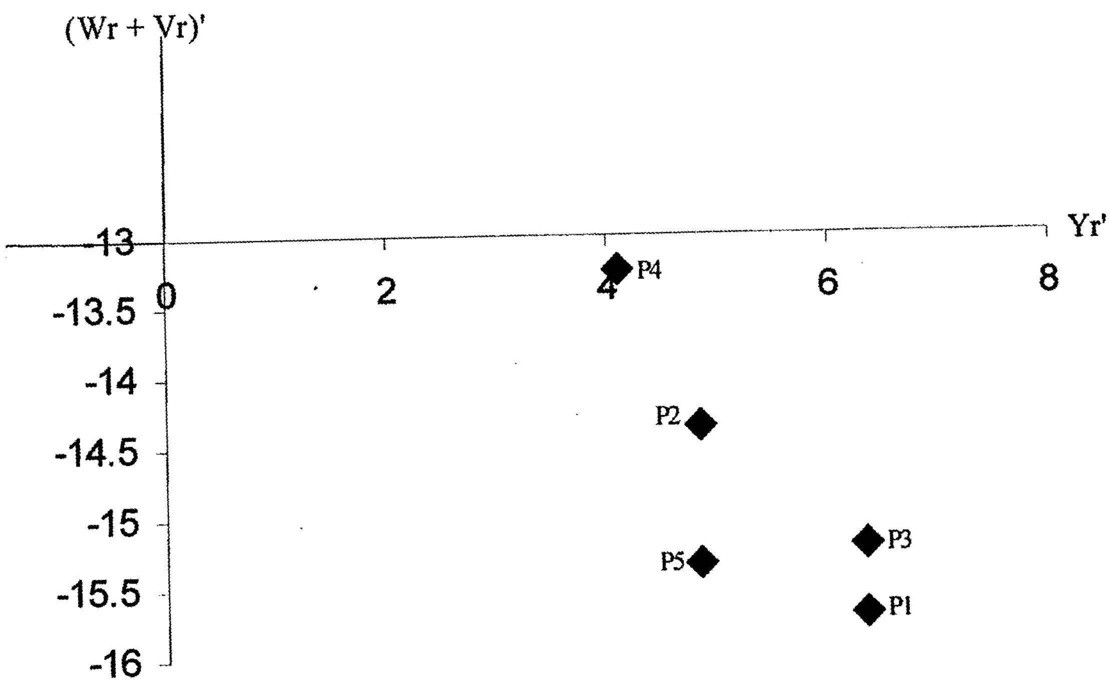
Inclination of candle (degrees)



Standardised Yr - (Wr+Vr) graph

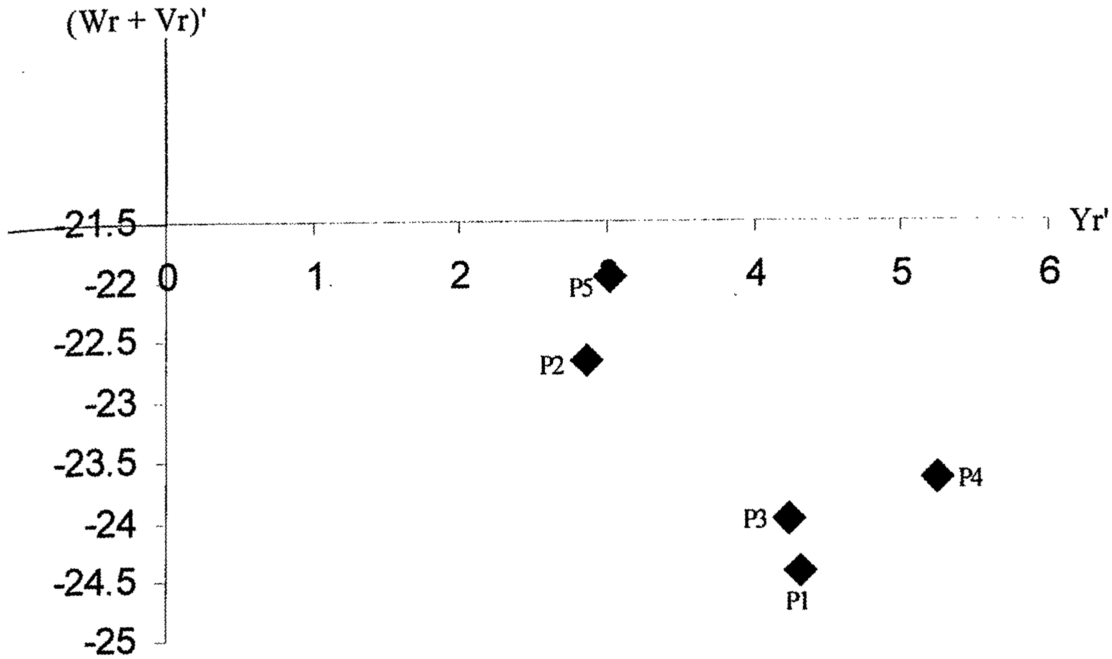


Life of spadix (days)

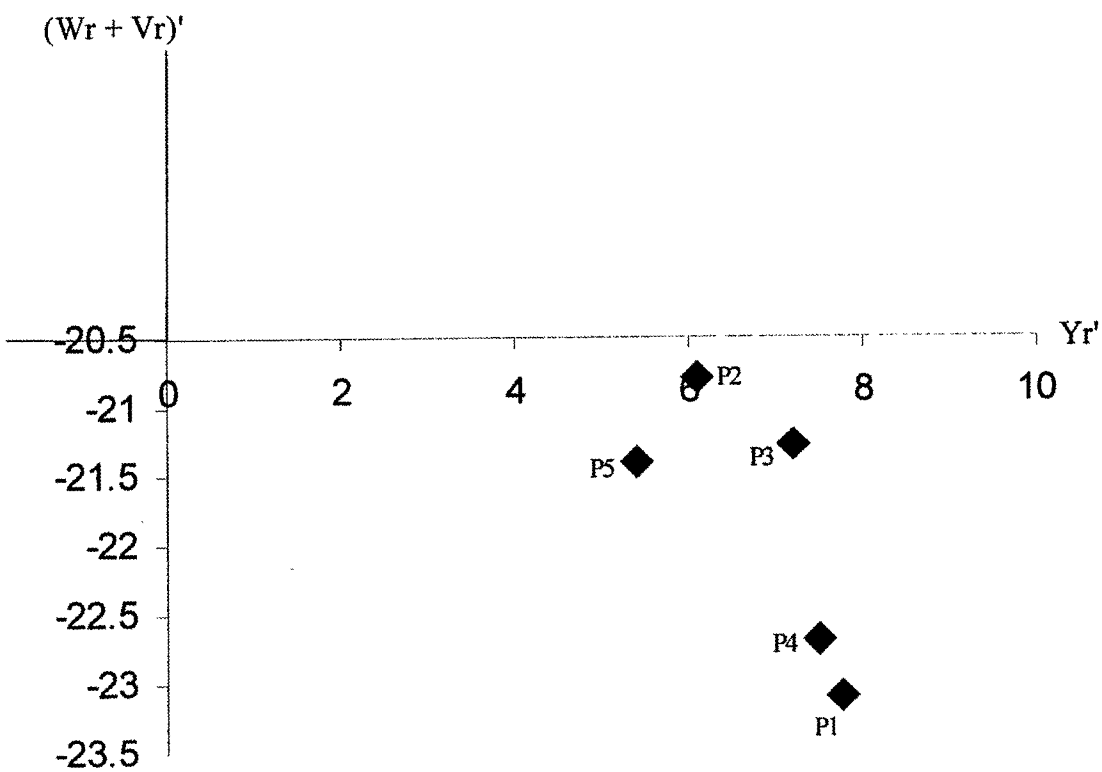


Days to initiation of female phase

Standardised Yr - (Wr+Vr) graph

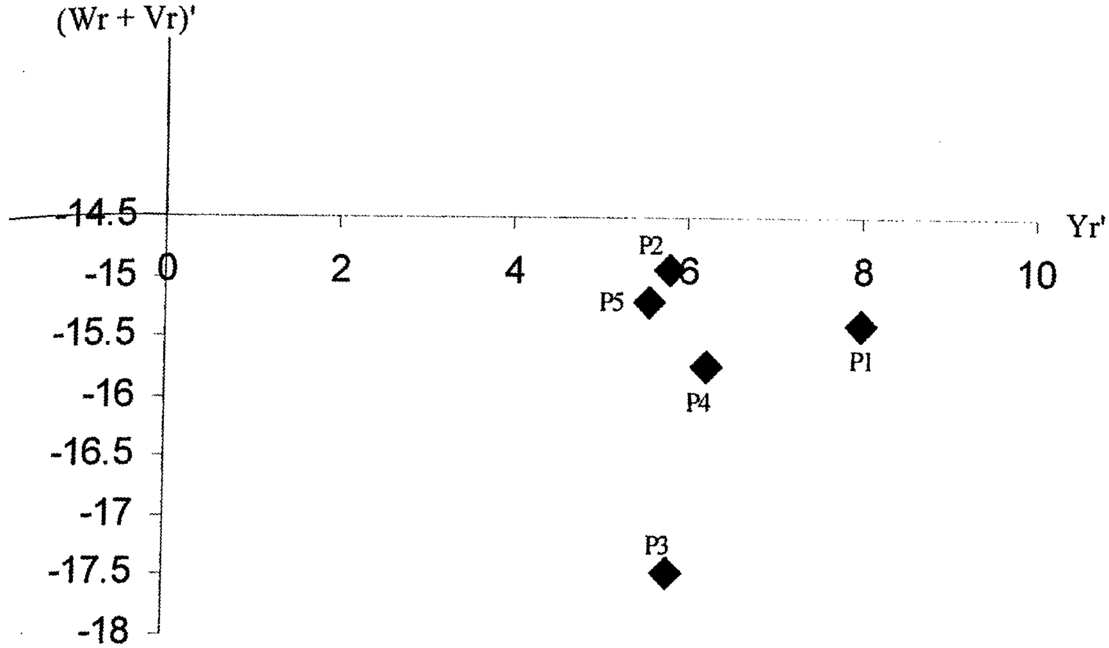


Duration of female phase

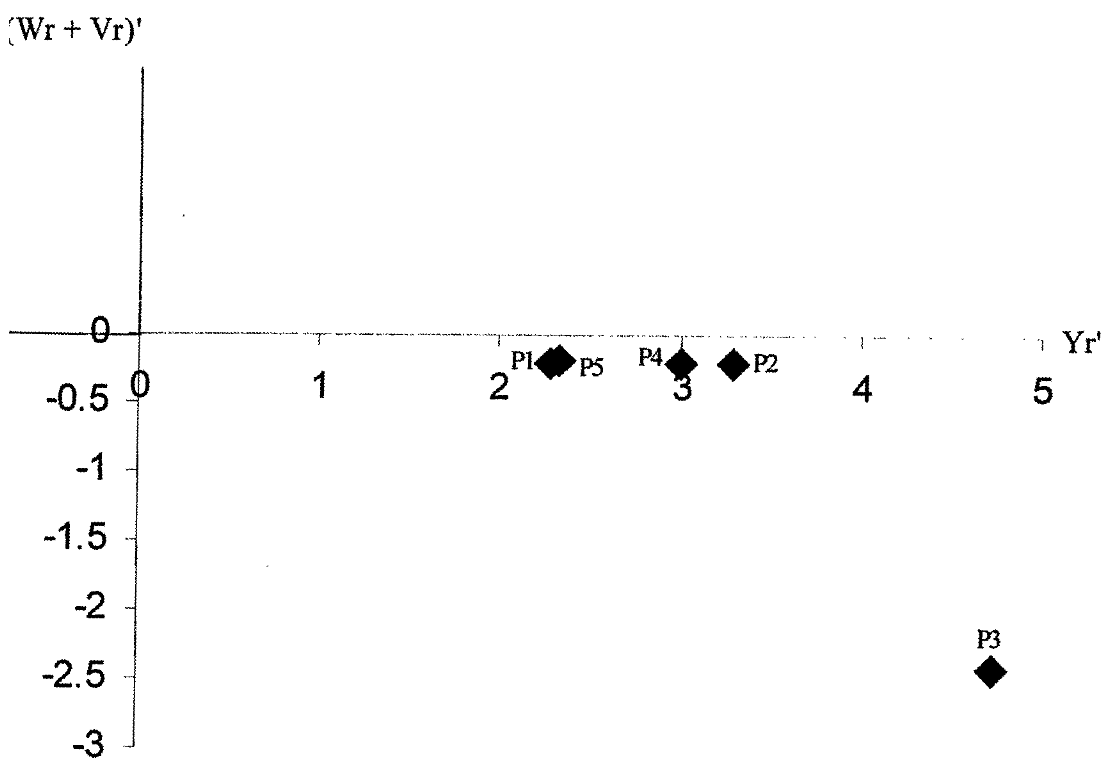


Days of interphase

Standardised Yr - (Wr+Vr) graph

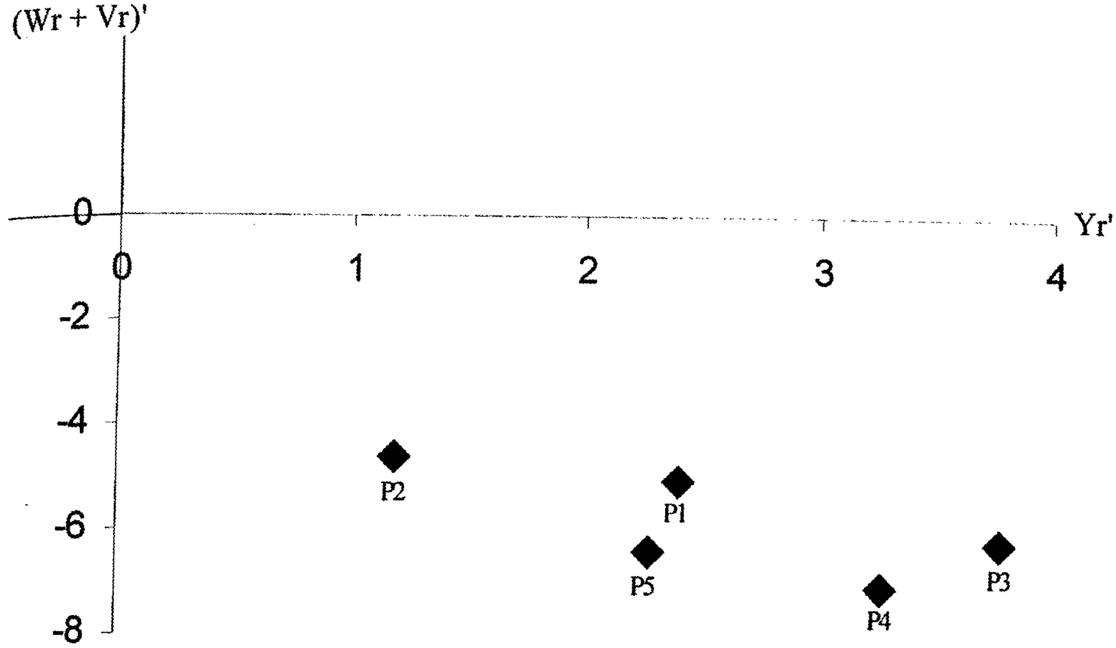


Duration of male phase

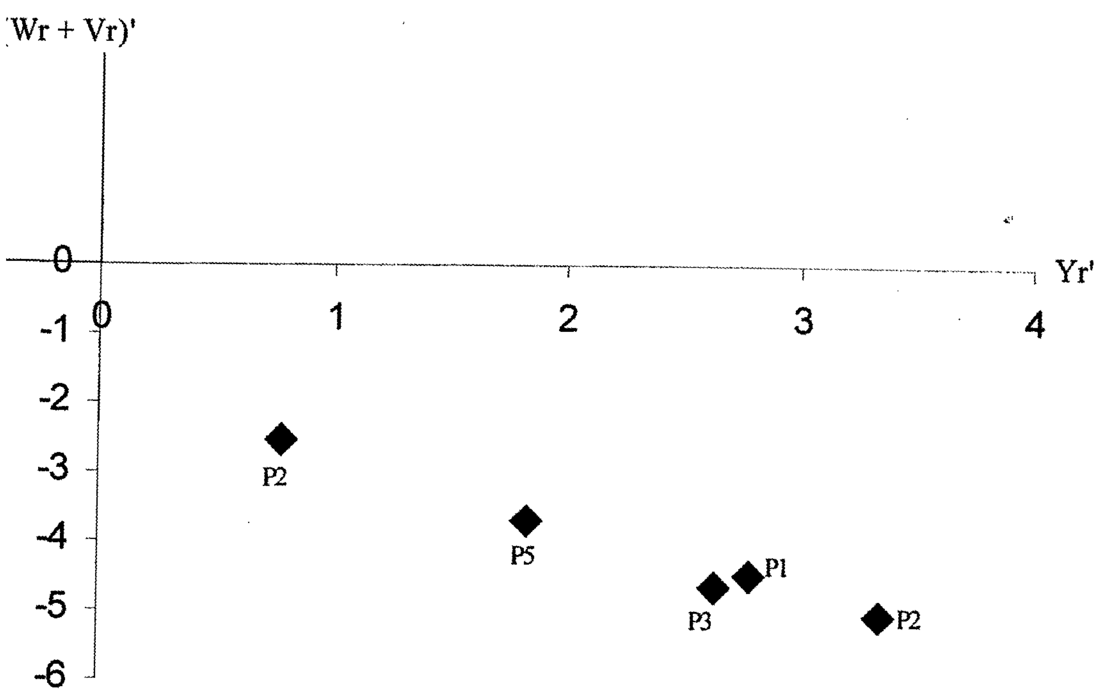


Pollen fertility (%)

Standardised Yr - (Wr+Vr) graph



Total Anthocyanin content (mg/g)



Carotene content (mg/100g)

5. Length of leaf blade

For this character also all the parents possessed most of the dominant genes with positive effects. P_2 possessed maximum frequency of alleles.

6. Width of leaf blade

All the parents possessed most of the dominant genes with positive effect, P_1 and P_2 having the highest frequency of alleles.

7. Leaf area

Parent P_1 possessed recessive genes with negative effects while P_2, P_3, P_4 and P_5 possessed dominant genes with positive effects.

8. Suckering ability

All the parents possessed most of the dominant genes with positive effects. P_3 was having the highest frequency of alleles.

B. FLORAL CHARACTERS

1. Time taken for first flowering

All the parents possessed most of the dominant genes with positive effects. P_3 was having the highest frequency of alleles.

2. Days from emergence to maturity of inflorescence

The graph showed that all the parents possessed most of the dominant genes with positive effects. P_4 was having the highest frequency of alleles.

3. Length of spathe

All the (W_r+V_r) values were negative. The position of these parents in the fourth quadrant revealed that these parents possessed most of the dominant genes with positive effects.

4. Width of spathe

All the parents possessed most of the dominant genes with positive effects.

5. Number of spadices / plant / year

Here also all the parents possessed most of the dominant genes with positive effects. P_2 possessed maximum frequency of alleles.

6. Candle length

All the parents possessed dominant genes with positive effects. P_1 was having the highest frequency of alleles.

7. Inclination of candle

All the (Wr+Vr) values were negative. The position of the parents in the fourth quadrant revealed that these parents possessed most of the dominant genes with positive effects.

8. Number of flowers/candle

P_2 possessed recessive genes with negative effects. Remaining parents possessed dominant genes with positive effects.

9. Life of spadix

All the parents possessed dominant genes with positive effects. P_1 was having the highest frequency of alleles.

10. Days to initiation of female phase

The graph revealed that all the parents possessed dominant genes with positive effects. P_1 was having the highest frequency of alleles.

11. Duration of female phase

All the parents possessed dominant genes with positive effects. P_1 was having the highest frequency of alleles.

12. Days of interphase

The graph revealed that parents possesed dominant genes with positive effects. P_1 had the highest frequency of alleles.

13. Duration of male phase

All the parents showed dominant genes with positive effects. P_3 was having the highest frequency of alleles.

14. Pollen fertility

All the parents lay in the fourth quadrant. But P_1, P_2, P_4 and P_5 lied near the border line indicating dominant as well as recessive nature. P_3 possessed the highest frequency of alleles.

15. Total anthocyanin content

All the parents possessed dominant genes with positive effects.

16. Carotene content

The graph revealed that all parents possessed dominant genes with positive effects. P_2 was having the highest frequency of alleles.

4.2.2.3 The correlation co-efficient (r) between parental means (Yr) and parental order of dominance (Wr+Vr)

The correlation co-efficients (r) between Yr and (Wr + Vr) were estimated and the significance of each correlation co-efficient was tested. The values are given in Table 4.2.2.3.

Significant negative correlation was observed in the case of characters like internode length, width of leaf blade, suckering ability, time taken for first flowering, inclination of candle, life of spadix, pollen fertility and carotene content. Leaf area was the lone factor with significant positive correlation. In the case of characters having significant negative correlation it was concluded that dominant alleles to have negative effect. The preponderance of dominant alleles may be the reasons attributed for negative correlation between parental means and parental order of dominance. However in the case of leaf area the dominant genes must be mostly positive and act in one direction.

Table 4.2.2.3. Correlation between parental means (Yr) and parental order of dominance (Wr+Vr)

Sl. No.	Character	r
1.	Plant height (cm)	0.7215
2.	Internode length (cm)	-0.9886**
3.	Days from emergence to maturity of leaves	-0.1206
4.	Number of leaves	-0.2515
5.	Length of leaf blade (cm)	-0.3709
6.	Width of leaf blade (cm)	-0.9854**
7.	Leaf area (cm^2)	0.8984*
8.	Suckering ability	-0.9254*
9.	Time taken for first flowering (months)	-0.9725*
10.	Days from emergence to maturity of inflorescence	0.6837
11.	Length of spathe (cm)	-0.8137
12.	Width of spathe (cm)	-0.2733
13.	Number of spadices / plant	-0.1487
14.	Candle length (cm)	-0.4105
15.	Inclination of candle (degrees)	-0.8834*
16.	Number of flowers / candle	0.8281
17.	Life of spadix (days)	-0.9715**
18.	Days to initiation of female phase	-0.8085
19.	Duration of female phase (days)	-0.7487
20.	Days to interphase	-0.7261
21.	Duration of male phase (days)	0.1697
22.	Pollen fertility (%)	-0.9037*
23.	Total anthocyanin content (mg/g)	-0.7376
24.	Carotene content (mg/100g)	-0.9936**

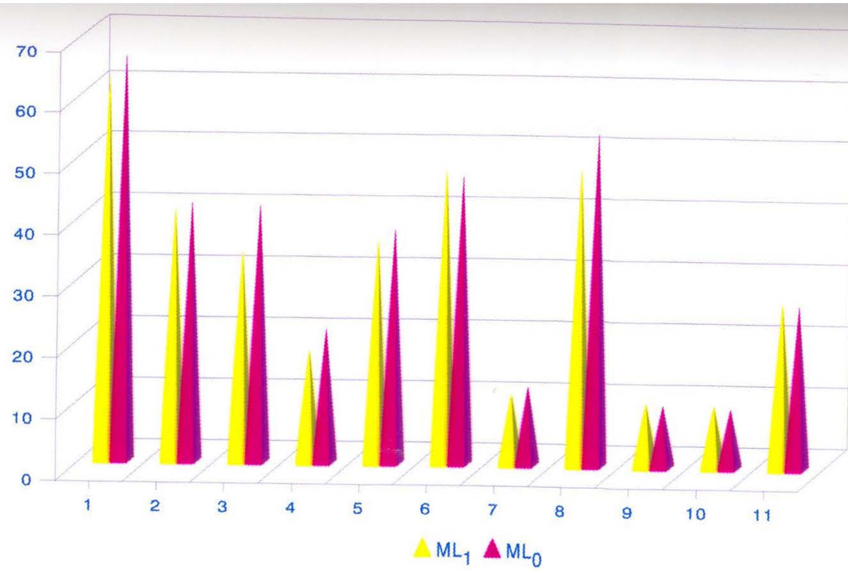
* Significant at 5 per cent level ** Significant at 1 per cent level

Table 4.2.2.4. Dominance effects and variance

Sl.No.	Character	M_{L1}	M_{L0}	M_{L1}-M_{L0}	$(M_{L1}-M_{L0})^2$
1.	Plant height	64.02	67.54	-3.54	12.53
2.	Internode length	1.19	1.22	-0.33	0.109
3.	Days from emergence to maturity of leaves	41.99	43.00	-1.01	1.02
4.	Number of leaves	7.21	7.16	0.05	0.003
5.	Length of leaf blade	34.88	42.67	-7.79	60.68
6.	Width of leaf blade	18.64	22.24	-3.60	12.96
7.	Leaf area	442.33	630.41	-188.08	35374.09
8.	Suckering ability	3.08	3.08	0.00	0.00
9.	Time taken for first flowering	36.96	38.88	0.08	0.006
10.	Days from emergence to maturity of inflorescence	48.83	47.72	1.11	1.23
11.	Length of spathe	11.69	12.95	-1.26	1.59
12.	Width of spathe	9.04	9.57	-0.53.	0.28

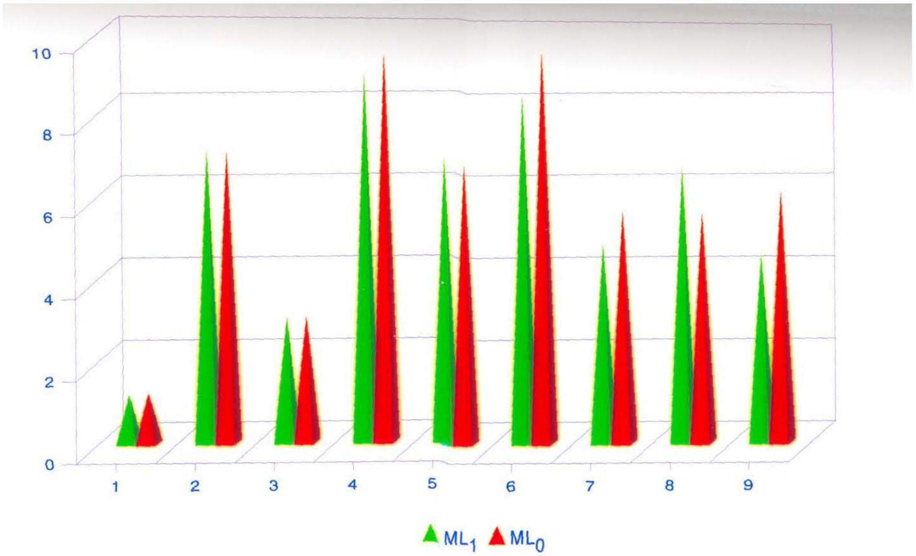
Table 4.2.2.4. (Contd...)

Sl.No.	Character	M_{L1}	M_{L0}	$M_{L1}-M_{L0}$	$(M_{L1}-M_{L0})^2$
13.	Number of spadices / plant	6.96	6.84	0.12	0.014
14.	Candle length	8.57	9.68	-1.11	1.23
15.	Inclination of candle	49.11	55.08	-5.97	35.64
16.	Number of flowers / candle	497.40	461.80	35.60	1267.36
17.	Life of spadix	113.57	104.96	8.61	74.132
18.	Days to initiation of female phase	4.89	5.68	-0.79	0.624
19.	Duration of female phase	10.59	10.20	0.39	0.152
20.	Days to interphase	10.33	9.80	0.53	0.281
21.	Duration of male phase	6.77	5.64	1.13	1.28
22.	Pollen fertility	27.47	27.00	0.47	0.221
23.	Total anthocyanin content	260.95	264.20	-3.25	10.56
24.	Carotene content	4.62	6.15	-1.53	2.34



1 - Plant height 2 - Days from emergence to maturity of leaves 3 - Length of leaf blade 4 - Width of leaf blade
5 - Time taken for first flowering 6 - Days from emergence to maturity of inflorescence 7 - Length of spathe
8 - Inclination of candle 9 - Female phase duration 10 - Days of interphase 11 - Pollen fertility

Fig. 11(a). Dominance effect



1 - Internode length 2 - Number of leaves 3 - Suckering ability 4 - Width of spathe
5 - Number of spadices/plant 6 - Candle length 7 - Days to female phase initiation
8 - Duration of male phase 9 - Carotene content

Fig. 11(b). Dominance effect (Contd...)

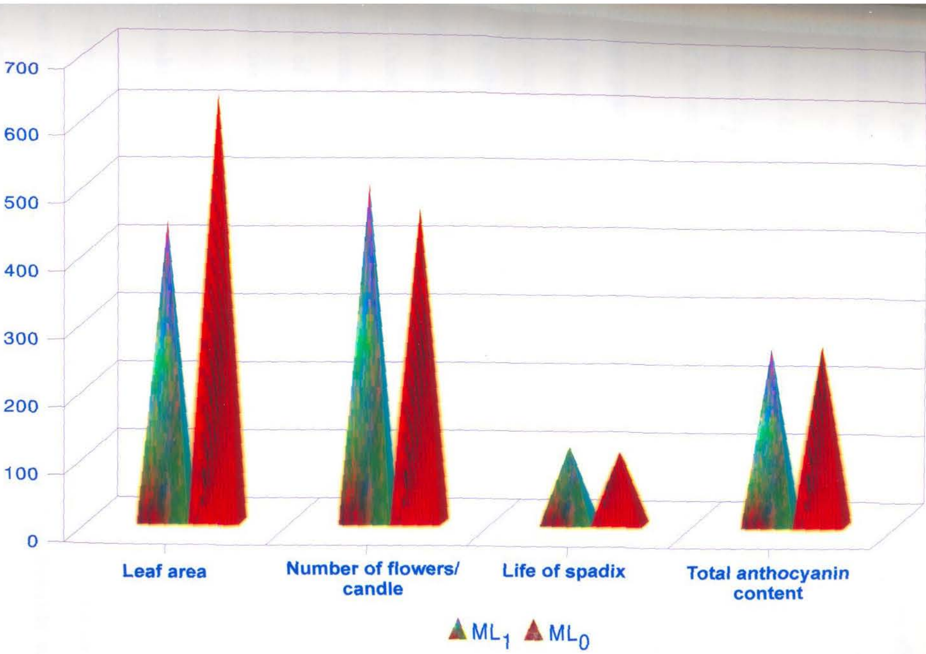


Fig. 11(c). Dominance effect (Contd...)

4.2.2.4 Dominance relationship

The square of the difference between mean of offsprings (M_{L1}) and the mean of parents (M_{L0}) is a measure of dominance effect. The effects are presented in Table 4.2.2.4 and Fig. 11 (a, b and c) for various characters.

The high dominance effects were observed for the characters like plant height, length of leaf blade, width of leaf blade, leaf area, inclination of candle, number of flowers / candle, candle length and total anthocyanin content.

Low plant height was dominant over tall plant height. Shorter length of leaf blade was dominant over longer length of leaf blade. Similarly short width for leaf blade was dominant over long width of leaf blade. Smaller leaf size was dominant over larger leaf size. Less inclination of candle with spathe was dominant over larger inclination of candle. Candle with less number of flowers was dominant over candle with less number of flowers. Long life for the spadix was dominant over short life of spadix. High content of anthocyanin in the spathe was dominant over lower content of anthocyanin.

4.2.3 Combining ability analysis

The general combining ability effects of parents involved in the cross and the specific combining ability effects of their hybrids were evaluated and the data are presented below.

The analysis of variance for combining ability was carried out for 24 characters studied (Appendix II & III). The gca and sca effects were found to be significant for most of the characters. The general combining ability effects of the parents and the specific combining effects of the hybrids for 24 characters are given in Tables 4.2.3 (a), (b), (c) and (d) and Fig. 13 (a, b and c).

VEGETATIVE CHARACTERS

1. Plant height

Significant gca effects were observed for the parents under study which implied the differential ability of the parents to transmit their genes to their hybrid progenies. HR, LR and CR were the parents having negative gca effects, of which the gca effect of HR only was found to be significant. The gca effect of HR was -2.789 cm while the average performance of the parent ie., the average plant height, was 58.40 cm. However the gca variance of this character was not estimable because of the presence of high sca variance. So HR may be a desirable parent for producing F_1 hybrids.

Significant differences in the sca effects of the various crosses were observed. LR x KR, LR x CR and HR x LR were the hybrids which showed significant negative sca effects.

2. Internode length

A significant negative gca effect was recorded for LR. Specific combining ability variance was higher than gca variance. LR may be a desirable parent for producing F_1 hybrids with less internode length.

There were no significant differences in the sca effects of the different crosses. A negative sca effect is preferred. P x CR registered

Table 4.2.3 (a). The general combining ability (gca) effects of the five parents for vegetative characters

Sl. No.	Character	Parents					F	$SE_{(gi)}$	$SE_{(gi-gj)}$	$CD_{(gi-gj)}$
		HR	P	LR	KR	CR				
1.	Plant height (cm)	-2.789*	3.283*	-0.200	2.123	-2.417	3.080*	1.370	4.700	9.410
2.	Internode length (cm)	-0.045	-0.065	-0.081*	-0.030	-0.058	2.410	0.038	0.035	0.007
3.	Days from emergence to maturing of leaves	0.097	0.669	-0.503	0.754	-1.017*	2.070	0.472	0.560	1.120
4.	Number of leaves	0.074	-0.011	-0.154*	0.074	0.017	1.110	0.080	0.016	0.032
5.	Length of leaf blade (cm)	0.336	2.827*	-1.010**	-0.784*	-1.370*	40.36**	0.240	0.140	0.289
6.	Width of leaf blade (cm)	3.155**	2.327**	-1.367**	-2.253**	-1.862**	258.280**	0.141	0.050	0.100
7.	Leaf size / Leaf area (cm^2)	88.890**	94.530**	-50.210**	-66.960**	-66.260**	208.200**	5.210	67.800	135.940
8.	Suckering ability	0.074	0.274*	0.331*	-0.526*	-0.154	15.34**	0.080	0.016	0.032

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

Table 4.2.3 (b). The general combining ability (gca) of the five parents for floral characters

Sl. No.	Character	Parents					F	$SE_{(gi)}$	$SE_{(gi-gj)}$	$CD_{(gi-gj)}$
		HR	P	LR	KR	CR				
1.	Time taken for first flowering (months)	-0.023	-0.051	0.463*	-0.280*	-0.109	9.38*	0.081	1.016	0.033
2.	Days from emergence to maturity of inflorescence	-0.623	-0.680	-0.480	1.577*	0.206	2.16	0.578	0.836	1.680
3.	Length of spathe (cm)	1.254*	-0.823*	-0.654**	-0.669*	-0.446*	22.79**	0.171	0.073	0.146
4.	Width of spathe (cm)	0.843*	-0.314*	-0.802*	0.378*	-0.105	15.45**	0.144	0.052	0.104
5.	Number of spadices/plant/year	0.149*	0.091	-0.080	-0.023	-0.137	2.18	0.072	0.013	0.026
6.	Candle length (cm)	0.543*	0.497*	-0.549*	0.209*	-0.700*	67.76**	0.064	0.010	0.020
7.	Inclination of the candle (degree)	9.337*	8.537*	-0.634**	-10.691**	-6.549*	2004.37**	0.178	0.079	0.159
8.	Number of flowers per candle	21.657**	31.086**	-26.343**	20.800*	-47.200*	412.04**	1.525	5.810	11.650
9.	Life of spadix (days)	6.790*	1.110	-2.610	-2.290	-3.010*	6.19**	1.487	5.530	11.090
10.	Days to initiation of female phase	0.380*	-0.170	0.260*	-0.540*	0.060	7.30**	0.120	0.036	0.072
11.	Duration of female phase	0.497*	-0.617*	0.326	0.583*	-0.789*	5.56*	0.247	0.152	0.305
12.	Days of interphase	-0.514*	0.629*	-0.114	0.429*	-0.429*	5.92**	0.188	0.088	0.176
13.	Duration of male phase	0.109	-0.320	-0.006	0.480*	-0.263	2.97*	0.167	0.070	0.140
14.	Pollen fertility (%)	-1.489*	-0.163	5.537*	-0.483*	-3.403*	194.74**	0.214	0.115	0.230
15.	Total anthocyanin content (mg/g)	-32.719*	-61.613*	28.990*	42.577*	22.760*	26345.55**	0.247	0.153	0.306
16.	Carotene content (mg/100g)	0.502*	-1.739*	0.547*	1.163*	-0.047*	41029.80**	0.005	0.000	0.007

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

Table 4.2.3 (c). The specific combining ability (sca) effects of hybrids for vegetative characters

Sl. No.	Hybrids	Plant height (cm)	Internode length (cm)	Days from emergence to maturity of leaves	No. of leaves	Length of leaf blade (cm)	Width of leaf blade (cm)	Leaf size / Leaf area (cm^2)	Suckering ability
1.	HR x P	1.486	0.257*	1.248	-0.076	-6.805**	-2.868**	-195.595**	0.171
2.	HR x LR	-7.931*	-0.029*	-0.981	-0.533*	-5.788**	-1.633**	-129.567**	-0.086
3.	HR x KR	2.846	-0.037	0.562	0.038	-3.573**	-0.908**	-84.717**	-0.229
4.	HR x CR	3.686	-0.106	0.733	0.095	-7.928**	-6.199**	-227.535**	-0.200
5.	P x LR	-2.503	-0.109	-1.752	0.152	-0.519	-1.125**	-49.242**	-0.286
6.	P x KR	-0.126	0.143	1.790	-0.076	-9.885**	-4.739**	-218.441**	-0.029
7.	P x CR	5.914*	-0.166*	-3.438*	0.381*	1.961*	0.970**	31.247*	-0.600*
8.	LR x KR	-12.123**	-0.103	-1.438	0.267	-7.868**	-0.765*	-76.433*	0.514*
9.	LR x CR	-10.603**	-0.091	-1.467	-0.076	-1.902*	-1.456**	-42.935**	0.143
10.	KR x CR	1.774	0.100	-0.324	0.095	3.352**	0.730*	52.772**	0.600*
	F	4.170**	1.780	2.08*	1.350	136.530**	85.820**	160.740**	2.830**
	SE (S_{ij})	2.797	0.077	0.964	0.162	0.490	0.288	10.630	0.163
	SE ($S_{ij} - S_{ik}$)	5.307	0.145	1.828	0.309	0.929	0.547	20.169	0.310
	SE ($S_{ij} - S_{kl}$)	4.845	0.133	1.670	0.282	0.848	0.500	18.412	0.283

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

Table 4.2.3 (d). The specific combining ability effects of hybrids for floral characters

Sl. No.	Hybrids	Time taken for first flowering (months)	Days from emergence to maturity of inflorescence	Length of spathe (cm)	Width of spathe (cm)	No. of spadices per plant	Candle length (cm)	Inclination of the candle (degrees)	No. of flowers / candle
1.	HR x P	0.114	-6.524**	-0.925*	-1.466**	-0.000	-2.127**	22.619**	49.86**
2.	HR x LR	0.000	-6.124**	2.307**	3.123**	-0.829**	1.819**	-3.410**	9.29**
3.	HR x KR	0.143	4.129**	-1.896**	-1.897**	0.114	0.122	-8.952**	60.14**
4.	HR x CR	-0.029	2.390*	0.398	1.526**	0.029	-1.270**	-31.095**	-21.86**
5.	P x LR	-0.571*	-1.067	-1.496**	-0.620*	0.029	-2.615**	-23.010**	-102.14**
6.	P x KR	-0.029	2.876*	-1.939**	-1.960**	0.171	-0.212	3.848**	50.71**
7.	P x CR	0.600*	2.848*	-1.145**	-1.337**	0.486**	-1.364**	-9.985**	-79.29**
8.	LR x KR	0.057	2.476*	-0.048	0.109	0.543**	0.773**	-1.381**	48.14**
9.	LR x CR	-0.114	3.648**	-3.193**	-2.229**	-0.143	0.602**	1.476**	134.14**
10.	KR x CR	0.229	0.390	1.664**	2.091**	0.200	-1.315**	19.933**	29.00**
	F	1.860	6.740**	16.370**	22.840**	4.320**	96.730**	1098.680**	309.270**
	SE (S_{ij})	0.165	1.181	0.347	0.294	0.146	0.130	0.363	3.110
	SE ($S_{ij} - S_{ik}$)	0.313	2.240	0.661	0.559	0.278	0.247	0.690	5.910
	SE ($S_{ij} - S_{kl}$)	0.286	2.040	0.604	0.510	0.253	0.225	0.629	5.390

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

Table 4.2.3 (d) (Contd....)

Sl. No.	Hybrids	Life of spadix (days)	Days to initiation of female phase	Duration of female phase	Days of interphase	Duration of male phase	Pollen fertility (%)	Total anthocyanin content (mg/g)	Carotene content mg/100g
1.	HR x P	2.124	-0.305	0.733	-0.248	-0.562	-1.822**	47.640**	1.438**
2.	HR x LR	3.038	-1.733**	1.390**	0.495	0.324	3.178**	-111.194**	-0.647**
3.	HR x KR	7.924*	-1.133**	-2.067**	0.752	0.838*	0.018	6.383**	-3.743**
4.	HR x CR	0.438	0.867**	0.705	0.010	-1.019*	8.218**	-43.458**	-0.835**
5.	P x LR	5.124	-0.390	0.305	-0.448	-0.648	-1.708**	-27.718**	-1.670**
6.	P x KR	3.610	0.610*	-0.152	-0.590	2.667**	1.792**	25.702**	-1.710**
7.	P x CR	10.324*	-1.190**	3.019**	2.067**	0.410	-0.768	-12.935**	0.038*
8.	LR x KR	2.124	-0.619*	-0.695	-0.648	0.552	-0.208	-13.371**	1.284**
9.	LR x CR	4.038	-0.019	-0.524	0.010	2.095**	-5.968**	17.031**	-1.775**
10.	KR x CR	4.324	-0.019	-0.781	1.267**	1.010*	-0.388	4.656**	0.001*
	F	3.330**	9.010*	5.010**	3.630**	10.600	38.390**	4955.590**	18281.92**
	SE (S_{ij})	3.030	0.246	0.504	0.383	0.341	0.437	0.504	1.010
	SE ($S_{ij} - S_{ik}$)	5.760	0.467	0.956	0.726	0.646	0.830	0.957	1.019
	SE ($S_{ij} - S_{kl}$)	5.260	0.427	0.873	0.663	0.589	0.758	0.873	1.018

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

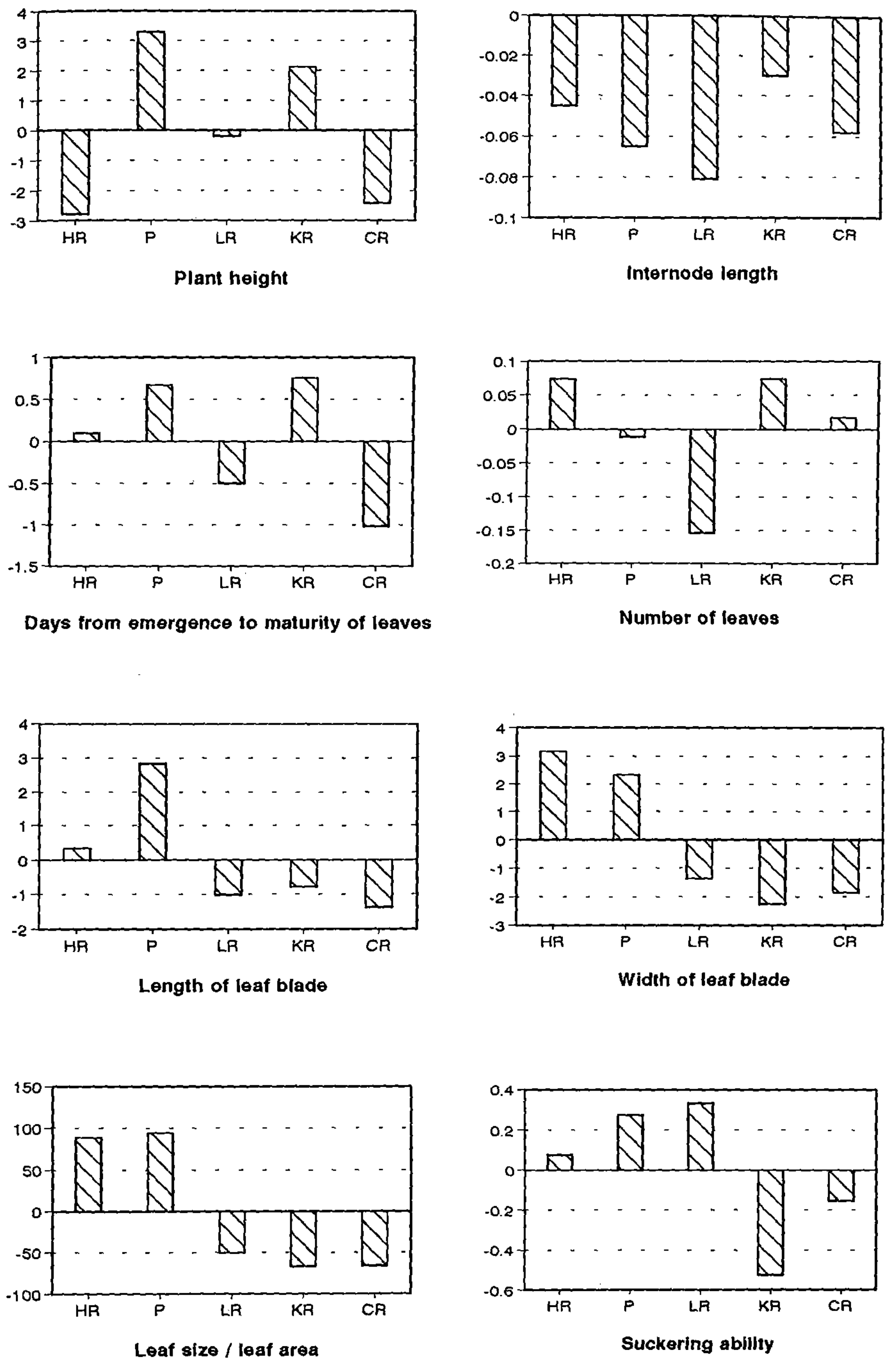


Fig. 12(a). gca effects of parents for vegetative characters

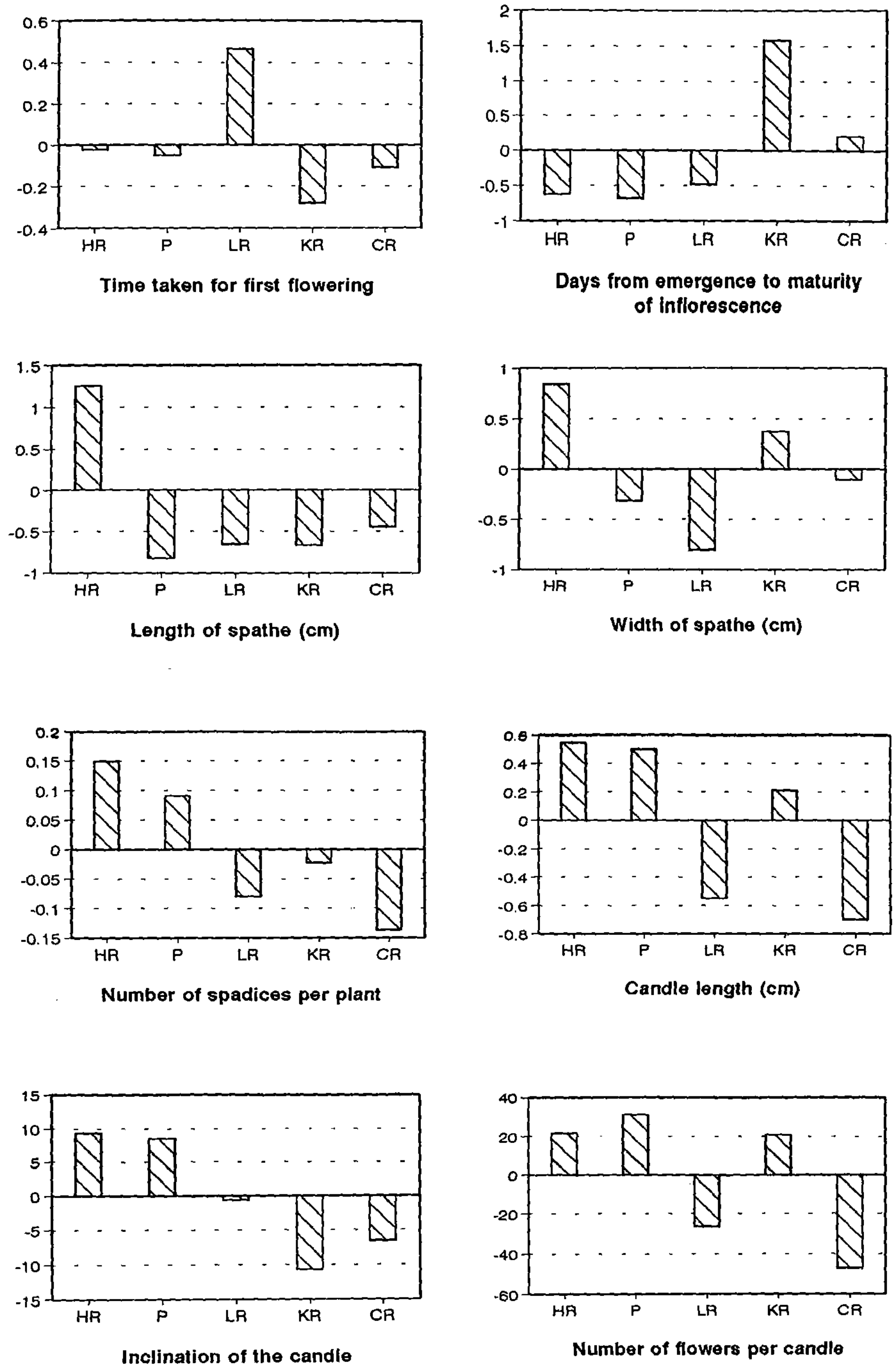


Fig. 12(b). gca effects of parents for floral characters

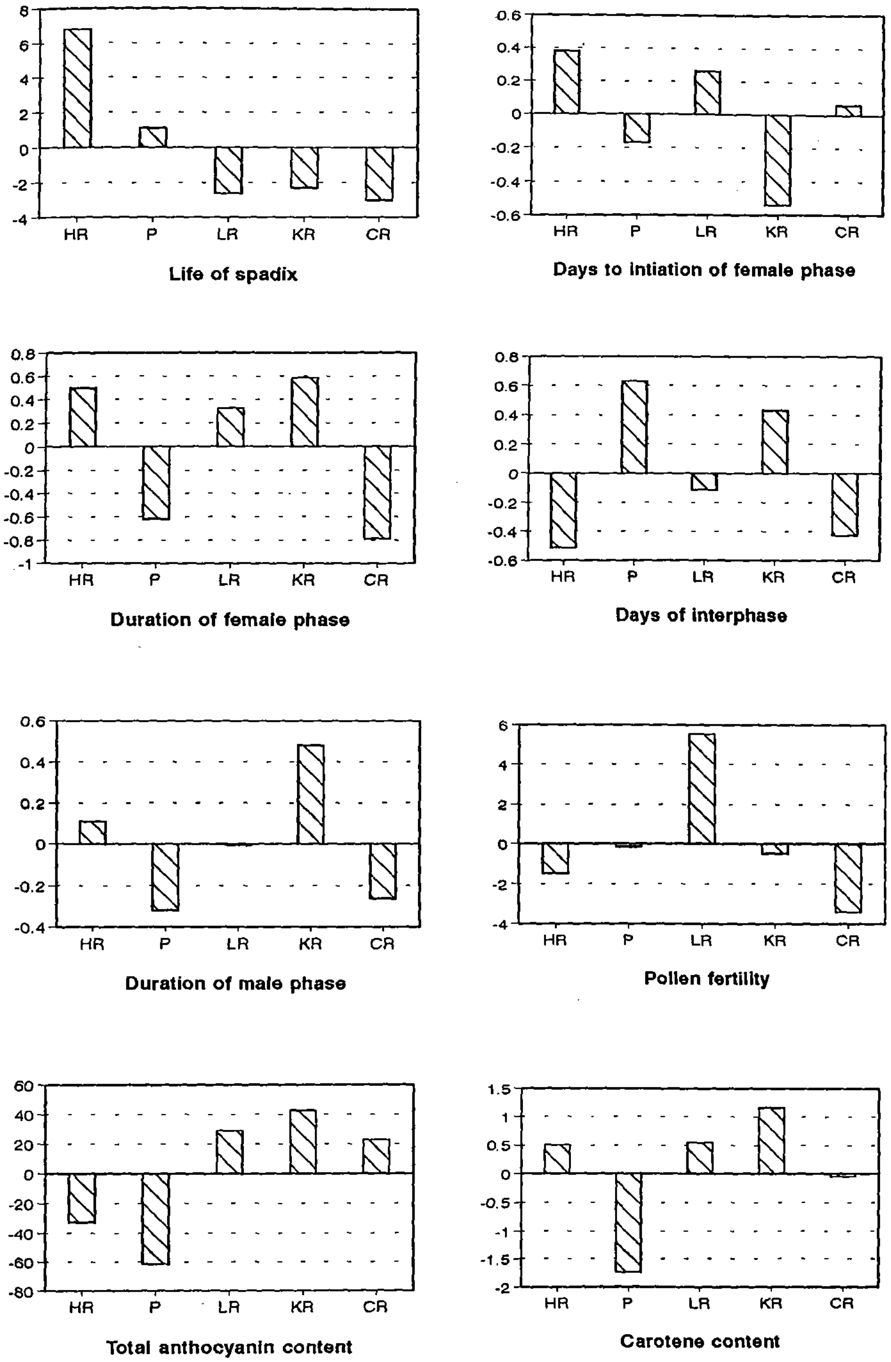


Fig. 12(c). gca effects of parents for floral characters (contd...)

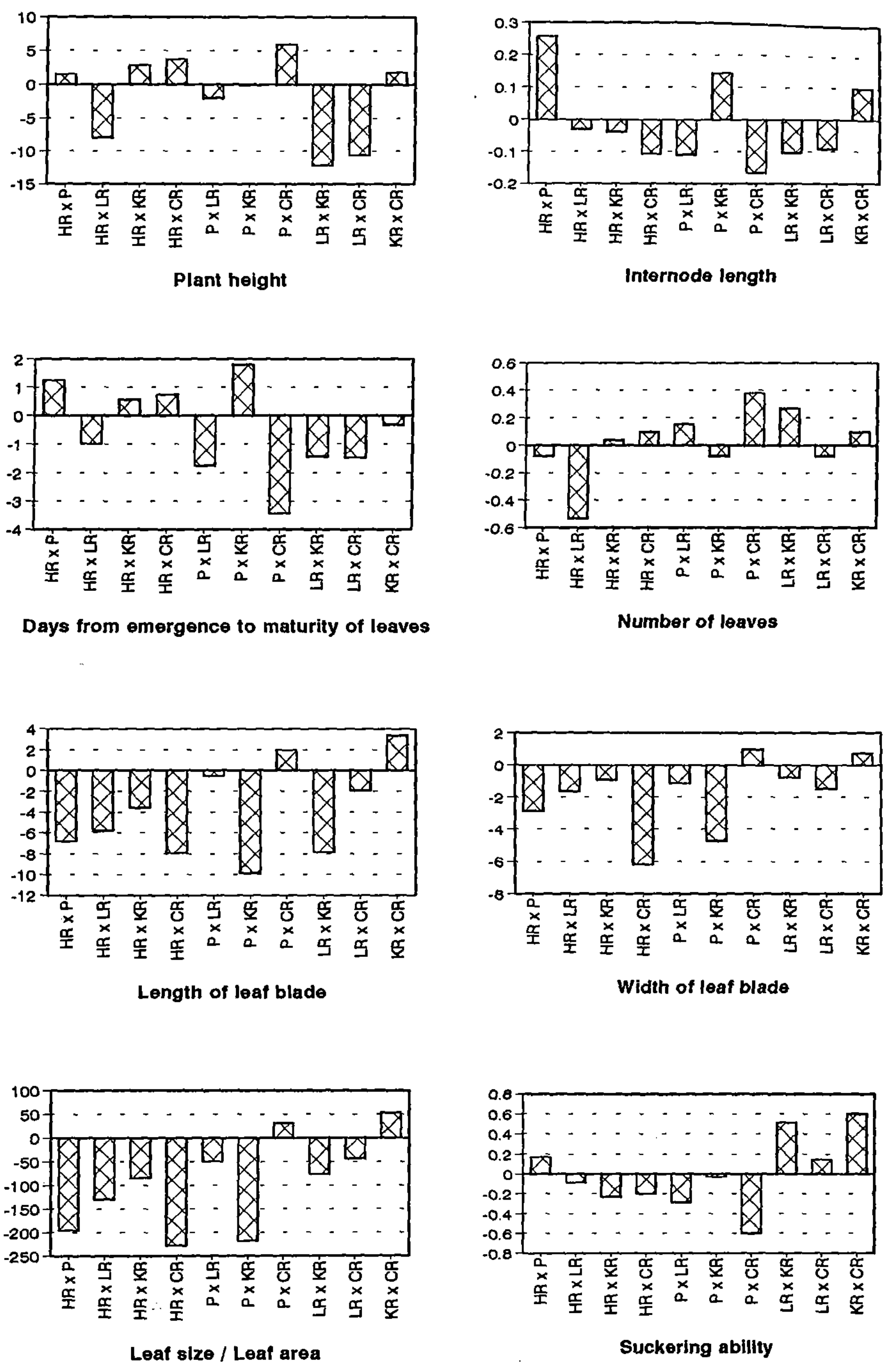


Fig. 13(a). sca effects of hybrids for vegetative characters

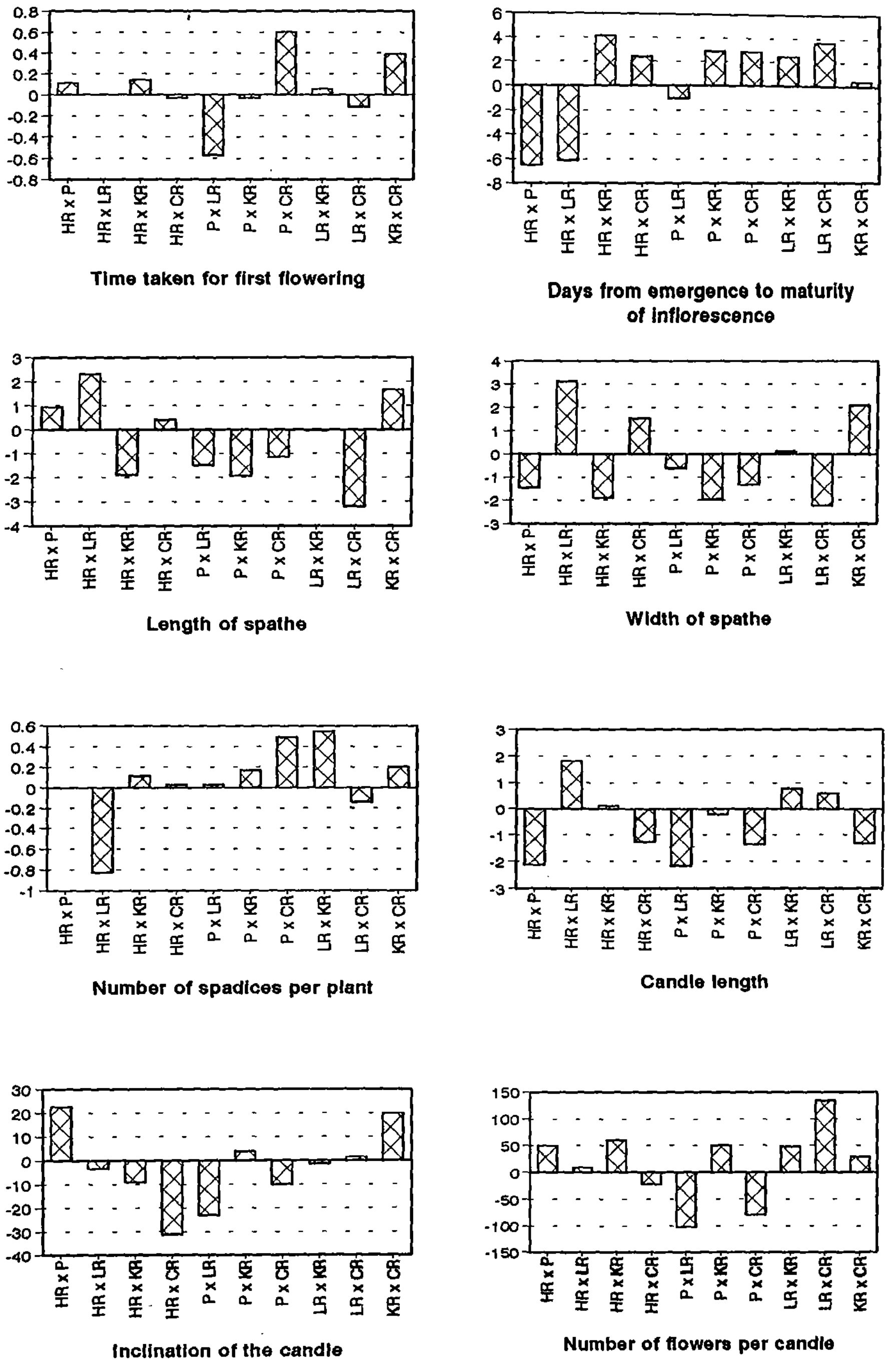


Fig. 13(b). sca effects of crosses for floral characters

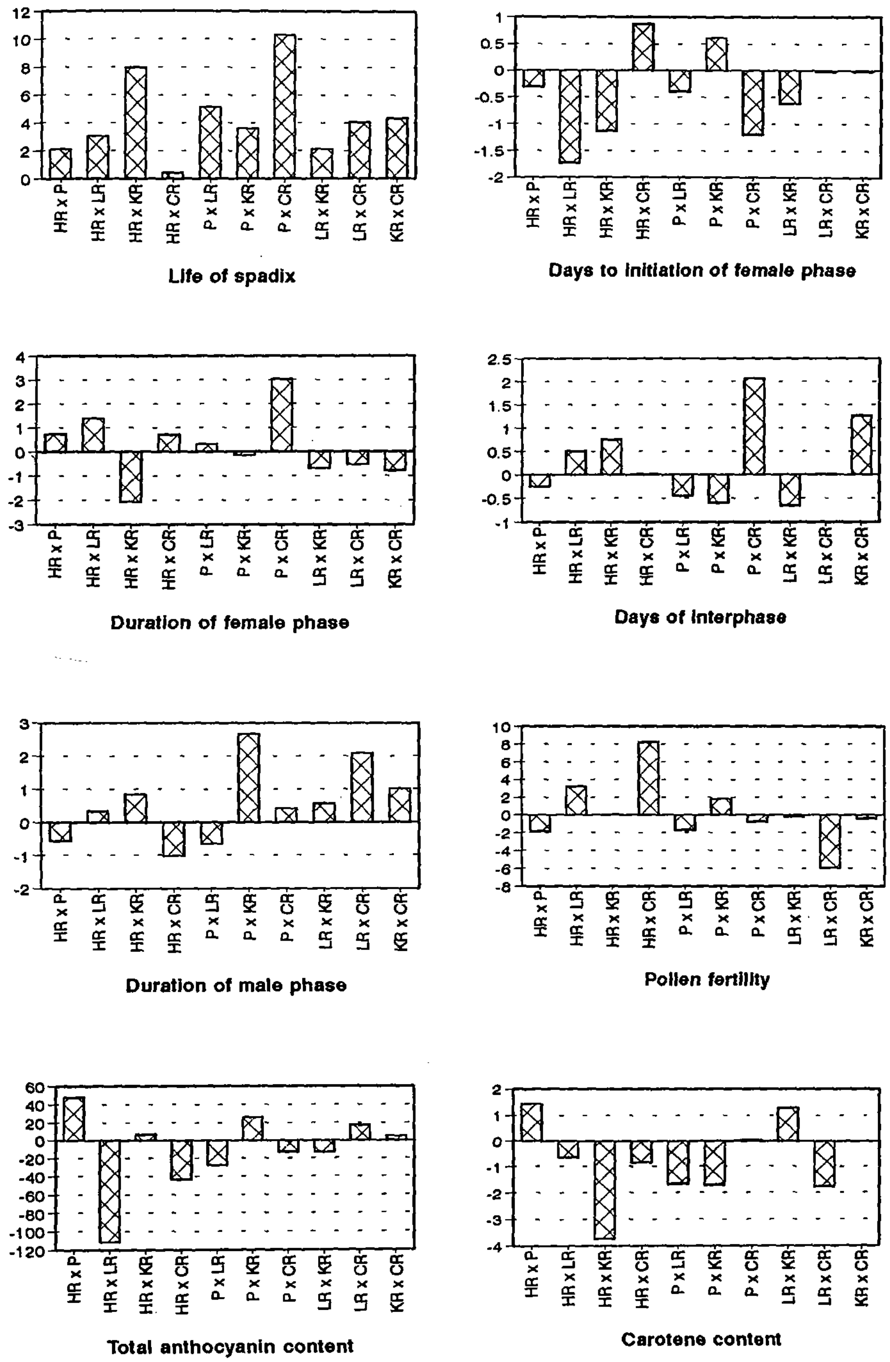


Fig. 13(c). sca effects of crosses for floral characters (contd...)

a negative significant sca effect of -0.166 cm. The average internode length of P x CR was 1.02 cm which was less than the average length of the crosses.

3. Days from emergence to maturity of leaves

The gca effects of the parents were not significantly different. Though the gca of CR was found to be significant, it was negative (-1.107). The additive gene action was not at all important for this character. Non-heritable variation assumed more importance here.

The sca effects were significantly different among the crosses. P x CR was the lone cross which registered a significant negative sca. Negative sca was preferred for this particular character. The average number of days from emergence to maturity of leaves was 38.20 which was below the general mean.

4. Number of leaves

The combining ability analysis for number of leaves showed that the gca effects were not significant.

LR registered a negative significant gca effect. Here also non-additive component assumed importance in transmitting the genes to the next generation.

The sca effects of the various crosses were not significantly different. However, P x CR registered a significant positive sca effect

(0.381), with average number of leaves being 7.60 which was above the general mean. The present investigation revealed that one spadix each was found to be produced from the axil of each leaf so that the number of leaves and number of spadices produced per plant annually was the same.

5. Length of leaf blade

The gca effects of parents were significantly different. The gca effect of LR, KR and CR was negative and significant but the gca variance was not estimable. This character was greatly influenced by non-additive gene action. As far as this character is considered LR, KR and CR may be desirable combiners for hybridisation.

There was significant difference in sca effects of most crosses. All hybrids except P x LR recorded significant sca effects. Negative sca effects were preferred for this character. Here also all the hybrids except P x LR, P x CR and KR x CR registered negative significant sca effect.

6. Width of leaf blade

Significant differences were observed among the parents with respect to their gca effects. KR, LR and CR recorded negative and significant gca effects of -2.253cm, -1.862cm and -1.367cm respectively. The gca variance was 4.304 cm and the sca variance was 14.82 cm. The high sca variance with negative gca effects for KR, LR and CR may be taken as desirable combiners for hybridization.

All the sca effects were significant among the hybrids. All the hybrids except P x CR and KR x CR registered significant negative sca effects.

7. Leaf area / leaf size

The gca effect was significant with a variance of 1608.76 cm^2. KR, CR and LR exhibited negative significant gca effects of -66.96 cm^2, -66.260 cm^2 and -50.210 cm^2 respectively. The very high sca variance implies the importance of non-allelic heritable variation in transmitting the genes to the next generation. The gca variance is less than sca variance, but with negative and significant gca effects. KR, CR and LR may be considered as desirable combiners to produce the next generation.

All the sca effects were significant among the hybrids. All the hybrids except P x CR and KR x CR registered significant negative sca effects.

8. Suckering ability

Parents recorded significant difference with respect to their gca effects. Positive gca effect was preferred over negative gca effect. P and LR exhibited significant positive gca effect of 0.274 and 0.331 with almost the same values for sca and gca variances. They were thus found to be potential specific combiners for transgressive breeding.

The sca effects were significantly different among the different crosses. The sca effects of P x CR, LR x KR and KR x CR were significant but the direction of P x CR was negative. The mean suckering ability of P x CR (2.60) was found to be less than that of LR x KR (3.4) and KR x CR (3.00).

FLORAL CHARACTERS

1. Time taken for first flowering

The gca effect was significantly different among the parents. Only LR recorded a positive gca effect which was significant (0.463) while KR recorded a significant negative gca effect (-0.28). The general average was 36.2 months for the first flowering. The character recorded an additive variance of 0.123. General combining ability variance was greater than sca variance, implying the importance of additive gene action in the inheritance of this character with lowest number of days for first flowering (36.20months) and also having a negative and significant gca effect. KR may be considered as a right choice as a parent to produce hybrid varieties.

No significant differences in the sca effect was observed among the crosses. A negative sca effect was preferred. P x LR registered a significant negative sca effect. Also for this particular character, gca variance was greater than sca variance.

2. Days from emergence to maturity of inflorescence

No significant differences in the gca effects among the parents were observed for this character. However the gca effects of HR, P and CR were negative but not significant while KR recorded a positive significant gca effect (1.577) and CR with an insignificant gca. But a positive gca is not preferred for this character.

The crosses recorded significant differences in their sca effects. All the crosses except P x LR and KR x CR registered significant sca effect. However less number of days for the emergence to maturity of inflorescence was preferred. So crosses with significant effects were superior to those with positive sca effect. HR x P and HR x LR registered significant negative sca effects (-6.524, -6.124) and no significant difference was observed between these two values. The two hybrids took 41 and 41.6 days which were much below the average of other hybrids. The general mean was 48.83. The sca variances were high; so HR x P and HR x LR are considered as potential specific combinations having differential ability to transmit their characters into hybrid progenies.

3. Length of spathe

The gca effects of parents differed significantly with respect to this character. The gca effects of all the parents were significant but HR alone recorded a positive significant gca effect (1.254 cm). However the spathe length was high in comparison to P, LR and CR which is not preferred. Flowers with medium spathe length is desirable. The gca variance was low compared to sca variance leading to the conclusion of the importance of non-additive gene action in the inheritance of this character. HR may be a desirable parent for the production of F_1 hyrbids.

The crosses showed significant sca effects for this character. Hybrids with medium spathe length were preferred over either smaller or larger hybrid combinations. The average length of spathe for these crosses were 14.6 cm and 13.58 cm respectively which were much higher than the average spathe length of 11.67 cm. The sca variances were much higher than gca variances.

5. Width of spathe

Significant positive gca effects were observed for HR and KR and significant negative gca effects were observed for P and LR. Significant differences in the sca effects of the crosses were observed. Crosses with medium spathe length were preferred. All the crosses except LR x KR recorded significant sca effect but HR x LR, HR x CR and KR x CR were the combinations having significant positive sca effects. Also sca variance assumed importance for this character which implied the role of non-additive gene action. But these combinations had widths of 11.3 cm and 11.4 cm which were higher than the average width of 9.04 cm .

5. Number of spadices/plant/year

The gca effects of parents were not significantly different from each other. However the gca effect of HR was positive and significant. The gca variance was greater than sca variance with an average of 7.6 spadices/plant/year. As far as this character was concerned, HR is certainly a right choice for developing hybrid varieties.

Significant differences were observed in the sca effects for the various crosses. A significant positive sca effect was exhibited by P x CR and LR x KR, but gca variance was very much higher than sca variance stressing the importance of additive gene action in the expression of this character. The above combinations had an average number of spadices of 7.40 which was higher than the average spadices of 6.96.

6. Candle length

Significant differences were observed in the gca effects of parents. Flowers with less candle length is preferred LR and CR recorded negative gca effects (-0.549 cm and -0.700 cm) while HR, P and KR recorded a positive gca effects. All the gca effects were found to be significant. However the sca variance was found to be predominant over gca variance but LR and CR were having smaller candle length compared to other parents. Hence LR and CR are desirable parents for developing hybrids.

Sca effects were significantly different among various crosses. Flowers with less candle length was preferred over flowers with longer candle length. HR x LR, LR x KR and LR x CR were the crosses with significant sca effect (1.819 cm, 0.773 cm and 0.602 cm). HR x P, HR x CR, P x LR, KR x CR registered significant negative sca effect of -2.127 cm, -1.270 cm, -2.615 cm and -1.135 cm respectively. The average candle length of offsprings was 8.57 cm while these crosses recorded a candle length of 10.38 cm, 7.14 cm, 5.90 cm and 6.76 cm respectively. High sca variances were registered by the crosses stressing the importance of non-additive gene action.

7. Inclination of candle

All the parents recorded a significant gca effect. Low-angled position of the candle was preferred because it helps in the close packing of the spadices in boxes during transport. HR and P recorded significant positive gca effect of 9.337° and 8.537° while KR, CR and LR registered significant negative gca effect of -10.691°, -6.549° and -0.634°. The sca variance was greater than gca variance which signifies the importance of non-additive gene action.

The sca effects were significantly different for the hybrids. The average inclination for candle observed was 49.11° in the offspring. All the hybrids except HR x P, LR x CR, KR x CR and P x KR showed significant negative sca effects. HR x CR, P x LR and LR x KR registered high sca effects (-31.095°, -23.010° and -1.381°). The above hybrids registered an angle of 20.80°, 34.00° and 43.40° for the candle position. So HR x CR, P x LR and LR x KR are better hybrids with respect to this character. The high sca variance signified the role of non-additive gene action in the expression of this character.

8. Number of flowers/candle

Significant differences in the gca effect was observed for number of flowers / candle. Significant positive gca effects were observed for P, HR and KR (31.086, 21.657 and 20.80) and significant negative gca effects were registered by LR and CR. Less number of flowers/candle was considered as a desirable character and hence LR and CR are desirable parents for producing F_1 hybrids. The sca variance was greater than gca variance which signified the importance of non-additive gene action.

The hybrids registered differential sca effects. All the hybrids registered significant sca effect. HR x P (49.86), HR x LR (9.29), HR x KR (60.14), P x KR (50.71), LR x KR (48.14), LR x CR (134.14) an KR x CR (29.00) were the cross combinations which exhibited positive sca effects. But the average number of flowers/candle was 497. HR x P, HR x LR, HR x KR, P x KR, LR x KR, LR x CR and KR x CR were the hybrids which produced more number of flowers/candle. The high sca variance signified the importance of non-additive gene action in the expression of this character.

9. Life of spadix

Parents exhibited significant difference in their gca effects. Positive gca effect was exhibited only by HR and P of which the gca effect of HR alone was significant (6.79). LR, KR and CR registered negative gca effects of -2.61, -2.29 and -3.010 respectively. The gca variances were less than sca variances. HR can be selected as a combiner.

The sca effects were significantly different among the hybrids. HR x KR and P x CR alone registered significant positive sca effect of 7.924 and 10.324 respectively. The average life of spadix observed was 113.7 days while these two hybrids recorded 126 and 122 days respectively. The sca variances were also high compared to gca variances. Hence non-additive gene action has assumed importance in this character.

10. Days to initiation of female phase

The gca effects of the parents were significantly different. Parents with significant negative gca effects were preferred. KR was the only parent which registered significant negative gca effect of -0.540. The gca variance was less than sca variance which implied the importance of non-additive gene action. KR is thus a desirable parent for hybridization.

Differential sca effects were exhibited by the hybrids. Combinations with less number of days to initiation of female phase are preferred. Average number of days was observed as 4.89 days. Significant negative sca effects were registered by HR x LR (-1.733), HR x KR (-1.133) and P x CR (-1.190). The sca effects HR x KR and P x CR were not significantly different. These three hybrids took 3.8, 3.6 and 3.6 days for initiation of female phase. The sca variance was very much higher than gca variance. The expression of this character was completely controlled by non-additive gene action.

11. Duration of female phase

HR and KR registered positive and significant gca effect of 0.497 and 0.583. As far as the duration of female phase is considered a positive value was preferred and as such HR and KR are desirable for the production of F_1 hybrids. The sca variance was greater than gca variance which signified the importance of non-additive gene action in the inheritance of this character.

The sca effects differed significantly among the hybrids. HR x LR and P x CR were the hybrids with positive significant sca effects of 1.390 and 3.019 respectively. HR x KR registered significant negative sca effect (-2.067). Positive sca effect was preferred over negative sca effect. These two hybrids (HR x LR and P x CR) took 12.80 and 12.20 days respectively which were above the average of 10.59 days. The high sca variance brings the importance on non-additive gene action in the expression of this character.

12. Days of interphase

The gca effects of the parents differed significantly with respect to this character. Short interphase was preferred over long interphase. Hence significant negative gca was preferred over significant positive gca effect. HR and CR were the only parents which registered significant negative gca effects of -0.514 and -0.429 respectively. So HR and CR may be recommended as desirable parents for hybridization. Here both gca and sca variances are high; so both HR and CR are potential specific combiners useful for transgressive breeding.

The hybrids differed significantly in the sca effects since less number of days of interphase was preferred. Negative sca effects were important. However none of the hybrids registered significant negative sca effects. Here additive variance was more than dominance variance.

13. Duration of male phase

The parents differed significantly in their gca effect. A positive gca effect was preferred. KR was the only parent which registered a significant positive gca effect of 0.480. The sca variance was greater than gca variance which signified the importance of non-additive gene action in the expression of this character. KR may be a desirable parent for the production of F_1 hybrids.

Significant differences among the crosses were observed with respect to the sca effect. Crosses with more duration of male phase was preferred over short duration of male phase. Significant positive sca effects were registered by HR x KR (0.838), P x KR (2.66) and LR x CR (2.095). The offspring generations recorded an average of 6.77 days while HR x KR, P x KR and LR x CR registered 8.20, 9.66 and 8.6 days respectively. Among these hybrids the highest sca effect was registered by P x KR. This P x KR with maximum number of days for male phase is a good hybrid as far as this character is concerned.

14. Pollen fertility

The parents differed significantly in their gca effect. High pollen fertility percentage was a desirable character. So high positive significant gca effect was preferred. LR was the only parent which registered a high significant positive gca effect of 5.537 per cent. With high sca variance and significant positive gca effect LR may be recommended as a desirable parent for hybridisation.

The sca effects were significantly different among the hybrids. Positive significant sca effect of HR x LR (3.178 per cent), HR x CR (8.222 per cent) and P x KR (1.792 per cent) with pollen fertility percentage of 34.71 per cent, 30.8 per cent and 28.62 per cent are considered good hybrids with respect to this character.

15. Total anthocyanin content

The parents differed significantly in their gca effect with respect to this character. KR, LR and CR are the only parents which registered a positive significant gca effect of 42.577 mg/g, 28.990 mg/g and 22.760 mg/g respectively. The sca variance is greater than gca variance and hence KR, LR and CR parents are desirable parents for producing F_1 hybrids.

All the sca effects differed significantly among the hybrids. All the hybrids registered high significant sca effects while HR x P, HR x KR, P x KR, LR x CR and KR x CR registered significant positive sca effects. On an average 260.95 mg/g of anthocyanin content was observed in the offspring generation. HR x KR, P x KR, LR x CR and KR x CR produced anthocyanin content above the average value. These hybrids were better combinations with respect to this character. The high sca variance brought out the importance of non-additive gene action in the expression of this character.

16. Total carotenoids

The parents differed significantly in their gca effect. Parents with higher carotene content was preferred over those with lower carotene content. So parents with significant positive gca effects were desirable. KR, LR and HR registered positive significant gca effect of which maximum carotene content was observed in KR (1.163 mg/100g). The sca variances were very high in comparison to gca variances. So KR, LR and HR may be desirable parents for producing F_1 hybrids.

Hybrids differed significantly with respect to its sca effect. Hybrids with good level of carotene content are preferred. HR x P (1.438 mg/100g), P x CR (0.038 mg/100g) and LR x KR (1.284 mg/100g) were the hybrid combinations with significant positive sca effects. Among these three hybrids, LR x KR produced maximum carotene content which was much above the average carotene content (4.62 mg/100g). The very high sca variance brings out the importance of non-additive gene action especially dominance deviation in the expression of this character.

4.2.4 Components of genetic variance

Additive and dominance components of genetic variance were calculated and presented in Table 4.2.4 (a) and 4.2.4 (b). Dominance variance was high compared to additive variance in all the characters studied except suckering ability, time taken for first flowering, number of spadices/plant/year, days to interphase, pollen fertility and total anthocyanin content. The additive variance to dominance variance ratio was more than unity for pollen fertility (1.20), days to interphase (1.73), suckering ability (2.00), time taken for first flowering (2.46) and number of spadices/plant/year (18.33).

4.2.5 Heterosis

Ornamental plants have much commercial value and hence commercial usefulness of a hybrid primarily depends upon its performance in comparison with the best commercial variety. One of the parents considered in the experiment ie., LR is known to be the best semi-

Table 4.2.4 (a). Components of gca and sca variances for vegetative characters

Sl. No.	Characters	σ^2 gca	σ^2 sca	σ^2 e	Additive variance σ^2 a	Dominance variance σ^2 d	$\sigma^2 a/\sigma^2 d$
1.	Plant height (cm)	ne	52.55	16.11	ne	52.16	—
2.	Internode length (cm)	0.11	0.97	0.01	0.22	0.97	0.23
3.	Days from emergence to maturity of leaves	ne	2.11	1.94	ne	2.11	—
4.	Number of leaves	ne	7.45	0.05	ne	7.45	—
5.	Length of leaf blade (cm)	ne	68.27	0.49	ne	68.27	—
6.	Width of leaf blade (cm)	4.30	14.82	0.17	8.61	14.82	0.58
7.	Leaf size / Leaf area (cm^2)	1608.76	35771.08	238.12	3217.53	35771.08	0.09
8.	Suckering ability	0.100	0.100	0.07	0.20	0.10	2.00

ne - not estimable

Table 4.2.4 (b). Components of gca and sca variances for floral characters

Sl. No.	Characters	σ^2gca	σ^2sca	σ^2e	Additive variance σ^2a	Dominance variance σ^2d	σ^2a/σ^2d
1.	Time taken for first flowering (days)	0.061	0.050	0.06	0.123	0.050	2.46
2.	Days from emergence to maturity of inflorescence	ne	16.80	2.93	ne	16.80	—
3.	Length of spathe (cm)	0.23	3.92	0.26	0.47	3.92	0.12
4.	Width of spathe (cm)	ne	3.98	0.18	ne	3.98	—
5.	Number of spadices / plant / year	1.38	0.15	0.05	2.75	0.15	18.33
6.	Candle length (cm)	ne	3.40	0.04	ne	3.40	—
7.	Inclination of candle (degrees)	35.88	304.43	0.28	71.77	304.43	0.24
8.	Number of flowers / candle	298.66	6271.16	20.34	597.33	6271.16	0.10
9.	Life of spadix (days)	7.92	45.00	19.35	15.85	45.00	0.35
10.	Days to initiation of female phase	ne	1.02	0.13	ne	1.02	—
11.	Duration of female phase (days)	0.042	2.14	0.53	0.084	2.14	0.04
12.	Days of interphase	0.702	0.809	0.31	1.404	0.809	1.74
13.	Duration of male phase (days)	ne	2.34	0.24	ne	2.34	—
14.	Pollen fertility (%)	8.98	15.02	0.40	17.96	15.02	1.20
15.	Total anthocyanin content (mg/g)	1631.53	2645.40	0.53	3263.06	2645.40	1.23
16.	Total carotene content (mg/100g)	0.714	3.798	0.0002	1.428	3.798	0.38

ne - not estimable

commercial variety at present. So it is decided to estimate heterosis in relation to this best commercial variety and this heterosis is generally referred to as economic or useful heterosis and a knowledge of this heterosis has high commercial or practical value (Singh, 1983).

The magnitude of economic heterosis for vegetative and floral characters are presented in Tables 4.2.5 (a) and (b) Fig. 14 (a, b and c).

4.2.5 (a) Vegetative characters

1. Plant height

Liver Red was the most marketable variety whose height was higher than the other parents. A negative heterosis is preferred in this case. All the crosses except P x KR and P x CR registered significant negative heterosis.

2. Internode length

Significant negative heterosis was registered by HR x LR, HR x KR, HR x CR, P x LR, P x CR and LR x KR.

3. Days from emergence to maturity of leaves

Average number of days taken from emergence to maturity of leaves was 43.80. P x CR and LR x CR showed a significant negative heterosis.

4. Number of leaves

All the crosses except HR x LR registered positive heterosis but not significant.

Table 4.2.5 (a). Heterosis in relation to the semi-commercial variety 'Liver Red' (Vegetative characters)

Parents / Hybrids	1 Plant height (cm)			2 Internode length (cm)			3 Days from emergence to maturity of leaves			4 Number of leaves		
	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)
1. HR	58.40			1.06			41.40			7.60		
2. P	68.20			1.00			44.40			7.00		
3. **LR**	**80.20**			**1.52**			**43.80**			**7.00**		
4. KR	72.08			1.08			43.20			7.20		
5. CR	58.80			1.44			43.20			7.00		
6. HR x P	66.00	-14.20	-17.71*	1.34	-0.18	-11.84	44.00	0.20	45.66	7.20	0.20	2.86
7. HR x LR	53.10	-27.10	-33.79*	1.20	-0.32	-21.05*	40.60	-3.20	-7.31	6.66	-0.34	-4.86
8. HR x KR	66.20	-14.00	-17.46*	1.08	-0.44	-28.95*	43.40	-0.40	-16.69	7.40	0.40	5.71
9. HR x CR	62.50	-17.70	-22.07*	1.10	-0.42	-27.63*	41.80	-2.00	-4.57	7.40	0.46	5.71
10. P x LR	64.60	-15.60	-19.45*	1.10	-0.42	-27.63*	40.40	-3.40	-7.76	7.20	0.20	2.86
11. P x KR	69.30	-10.90	-13.59	1.24	-0.28	-18.42	45.20	1.40	3.20	7.20	0.20	2.86
12. P x CR	70.80	-9.40	-11.72	1.02	-0.50	-32.89*	38.20	-5.60	-12.79*	7.60	0.60	8.57
13. LR x KR	53.82	-26.38	-32.89*	1.14	-0.38	-25.00*	40.80	-3.00	-6.85	7.40	0.20	2.86
14. LR x CR	50.80	-29.40	-36.66*	1.24	-0.28	-18.42	39.00	-4.80	-10.96*	7.00	0.00	0.00
15. KR x CR	65.50	-14.70	-18.33*	1.32	-0.20	-13.16	41.40	-2.40	-5.48	7.40	0.40	5.71
CD	11.35			0.313			3.935			0.645		

* Significant at 5 per cent level   EH - Economic heterosis

Table 4.2.5 (a). (Contd....)

Parents / Hybrids	5 Length of leaf blade (cm)			6 Width of leaf blade (cm)			7 Leaf Area (cm^2)			8 Suckering ability		
	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)
1. HR	47.60			30.76			938.81			3.40		
2. P	48.16			27.18			847.41			4.00		
3. **LR**	**40.90**			**18.40**			**491.00**			**3.60**		
4. KR	42.30			16.98			471.82			1.60		
5. CR	34.40			17.90			403.03			2.80		
6. HR x P	31.24	-9.66	-23.62*	21.26	2.86	15.54*	430.15	-60.85	-12.39	3.60	0.00	0.00
7. HR x LR	28.42	-12.48	-30.51*	18.80	0.40	2.17*	351.44	-139.56	-28.42*	3.40	-0.20	-5.56
8. HR x KR	30.86	-10.04	-24.55*	18.64	0.24	1.30	379.54	-111.46	-22.70*	2.40	-1.20	-33.33*
9. HR x CR	25.92	-14.98	-36.63*	13.74	-4.66	-25.33*	237.42	-253.58	-51.65*	2.80	-0.80	-22.22*
10. P x LR	36.18	-4.72	-11.54*	18.48	0.08	0.43	437.41	-53.59	-10.91	3.40	-0.20	-5.56
11. P x KR	27.04	-13.86	-33.89*	13.98	-4.42	-24.02*	251.46	-239.54	-48.79*	2.80	-0.80	-22.22*
12. P x CR	38.30	-2.60	-6.36*	20.08	1.68	9.13*	501.85	10.85	2.21	2.60	-1.00	-27.98*
13. LR x KR	25.22	-15.68	-38.34*	14.26	-4.14	-22.50*	248.73	-242.27	-49.34*	3.40	-0.20	-5.56
14. LR x CR	30.60	-10.03	-24.52*	13.96	-4.44	-24.13*	282.93	-208.07	-42.38*	3.40	-0.20	-5.56
15. KR x CR	36.08	-4.82	-11.78*	15.26	-3.14	-17.07*	361.88	-129.12	-26.30*	3.00	-0.60	-16.67*
CD	0.665			0.352			100.47			0.581		

* Significant at 5 per cent level EH - Economic heterosis

Table 4.2.5 (b). Heterosis in relation to the semi-commercial variety 'Liver Red' (Floral characters)

Parents / Hybrids	1 No. of days taken for first flowering (months)			2 Days from emergence to maturity of inflorescence			3 Length of spathe (cm)			4 Width of spathe (cm)		
	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)
1. HR	36.80			50.60			14.26			10.08		
2. P	36.80			48.40			12.80			11.10		
3. **LR**	**38.20**			**48.40**			**11.60**			**7.24**		
4. KR	36.20			47.00			14.14			10.62		
5. CR	36.40			44.60			11.94			8.80		
6. HR x P	37.00	-1.20	-3.14*	41.00	-7.40	-15.28*	11.20	-0.40	-3.49	8.10	0.86	11.88
7. HR x LR	37.40	-0.80	-2.09*	41.60	-6.80	-14.05*	14.60	3.00	25.86*	12.20	4.96	68.51*
8. HR x KR	36.80	-1.40	3.66*	54.00	5.60	-11.57*	11.72	0.12	1.03	8.36	1.12	15.47
9. HR x CR	36.80	-1.40	-3.66*	50.80	2.40	4.96	12.90	1.30	11.20	11.30	4.06	56.08*
10. P x LR	36.80	-1.40	-3.66*	46.60	-1.80	-3.72	8.72	-2.88	-24.83*	7.30	0.06	0.83
11. P x KR	36.60	-1.60	-4.19*	52.60	4.20	8.68	9.60	-2.00	-17.24*	7.14	-0.10	1.38
12. P x CR	37.40	-0.80	-2.09*	51.20	2.80	5.79	9.28	-2.32	-20.00*	7.28	0.04	0.55
13. LR x KR	37.20	-1.00	-2.62*	52.40	4.00	8.26	11.66	0.06	0.52	8.72	1.48	20.44*
14. LR x CR	37.20	-1.00	-2.62*	52.20	3.80	7.85	7.40	4.20	36.21*	5.90	-1.34	-18.51*
15. KR x CR	36.80	-1.00	-3.66*	51.00	2.60	5.37	13.58	1.98	17.07*	11.40	4.16	57.46*
CD		0.451			4.672			1.973			1.169	

* Significant at 5 per cent level   EH - Economic heterosis

Table 4.2.5 (b). (Contd....)

Parents / Hybrids	5 Number of spadices/ plant			6 Candle length (cm)			7 Inclination of candle (degrees)			8 No. of flowers / candle		
	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)
1. HR	7.60			10.38			78.20			492		
2. P	6.80			12.72			69.40			600		
3. **LR**	**7.00**			**7.18**			**61.00**			**400**		
4. KR	6.40			9.30			21.00			445		
5. CR	6.40			8.84			45.80			372		
6. HR x P	7.20	0.20	2.86	7.48	0.30	4.18	89.60	28.60	46.89*	600	200.00	50.00*
7. HR x LR	6.20	-0.80	11.43*	10.38	3.20	44.57*	54.40	-6.60	-10.81*	502	102.00	25.50*
8. HR x KR	7.20	0.20	2.86	9.44	2.26	31.48*	38.80	-22.20	-36.39*	600	200.00	50.00*
9. HR x CR	7.00	0.00	0.00	7.14	-0.04	-0.56	20.80	-40.20	-65.90*	450	50.00	12.50*
10. P x LR	7.00	0.00	0.00	5.90	-1.28	-17.83*	34.00	-27.00	-44.26*	400	0.00	0.00
11. P x KR	7.20	0.20	2.86	9.06	1.88	26.18*	50.80	-10.20	-16.72*	600	200.00	50.00*
12. P x CR	7.40	0.40	5.71	7.00	-0.18	-2.51	41.20	-19.80	-32.46*	402	2.00	0.50
13. LR x KR	7.40	0.40	5.71	9.00	1.82	25.35*	36.40	-24.60	-40.33*	540	140.00	35.00*
14. LR x CR	6.60	-0.40	-5.71	7.92	0.74	10.31*	43.40	-17.60	-28.85*	558	158.00	39.50*
15. KR x CR	7.00	0.00	0.00	6.76	-0.42	-5.85	51.80	-9.20	-15.08*	500	100.00	25.00*
CD		0.593			0.551			1.51			124.36	

* Significant at 5 per cent level EH - Economic heterosis

Table 4.2.5 (b). (Contd....)

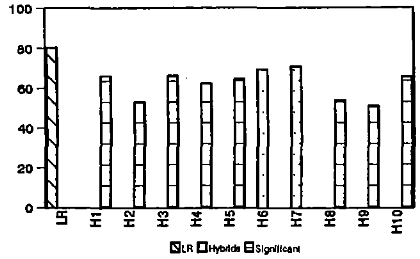
Parents / Hybrids	9 Life of spadix (days)			10 Days to initiation of female phase			11 Duration of female phase			12 Days of interphase		
	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)
1. HR	120.40			6.80			11.20			8.80		
2. P	105.20			5.20			7.40			11.20		
3. **LR**	**101.20**			**6.80**			**11.00**			**10.40**		
4. KR	100.00			4.40			13.60			10.80		
5. CR	98.00			5.20			7.80			7.80		
6. HR x P	123.60	22.40	22.13*	4.80	-2.00	-29.41*	11.20	0.20	1.82	10.20	-0.20	-1.92
7. HR x LR	120.80	19.60	19.37*	3.80	-3.00	-44.12*	12.80	1.80	16.36	10.20	-0.20	-1.92
8. HR x KR	126.00	24.80	24.51*	3.60	-3.20	-47.05*	9.60	-1.40	12.73	11.00	0.60	5.77
9. HR x CR	117.80	16.60	16.40*	6.20	-0.20	-2.95	11.00	0.00	0.00	9.39	-1.01	-9.71
10. P x LR	117.20	16.60	15.81*	4.60	-2.20	-32.35*	10.60	-0.40	-3.64	10.46	0.06	0.58
11. P x KR	116.00	14.80	14.62*	4.80	-2.00	-29.41*	10.40	-0.60	-1.36	10.80	0.40	3.85
12. P x CR	122.00	20.80	20.55*	3.60	-3.20	-47.05*	12.20	1.20	10.91	12.60	2.20	21.15*
13. LR x KR	110.80	9.60	9.49	4.00	-2.50	-41.18*	10.80	-0.20	-1.82	10.00	-0.40	-3.85
14. LR x CR	112.00	10.80	10.67	5.20	-1.60	-2.35*	9.60	-1.40	-12.73	9.80	-0.60	-5.77
15. KR x CR	112.60	11.40	11.26	4.40	-2.40	-35.29*	9.60	-1.40	-12.73	11.60	1.20	11.54
CD	12.989			1.048			2.073			1.586		

* Significant at 5 per cent level EH - Economic heterosis

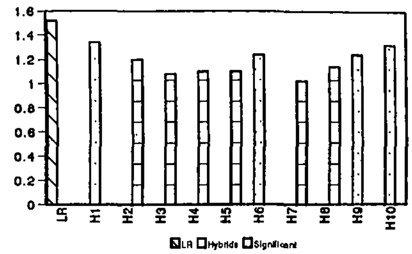
Table 4.2.5 (b). (Contd....)

Parents / Hybrids	13 Duration of male phase			14 Pollen fertility (%)			15 Total Anthocyanin content (mg/g)			16 Carotene content (mg/100g)		
	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)	Mean	$\overline{F_1} - \overline{P_3}$	EH (%)
1. HR	7.20			19.70			245.83			7.52		
2. P	5.20			28.40			121.38			2.10		
3. **LR**	**5.60**			**40.90**			**386.56**			**7.12**		
4. KR	5.20			25.90			334.42			9.03		
5. CR	5.00			20.12			323.83			4.96		
6. HR x P	6.00	0.40	7.14	24.00	-16.90	-41.32*	214.26	-172.30	-44.57*	4.82	-2.30	-32.30
7. HR x LR	7.20	1.60	28.57*	34.70	-6.20	-15.16*	146.03	-240.53	-62.22*	5.02	-2.10	-29.49
8. HR x KR	8.20	3.00	53.57*	25.52	-15.38	-37.60*	277.19	-109.37	-28.29*	2.54	-4.58	-64.33*
9. HR x CR	5.60	0.00	0.00	30.82	-10.10	-24.69*	207.54	-179.02	-46.31*	3.82	-3.30	-46.35
10. P x LR	5.80	0.20	3.57	31.14	-9.76	-23.86*	200.61	-185.95	-48.10*	1.76	-5.36	-75.28*
11. P x KR	9.60	4.00	71.43*	28.62	-12.28	-30.02*	207.62	-118.94	-30.77*	2.34	-4.78	-67.13*
12. P x CR	6.60	1.00	17.86	23.14	-17.76	-43.42*	209.17	-117.39	-45.89*	2.45	-4.67	-65.59*
13. LR x KR	7.80	2.20	39.29*	32.32	-8.58	-20.98*	319.15	-67.41	-17.43*	7.62	0.50	7.02
14. LR x CR	8.60	3.00	53.57*	23.64	-17.26	-42.20*	329.74	-56.82	-14.70*	2.92	-4.20	-58.99
15. KR x CR	8.00	2.40	42.86*	23.20	17.76	-43.28*	330.95	-55.61	-14.39*	5.31	-1.81	-25.42
CD		1.493			1.75			2.04			4.285	

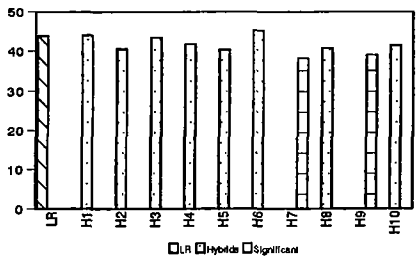
* Significant at 5 per cent level   E.H. Economic heterosis



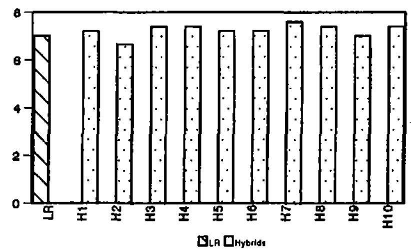
1. Plant height (cm)



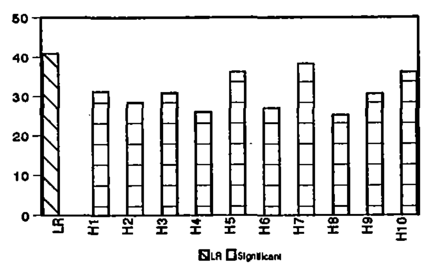
2. Intenode length (cm)



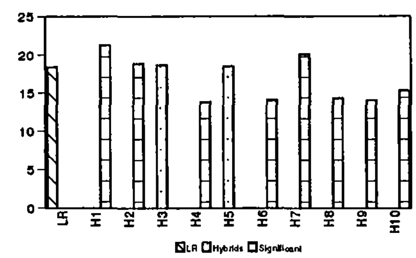
3. Days from emergence to maturity of leaves



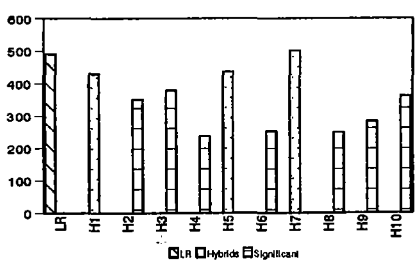
4. Number of leaves



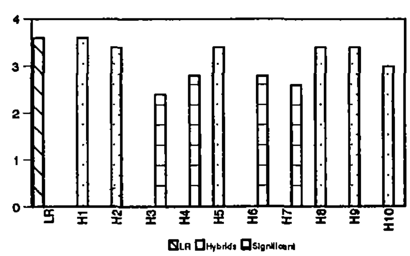
5. Length of leaf blade (cm)



6. Width of leaf blade (cm)

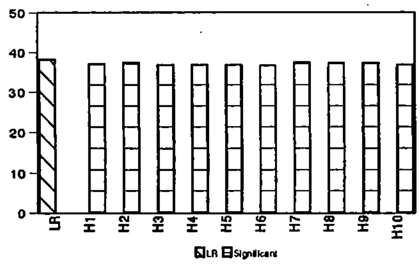


7. Leaf area

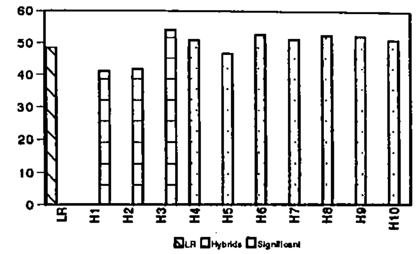


8. Suckering ability

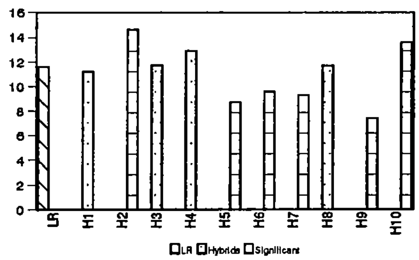
Fig. 14(a). Performance of hybrids with Liver Red (Vegetative characters)



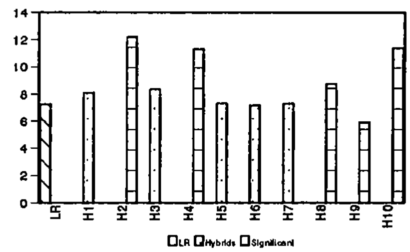
9. Number of days taken for first flowering



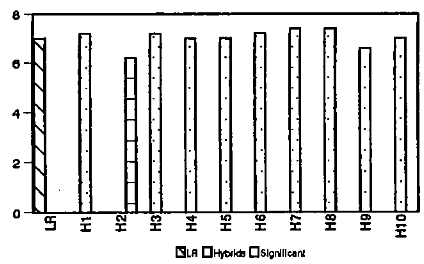
10. Days from emergence to maturity of inflorescence



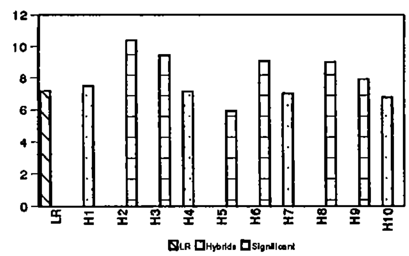
11. Length of spathe (cm)



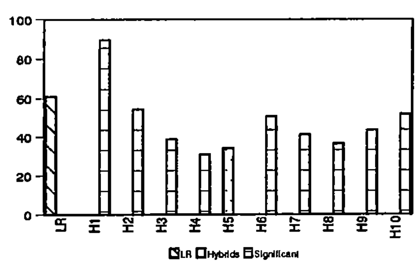
12. Width of spathe (cm)



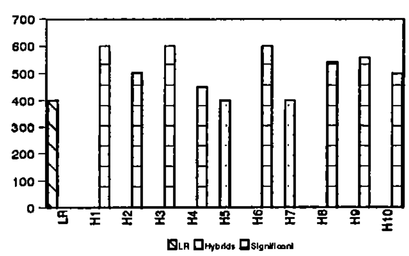
13. Number of spadices per plant



14. Candle length (cm)

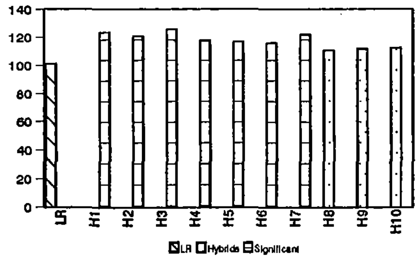


15. Inclination of candle

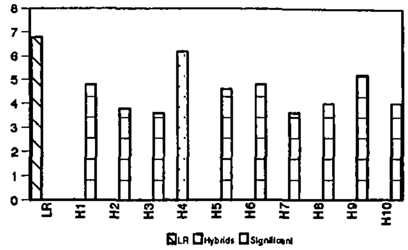


16. Number of flowers per candle

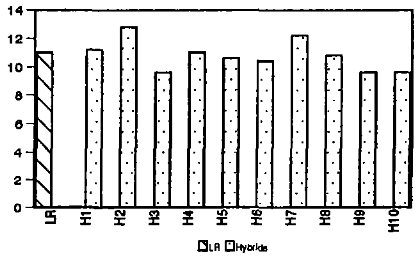
Fig. 14(b). Performance of hybrids with Liver Red (Floral characters)



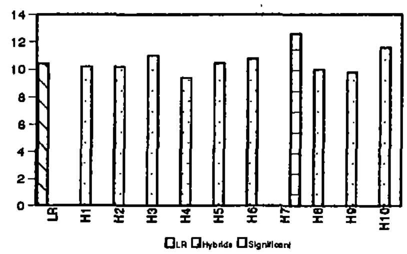
17. Life of spadix (days)



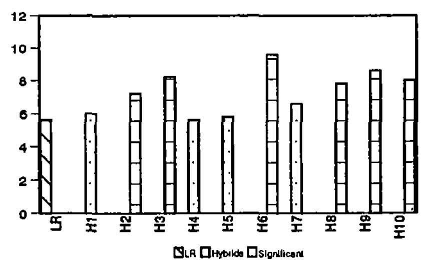
18. Days of initiation of female phase



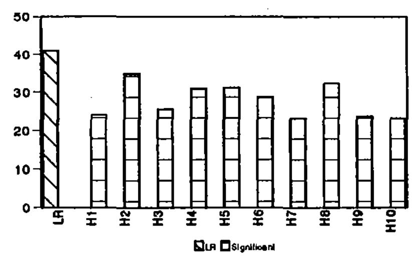
19. Duration of female phase



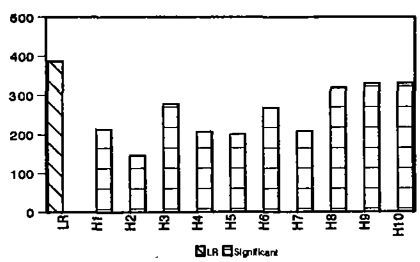
20. Days of interphase



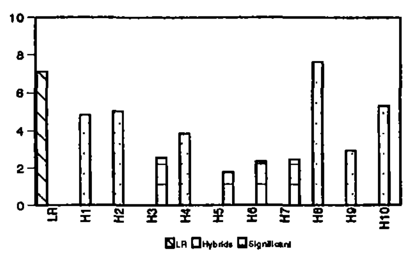
21. Duration of male phase



22. Pollen fertility



23. Total Anthocyanin content



24. Carotene content

Fig. 14(c). Performance of hybrids with Liver Red (Floral characters) [contd..]

5. Length of leaf blade

Average length of leaf blade was found to be 40.90 cm. All the F_1's registered lesser length of leaf blade than LR. Significant negative heterosis was observed for all the F_1's.

6. Width of leaf blade

Average width of leaf blade recorded was 18.40 cm. Significant positive heterosis was registered by HR x P, HR x LR and P x CR whereas HR x CR, P x KR, LR x KR, LR x CR and KR x CR showed a significant negative heterosis.

7. Leaf area

Significant negative heterosis was observed in all the crosses except HR x P, P x LR and P x CR which were on par with LR.

8. Suckering ability

All the hybrids recorded less suckering ability than LR. Significant negative heterosis was registered by HR x KR, HR x CR, P x KR, P x CR and KR x CR.

4.2.5 (b) Floral characters

1. Number of days taken for first flowering

Average number of days taken from the first flowering was 38.20 months. All the crosses recorded significant negative heterosis.

2. Days from emergence to maturity of inflorescence

Average number of days taken from emergence to maturity of inflorescence was 48.40 for LR. A negative heterosis is recommended. Significant negative heterosis was recorded by HR x P, HR x LR and HR x KR.

3. Length of spathe

Average length of spathe was 11.60 cm. Significant positive heterosis was recorded by HR x LR, LR x CR and KR x CR. Significant negative heterosis was registered by P x LR, P x KR and P x CR.

4. Width of spathe

Average width of spathe was 7.24 cm for LR. HR x LR, HR x CR, LR x KR and KR x CR registered a significant positive heterosis while LR x CR was the only hybrid which recorded a significant negative heterosis.

5. Number of spadices/plant/year

LR recorded an average of seven spadices / plant.. HR x LR was the only hybrid which registered a significant positive heterosis.

6. Candle length

The average candle length recorded for LR was 7.18 cm. Hybrids HR x LR, HR x KR, P x KR, LR x KR and LR x CR registered a significant positive heterosis while P x LR was the only hybrid which recorded a significant negative heterosis.

7. Inclination of candle

The average inclination of the candle was 61 degrees for LR which was greater than that of the hybrids. HR x P was the only hybrid which registered a significant positive heterosis while the others registered significant negative heterosis.

8. Number of flowers/candle

The average number of flowers/candle in LR was 400. All the hybrids except P x LR and P x CR registered significant positive heterosis. These hybrids were on par with parent Liver Red.

9. Life of spadix

The average life of spadix recorded for LR was 101.20 days. Durations of average life of spadix for all the crosses were greater than that of LR. All the F_1's except LR x KR, LR x CR and KR x CR registered significant positive heterosis.

10. Days to initiation of female phase

All the hybrids except HR x CR recorded significant negative heterosis.

11. Duration of female phase

The average duration of female phase was 11 days in LR. None of the F_1's registered significant heterosis.

12. Days of interphase

The average number of days for interphase was 10.40 in LR. P x CR was the only hybrid which registered a significant positive heterosis.

13. Duration of male phase

The average number of days for male phase was 5.60 in LR which was lesser than that of the hybrids. Significant positive heterosis was registered in hybrids HR x LR, HR x KR, P x KR, LR x KR, LR x CR and KR x CR.

14. Pollen fertility

The average pollen fertility recorded for LR was 40.90 per cent which was quite high when compared to the hybrids. All the hybrids registered a significant negative heterosis.

15. Total anthocyanin content

Average anthocyanin content was found to be 386.56 mg/100 gm for LR. All the F_1's registered lesser anthocyanin content than that in LR. All the hybrids also registered significant negative heterosis.

16. Carotene content

Average carotene content in LR was 7.12 mg/100 gm. Significant negative heterosis in carotene content was observed for the hybrids HR x KR, P x LR, P x KR and P x CR.

DISCUSSION

5. DISCUSSION

Anthurium is a tropical, evergreen high value ornamental crop cultivated for its colourful long-lasting flowers and handsome foliage. It is gaining popularity as one of the most important commercial ornamental crops of the world. The greatest advantage of anthurium is that it produces flowers all round the year. The present study is aimed at the improvement of anthurium through the creation of variability and to know the mode of gene action for character expression. Due to the differences in the genetic make up of the individuals of a population or the environment in which they are grown, variations are observed. When there is genetic variability among the individuals in a population, selection of parents for hybridisation is effective for crop improvement. The present study to assess the genetic divergence is conducted as two experiments. Experiment No. I deals with genetic divergence among hundred genotypes of anthurium and the experiment No. II estimates gene action and heterosis.

Experiment No. I : Genetic divergence analysis

The observed value of a particular characteristic of an individual is the phenotypic value which is determined partly by the genotype and partly by the environment in which the individual grows. The performance of a crop is the resultant effect of its genotype and the respective environment. Hence the phenotypic variance of a character can be partitioned into genotypic and environmental components. When more than one character is measured on individuals, the correlation between two characters also assumes importance. The correlation we observe between two characters is the phenotypic correlation which is also the result of both the genotype and the environment. Pleiotropy is found to be the major cause of correlation because quantitative characters are controlled by polygenes. Linkage is another cause of correlation. Thus genes have effects on the mean, variance and co-variance of a metric trait. So the estimation of these components is very much important as far as a breeder is concerned.

Heritability and genetic advance are two important genetic parameters. The relative importance of the genetic and environmental components of variance in the character expression is understood by the heritability co-efficient (H^2). If the values of these co-efficients are high, the selection of phenotypically superior plants may result in a significant improvement in the next generation. Similarly the magnitude of improvement in the performance of selected individuals over the population assumes importance. This is estimated through the parameter genetic advance.

Hybridization is a powerful technique in crop improvement, the main objective being creation of genetic variation. This is achieved when the genes from divergent parents are brought together in the F_1. So selection of divergent parents are needed. Most rapid improvement in the economic value of a genotype is expected from selection applied simultaneously to several characters which determines the economic value of a crop. The component characters is often found to be correlated among themselves. Mahalanobis D^2 statistic helps in the selection of genetically divergent parents for the exploitation of hybridization. The relative contribution of each character towards divergence, choice of clusters with maximum D^2 values and selection of genotype from divergent clusters are the criteria to be kept in mind while selecting parents for hybridization.

Twenty varieties and eighty hybrids belonging to 22 cross combinations of anthurium showing variations in spathe colour, shape and size and other commercially valuable morphological characters available in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani were evaluated using appropriate design with sufficient replications. The genotypic differences existing among these 100 genotypes with respect to various characters stated in chapter 3 are classified into three categories as low, medium and high based on the area property of normal distribution [Table 4.1.1 (d)].

The average plant height has been estimated as 61.02 cm with a range of 37 cm to 96.97 cm. Of these 100 genotypes, 24 per cent of the genotypes is having a height less than 52.91 cm, 52 per cent having a medium height between 52.91 cm to 69.12 cm and 24 per cent having a height greater than 69.12 cm. Plant height can be considered as a varietal character in earlier studies by Bindu and Mercy (1994) showed that the five varieties studied by them varied significantly in their heights. The six varieties studied by Sindhu (1995) also showed significant variation in plant height. Renu (2000) observed great differences in plant height ranging from 29.70 cm in 'Midori Green' to 70.90 cm in 'Pompon Red'.

The average length of spathe is found to be 10.80 cm with an equal distribution of hundred genotypes in the three designated categories. Most of the plants are found to have a spathe width of 7.08 cm while the average width is found to be 7.76 cm. In commercial anthurium cultivation the above two characters ie., spathe length and spathe width are the important traits which determine the value of the cut flower. The United States Department of Agriculture standards were used by Singh (1987) to grade the anthurium flower as miniature (under 8 cm), small (8-10 cm), medium (10-13 cm), large (13-15 cm) and extra large (> 15 cm) based on width (in cm) of the spathes. As per the present classification flowers with spathe width less than 7.08 cm is classified as small (including miniature), those between 7.08 cm to 8.44 cm as medium, and above 8.44 cm as high (based on length x width). Bindu and Mercy (1994) observed the largest spathe size for 'Pink' (10.4 x 9.7 cm) and smallest for 'Lady Jane' (6.5 x 3.5 cm). They also found that the varieties 'Pink' and 'Kalympong Red' produced super large flowers and the smallest flowers were produced in the variety 'White'. Most of the varieties in the present study produced small to medium sized flowers. Such flowers have much commercial value.

Mature plants three or more years old produce plantlets called suckers from the base of the stem, one or two at a time. This is, however, a very slow and undependable process because most of the good commercial and hybrid varieties are very shy in suckering or do not sucker at all. The present study revealed that the average number of suckers is 2.06 with a range of 0.67 to 4.0. This character is found to be variable among the genotypes, 39 per cent of the genotypes belong to the low category, 23 per cent in the medium category and 38 per cent in the high category. Mercy and Dale (1994) reported that the propagation of anthurium using suckers was very slow because most of the good commercial and hybrid varieties are shy in suckering. Suckering is a very desirable character as it increases plant number and thereby the overall productivity.

The average length of leaf blade is 21.74 cm. It ranged from 17.00 cm to 47.67 cm. Thirty six per cent of the genotypes are in the low category, 37 per cent in the medium category and 27 per cent in the high category. Similarly the average width of leaf blade is 16.57 cm. It ranged from 9.83 cm to 28.33 cm. Here 34 per cent genotypes are in the low category, 40 per cent in the medium category and 26 per cent in the high category. Leaf length and width are significantly influenced by the different levels of shade and growth regulators. Salvi (1997) reported that 80 per cent shade intensity recorded maximum leaf length (7.76 cm) and width (5.93 cm). According to him, response to shade leads to highly conservative utilization of resources, commonly accompanied by enhancement of photosynthetic energy, thereby increasing the length and width of spathe and leaf area (Smith, 1982). With decline in shade intensity, considerable decrease in length and width was observed. The present results are obtained under 75 per cent shade.

The flower-bearing axis is called 'candle'. Short and slender candle is a desirable feature for anthurium flowers. In the present study the average candle length observed is 7.51 cm with a range of 4.30 cm to 13.70 cm. Here 40 per cent of the genotypes have a candle length less than 6.87 cm, 28 per cent of the genotypes have candle length between 6.87 cm and 8.15 cm and 32 per cent of the genotypes have candle length greater than 8.15 cm. These findings confirm the reports of Bindu and Mercy (1994) that the candle was long and fleshy in ordinary non-commercial varieties, while it is shorter and slender in hybrids. Renu (2000) also observed that most of the commercial varieties like 'Tropical Red', 'Nitta Orange', 'Mauritius Orange', 'Lady Jane Red', 'Pompon Red' and 'Midori Green' produced smaller candles. Forty per cent of the experimental material is found to have low candle length. The smaller the candle size, the lesser the number of flowers per candle. Larger candles with a high number of flowers are found in non-commercial or wild varieties which indicate primitiveness.

The angle between the spathe and candle is found to be on an average of 53° with a range of 21.67° to 79°. Many genotypes (47 per cent) have inclination for the candle less than 50.67°, 10 per cent have 50.67° to 55.33° and 43 per cent have an inclination more than 55.33°. Mercy and Dale (1994) recommended that it is ideal for anthurium varieties to have a short candle, curving towards the tip of the spathe and held at an angle less than 45°. Sindhu (1995) found ideal position of candle in 'Chilli Red', 'Kalympong Orange' and 'Kalympong Red'. Renu (2000) observed an angle above 45° between the spathe and candle in 'Liver Red', 'Dragons Tongue' and 'Lady Jane'. An angle less than 45° is considered desirable as it allows more compact packing of inflorescences for transportation.

One spadix each is found to be produced from the axil of each leaf so that the number of leaves and the number of spadices produced annually per plant is the same. The average production of spadices per plant/year is 6.12 and the parameter ranged from 4.67 to 8.00. Close association between the number of leaves and the number of spadices was observed by Gajek and Schwarz (1980) by a comparison of 120 individual plants. Steen and Vijverberg (1973) revealed four to sixteen flowers over two years. Mercy and Dale (1994) recorded the annual production of spadices as five to eight while Sindhu (1995) and Renu (2000) recorded it as four to eight. The observations in the present study are in conformity with these reports.

The average leaf area recorded is 338.07 cm^2 with a range of 116.62 cm^2 to 827.88 cm^2. Some genotypes (39 per cent) have a leaf area less than 274.75 cm^2, 30 per cent have leaf area between 274.74 cm^2 - 401.40 cm^2 and 31 per cent have leaf area more than 401.40 cm^2. Salvi (1997) reported that the different levels of shade and growth regulators have significant influence on the index and total leaf area of the plant. With decline in shade intensity, leaf area also decreased significantly. The highest shade intensity (80 per cent) recorded the maximum index leaf area (50.75 cm^2) and total leaf area (423.25 cm^2).

Quantitative traits are controlled by polygenes and show continuous variation. Thus, characters are affected by both the genotypes and environment and hence the partition of variation into genotypic as well as environment assumes importance for the breeder. Quantitative characters are considerably affected by environment resulting in masking the differences among different genotypes and producing a continuous variation in the character. Among the ten characters studied the contribution of environmental variation is from two per cent (inclination of candle) to 54 per cent (number of spadices/plant/year). When the effect of environment on the phenotypes is less, the genotypes determine the phenotypes and as such the inclination of candle is highly governed by genes. This is also evident from the heritability co-efficient of 98 percentage for this character. On the other hand, for the character number of spadices/plant/year, the highest influence of environment is observed. This indicates that this character which decide the productivity of the crop can be improved by manipulating the environment.

Length and width of spathe and candle length are also some important traits in anthurium where the effect of environment is less. The characters recorded a heritability coefficients of 88.8, 91.4 and 90.6 per cent respectively. Plants with less length and less width for the spathe and small candle are preferred for hybridisation for improvement in anthurium. Length and width of leaf blade and leaf area are also characters with high heritability.

In the case of plant height 70 per cent of the contribution comes from genotypes and only the remaining from environment. So height is not much modified by environment. Number of spadices per plant per year is the only character which is affected more by environment than genotype. It is important for the breeder to know the improvement expected in the mean genotypic value over the original population under selection. High heritability does not necessaarily mean a high genetic advance for a particular character (Allard, 1960). Heritability along with genetic advance is more useful than heritability alone in predicting the resultant effect of selecting the best individuals (Johnson *et al.,* 1955).

Fig. 3 shows the distribution of characters in terms of heritability (H^2) and genetic advance (GA). Leaf area is the character which can be improved to maximum. All the other characters except number of spadices/plant/year shows high heritability followed by genetic advance. So selection of phenotypically superior plants with respect to these characters will result in a significant improvement in the next generation. If five per cent selection is to be practised maximum genetic advance is expected for leaf area followed by number of suckers per plant and minimum by number of spadices per plant per year. Comparison of the improvements expected from these characters are seen from Fig. 4. According to Panse (1957), the characters with high heritability and genetic advance were controlled by additive gene action and therefore amenable to genetic improvement through selection.

A breeder is always interested to know the inherent association (genotypic correlation) of characters apart from the observable correlation between two characters (phenotypic correlation). The presence of genotypic correlation may be attributed to both pleiotropy or linkage or both. Phenotypic correlation is observed for most of the characters like length and width of the spathe, candle length and inclination of candle with the spathe which are also important characters determining the commercial value of anthurium flower. Environmental correlations are absent for almost for all pairs of characters except for a very few pairs. The significant pair-wise correlations are seen in Fig. 5, 6 and 7. If a positive genotypic correlation was observed for a pair of characters, certainly the improvement in one character will improve the other character also, thus helping a breeder to select characters on the correlated response to selection. If the improvement in one character results in a decrease in other character, this will also help the breeder in the selection of characters if necessary. The inclination of the candle to the spathe is influenced by the length and width of leaf blade as well as length and width of spathe. Height of plant is also a character which is positively influencing the inclination of the candle. This may be attributed to the indirect effect of height resulting through an increase in the number of leaves. The number of leaves or spadices per plant is found to have a negative genotypic correlation with the inclination of the candle. Plants with less inclination of the candle and its negative association with number of spadices produced per plant per year is a favourable attribute.

An assessment of genetic diversity is of much importance in plant breeding research as far as the selection of parents for hybridisation is concerned. The economic value of a plant is determined by several characters which may be correlated. Mahalanobis D^2 - statistics gives a quantitative measure of divergence based on multiple characters. The 100 genotypes are clustered into 17 groups. The Fig. 15 shows the genetic diversity at intra and intercluster levels. The greater the distance between two clusters the greater is the divergence between genotypes belonging to the two clusters and vice versa. The genotypes within a cluster are less divergent than those which are in different clusters. In the selection of parents for hybridisation three points mainly need to be considered. They are the relative contribution of each character to the total divergence, choice of the clusters with maximum genetic distance and selection of one or two genotypes from such clusters. The cluster C_{11} is

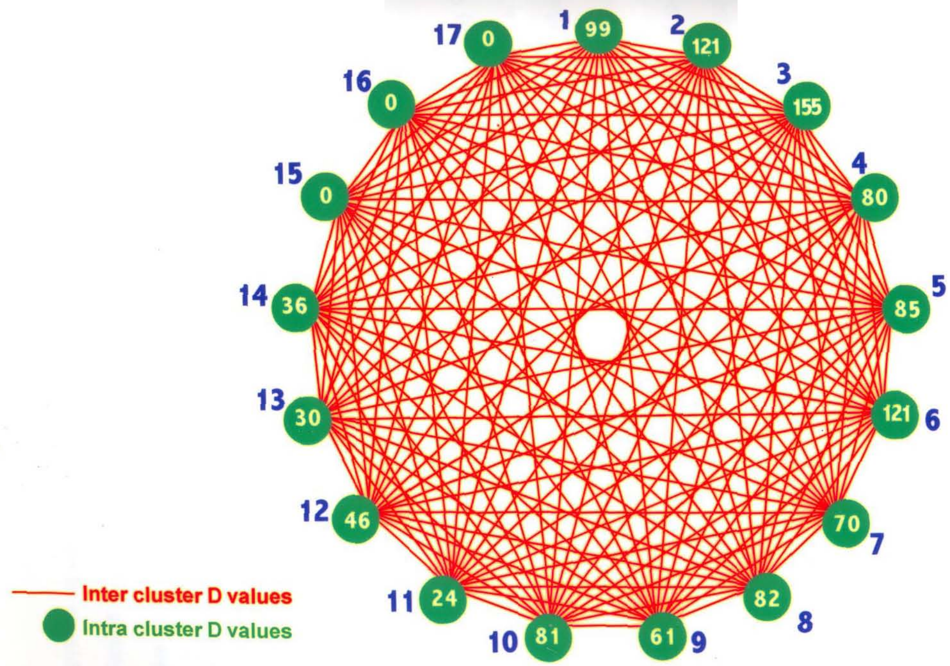


Fig. 15. Cluster diagram

found to have maximum intercluster distance with eleven of the 17 clusters formed (Fig. 10). This is followed by C_{17} (00 x KR (8)) which kept maximum divergence between five out of the 17 clusters. C_{15} ie., HR x LJ(1) kept maximum distance with C_7.

So selection of parents from these divergent clusters will be very effective in hybridisation. Character-wise performance at cluster level is seen from Fig. 8 (a and b). Plant height, spathe length, spathe width, length and width of leaf blade and leaf area are least in cluster 17. The genotypes with high value for the above traits are not preferred and hence C_{17} ie., OO x KR (8) may be selected for further hybridisation. Suckering ability and candle length were found to be low in C_{12}. Number of spadices per plant was found to be high in C_{15}.

For an ideal anthurium flower, candle length should be less than the length of the spathe. Candle length is lowest for cluster C_{12} followed by C_{17}. It is higher than spathe length only in clusters C_{11} (comprising HR and P) and C_5 (containing variety Kalympong Orange and eight hybrid genotypes).

Suckering ability registered the maximum co-efficient of variation (24.79 per cent) followed by leaf area (16.52 per cent) at genotypic level. Leaf area registered the maximum co-efficient of variation (49.44 per cent) followed by suckering ability (32.32 per cent) at the intercluster level. The relative contributions of characters towards divergence at intercluster levels are seen from the Fig. 8 (a and b). Leaf area and suckering ability are two characters which contribute maximum for the divergence of the genotypes. So both at genotypic and cluster level these two characters can be considered as potential contributors of differentiation.

Experiment No. II : Estimation of heterosis and gene action

Diallel crossing helps to select parents for genetic improvement of various quantitative traits through realisation of their combining ability. It also helps to assess the magnitude of additive and dominant components of genetic variance.

Haymans graphical approach of diallel analysis ascertains the genetic make up of the parents. This approach is based on the additive - dominance model of gene action. This analysis will help to detect the presence or absence of non-allelic interaction or epistasis. The difference between progeny mean and parental mean will describe the dominance relationship in the action of genes involved in the character expression.

The distribution of parental arrays along the regression line will provide valid information on the gene action involved in the expression of the character. In the absence of non-allelic interaction and linkage all the array points will lie on a regression line of unit slope. The Vr and Wr of array whose common parent bears most of the dominant genes will be relatively smaller in magnitude than the array whose common parent bears most of the recessive genes. Points for the array whose common parent bears most of the dominant genes will find place near the origin and with recessive genes will find its place far away from the origin. If there is no dominance, all the array points will cluster at one point. If the Wr intercepts of the regression line is positive, the Wr-Vr line will be above the origin and if negative, the line will be below the origin. This leads to the conclusion that additive gene action is important in the expression of the character in the former case and dominance gene action important in the latter case ie., it is implied that parental dominance and over dominance are the gene actions involved in the expression of the character. If the regression line passes through the origin then complete dominance is expected. Array points at the extreme position implies the differential proportion of dominant and recessive genes.

All the 100 genotypes of Experiment No.I were crossed among themselves but only with 5 parents namely HR, P, LR, KR and CR compatible crosses were produced. These were the base materials used to estimate combining ability and heterosis. These five parents and their F_1's were raised in completely randomised design with five replications. The data generated from this experiment gave the following conclusions. Significant differences were detected among the five parents and the ten hybrids for all the twentyfour characters (vegetative and floral) studied.

The mean plant height of the parents ranged from 58.40 cm (HR) to 80.20 cm (LR) and that of the hybrids ranged from 50.80 cm (LR x CR) to 70.80 cm (P x CR). Abdussammed (1999) has reported that nutrients significantly influenced the plant height, both in ground as well as pot planting. But plant height can be considered as a varietal character, as earlier studies by Bindu and Mercy (1994) have showed that the five varieties studied by them significantly varied in their heights. The six varieties studied by Sindhu (1995) also recorded significant variation in height. For internode length, the mean values recorded by the parents ranged from 1.00 cm (P) to 1.52 cm (LR) and in the crosses it ranged from 1.02 cm in P x CR to 1.34 cm for HR x P. Mercy and Dale (1994) reported that the plants with short leaf internodes which give the plant a compact appearance are preferred. The number of days taken from emergence to maturity of leaves among the parents ranged from 41.40 days in HR to 44.40 days in P. In the crosses it ranged from 38.20 days in P x CR to 45.20 days in P x KR.

The present investigation revealed that generally a single spadix was found to be produced from the axil of each leaf so that the number of leaves and number of spadices produced annually per plant was equal. The annual production of leaf was highest in HR followed by KR, LR, P and CR. Almost all the hybrids produced leaves equal to that of the parents. Similar close correlation between the number of leaves and the number of flowers was observed by Gajek and Schwarz (1980). Steen and Vijverberg (1973) compared the productivity of 120 individual anthurium plants and found that it ranged between four to sixteen flowers over the two years. Mercy and Dale (1994) recorded the annual production of spadices as five to eight while Sindhu (1995) recorded it as four to eight. The observations in the present study are in conformity with these reports.

Though propagation of anthurium using suckers is a slow process, it is an important trait considered in the selection of superior genotypes. The present investigation revealed that the suckering ability ranged from 1.6 in KR to 4.0 in P in the parents. Among the hybrids it ranged from 2.40 (HR x KR) to 3.60 (HR x P). Mercy and Dale (1994) opined that most of the good commercial anthurium varieties are very shy suckering or did not sucker at all. High suckering ability contributes to increased productivity.

In commercial anthurium cultivation, spathe size is an important character which determines the value of the cut flower. Spathe size is taken as the sum of the length and width of the spathe. The United States Department of Agriculture Standards were used by Singh (1987) to grade the Anthurium flowers as miniature (under 8 cm), small (8-10 cm), medium (10-13 cm), large (13-15 cm) and extra large (>15 cm) based only on width (in cm) of the spathes. In the present study the mean spathe width ranged from 8.80 cm in LR to 11.10 cm in Pink among the parents. In the hybrids it ranged from LR x CR (5.90 cm) to HR x LR (12.20 cm). The length of spathe in the parents was maximum in HR (14.26 cm) and minimum in LR (11.60 cm). Among the hybrids, the length of spathe ranged from 7.40 cm in LR x CR to 14.60 cm in HR x LR.

Short and slender candle is a desirable feature for anthurium flowers. In the present investigation, the longest candles were recorded for pink (12.72 cm) and shortest in Liver Red (7.18 cm) among the parents. In the hybrids this character ranged from 5.90 cm (P x LR) to 10.38 cm (HR x LR). The five varieties studied by Bindu and Mercy (1994) showed a candle length range of 4 cm to 9.5 cm. The candle length of six varieties studied by Sindhu (1995) ranged from 6.6 cm to 12.1 cm. Almost all the parents and hybrids studied in the present investigation have short candles which is a desirable character. Studies by Mercy and Dale (1994) showed that the candle was long and fleshy in ordinary non-commercial varieties, while it was shorter and more slender in highly bred hybrids.

Mercy and Dale (1994) recommended that ideal anthurium flower should have a short candle, curving towards the tip of the spathe and held at an angle less than 45°. Such inclinations of candle were observed in the parents KR (21°) and CR (45.88°). The lowest degree of inclination of candle was found in HR x CR (20.80°). In a similar study Sindhu (1995) found that the varieties with the ideal position of candles were CR, KO, KR and W.

The commercial anthurium flower consists of a modified bract, the spathe and hundreds of small flowers on the candle like inflorescence, which is botanically a spadix. The flowers are bisexual, regular, protogynous, arranged in a series of spirals on the candle, in an acropetal succession (Mercy and Dale, 1994). The number of flowers per candle for different varieties was variously reported as 300 by Watson and Shirakawa (1967), 50-150 by Bindu and Mercy (1994), 150-350 by Mercy and Dale (1994) and as 175-375 by Sindhu (1995). In the present study the number of flowers per candle varied from genotype to genotype. It ranged from about 372 in CR to about 600 in P among the parents. But in the hybrids it ranged from about 400 in P x LR to about 600 HR x P and P x KR.

According to Paull (1982), the non reversible visible changes accompanying the senescence of anthurium flowers were, loss of spathe-gloss, necrosis of spadix and greening of spathe and spadix. Mercy and Dale (1994) also noted the senescence was marked by yellowing of peduncle and withering of spathe and candle, which took nearly 4 to 7 months from the emergence of young spadix. In the present stuudy, the time span from emergence of a spadix to its senescence varied from 98 days in CR to 120.40 days in HR. A wide variability of this character was seen among the hybrids with a range of 110.80 days (LR x KR) to 126 days in (HR x KR). Sindhu (1995) also reported that the life of unfertilized spadix was about 1.5 to 3.5 months while in fertilized spadices it increased to 4.5 to 8 months.

Studies by Paull (1982) revealed that, in anthurium, flower maturation started from the basal portion of candle and proceeded regularly towards the apex. He listed many protogynous species of *Anthurium*, in which *A. andreanum* was not included. However, later studies by Bindu and Mercy (1994) and Mercy and Dale (1994) revealed the protogynous nature in *A. andreanum* varieties. Observations in the present study highlighted the clear protogynous nature of this species. The number of days, from the day the candle became visible to intiation of female phase was observed to vary from 4.40 days (KR) to 6.80 days (HR and LR) in the parents. Among the hybrids, this character ranged from 3.60 days (HR x KR, P x CR) to 6.20 days (HR x CR). Intiation of female phase was identified by the slight projection by stigmas and presence of a viscous exudate on the candle. Sindhu (1995) also reported that the days to intiation of female phase ranged within a period upto ten days, with the variety HR showing the longest period among the six varieties studied by her.

The number of days in female phase was recorded based on the presence of exerted stigma, honey-dew like secretion and some amount of insect activity on the candle. Daumann (1921) and Mercy and Dale (1994) have recommended the above criteria to identify the female phase.

The duration of female phase ranged from 7.40 days in P to 13.60 days in KR. The hybrids also showed a wide range of variability from 9.60 days (HR x KR, LR x CR and KR x CR) to 12.80 days (HR x LR).

The interphase between, the female and male phase was marked by drying up of stigmatic droplets. Observations from the present study showed that the interphase may range from 7.80 days in CR to 11.20 days in P. Among the hybrids it ranged from 9.39 days (HR x CR) to 12.60 days (P x CR). Bindu and Mercy (1994) noticed that interphase lasted for about four to seven days, while Mercy and Dale (1994) opined that it may last for about a week in general. Studies on six varieties by Sindhu (1995) showed that interphase lasted for four to ten days.

Following the interphase, a male phase was observed, marked by anther extrusion starting from the base of the candle and proceeding upwards. The average number of days for which the candles remained in male phase ranged from five days in CR to 7.20 days in HR. Among the hybrids the duration was maximum in P x KR (9.60 days) and minimum in HR x CR (5.60 days). Bindu and Mercy (1994) reported that male phase lasted for three to seven days whereas Mercy and Dale (1994) observed that it may last for four to eight days. In the six varieties studied by Sindhu (1995), the duration of male phase ranged from three to eight days.

According to Mercy and Dale (1994), in very cold or hot seasons, male phase may be suppressed for shorter or long periods. Anther emergence is comparatively less during the months of March to July. Suppression of male phase in some varieties during March to August was also observed by Sindhu (1995).

The highest pollen fertility was observed for the parent LR (45.90 per cent) followed by P (28.40 per cent), whereas in the hybrids it was highest in HR x LR (34.70 per cent) followed by LR x KR (32.32 per cent). Lalithambika (1978) observed that the pollen fertility of *A. andreanum* ranged from 25 to 30 per cent. Bindu and Mercy (1994) reported that the pollen fertility in *A. andreanum* varied from 20.4 per cent o 28.8 per cent, which again substantiates the findings of this study. As sterility is a condition frequently associated with hybridity, we can take the low pollen fertility in *A. andreanum* as an indication of its hybrid nature.

Anthocyanins contribute various colours to the spathe of anthurium. The mean total anthocyanin content in the parents ranged from 121.38 mg/g in P to 386.56 mg/g in LR. In the hybrids it ranged from 146.03 mg/g (HR x LR) to 330.95 mg/g (KR x CR). Carotenoids are predominantly orange or red-orange pigments. The variety KR recorded the highest carotene content of 9.03 mg/100 g in the parents, and in the hybrids it was 7.62 mg/100 gm in LR x KR.

A study of five qualitative traits such as plant type, spathe colour, spathe texture, candle colour and type of inflorescence axis revealed great variations. The five parents and 10F_1's under present study showed a complete range of spathe colour, from deep maroon to dark red to red to pink. This wide variation can be explained on the basis of many reported studies conducted on the mechanisms of spathe colour development in anthurium. Iwata *et al.* (1979) identified the anthocyanins in the spathe of *A. andreanum* to be cyanidin 3-rhamnosyl glucoside and pelargonidin

3-rhamnosyl glucoside. They concluded that both the pigments were present in the red cultivars while orange and coral varieties contained only pelargonidin 3-rhamnosyl glucoside. In white either both these pigments or pelargonidin only are absent. Iwata *et al.* (1985) further explained that a predominance of cyanindin 3- rhamnosyl glucoside resulted in coral and orange. They have added that flavone, which is another group of pigments, although present in variable amounts, had no effect on cyanic shades. In the present study, anthocyanin estimates indicate that the varieties LR, CR, KR and HR with varying red coloured spathes have the presence of both the above pigments in high concentration (386.56 mg/gm to 245.83 mg/gm). In variety P, the anthocyanin content is 121.38 mg/gm and the colour is pink.

The genetics of spathe colour inheritance was studied in detail by Kamemoto *et al.* (1988). They concluded that two major genes, M and O were responsible for the five major colours - red, orange, pink, coral and white. The gene M was found to control the production of cyanidin 3-rutinoside while gene O controlled that of pelargonidin 3-rutinoside. Red and pink resulted when both M and O genes are present. So the red and pink-spathed varieties under the present study have both M and O genes. But the variation in red spathe colour from maroon to dark red to red and pink is explained by their findings that, the incremental effects of M appeared to be greater than that of O and therefore the intensity of colour decreased from MMOO, MMOo, MmOO to MmOo. They have also concluded that orange had a genotype of mmOO and was true breeding while mmOo expressed a lighter orange shade called coral. The recessive oo was epistatic to M and therefore white colour resulted when both were recessive (mmoo) or M was in combination with recessive oo (MMoo, Mmoo). Wannakrairoj and Kamemoto (1990) studied the inheritance of purple spathe in anthurium and proposed a scheme to explain this. A recessive allele p, was found to modify the colour of anthocyanins controlled by M and O loci. A spathe was purple when the genotype was M-O-pp. The dominant P allele has no effect on colour in any combinations. The colour genotypes and their phenotypes are as follows.

MMOO		
MmOO	=	Reds
MMOo		
MmOo	=	Pink
mmOO	=	Orange
mmOo	=	Coral
MMoo		
Mmoo	=	White
mmoo		
M-O-pp	=	Purple

Based on this, the genotypes of the five parent varieties in the present study can be interpreted as detailed in Table 5.1 by correlating the total average anthocyanin content of the spathe of each variety to the incremental effect of anthocyanin producing genes, M and O.

Table 5.1. Spathe colour genotypes of parent varieties in relation to anthocyanin content

Sl. No.	Variety	Anthocyanin content (mg/gm)	Spathe colour	Probable genotype
1	LR	386.56	Deep maroon	MMOO
2	KR	334.42	Dark red	MMOo
3	CR	323.83	Dark red	MMOo
4	HR	245.83	Red	MmOO
5	P	121.38	Pink	MmOo

The variety LR with the maximum anthocyanin content must have all the four dominant alleles (MMOO) and shows the deepest maroon red colour, while KR and CR, both with dark red spathes and comparatively similar anthocyanin content (but less than that of LR) must have the M gene in homozygous condition while O gene is in heterozygous condition (MMOo). The variety HR with red spathes and a much lower anthocyanin content must be MmOO. Though these three varieties, have three dominant alleles each, with the incremental effect of M being greater than that of O, KR and CR with two dominant alleles of M and one dominant allele of O have a greater anthocyanin content and deeper red colours than HR with one dominant allele of M and two dominant alleles of O. The variety P with pink spathes is heterozygous for M and O and has also the lowest anthocyanin content.

Based on the anthocyanin contents of the spathes it is also possible to suggest the probable genotypes of the ten F_1 hybrids derived from the five parents (Table 5.2).

They fall into four genotypes and four spathe colours ranging from dark pink to red, dark red and deep maroon. Three hybrids, LR x KR, LR x CR and KR x CR with deep maroon spathes all have possibly the same genotype of MMOO (Appendix IV). The anthocyanin contents of their spathes is also high (319.15 to 330.95 mg/gm) comparable to that of the LR parent of the same genotype. The hybrid HR x KR with dark red spathe is possibly MMOo and has a correspondingly lesser anthocyanin content of 277.19. The two dark pink-spathed hybrids P x KR and P x CR must be heterozygous

Table 5.2. Spathe colour genotypes of F_1 hybrids in relation to anthocyanin content

Sl. No.	Hybrid combination	Anthocyanin content (mg/gm)	Spathe colour	Probable genotype
1	HR x P	214.26	Red	MMOo
2	HR x LR	146.03	Red	MmOO
3	HR x KR	277.19	Dark red	MMOo
4	HR x CR	207.54	Red	MmOO
5	P x LR	200.61	Red	MmOO
6	P x KR	207.62	Dark pink	MmOo
7	P x CR	209.17	Dark pink	MmOo
8	LR x KR	319.15	Deep maroon	MMOO
9	LR x CR	329.74	Deep maroon	MMOO
10	KR x CR	330.95	Deep maroon	MMOO

for both genes ie., MmOo because pink spathe colour indicates heterozygosity of spathe colour genes. Of the four red-spathed hybrids, three ie., hyrbids HR x LR, HR x CR and P x LR have possibly the same genotype MmOO and have anthocyanin contents ranging from 146.03 to 207.54 mg/gm while hybrid HR x P with an anthocyanin content of 214.26 mg/gm must belong to another genotype MMOo.

Critical evaluation of anthocyanin content of spathes and spathe colour genotypes reveals that the anthocyanin content of hybrids HR x LR (146.03 mg/gm) with red spathe and genotype MmOO is lower than the value anticipated while hybrids P x KR and P x CR both of which have dark pink coloured spathes and dihybrid spathe colour genotypes (MmOo) have higher anthocyanin content than expected. Compared to the parent P which has light pink spathes, these hybrids have spathes with darker pink colour and more anthocyanin though the genotypes of all the three are the same. This observed discrepancy may probably be due to the effect of the environment in the development of anthocyanin pigment. As plants are raised in the green house under a minimum controlled environment, there is the possibility of some plants getting exposed to more sunlight while other get less light and more shade. Thus HR x LR hybrid of genotype MmOO getting possibly more sunlight, has faded spathes with a lighter red colour and lower anthocyanin content while the P x KR and P x CR hybrids of genotype MmOo, possibly growing under more shade have spathes with deep pink colour but higher anthocyanin content.

Spathe texture showed high variation among the parents and the hybrids studied, from thick smooth glossy in HR and LR to medium thick and smooth in P to medium thick, deeply blistered and glossy in KR and CR. In the hybrids the spathe texture varied from thick, smooth and glossy in HR x P, HR x LR, HR x KR, KR x CR and P x CR to medium thick blistered and glossy in HR x CR, P x LR and P x KR. According to Birdsey (1956), Linden described the spathe of *A. andreanum* based on varying degrees of smoothness and blistering. Mercy and Dale (1994) have opined that the spathe of floral anthuriums may be smooth, thick and glossy without prominent veins or it may be thinner, deeply veined and blistered. The six varieties studied by Sindhu (1995) also showed variation from thick to thin and deep to shallowly blistered spathes.

Candle colour was light pink in P to red in HR and LR, yellow and white in KR and light red in CR. In the hybrids the candle colour varied from Pink to light pink, yellow to yellowish white to red and cream. According to Mercy and Dale (1994), the candle had a single colour red, pink or green in ordinary anthurium varieties and hybrids had yellow, white, pink or red colours in two or more bands. Sindhu (1995) reported that the six varieties studied had candles with either a single colour or two or more bands of colours. Henny (1999) observed that the anthurium hybrid 'Red Hot' had a candle which was orange-red apically blending to red basally.

The nature of inflorescence axis is one of the most important factors that determines the appearance and hence the value of anthurium flowers, when marketed as cut flower. Mercy and Dale (1994) suggested that good anthurium hybrids should have strong and straight inflorescence axis. Among the five parents and 10 F_1's studied, the axis nature varied from long, straight and very strong in all the parents and hybrids except for the parent variety KR on which, it is long, thin and slightly curving.

Based on Hayman's Graphical analysis to study gene action, the nature and magnitude of the constant in the regression equation provided an idea of the degree of dominance in the expression of each trait. It was negative for all the fitted regressions indicating the overdominance of the genes in character expression. So the individual parents were compared for their dominance relationship. The parental order of dominance was determined by $(W_r + V_r)$ value. The individual parents for their dominance relationship were ranked in the magnitude of $(W_r + V_r)$ values, low $(W_r + V_r)$ value represented high dominant alleles in a parent and vice versa. This parental order of dominance is presented in Table 5.3.

The parent HR carried the highest number of dominant alleles (over-dominance) for the characters leaf area, days from emergence to maturity of inflorescence and days of interphase. Lowest number of dominant alleles in the parent HR were for the characters width of leaf blade, length and width of spathe, candle length, life of spadix and days to initiation of female phase.

For the parent P the characters plant height, internode length, length and width of the spathe, duration of male phase and carotene content were controlled by the highest number of dominant alleles. Length of leaf blade, number of spadices/plant/year, inclination of candle, days of interphase and total anthocyanins were controlled by least number of dominant alleles in P.

Table 5.3. Parental order of dominance for 24 characters in *Anthurium andreanum*

Parents	1 Plant height (cm)	2 Internode length (cm)	3 Days from emergence to maturity of leaves	4 Number of leaves	5 Length of leaf blade (cm)	6 Width of leaf blade (cm)	7 Leaf area (cm^2)	8 Suckering ability
HR	2	2	3	2	3	5	1	3
P	1	1	4	3	5	4	2	4
LR	5	5	2	1	1	3	3	5
KR	3	3	5	5	2	1	5	1
CR	4	4	1	4	4	2	4	2

Time taken Parents	9 Days from for first flowering	10 Length of emergence to maturity of inflorescence	11 Width of spathe (cm)	12 Number of spathe (cm)	13 Candle spadices / plant / year	14 Initiation of length (cm)	15 Number of candle (degrees)	16 flowers / candle
HR	4	1	5	5	3	5	4	3
P	3	2	1	1	5	3	5	4
LR	5	3	2	2	1	2	3	2
KR	1	4	4	4	4	4	1	5
CR	2	5	3	3	2	1	2	1

Table 5.3. (Contd....)

Parents	17 Life of spadix (days)	18 Days to initiation of female phase	19 Duration of female phase	20 Days of interphase	21 Duration of male phase	22 Pollen fertility (%)	23 Total anthocyanin content (mg/g)	24 Carotene content (mg/100g)
HR	5	5	5	1	3	2	4	3
P	4	2	2	5	1	3	5	1
LR	1	3	4	2	4	5	1	4
KR	3	1	3	4	5	4	3	5
CR	2	4	1	3	2	1	2	2

LR carried the highest number of dominant alleles in the expression of characters like number of leaves, length of leaf blade, number of spadices/ plant/year, life of spadix and total anthocyanin content and least number of dominant alleles for plant height, internode length, suckering ability, time taken for first flowering and pollen fertility.

For the expression of characters like width of leaf blade, suckering ability, time taken for first flowering, inclination of candle and days to initiation of female phase - the parent KR recorded the highest number of dominant alleles. KR recorded the lowest number of dominant alleles for days from emergence to maturity of leaves, number of leaves, leaf area, number of flowers/candle, duration of male phase and total carotenoids.

CR carried the highest number of dominant alleles in the expression of characters like days from emergence to maturity of leaves, candle length, number of flowers/candle, duration of female phase and pollen fertility and lowest number of dominant for days from emergence to maturity of inflorescence.

The magnitude of standardised (W_r + V_r) values showed the preponderance of dominant alleles in the parents with positive and negative gene effects. All the parents possessed high frequency of dominant alleles for all the characters except for plant height (Page No. 145 to 156).

In the case of plant height parent P_2 (Pink) possessed both dominant and recessive genes with positive effect. The predominance of alleles producing positive effects was evident for all the parents for this character.

The difference in the performance of F_1's over their parents averaged over all loci revealed the dominance relationship in the character expression. This dominance relationship with respect to all characters can be observed from Fig. 11 (a, b and c).

Low plant height, shorter length and width of leaf blade, smaller leaf size, lesser inclination of the candle with the spathe, candle with less number of flowers and long life of the spadix were the characters which are dominant over the others. All these are commercially valuable characters.

Combining ability analysis

Anthurium is a cross pollinated crop and considerable degree of variability is expected in this crop. In anthurium, seed propagated progenies show segregation for vegetative and floral characters because plants are highly heterozygous. They may show great variation in flower production, spathe colour, spathe shape and general vigour in even among the progenies of the same cross.

The additive nature of gene action is represented by the general combining ability (gca) effects of the parents involved in the cross. The performance of the parent is also considered in unison with the gca effect of the parent because the performance of the parent is an authentic guide for the selection of the parent with respect to its gca effect. A parent showing high gca variance has a significant role in the choice of the parent. A parent showing high gca variance, low specific combining ability (sca) variance and with high gca effects and better performance will certainly be a right choice as a component of a synthetic variety. A parent with high gca and sca variances is a better one for creating high yielding specific combinations because high sca variance arise mainly from high specific combining effects to transmit its genes into hybrid progenies.

Gene action in terms of combining ability of the parents and their hybrids is studied using Griffing's method of analysis of diallel crosses. The additive nature of gene action is studied through the gca effects of the parents and non-additive gene action especially the dominance deviation is studied through the sca effects in character expression. Significant differences in the gca effects of parents are found to be significant in the case of all characters to name a few ie., internode length, days from emergence to maturity of leaves, number of leaves, days from emergence to maturity of inflorescence and number of spadices/plant. A comparison of gca effects of parents and sca effects of crosses are seen from Fig. 12 (a, b and c) and 13 (a, b and c).

P and HR were the parents with significant positive and negative gca effects. The average height of P was 68.20 cm and HR is 58.40 cm. The mean height of all the hybrids was 64.20 cm. The parent HR showed the maximum negative gca effect (-2.789 cm) which was statistically significant. Negative gca effect for plant height was also observed for CR (-2.417 cm) and LR (-0200 cm), though the values were not significant. This indicates HR and CR to be desirable parents for the production of F_1 hybrids with lower height.

LR recorded a significant negative gca effect for the character internode length (-0.081 cm). The sca variance was higher than gca variance. Hence LR is a desirable parent for producing F_1 hybrids with less internode length. The expression of the character, length of leaf blade is due to non-additive nature of gene action. As far as this character is considered LR, KR and CR may be desirable parents for producing hybrids with smaller sized leaves. Considering the width of leaf blade, the high sca variance with significant negative gca effects for LR, KR and CR indicates that these parents may be desirbale combiners for hybridisation.

Leaf area / leaf size is a character influenced by non additive gene action. The gca variance is less than sca variance, but with negative and significant gca effects, KR, CR and LR may be considered as desirable combiners to produce the next generation with smaller leaves. In the case of suckering ability positive gca effect is preferred over negative gca effect. The parents P and LR exhibited significant positive gca effect with almost the same value for sca and gca variances. So P and LR may be potential specific combiners as far as for suckering ability is considered.

Additive gene action is important for the expression of the character "time taken for first flowering", with lowest number of days taken by KR. The gca variance is greater than sca variance. So KR may be considered a right choice as a parent to produce hybrids. Non additive gene action is important for the character expression "length and width of the spathe". The gca variance is low compared to sca variance. The variety LR may be desirable parent for the production of F_1 hybrids as far as these characters are considered. In anthurium, flowers with less candle length is preferred. The sca variance is found to be predominant over gca variance but LR and CR are having smaller candle length compared to other parents. So for developing hybrids with smaller candle length, LR and CR may be chosen as parents.

Non-additive gene action is important in the expression of the character "inclination of candle with the spathe". Parents KR, CR and LR can be selected as better combiners to produce F_1 hybrids for this character based on the significant negative gca effects observed. Less number of flowers/candle is considered a desirable character in anthurium. Significant negative gca effects have been observed for this character in LR and CR. So they are potential specific combiners to produce F_1 hybrids. The sca variance is greater than gca variance which signifies the importance of non-additive gene action. Positive gca effect was exhibited by HR and P for the character "life of spadix". But the gca effect of HR alone is significant. The gca variance is greater than sca variance. The parent HR can be selected as a general combiner for the production of F_1 hybrids as far as life of spadix is considered. Parents with significant negative gca effects are preferred for the character expression of days to initiation of female phase. The variety KR is the only parent which registered negative significant gca effect. The gca variance is less than sca variance. KR is found to be a desirable parent for the production of F_1 hybrids for the improvement of this character. As far as the duration of female phase is considered a positive value is preferred and as such HR and KR may be considered desirable for the production of F_1 hybrids. Shortest interphase is preferred over longest interphase. The parents HR and CR were the only parents which registered significant negative gca effect for this character. So these varieties will be potential specific combiners useful for transgressive breeding. A positive gca effect is preferred for this character duration of male phase. The parent KR is the only parent to be recommended as a potential combiner for the duration of male phase. High pollen fertility percentage is a desirable character for anthurium. LR alone registered a high positive significant gca effect. With high sca variance and significant gca effect LR may be recommended as a desirable parent for hybridisation for improvement of pollen fertility.

Anthocyanins contribute various colours to the spathe of anthurium. The parents LR, KR and CR registered positive significant gca effects. So the above parents may be desirable for producing F_1 hybrids with increased anthocyanin content and enhanced colour intensity. Carotenoids are predominantly orange or red orange pigments. They prevent chlorophyll degradation and pass the energy to chlorophyll for ultimate use in photosynthesis. Parents KR, LR and HR registered positive significant gca effects. So these varieties may be desirable parents for producing F_1 hybrids with increased carotenoids.

Heterosis

Considerable degree of heterosis is expected in cross pollinated crops. The progress in crop improvement depends on a better understanding of heterosis. The superiority / inferiority on the performance of F_1 over the parents in terms of the characters under study is heterosis. It is estimated as the amount by which the mean performance of F_1 differs from the parental mean, which may be positive or negative. In certain characters negative heterosis is preferred.

Anthurium is an export-oriented ornamental cut flower crop with much commercial value. In ornamental crops the commercial usefulness of a hybrid primarily depends upon its performance in comparison with the best commercial variety. The variety LR is being considered as the best semi-commercial variety under the present study. A knowledge of the superiority of the F_1 hybrids developed over this semi-commercial variety is of immense value for both the plant breeder as well as for the farmer. So the heterosis of the hybrids against LR was studied in detail. [Fig. 14 (a, b and c)].

Plants of medium height are preferred. A negative heterosis has much value as far as this character is concerned. The hybrids HR x LR, HR x KR and HR x CR with significant negative heterosis have an average plant height less than that of LR.

Plants with shorter internodes are preferred over longer internodes. Significant negative heterosis is of importance here. All the hybrids recorded significant negative heterosis and the mean value is much less than that of LR and all hybrids are found to be equally good. Less number of days for emergence to maturity of leaves is ideal for anthurium. The hybrids P x CR and LR x CR registered a high significant negative heterosis whose mean value is much less than that of LR. Again, in anthurium, plants with medium length for the leaf blade is of importance. Significant negative heterosis is observed for all the F_1's and all the hybrids are superior to LR. All the hybrids except HR x P, HR x LR, HR x KR, P x LR and P x CR recorded negative heterosis for width of leaf blade. The hybrids HR x CR, P x KR, LR x KR and LR x CR possessed high significant negative heterosis and its mean value is much lower than that of LR. Significant negative heterosis is observed in the case of leaf area for all the hybrids except for HR x P, P x LR and P x CR.

Plants with more number of suckers/plant is an ideal and a very desirable character. None of the hybrids was found to have more suckers than LR parent. All the hybrids took less number of days than LR for first flowering. Lesser number of days for the emergence to maturity of inflorescence is a preferred character for anthurium. A high significant negative heterosis is preferred here. The hybrids HR x P and HR x LR recorded a significant negative heterosis and its average value is lesser than that of LR. Plants with medium length and width for spathe is preferred for export market. Significant negative heterosis was registered by hybrids P x LR, P x KR and P x CR whose mean value is much less than that of LR. For width of spathe LR x CR is the only cross with significant negative heterosis whose mean value is less than that of LR. The average number of spadices/plant is seven in LR. Hybrids with more number of spadices/plant is preferred. HR x LR is only hybrid with significant positive heterosis. Plants with short candle length are desirable and for this character, a negative heterosis is important. P x LR is the only hybrid having a significant negative heterosis and its average candle length was less than that of LR.

All the hybrids except HR x P are found to have less inclination for the candle with the spathe than LR. Flowers with short candles curving towards the tip of the spathe and with an angle preferably less than 45^{o} are ideal for packing (Mercy and Dale, 1994).

The average life of spadix for all the crosses are greater than that of LR. All the hybrids except LR x KR, LR x CR and KR x CR are superior to LR for this character. Lesser number of days for the initiation of female phase is ideal and all the hybrids except HR x CR are found to take less number of days to initiation of female phase than LR. None of the hybrids has more duration of female phase than LR. The hybrids HR x LR, HR x KR, P x KR, LR x KR, LR x CR and KR x CR have more number of days in male phase than in LR. The average pollen fertility for LR is 40.90 per cent. None of the hybrids has a better pollen fertility than LR. Reports are available that pollen sterility is quite high in anthurium ie., 60-75 per cent (Mercy and Dale, 1994). This reveals the hybrid nature of this crop. All the hybrids registered significant negative heterosis for total anthocyanin contents and carotenoids and all had lower anthocyanin and carotenoids than LR which is the parent variety with maximum anthocyanin content in the study.

In conclusion, the genetic divergence analysis conducted on 100 genotypes in *Anthurium andreanum* revealed significant genotypic differences for almost all the characters. All characters were highly influenced by genotypic variation excepting for number of spadices per plant per year which was under environmental control. This clearly indicates that flower productivity can be enhanced by manipulating the environment. The 100 genotypes were grouped into 17 clusters using Mahalanobis D^2 statistic and the cluster C_{11} was found to have maximum inter-cluster distance followed by C_{17}. These results suggest that selection of parents from these divergent clusters will be effective in future hybridisation programmes. The characters leaf area and suckering ability were found to contribute maximum for the divergence of the genotypes and these two characters can be considered as potential contributors of differentiation in anthurium. Gene action was studied by diallel analysis of five selected parents and their ten hybrids. Dominance (over dominance) gene action was found to be responsible for all the characters in their expression. Heterosis of F_1's over the parent LR (which was the most acceptable variety under the study) was worked out. Most of the F_1 hybrids registered negative heterosis for many characters such as plant height, leaf size, candle length, inclination of candle etc. This is highly desirable in anthurium where short height, medium sized leaves, small candles and reduced angle of inclination of candle are commercially preferred.

Earlier reports on the genetics of spathe colour in anthurium, have identified two genes to control the production of anthocyanin pigments to give rise to different spathe colour shades ranging from dark maroon to red to pink to orange to coral to white. Based on their anthocyanin contents, the probable spathe colour genotypes of five selected parents and their ten F_1 hybrids of anthurium in the present study have been worked out for the first time by correlating the total average anthocyanin content of the spathe of each variety to the incremental effect of anthocyanin producing genes, M and O.

Anthurium andreanum is a native of Columbia and is now a very high value cut flower crop of significance in the Netherlands, Hawaii, Mauritius, Philippines, Sree Lanka etc., where hybrids for commercial cultivation are being evolved through hybridisation. It is an introduced crop in Kerala where cultivation depends on imported varieties. This pioneer study highlights the use of hybridisation for producing commercially viable indigenous hybrids here which can replace the imported varieties in the near future to establish an anthurium cut flower industry in Kerala.

SUMMARY

6. SUMMARY

Genetic divergence studies were conducted on 100 different genotypes of *Anthurium andreanum* Linden, comprising of 20 varieties and 80 F_1 hybrids generated from a previous hybridization programme in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani. As the parental varieties themselves had a long history of hybridization in their background, the entire material was highly heterozygous. The results of the analysis are summarised below.

- Significant genotypic differences were observed among the hundred genotypes for all the ten characters namely plant height, spathe length, spathe width, number of suckers per plant, length of leaf blade, width of leaf blade, candle length, inclination of candle with the spathe, number of spadices per plant per year and leaf area.

- Except for number of spadices/plant/year, all the characters were highly influenced by genotypic variation.

- Maximum variability both at phenotypic and genotypic level was observed for number of suckers per plant followed by leaf area.

- Based on Allards classification of heritability, high heritability with a good genetic advance was found for all the characters studied, except for number of spadices/plant/year which exhibited medium heritability and low genetic advance.

- These results indicate that selection of plants which are phenotypically superior with respect to the nine characters, namely plant height, spathe length, spathe width, number of suckers/plant, length of leaf blade, width of leaf blade, candle length, inclination of candle and leaf area will certainly result in a significant improvement in the next generation.

- Most of the characters were correlated with each other both at phenotypic and genotypic levels. Only spathe length was uncorrelated with suckering ability, inclination of candle and number of spadices per plant/year at phenotypic and genotypic levels.

- Environmental correlation was absent for all the characters except for number of spadices/plant/year indicating the influence of environment on this character suggesting the possibility of improving productivity (of flowers) of the crop by manipulating the environment.

- The 100 genotypes of anthurium were grouped into seventeen clusters using Mahalanobis D^2 statistic.

- Three hybrid genotypes (Honeymoon Red x Lady Jane [HR x LJ(1)], Ordinary Orange x Kalympong Red [OO x KR(3)] and OO x KR(8)), could not be grouped with others and so are kept as independent as clusters C_{15}, C_{16} and C_{17}.

- The cluster C_{11} was found to have maximum intercluster distance with eleven of the seventeen clusters formed. This was followed by C_{17} which showed maximum divergence between five out the seventeen clusters.

- The results suggest that selection of parents from these divergent clusters will be effective in future hybridization programmes.

- Leaf area and suckering ability were found to be the two characters that contributed maximum for the divergence of the genotypes. So both at phenotypic and cluster levels, these two characters can be considered as potential contributors of differentiation in *Anthurium*.

- Five parents namely 'Honeymoon Red' (HR), 'Pink' (P), 'Liver Red' (LR), 'Kalympong Red' (KR) and 'Chilli Red' (CR) which produced compatible crosses and their 10 hybrids were selected as base material for Experiment No. 2. They were raised in a diallel fashion in completely randomised design with five replications. Among these Honeymoon Red and Pink belonged to the same cluster.

- The gene action was studied using both Hayman's and Griffing's approaches of diallel analysis. Twenty four characters – eight vegetative and sixteen floral – were studied.

- Dominance (over dominance) gene action was responsible for all the characters in their expression.

- Standardised Yr^1 - $(Wr + Vr)^1$ graph revealed that for almost for all the characters except for plant height, the selected parents possessed most of the dominant genes with positive effects.

- Of the 24 characters studied, the parent 'Pink' carried maximum dominant alleles (over dominance) for six characters, 'Chilli Red', 'Liver Red' and 'Kalympong Red' for five characters each and 'Honeymoon Red' for three characters (Table 5.2).

- The gca effect of the parents was significant for all the characters except for internode length, days from emergence to maturity of leaves, days from emergence to maturity of inflorescence and number of spadices per plant per year.

- Based on the gca and sca effects, the parent 'Honeymoon Red' was found to be the best general combiner for several traits like plant height, width of leaf blade, length of spathe, number of spadices/plant/year, duration of female phase, days of interphase, life of spadix and carotene content.

- For the characters, length and width of leaf blade, leaf area, time taken for first flowering, inclination of candle, days to intiation of female phase, duration of male phase, duration of female phase, total anthocyanin content and total carotenoids, the best general combiner was 'Kalympong Red'.

- For the characters, plant height, length and width of leaf blade, suckering ability, the best general combiner was 'Pink'.

- The parent 'Chilli Red' was the best general combiner for characters viz., days from emergence to maturity of leaves, length and width of leaf blade, leaf area, candle length, inclination of candle, number of flowers/candle, total antocyanin content and days of interphase.

- The parent 'Liver Red' was the best general combiner for characters namely candle length, inclination of candle, internode length, length and width of leaf blade, leaf area, suckering ability, number of flowers/candle, pollen fertility, total anthocyanin content and total carotenoids.

- The heterosis of F_1's over parent 'Liver Red', which is the most acceptable semi-commercial variety under the study, was worked out. Most of the F_1 hybrids registered negative heterosis, for characters such as plant height, length and width of leaf blade, days from emergence to maturity of leaves, leaf area, time taken for first flowering and inclination of candle. This is highly desirable in the case of anthurium, because, the best commercial varieties of *Anthurium* should have medium plant height with medium sized leaves for accommodation of more plants within a unit green house area, earliness to maturity of leaves and shorter time taken for first flowering for enhancing the number of leaves and flowers/plant/year and a reduced inclination of candle for accommodating more flowers at the time of packing for transportation.

- For the character internode length, all the crosses were found to have negative heterosis which again will reduce the height of plant and hence is a desirable attribute.

- Pollen fertility in all the parent varieties under the study is low ranging from 19.70 per cent to 40.70 per cent. The hybrids also recorded low fertility of 23.14 per cent to 34.77 per cent.

- Based on the anthocyanin contents, the probable spathe colour genotypes of five selected parents and their 10 F_1 hybrids of the present study have been worked out for the first time in anthurium by correlating the total average anthocyanin content of the spathe of each variety to the incremental effect of the two anthocyanin producing genes, M and O.

To sum up, this pioneering study, the first of its kind in *Anthurium*, indicates that hybridisation is the easiest and sure method for achieving genetic improvement in this export oriented cut-flower crop. Reductions in plant height, leaf size, leaf area, days to maturity of leaves, days to first flowering and inclination of candle observed in the hybrids when compared with the parents are highly desirable attributes of commercial hybrids. The fact that the character number of spadices/plant/year is controlled by the environment indicates that flower productivity can be enhanced by judicial manipulations of environmental conditions. Spathe colour genotypes of five parents and their ten hybrids have been determined for the first time based on the anthocyanin pigment assay of their spathes. The study highlights the feasibility of producing commercially viable indigenous anthurium hybrids for commercial cultivation in Kerala.

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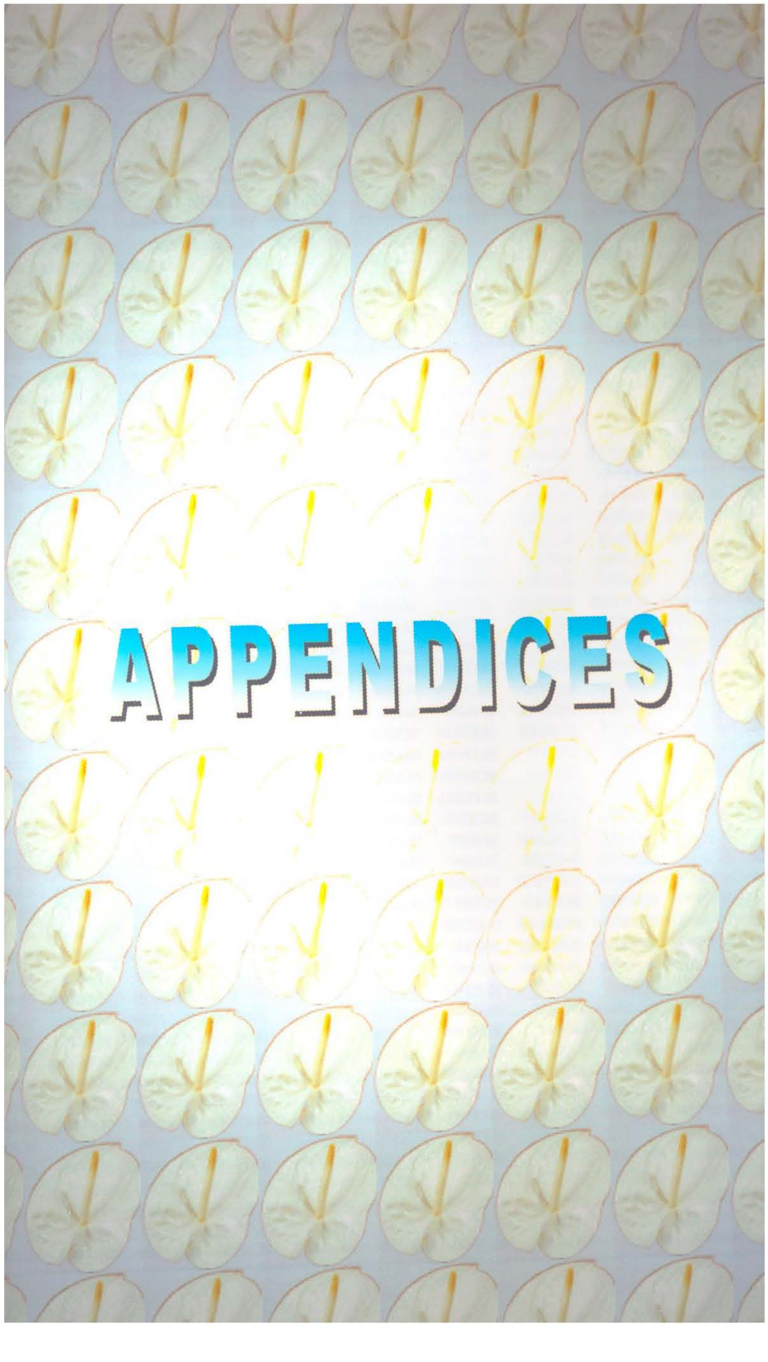
APPENDICES

Appendix I

D^2 values

	1	2	3	4	5	6	7	8	9	10	
1	0.00	66937.68	97279.81	1577803.00	1655120.00	2801.65	46935.69	300966.10	166848.70	424711.20	1
2	66937.68	0.00	4622.95	1000453.00	1061919.00	90332.88	2089.54	645795.80	440440.50	820387.10	2
3	97279.81	4622.95	0.00	893379.90	951203.20	126360.30	12211.19	739820.80	518143.60	927255.10	3
4	1577803.00	1000453.00	893379.90	0.00	1179.46	1689547.00	1090338.00	3250739.00	2766937.00	3628127.00	4
5	1655120.00	1061919.00	951203.20	1179.46	0.00	1768760.00	1154670.00	3362059.00	2869192.00	3746067.00	5
6	2801.65	90332.88	126360.30	1689547.00	1768760.00	0.00	66602.00	256231.10	133521.50	371376.90	6
7	46935.69	2089.54	12211.19	1090338.00	1154670.00	66602.00	0.00	577027.60	384231.30	742276.70	7
8	300966.10	645795.80	739820.80	3250739.00	3362059.00	256231.10	577027.60	0.00	19890.87	10901.14	8
9	166848.70	440440.50	518143.60	2766937.00	2869192.00	133521.50	384231.30	19890.87	0.00	59868.79	9
10	424711.20	820387.10	927255.10	3628127.00	3746067.00	371376.90	742276.70	10901.14	59868.79	0.00	10
11	264239.20	591736.40	681252.60	3129746.00	3238327.00	221526.80	526222.80	1677.19	11191.76	20236.73	11
12	149972.60	413116.00	487917.40	2697859.00	2798580.00	118147.40	358881.30	26794.68	624.44	71621.82	12
13	11185.96	24465.48	44907.19	1334526.00	1405048.00	21014.49	13320.88	422244.00	259449.50	566425.80	13
14	312111.10	662801.60	757284.50	3289761.00	3401353.00	266021.50	593257.60	356.11	22672.44	9691.37	14
15	223512.70	529960.10	614991.80	2984797.00	3091107.00	184808.40	467965.70	5912.41	4177.45	32655.97	15
16	40008.12	206031.60	260565.10	2113310.00	2202648.00	24626.43	168241.00	122541.50	44036.62	205162.50	16
17	73359.81	276366.80	338796.50	2326096.00	2420139.00	52431.42	232183.40	77363.60	19187.12	145219.30	17
18	435338.60	837874.50	943853.10	3665007.00	3783396.00	381658.60	759176.50	12612.09	63801.78	833.53	18
19	541616.00	983459.40	1097694.00	3963696.00	4086654.00	481142.90	898193.80	35479.63	107864.70	8454.53	19
20	333185.70	102689.90	71252.33	464399.20	505877.20	383530.80	133178.80	1262854.00	967614.50	1503190.00	20
21	149255.00	407424.60	484886.10	2681454.00	2782669.00	118158.50	352900.70	28091.16	2027.26	71714.28	21
22	287796.20	624134.20	718151.20	3201946.00	3312466.00	243685.00	556244.50	597.88	16924.39	13547.83	22
23	312271.20	661363.40	757087.00	3286484.00	3398226.00	266054.50	591649.80	249.58	22746.63	9031.15	23
24	481912.80	900249.10	1011256.00	3796257.00	3916378.00	424059.10	818541.70	21275.68	81774.07	2338.60	24
25	1584.16	70243.23	104474.40	1597489.00	1675779.00	3263.49	48856.46	290672.80	159864.20	411095.90	25
26	24412.31	164352.20	214907.70	1972576.00	2059511.00	13797.57	130479.90	159040.70	67696.79	250501.60	26
27	186894.00	469393.00	551800.10	2836815.00	2941000.00	152054.50	410754.00	14593.73	1685.82	48739.64	27
28	112821.30	344787.00	416498.10	2514756.00	2613108.00	86831.84	294678.30	48010.65	7854.10	101865.80	28
29	205927.20	500001.20	584569.30	2911325.00	3016861.00	169375.40	439443.30	9731.36	2966.70	39486.11	29
30	42124.60	209660.60	265367.20	2123973.00	2213925.00	26851.95	171310.00	119580.00	42663.66	200717.40	30
31	15282.44	21332.98	43381.24	1309618.00	1380418.00	26540.07	10285.66	434694.10	270423.80	579054.70	31
32	10726.75	27175.13	50937.14	1356348.00	1427937.00	19630.84	14640.57	408878.40	249694.00	549746.50	32
33	313400.00	92860.09	62177.31	484958.50	528174.30	364370.50	121789.00	1225679.00	935615.70	1462474.00	33
34	19028.29	16793.26	36048.14	1267368.00	1337408.00	32961.33	7367.31	458835.60	289758.90	606974.80	34
35	633821.00	291144.20	235378.80	212719.40	241174.60	704022.80	340739.40	1803545.00	1447412.00	2088040.00	35
36	236046.70	52749.09	31050.45	594683.30	642192.60	279632.50	75119.04	1066439.00	796968.60	1288125.00	36
37	242497.20	55755.16	33680.21	584655.50	631922.00	286785.70	78612.33	1079489.00	808471.40	1302243.00	37
38	144518.20	401447.60	477257.50	2667864.00	2768454.00	113513.70	347512.00	29146.74	1285.98	74448.41	38
39	79788.10	285637.00	350617.20	2353998.00	2448404.00	57126.10	240428.80	72841.93	17211.24	138197.90	39
40	243425.40	558203.50	647038.00	3050164.00	3158072.00	203257.90	494137.90	3468.69	7773.99	25232.59	40
41	188786.30	476314.90	556775.60	2853064.00	2957535.00	154531.20	417653.90	13196.71	1212.13	47508.00	41
42	96214.44	315488.50	384108.10	2436703.00	2533136.00	71676.22	267730.30	59122.39	11533.35	118548.70	42
43	85452.62	296104.50	362483.80	2382007.00	2477446.00	62699.92	249939.30	67757.47	15298.46	130827.70	43
44	371238.80	123929.20	90059.42	420572.40	460827.20	425324.60	156729.10	1334391.00	1031196.00	1580068.00	44
45	16219.43	19287.79	40137.82	1294372.00	1364686.00	28158.50	8928.29	443247.40	277018.30	589167.50	45
46	461797.10	873987.20	982477.80	3741276.00	3860695.00	405840.00	793589.70	17293.15	73826.62	1533.43	46
47	33225.62	7014.43	22016.48	1170141.00	1236898.00	49585.57	1586.34	521529.90	339521.10	678799.50	47
48	505062.70	929601.60	1043523.00	3857028.00	3977725.00	444797.80	846391.40	27017.84	91627.62	4543.40	48
49	11198.64	24057.96	44783.48	1329157.00	1400523.00	22716.57	12686.97	422934.40	260770.80	566606.00	49
50	151337.70	411437.30	488935.10	2690557.00	2792211.00	120635.60	356531.70	27140.97	2067.14	70039.88	50

Appendix I (Contd...)

	1	2	3	4	5	6	7	8	9	10	
51	65583.56	261248.50	321882.50	2280314.00	2373725.00	46568.97	218353.10	85967.94	23844.75	156647.50	51
52	218040.70	521614.70	606039.50	2964059.00	3070253.00	180333.70	460098.70	6718.40	3597.55	34406.19	52
53	304885.20	653319.20	746449.30	3266258.00	3377945.00	260515.10	584323.30	425.38	21301.06	10997.38	53
54	288443.90	629114.10	720501.80	3212839.00	3323327.00	244878.10	561568.80	520.62	16950.19	14362.27	54
55	658.09	55172.74	83205.23	1517652.00	1593726.00	5780.22	37196.17	327432.60	186925.00	455807.20	55
56	90588.81	308390.20	374604.80	2416497.00	2512602.00	67435.68	261491.40	61768.50	12190.45	123181.30	56
57	43779.61	213098.30	269360.10	2135272.00	2225393.00	27948.24	174346.20	117031.60	41098.73	197433.50	57
58	163164.10	22268.30	9825.38	727159.70	780265.90	200789.60	37247.34	903091.50	657252.60	1107499.00	58
59	196324.40	36043.20	18227.85	661217.90	711886.10	237738.50	54691.91	980599.80	723475.80	1193607.00	59
60	604012.30	1067659.00	1185921.00	4130622.00	4256103.00	540213.60	978878.80	52992.78	136864.60	17796.28	60
61	181241.50	28833.97	14432.76	691034.90	742708.50	220331.90	45603.58	944455.60	692561.70	1153158.00	61
62	4826.50	100658.50	140330.60	1733953.00	1815169.00	1634.50	74717.41	236669.00	120241.40	346667.10	62
63	220453.10	525664.50	610200.00	2973552.00	3079928.00	182569.90	463968.20	6290.65	3913.76	33578.60	63
64	556167.60	1003527.00	1118409.00	4003927.00	4127407.00	494880.40	917555.30	39466.73	114491.90	10618.68	64
65	395665.00	783588.30	885162.60	3550654.00	3666951.00	344525.70	707950.50	7019.79	49340.06	2084.39	65
66	100202.20	329142.90	394903.60	2471482.00	2568544.00	76268.25	281205.90	54547.97	9238.01	113714.50	66
67	358308.00	728549.30	828287.20	3433547.00	3547901.00	309152.30	655353.10	2509.73	36361.06	3163.72	67
68	376.84	67545.15	99640.54	1584363.00	1661999.00	2605.85	46907.89	296814.70	163923.80	419208.90	68
69	280321.00	615531.50	707199.80	3182798.00	3292828.00	237109.30	548478.20	419.50	14806.31	15279.70	69
70	714864.50	1212260.00	1339227.00	4410354.00	4540272.00	645282.60	1117225.00	88506.06	191804.20	38749.99	70
71	69827.03	270383.10	331555.00	2306295.00	2400299.00	50347.26	226803.20	81133.10	21421.40	150308.10	71
72	162470.20	433488.40	510621.10	2747968.00	2850305.00	130434.70	377613.50	21283.48	286.15	61990.18	72
73	61475.79	250827.80	311523.30	2249561.00	2342426.00	42990.50	208613.10	91943.38	27300.56	164165.60	73
74	13260.62	21212.63	41468.26	1309894.00	1380615.00	25084.03	10554.63	433869.50	269313.00	579081.60	74
75	4056.94	91843.24	130701.30	1695828.00	1776371.00	2171.54	67058.03	250957.00	130854.20	363423.50	75
76	363107.50	736689.00	835957.10	3450510.00	3565184.00	314047.90	663243.00	3115.90	38099.67	3231.63	76
77	9769.04	121642.90	164923.50	1818640.00	1901658.00	3468.24	93044.57	206938.20	99239.52	310670.80	77
78	147066.90	407738.60	482954.70	2681948.00	2783205.00	116916.30	353604.60	27379.18	1055.71	71990.00	78
79	20623.24	156373.50	204874.10	1946542.00	2032460.00	10407.08	123627.10	166637.10	72047.98	260780.00	79
80	5427.15	44604.10	73661.54	1459131.00	1534315.00	12261.23	27907.93	354709.40	208827.00	485686.70	80
81	180625.70	462114.40	542143.70	2820708.00	2924110.00	145968.50	404329.20	15449.68	334.15	51826.38	81
82	160820.60	431397.80	507906.70	2742873.00	2844955.00	128776.20	375792.70	21859.07	205.25	63355.16	82
83	221303.80	528233.30	611859.10	2978877.00	3085269.00	183611.30	466612.00	6511.78	4277.97	34038.14	83
84	98546.44	323175.00	390748.00	2458452.00	2555194.00	73871.29	275210.70	55317.85	9246.18	114286.50	84
85	322871.70	678791.10	774242.90	3324081.00	3436577.00	276614.70	608431.20	528.46	25842.44	7715.16	85
86	53120.74	235497.50	293227.60	2204768.00	2296151.00	35494.15	194946.30	101631.80	31955.02	177831.80	86
87	505693.00	933703.90	1046033.00	3863187.00	3984675.00	447244.30	850520.10	26476.02	92058.74	4087.22	87
88	226500.60	533139.60	619491.30	2991909.00	3098597.00	187661.10	470764.80	5505.07	4816.94	31081.44	88
89	10290.87	124948.10	168267.40	1829746.00	1913291.00	4372.78	95987.26	202950.30	96663.06	305703.00	89
90	1142.85	66062.00	98916.46	1578774.00	1656237.00	2993.73	45364.80	299325.30	165842.60	421749.40	90
91	107784.30	4973.76	1784.75	865605.70	922672.20	137026.80	13257.19	763350.60	538361.80	952360.00	91
92	20397.48	153911.20	202667.30	1936005.00	2022090.00	11033.06	121251.10	169601.20	74526.35	263802.70	92
93	10370.80	27113.34	50497.53	1353743.00	1425740.00	20355.59	14547.07	409292.90	250320.00	550063.60	93
94	50675.44	1520.77	10816.98	1071993.00	1136044.00	71468.06	236.25	589889.10	395015.70	756754.80	94
95	310257.70	658509.30	754027.30	3279606.00	3391373.00	264480.40	588940.10	142.69	22286.64	9182.21	95
96	77682.13	280453.00	345491.70	2337889.00	2432271.00	55705.88	235571.30	75758.03	19072.71	141735.20	96
97	17819.59	149745.20	196744.60	1921636.00	2007232.00	8946.93	117815.50	173848.10	76900.53	269937.80	97
98	119390.40	360631.00	431555.80	2559436.00	2658216.00	92251.33	309806.80	41334.99	4254.72	93813.52	98
99	446860.30	854643.80	960915.60	3700367.00	3819113.00	392277.80	775485.10	14821.46	68253.18	1702.61	99
100	93381.81	314795.80	380790.30	2433439.00	2529949.00	70202.06	267554.10	59283.54	11118.10	119904.60	100

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	11	12	13	14	15	16	17	18	19	20	
1	264239.20	149972.60	11185.96	312111.10	223512.70	40008.12	73359.81	435338.60	541616.00	333185.70	1
2	591736.40	413116.00	24465.48	662801.60	529960.10	206031.60	276366.80	837874.50	983459.40	102689.90	2
3	681252.60	487917.40	44907.19	757284.50	614991.80	260565.10	338796.50	943853.10	1097694.00	71252.33	3
4	3129746.00	2697859.00	1334526.00	3289761.00	2984797.00	2113310.00	2326096.00	3665007.00	3963696.00	464399.20	4
5	3238327.00	2798580.00	1405048.00	3401353.00	3091107.00	2202648.00	2420139.00	3783396.00	4086654.00	505877.20	5
6	221526.80	118147.40	21014.49	266021.50	184808.40	24626.43	52431.42	381658.60	481142.90	383530.80	6
7	526222.80	358881.30	13320.88	593257.60	467965.70	168241.00	232183.40	759176.50	898193.80	133178.80	7
8	1677.19	26794.68	422244.00	356.11	5912.41	122541.50	77363.60	12612.09	35479.63	1262854.00	8
9	11191.76	624.44	259449.50	22672.44	4177.45	44036.62	19187.12	63801.78	107864.70	967614.50	9
10	20236.73	71621.82	566425.80	9691.37	32655.97	205162.50	145219.30	833.53	8454.53	1503190.00	10
11	0.00	16206.20	377987.20	2096.99	1792.19	99496.97	59616.21	22102.74	49995.06	1186398.00	11
12	16206.20	0.00	238140.60	29668.86	7591.51	35773.45	14111.86	75457.16	122588.60	926353.20	12
13	377987.20	238140.60	0.00	435332.70	329259.80	89886.57	138313.10	579869.30	701475.50	225382.60	13
14	2096.99	29668.86	435332.70	0.00	7434.32	129789.70	83310.96	10625.37	31717.40	1286274.00	14
15	1792.19	7591.51	329259.80	7434.32	0.00	75167.91	41020.52	35398.92	69715.66	1098423.00	15
16	99496.97	35773.45	89886.57	129789.70	75167.91	0.00	5255.25	213282.80	289422.00	598931.50	16
17	59616.21	14111.86	138313.10	83310.96	41020.52	5255.25	0.00	151907.20	217194.00	715405.70	17
18	22102.74	75457.16	579869.30	10625.37	35398.92	213282.80	151907.20	0.00	5938.19	1526520.00	18
19	49995.06	122588.60	701475.50	31717.40	69715.66	289422.00	217194.00	5938.19	0.00	1720732.00	19
20	1186398.00	926353.20	225382.60	1286274.00	1098423.00	598931.50	715405.70	1526520.00	1720732.00	0.00	20
21	18771.70	2303.23	236019.00	32393.26	9284.60	35042.72	13697.33	77972.87	126382.90	918777.50	21
22	1550.40	23478.74	405464.50	1521.69	4641.83	113699.70	70576.47	16492.25	41593.24	1232602.00	22
23	2373.40	30003.04	434841.80	322.69	7548.65	129432.30	83041.18	10889.75	32223.35	1284546.00	23
24	32784.27	94840.98	632003.50	18557.58	49104.79	245332.00	179478.60	1676.79	2347.89	1610268.00	24
25	255528.60	143994.30	13473.21	302536.50	215228.60	36338.56	68401.11	423498.50	528827.20	342425.80	25
26	133658.90	57942.76	64467.46	168093.10	104944.80	3071.22	15017.42	260644.60	344561.40	526587.60	26
27	8566.89	3951.72	283463.50	17918.64	2892.92	54394.03	26235.36	53903.19	95158.26	1010807.00	27
28	35598.75	6157.82	189655.90	53667.16	21639.22	19220.57	5025.20	109168.90	165637.00	823455.00	28
29	5195.44	6155.84	307166.50	12547.67	1323.65	64924.35	33568.86	44032.01	81940.53	1055547.00	29
30	97410.05	34960.00	93031.24	127208.00	73179.15	275.54	4733.05	209359.90	285125.30	605568.50	30
31	391305.00	249571.60	1968.36	449190.00	341184.20	96494.08	145923.50	594522.50	718230.80	216808.30	31
32	366245.90	229385.00	1093.52	422557.50	318018.70	84140.19	130992.00	564484.70	684946.30	234965.90	32
33	1151221.00	895422.50	210835.90	1249160.00	1064112.00	573945.10	687395.20	1484900.00	1676946.00	1443.54	33
34	414642.90	268261.90	3048.73	473888.90	362777.20	108240.60	159950.00	622334.50	748924.50	200862.50	34
35	1712711.00	1397219.00	482242.30	1832025.00	1606308.00	986647.60	1134225.00	2115817.00	2343872.00	48554.21	35
36	996723.60	759727.10	147580.20	1088182.00	915983.90	466446.60	569535.00	1309435.00	1489911.00	8568.58	36
37	1009606.00	771084.00	152735.90	1101552.00	928264.10	475248.30	579180.50	1323905.00	1505383.00	7596.02	37
38	18798.31	917.74	230466.40	32942.83	9199.99	32604.87	12032.47	79878.21	128711.10	909707.10	38
39	55647.51	12724.61	145433.20	78757.72	37890.52	6904.01	610.68	145776.70	209826.00	730477.40	39
40	1472.96	12527.24	352733.40	5268.18	990.94	86603.53	49552.16	28804.76	60507.04	1139343.00	40
41	7106.46	3252.10	287640.50	15880.98	1888.59	56179.73	27137.31	50882.96	91131.32	1020633.00	41
42	44403.46	8435.39	167473.60	64893.54	28640.70	12434.94	2094.95	126023.00	186076.20	777744.50	42
43	51913.82	11462.22	153456.00	73919.60	34662.16	8886.36	976.69	138476.40	201204.30	747190.10	43
44	1256872.00	989206.60	257576.00	1359248.00	1165829.00	649178.50	769724.10	1604808.00	1804282.00	1803.46	44
45	399287.20	255837.80	1757.82	457776.70	348644.30	100334.00	150716.00	604497.30	729199.60	210489.20	45
46	27886.32	86216.36	609805.20	14778.32	42954.67	231582.20	167550.60	498.42	3308.63	1575080.00	46
47	473610.00	315938.90	6905.47	537236.80	418410.30	139213.10	197764.50	695491.60	828733.50	162159.60	47
48	39243.78	105409.60	657035.60	23958.43	57002.12	261366.60	193660.20	4443.82	2904.60	1649307.00	48
49	379901.10	239928.90	959.18	436849.00	330502.40	90684.59	138672.10	580390.80	702530.50	224873.00	49
50	18272.22	2575.83	239298.90	31488.74	8862.32	36358.65	14349.31	76050.08	124156.80	924997.30	50

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	11	12	13	14	15	16	17	18	19	20	
51	67540.97	18330.13	128031.50	92441.74	47565.80	3708.11	365.97	163643.00	231306.70	691045.50	51
52	2537.48	6960.54	322934.50	8585.62	138.18	72157.37	38668.67	37381.75	72660.72	1086589.00	52
53	2255.03	28184.91	427933.40	441.62	6809.67	125886.20	79910.88	11683.96	33835.23	1273121.00	53
54	968.88	23062.49	408020.30	641.99	4466.98	115231.90	71606.29	15300.43	39601.68	1239075.00	54
55	289447.00	169173.00	7084.40	339337.40	246615.50	50006.37	86677.32	467136.90	577112.80	306194.00	55
56	46462.94	8622.60	161615.40	67403.58	30169.87	10615.62	990.62	129697.50	190578.60	766577.30	56
57	94996.18	33456.48	95227.33	124488.20	71128.23	279.13	4261.58	205988.50	281144.50	611338.90	57
58	839826.30	623935.40	92297.85	923610.70	765524.00	361292.80	452162.20	1127417.00	1295579.00	31356.14	58
59	914480.40	688264.00	117879.50	1001762.00	836907.50	410893.30	507407.90	1213624.00	1387744.00	19500.98	59
60	70258.94	153272.50	772602.70	48247.44	93419.12	335862.40	257660.60	14113.14	1791.04	1831408.00	60
61	879613.80	658286.70	105558.70	965392.60	803593.50	387487.20	481567.70	1173696.00	1345155.00	24033.59	61
62	204658.60	106437.70	27251.15	247098.20	168868.60	18843.10	43499.81	357748.20	454983.00	406453.30	62
63	2292.43	7314.62	326002.50	8063.81	122.71	73637.06	39758.55	36340.58	71143.26	1092275.00	63
64	54511.87	129599.80	718255.00	35386.43	75116.07	300324.10	226680.00	7691.61	177.64	1747175.00	64
65	14010.49	59435.94	534203.10	5337.34	24996.46	186219.30	129296.40	1221.91	11505.76	1452490.00	65
66	39935.76	5903.80	175844.50	59250.19	25156.58	15112.25	2938.23	118264.80	176204.10	797932.00	66
67	7567.82	45403.00	489584.70	1799.11	15955.72	159976.80	107665.20	4003.52	19238.92	1377618.00	67
68	260657.20	147437.40	11574.30	308238.50	220074.80	38202.11	71131.10	430653.30	536663.30	335947.90	68
69	562.11	20858.99	397737.60	1033.50	3301.34	109526.80	67110.60	17239.98	43013.78	1220469.00	69
70	110934.60	211444.00	897023.60	82761.00	139522.60	419201.00	331160.50	34550.46	12071.86	2019794.00	70
71	63353.11	16183.76	134323.40	87392.13	44041.28	4896.11	275.60	156811.60	223114.80	705541.10	71
72	12765.86	957.40	254630.10	24525.55	5046.04	42065.89	17668.07	66133.90	111219.80	957643.40	72
73	73141.75	21552.73	121294.60	98939.15	52256.13	2762.58	937.46	172118.70	241436.20	674155.80	73
74	390172.10	248171.40	902.51	447987.70	340136.00	95652.66	144960.30	593386.40	716845.80	216637.80	74
75	218394.70	116687.40	23404.09	262050.70	181287.00	23335.71	49987.84	375375.40	474898.50	388550.30	75
76	8388.19	47218.35	495947.10	2145.81	17138.57	163736.70	110659.50	3351.42	17842.85	1388680.00	76
77	176943.30	86661.91	38272.40	216617.80	143872.70	11102.96	31374.61	321179.50	413426.60	447397.40	77
78	17799.89	986.37	235162.30	31247.37	8360.12	34413.90	12828.73	76733.57	124851.60	919110.10	78
79	139896.90	61514.76	58657.85	175370.30	110645.20	3486.45	17023.57	270419.90	355583.20	512106.20	79
80	316411.60	191083.20	5929.17	368306.20	271270.50	61753.19	101645.60	500027.00	614132.20	281453.50	80
81	8125.15	1761.98	276401.80	18085.51	2365.32	51107.35	23874.14	55758.10	97407.35	999771.60	81
82	12985.58	548.41	252550.50	24903.75	5230.07	41265.27	17222.25	67119.82	112281.00	954115.20	82
83	2367.92	7543.28	327646.10	8000.85	353.77	74677.50	40552.48	36069.73	70561.37	1095631.00	83
84	40657.63	6066.99	172042.60	60493.45	25579.46	13270.07	1883.52	120413.30	179141.50	789618.50	84
85	3377.33	33461.97	448616.50	256.98	9331.30	137049.00	88954.49	8522.92	28216.02	1308684.00	85
86	80856.55	25112.24	109728.00	108278.90	59034.01	1063.01	1692.65	185218.40	256649.50	648619.70	86
87	39555.10	105963.00	660102.80	23553.36	57107.85	262910.00	194310.20	2741.82	817.25	1654957.00	87
88	2028.49	8694.45	332449.80	7421.46	286.70	76665.10	42099.86	34614.42	68740.35	1103353.00	88
89	173573.40	84458.74	40442.97	212718.10	140678.80	10424.67	29810.22	315968.60	407690.00	453829.60	89
90	262999.60	149324.90	11275.58	310887.70	222245.40	39107.80	72458.90	433824.90	540300.10	333109.60	90
91	704407.20	507960.70	50882.89	781762.40	636896.60	274496.70	354960.80	971133.90	1127338.00	62616.49	91
92	143248.10	64240.77	58035.90	178879.60	113449.20	4454.90	18240.36	274049.80	360014.90	507882.70	92
93	367156.20	230207.60	1445.97	423268.50	318629.90	84558.78	131134.30	564673.80	685351.30	234921.60	93
94	538920.10	369443.30	15533.78	606573.00	479832.50	175414.90	240450.70	773974.10	914255.80	127161.50	94
95	2355.55	29575.76	432698.70	388.98	7287.35	128221.20	81986.65	11123.38	32790.34	1280658.00	95
96	58684.18	14584.54	142281.10	82134.13	40353.85	6555.71	858.66	149871.00	214766.20	722185.30	96
97	146705.30	65970.48	54643.01	182813.10	116615.80	4698.57	19318.12	279384.40	365871.90	499887.70	97
98	28936.38	2444.73	199620.50	45845.21	16434.16	21677.12	5620.81	99158.72	153057.20	847616.10	98
99	24611.70	80099.76	593266.50	12404.75	38820.64	221620.20	159052.40	295.20	4600.70	1548797.00	99
100	44305.91	7698.25	166106.30	64698.46	28423.90	11926.97	1400.76	125803.00	185820.20	776486.60	100

Appendix I (Contd...)

	21	22	23	24	25	26	27	28	29	30	
1	149255.00	287796.20	312271.20	481912.80	1584.16	24412.31	186894.00	112821.30	205927.20	42124.60	1
2	407424.60	624134.20	661363.40	900249.10	70243.23	164352.20	469393.00	344787.00	500001.20	209660.60	2
3	484886.10	718151.20	757087.00	1011256.00	104474.40	214907.70	551800.10	416498.10	584569.30	265367.20	3
4	2681454.00	3201946.00	3286484.00	3796257.00	1597489.00	1972576.00	2836815.00	2514756.00	2911325.00	2123973.00	4
5	2782669.00	3312466.00	3398226.00	3916378.00	1675779.00	2059511.00	2941000.00	2613108.00	3016861.00	2213925.00	5
6	118158.50	243685.00	266054.50	424059.10	3263.49	13797.57	152054.50	86831.84	169375.40	26851.95	6
7	352900.70	556244.50	591649.80	818541.70	48856.46	130479.90	410754.00	294678.30	439443.30	171310.00	7
8	28091.16	597.88	249.58	21275.68	290672.80	159040.70	14593.73	48010.65	9731.36	119580.00	8
9	2027.26	16924.39	22746.63	81774.07	159864.20	67696.79	1685.82	7854.10	2966.70	42663.66	9
10	71714.28	13547.83	9031.15	2338.60	411095.90	250501.60	48739.64	101865.80	39486.11	200717.40	10
11	18771.70	1550.40	2373.40	32784.27	255528.60	133658.90	8566.89	35598.75	5195.44	97410.05	11
12	2303.23	23478.74	30003.04	94840.98	143994.30	57942.76	3951.72	6157.82	6155.84	34960.00	12
13	236019.00	405464.50	434841.80	632003.50	13473.21	64467.46	283463.50	189655.90	307166.50	93031.24	13
14	32393.26	1521.69	322.69	18557.58	302536.50	168093.10	17918.64	53667.16	12547.67	127208.00	14
15	9284.60	4641.83	7548.65	49104.79	215228.60	104944.80	2892.92	21639.22	1323.65	73179.15	15
16	35042.72	113699.70	129432.30	245332.00	36338.56	3071.22	54394.03	19220.57	64924.35	275.54	16
17	13697.33	70576.47	83041.18	179478.60	68401.11	15017.42	26235.36	5025.20	33568.86	4733.05	17
18	77972.87	16492.25	10889.75	1676.79	423498.50	260644.60	53903.19	109168.90	44032.01	209359.90	18
19	126382.90	41593.24	32223.35	2347.89	528827.20	344561.40	95158.26	165637.00	81940.53	285125.30	19
20	918777.50	1232602.00	1284546.00	1610268.00	342425.80	526587.60	1010807.00	823455.00	1055547.00	605568.50	20
21	0.00	23159.81	31173.44	97010.03	139906.30	54404.55	2226.87	2816.16	4844.54	32885.13	21
22	23159.81	0.00	736.41	25417.18	276285.50	148178.80	11102.49	41696.62	6990.77	110519.50	22
23	31173.44	736.41	0.00	18393.14	301355.30	166863.30	16875.15	52298.89	11674.81	126447.60	23
24	97010.03	25417.18	18393.14	0.00	468535.20	295904.90	70006.71	132083.30	58839.77	241192.90	24
25	139906.30	276285.50	301355.30	468535.20	0.00	19834.92	176965.60	104139.40	195895.90	37481.22	25
26	54404.55	148178.80	166863.30	295904.90	19834.92	0.00	78350.87	33128.74	91136.41	2934.18	26
27	2226.87	11102.49	16875.15	70006.71	176965.60	78350.87	0.00	9792.31	513.44	51848.59	27
28	2816.16	41696.62	52298.89	132083.30	104139.40	33128.74	9792.31	0.00	14625.96	17178.12	28
29	4844.54	6990.77	11674.81	58839.77	195895.90	91136.41	513.44	14625.96	0.00	62239.60	29
30	32885.13	110519.50	126447.60	241192.90	37481.22	2934.18	51848.59	17178.12	62239.60	0.00	30
31	243433.10	416362.90	447348.70	646989.60	14665.76	67923.38	291889.10	195433.20	316226.50	98454.19	31
32	224526.20	391343.10	421067.90	615356.90	10500.57	58253.28	271173.70	178912.00	294628.20	86392.18	32
33	887708.40	1196501.00	1247768.00	1568986.00	322928.00	502690.80	977875.90	793317.50	1021650.00	579953.00	33
34	262062.00	440457.00	472267.70	676843.80	19213.16	77748.28	312045.80	211813.00	337042.30	110193.50	34
35	1386604.00	1767221.00	1829764.00	2214934.00	646323.90	892133.40	1499099.00	1268167.00	1553438.00	994521.10	35
36	752741.80	1038902.00	1086662.00	1387744.00	243873.10	402612.40	836092.40	666408.90	876737.20	472086.10	36
37	763509.30	1051634.00	1099841.00	1402630.00	250035.20	410485.00	847457.40	676433.10	888401.90	480783.90	37
38	420.87	24599.40	32309.33	99395.07	136564.10	52518.33	2997.29	3057.46	5720.93	31049.93	38
39	11043.39	65450.52	77889.16	171842.30	73320.13	17066.89	22963.56	3464.03	30066.13	6080.32	39
40	12039.84	1901.95	4587.71	40886.52	232980.60	116985.80	3943.38	26064.29	1661.20	83751.11	40
41	4117.86	11073.95	15892.90	67845.10	181136.90	81686.98	1154.05	12123.62	1198.81	54153.07	41
42	5894.47	52221.44	63712.28	150326.60	88478.05	24552.57	15277.05	853.42	21234.24	11038.87	42
43	8914.14	60541.73	72799.11	164170.40	78238.60	19306.28	19889.15	1997.24	26586.60	7616.76	43
44	979113.80	1302761.00	1356841.00	1691019.00	379548.10	572371.80	1074035.00	879928.20	1120183.00	655203.90	44
45	250067.70	424975.40	456147.30	657595.60	16176.52	71364.75	299108.80	201376.80	323673.00	102458.40	45
46	88999.18	21529.45	14966.58	417.68	449454.10	280995.60	63163.94	122456.90	52507.69	227621.90	46
47	309446.00	501471.70	535332.10	752033.70	33789.31	104688.30	363827.50	255080.20	390940.40	141791.60	47
48	106838.30	30847.14	23385.13	864.76	490439.20	313242.10	78631.18	143706.30	66923.22	257031.80	48
49	236100.00	406049.20	435967.10	633363.40	12583.87	63899.05	283480.20	188913.10	307206.30	93050.97	49
50	186.36	22416.27	30343.78	95369.61	142050.20	55791.39	2023.57	3037.47	4440.72	33978.24	50

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	21	22	23	24	25	26	27	28	29	30	
51	17413.08	78854.06	92106.11	192580.60	60838.82	11674.71	31263.12	6965.85	39218.73	3046.29	51
52	8118.59	5282.75	8583.89	51716.98	209671.50	101005.50	2215.67	19672.49	882.29	69976.53	52
53	30818.34	1800.56	890.57	20830.76	295764.60	163263.00	16741.19	51061.53	11554.32	123090.30	53
54	25991.55	1489.90	1153.65	25196.04	279799.40	151491.70	13382.81	44909.74	8869.98	112798.00	54
55	167612.70	313477.20	339245.80	515354.40	2180.36	31676.46	207484.80	128581.40	227602.70	52111.22	55
56	7565.84	55567.72	66895.63	155298.60	84528.85	22731.12	17330.32	1761.64	23385.76	9544.66	56
57	31535.70	107967.30	123703.90	237433.10	38995.94	3379.49	50174.57	16304.91	60425.99	56.05	57
58	616601.80	877871.40	922068.50	1200751.00	169201.10	304758.90	692096.20	538261.50	729039.00	365735.20	58
59	681582.10	954773.70	1000545.00	1290072.00	203921.80	350891.40	760708.10	599134.50	799321.20	415895.30	59
60	158007.30	60556.30	49068.45	7984.28	591105.50	395313.60	122840.90	201526.50	107731.20	331361.90	60
61	650556.60	918380.80	963666.60	1248190.00	187289.20	328818.80	728149.40	570094.10	766085.60	392143.50	61
62	103584.40	223881.80	246279.90	399195.90	2925.17	7999.97	135717.30	73401.12	152269.60	19833.09	62
63	8763.26	5055.86	8148.25	50552.06	212232.20	102865.00	2591.78	20631.61	1135.57	71519.86	63
64	133950.20	46114.95	36116.20	3534.03	543712.10	356710.80	101762.90	174282.80	88064.25	296054.60	64
65	63026.94	10604.62	5992.79	5081.69	385452.90	231321.30	41753.78	91315.96	33169.88	182951.50	65
66	7650.69	50045.58	59799.03	143662.90	96176.94	30094.11	15577.41	3692.00	20676.92	14546.70	66
67	47059.71	4387.49	1725.99	9197.27	347063.90	201341.30	28897.74	72164.71	21845.87	156607.20	67
68	145198.40	282991.80	307798.30	476544.10	486.92	22163.96	182669.70	108994.80	201682.00	39920.03	68
69	22305.50	567.05	1020.24	27208.57	270629.70	144364.20	10582.24	40309.74	6533.66	106784.80	69
70	215252.40	97382.35	83155.35	23586.12	699589.90	484480.60	173780.70	265591.10	155768.10	413688.30	70
71	15745.13	74511.23	87250.54	185417.80	65305.78	13851.96	28741.85	6149.27	36280.26	4269.30	71
72	1576.73	18182.06	24465.10	84923.91	155284.00	64631.67	1629.34	6471.48	3105.18	40329.22	72
73	19281.36	83984.59	98081.62	201249.50	55728.60	9173.76	34205.19	7777.51	42721.15	1926.55	73
74	243890.30	416507.00	446922.30	646577.00	14404.17	67963.53	292140.50	195921.80	316292.00	98038.38	74
75	112589.90	237429.80	260805.00	417589.80	1523.13	10488.69	146117.50	80805.81	163385.20	24118.84	75
76	49807.35	5618.08	2483.60	8753.52	352694.00	205903.90	31099.70	75312.56	23742.49	160479.90	76
77	84328.02	195010.50	215839.30	360200.10	7361.45	3541.57	113556.90	57607.96	128772.80	12013.37	77
78	929.95	23631.06	30974.79	96838.96	139852.80	54746.41	2863.10	3702.44	5240.19	32725.56	78
79	59461.95	155974.00	174661.40	306357.40	17378.82	412.57	84297.08	37488.68	97435.89	3957.65	79
80	184690.40	338293.40	366481.80	548747.40	3557.62	38830.69	227013.40	142846.30	248448.40	62766.93	80
81	2650.48	12667.52	17924.86	72540.25	172791.50	75970.41	807.19	10063.53	1415.30	49416.89	81
82	1969.60	18935.82	25073.93	86043.96	154174.50	64108.93	2179.08	6849.34	3706.46	39876.10	82
83	10131.33	5851.34	8553.16	50628.99	214095.10	104560.40	3722.24	22143.86	2100.37	72802.91	83
84	5631.30	49554.29	60111.58	144922.40	92504.05	27012.97	14191.59	1396.17	19690.83	12316.95	84
85	35821.23	2091.51	533.59	16132.87	313055.70	175926.30	20357.36	57848.46	14535.48	134121.60	85
86	24641.02	93778.93	108047.90	215479.00	49111.53	7096.03	40985.69	11878.14	50072.06	981.21	86
87	108361.10	31464.22	23602.08	527.51	492404.20	315042.40	79591.29	144931.00	67560.87	258509.10	87
88	8886.21	3774.26	6989.02	47889.90	217017.00	105856.50	2340.24	21309.65	763.79	74193.57	88
89	82011.35	191415.40	212069.10	355220.80	8055.38	3085.32	110705.80	55446.51	125644.00	11066.00	89
90	146271.00	284872.50	310036.10	479343.70	367.22	22501.64	184072.10	109914.30	203308.40	40668.52	90
91	501820.90	739768.00	780239.30	1038147.00	112308.60	226107.00	570380.30	432034.20	604078.50	278826.30	91
92	60792.32	158557.20	177790.80	310363.30	16362.13	237.41	85924.64	38112.59	99229.38	4425.85	92
93	224952.60	391919.20	421778.90	616229.00	10178.91	58166.07	271497.60	178890.10	294897.80	86491.88	93
94	362912.30	568896.70	604804.40	834018.00	52477.23	136480.20	421529.30	303679.00	450613.60	178385.70	94
95	30466.17	617.90	37.06	18900.17	299287.70	165297.20	16301.66	51281.55	11165.23	125118.60	95
96	11879.15	67943.85	80888.12	176214.90	70534.62	15609.05	24279.89	3613.57	31677.70	5445.63	96
97	64139.59	163237.90	182248.10	316354.50	15097.71	753.26	89692.50	41110.66	103168.20	5219.55	97
98	2367.23	36541.63	45594.24	121748.00	112951.50	38523.88	7879.73	1314.97	11918.92	20438.94	98
99	83673.01	19342.57	12990.58	1383.92	435673.80	270401.40	58733.23	116002.10	48437.74	217946.30	99
100	7401.63	53666.19	64529.15	151482.50	87967.60	24831.42	16546.01	2079.92	22288.17	10896.55	100

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	31	32	33	34	35	36	37	38	39	40	
1	15282.44	10726.75	313400.00	19028.29	633821.00	236046.70	242497.20	144518.20	79788.10	243425.40	1
2	21332.98	27175.13	92860.09	16793.26	291144.20	52749.09	55755.16	401447.60	285637.00	558203.50	2
3	43381.24	50937.14	62177.31	36048.14	235378.80	31050.45	33680.21	477257.50	350617.20	647038.00	3
4	1309618.00	1356348.00	484958.50	1267368.00	212719.40	594683.30	584655.50	2667864.00	2353998.00	3050164.00	4
5	1380418.00	1427937.00	528174.30	1337408.00	241174.60	642192.60	631922.00	2768454.00	2448404.00	3158072.00	5
6	26540.07	19630.84	364370.50	32961.33	704022.80	279632.50	286785.70	113513.70	57126.10	203257.90	6
7	10285.66	14640.57	121789.00	7367.31	340739.40	75119.04	78612.33	347512.00	240428.80	494137.90	7
8	434694.10	408878.40	1225679.00	458835.60	1803545.00	1066439.00	1079489.00	29146.74	72841.93	3468.69	8
9	270423.80	249694.00	935615.70	289758.90	1447412.00	796968.60	808471.40	1285.98	17211.24	7773.99	9
10	579054.70	549746.50	1462474.00	606974.80	2088040.00	1288125.00	1302243.00	74448.41	138197.90	25232.59	10
11	391305.00	366245.90	1151221.00	414642.90	1712711.00	996723.60	1009606.00	18798.31	55647.51	1472.96	11
12	249571.60	229385.00	895422.50	268261.90	1397219.00	759727.10	771084.00	917.74	12724.61	12527.24	12
13	1968.36	1093.52	210835.90	3048.73	482242.30	147580.20	152735.90	230466.40	145433.20	352733.40	13
14	449190.00	422557.50	1249160.00	473888.90	1832025.00	1088182.00	1101552.00	32942.83	78757.72	5268.18	14
15	341184.20	318018.70	1064112.00	362777.20	1606308.00	915983.90	928264.10	9199.99	37890.52	990.94	15
16	96494.08	84140.19	573945.10	108240.60	986647.60	466446.60	475248.30	32604.87	6904.01	86603.53	16
17	145923.50	130992.00	687395.20	159950.00	1134225.00	569535.00	579180.50	12032.47	610.68	49552.16	17
18	594522.50	564484.70	1484900.00	622334.50	2115817.00	1309435.00	1323905.00	79878.21	145776.70	28804.76	18
19	718230.80	684946.30	1676946.00	748924.50	2343872.00	1489911.00	1505383.00	128711.10	209826.00	60507.04	19
20	216808.30	234965.90	1443.54	200862.50	48554.21	8568.58	7596.02	909707.10	730477.40	1139343.00	20
21	243433.10	224526.20	887708.40	262062.00	1386604.00	752741.80	763509.30	420.87	11043.39	12039.84	21
22	416362.90	391343.10	1196501.00	440457.00	1767221.00	1038902.00	1051634.00	24599.40	65450.52	1901.95	22
23	447348.70	421067.90	1247768.00	472267.70	1829764.00	1086662.00	1099841.00	32309.33	77889.16	4587.71	23
24	646989.60	615356.90	1568986.00	676843.80	2214934.00	1387744.00	1402630.00	99395.07	171842.30	40886.52	24
25	14665.76	10500.57	322928.00	19213.16	646323.90	243873.10	250035.20	136564.10	73320.13	232980.60	25
26	67923.38	58253.28	502690.80	77748.28	892133.40	402612.40	410485.00	52518.33	17066.89	116985.80	26
27	291889.10	271173.70	977875.90	312045.80	1499099.00	836092.40	847457.40	2997.29	22963.56	3943.38	27
28	195433.20	178912.00	793317.50	211813.00	1268167.00	666408.90	676433.10	3057.46	3464.03	26064.29	28
29	316226.50	294628.20	1021650.00	337042.30	1553438.00	876737.20	888401.90	5720.93	30066.13	1661.20	29
30	98454.19	86392.18	579953.00	110193.50	994521.10	472086.10	480783.90	31049.93	6080.32	83751.11	30
31	0.00	657.19	202042.60	681.33	468226.10	140390.80	144959.30	239370.30	152216.30	362961.40	31
32	657.19	0.00	220218.10	2341.42	495677.90	155358.30	160346.00	220202.90	136966.70	339652.70	32
33	202042.60	220218.10	0.00	185490.50	56077.46	5884.09	5022.84	878998.90	703165.60	1104289.00	33
34	681.33	2341.42	185490.50	0.00	443772.00	127166.20	131440.90	257895.20	167235.70	385326.00	34
35	468226.10	495677.90	56077.46	443772.00	0.00	96415.26	92517.62	1376118.00	1153349.00	1655036.00	35
36	140390.80	155358.30	5884.09	127166.20	96415.26	0.00	92.55	744566.70	583483.00	953305.10	36
37	144959.30	160346.00	5022.84	131440.90	92517.62	92.55	0.00	755512.30	593177.30	965535.50	37
38	239370.30	220202.90	878998.90	257895.20	1376118.00	744566.70	755512.30	0.00	9888.06	13042.30	38
39	152216.30	136966.70	703165.60	167235.70	1153349.00	583483.00	593177.30	9888.06	0.00	45392.02	39
40	362961.40	339652.70	1104289.00	385326.00	1655036.00	953305.10	965535.50	13042.30	45392.02	0.00	40
41	298272.50	277120.70	986439.80	317841.10	1511103.00	844488.10	856113.20	3963.39	25199.28	4048.77	41
42	173727.80	157782.10	749206.00	189540.00	1212067.00	625621.10	635456.80	5467.02	945.47	34522.77	42
43	159463.10	144252.60	718938.00	174467.80	1173728.00	598101.80	607717.80	8308.22	355.94	41296.53	43
44	246182.30	266482.60	3162.18	228651.50	35476.89	15465.41	13803.31	970670.70	785138.00	1206767.00	44
45	96.75	904.75	195767.20	410.20	459020.80	135251.80	139787.70	245802.00	157329.90	370926.10	45
46	624991.50	593995.60	1533483.00	653888.40	2173369.00	1354717.00	1369475.00	90995.28	160783.50	35637.44	46
47	3994.43	6994.51	149771.60	2541.13	386179.50	97344.18	101158.30	304740.40	205083.30	442695.80	47
48	671796.30	639445.80	1608613.00	702938.90	2260892.00	1424620.00	1439693.00	109564.00	184792.20	47699.03	48
49	1030.34	1088.04	208755.50	1265.60	480122.80	146382.40	151229.20	231336.90	146176.70	353128.30	49
50	246486.90	227757.00	893039.90	264871.80	1393696.00	758009.00	768801.50	651.80	11914.35	11422.38	50

Appendix I (Contd...)

	31	32	33	34	35	36	37	38	39	40	
51	134971.20	120924.00	662843.10	148136.30	1102928.00	547515.80	556906.00	15791.74	1451.22	56464.57	51
52	334321.70	311654.70	1051964.00	355451.50	1591585.00	904924.80	917038.10	8196.38	35751.10	1096.36	52
53	441412.50	415424.50	1234967.00	465227.20	1815541.00	1075491.00	1088716.00	31397.79	76121.66	4849.59	53
54	421761.10	396099.00	1201957.00	445266.50	1775265.00	1044467.00	1057552.00	26251.26	67966.33	3302.81	54
55	10099.87	6710.29	287015.00	12860.52	596133.30	213263.20	219287.40	162967.10	93517.69	267101.30	55
56	169037.20	153232.00	737308.50	184020.20	1198046.00	615157.00	625037.10	6531.93	948.56	37098.39	56
57	100764.20	88517.19	585860.50	112785.60	1002074.00	477253.90	486017.20	29637.21	5439.37	81585.15	57
58	85697.09	97920.25	24720.62	74867.66	154581.80	7224.25	8197.05	609650.10	464905.60	799180.40	58
59	111288.30	124978.00	13818.16	98724.96	125313.80	2408.82	2946.05	673933.10	521434.70	872595.20	59
60	790712.20	755686.60	1785994.00	822726.30	2472744.00	1592951.00	1608999.00	160497.40	249880.70	82951.60	60
61	98361.21	111407.40	18537.18	86981.62	137925.80	4002.90	4685.44	643454.60	494399.60	837946.50	61
62	30257.66	23717.05	385443.00	36850.23	733717.00	298515.50	305491.40	100327.40	47487.16	185031.60	62
63	337644.20	314808.70	1057559.00	358824.20	1598544.00	910099.10	922251.10	8798.76	36950.07	1111.09	63
64	735717.10	701872.20	1702971.00	766711.40	2374794.00	1514554.00	1530228.00	136220.00	219313.40	65811.79	64
65	549591.80	520367.00	1412018.00	576251.10	2028886.00	1241014.00	1255222.00	64193.74	124176.80	20271.55	65
66	185794.70	168890.10	767365.10	200804.40	1237185.00	643060.30	653402.60	5805.35	3896.60	32839.34	66
67	502982.80	475176.00	1338913.00	529026.40	1940279.00	1172178.00	1185861.00	48550.12	102134.10	11557.40	67
68	14329.39	9970.38	316407.00	18471.06	637717.40	238372.20	244698.30	141038.10	76790.46	239037.10	68
69	410126.50	384982.20	1183936.00	433634.20	1752877.00	1027549.00	1040442.00	23023.44	62921.89	1746.37	69
70	915097.10	877751.40	1972096.00	949667.00	2690573.00	1768945.00	1785692.00	218920.70	321665.90	125673.50	70
71	141713.10	127286.30	676825.90	154984.00	1121180.00	560339.30	569837.20	14102.18	1538.24	52830.64	71
72	264706.20	244636.60	924898.50	283431.20	1434486.00	787490.80	798818.30	1101.90	15993.32	8446.92	72
73	126954.20	113471.20	646742.40	140014.50	1081531.00	532673.40	541781.50	18085.05	1624.85	60888.38	73
74	577.87	902.77	201208.60	775.39	468300.00	139923.10	144669.90	239180.00	152243.50	362904.80	74
75	25166.19	19443.57	368041.60	31272.80	709284.00	283216.10	289856.00	109691.60	53939.51	197421.30	75
76	510150.80	482103.50	1349256.00	536017.50	1953273.00	1182148.00	1195976.00	51016.12	105606.20	13038.57	76
77	42206.17	34187.54	425880.80	50161.00	788873.70	333976.10	341361.70	81283.53	34721.59	158962.30	77
78	244454.30	225301.80	886979.90	262362.70	1387104.00	752518.50	763462.50	544.07	11501.47	12264.00	78
79	63408.96	53597.85	488901.30	73006.08	873970.50	390146.20	398113.30	56854.47	19529.64	123886.40	79
80	4517.74	3063.32	263435.30	6909.15	560265.50	192872.20	198101.80	181600.70	107131.50	290255.50	80
81	287069.90	265901.90	967227.10	307014.30	1486534.00	826112.50	837717.80	2294.60	21440.57	4966.81	81
82	263312.60	243071.40	921688.40	281983.50	1430520.00	784379.80	795723.90	1177.59	15821.41	9106.74	82
83	340267.30	317201.50	1060484.00	361234.50	1602575.00	913052.30	925345.40	9751.77	38272.24	1885.11	83
84	180189.80	163602.80	760355.20	195848.40	1227251.00	636016.00	646135.90	4525.13	1589.27	32270.71	84
85	462246.20	435478.80	1270587.00	486946.20	1858302.00	1108504.00	1121908.00	36716.85	84481.62	6587.74	85
86	116935.90	103492.40	622070.20	129564.00	1049795.00	510189.80	519375.70	22468.09	2991.54	69267.53	86
87	675409.80	643306.60	1612174.00	705339.00	2266826.00	1428832.00	1443873.00	110949.10	186922.70	48282.05	87
88	343159.00	320269.40	1068962.00	364922.50	1611902.00	920461.20	932588.70	9415.73	38455.01	391.01	88
89	44266.95	36298.23	431263.40	51944.71	796787.20	339218.60	346648.40	79117.25	33434.55	155554.90	89
90	13182.44	9013.67	314209.50	17682.24	633925.80	236178.80	242467.00	142309.40	77518.97	240851.10	90
91	46547.96	55076.09	55348.85	39516.59	220478.40	25525.05	27625.09	495177.70	365488.30	667887.40	91
92	61453.11	52252.02	484164.10	70698.13	867626.60	386235.80	394007.00	58718.44	20637.31	126129.50	92
93	507.45	323.61	219094.20	1609.65	494783.40	154812.40	159681.60	220803.90	137555.70	340052.10	93
94	11942.77	16805.67	115802.90	8505.33	330810.60	70491.50	73735.60	357729.60	249005.60	506082.40	94
95	444918.00	418828.40	1243633.00	469614.10	1824906.00	1082964.00	1096076.00	31727.62	76948.13	4268.57	95
96	148052.20	133327.70	694900.20	162838.90	1142548.00	575972.50	585441.60	11085.22	197.58	47499.78	96
97	59336.14	50006.13	476400.00	68264.31	857694.50	379196.30	387031.50	61383.60	22439.19	130328.20	97
98	208404.90	190640.20	816954.30	225045.80	1299105.00	688033.50	698556.50	1491.84	4921.34	21942.22	98
99	609137.30	578400.60	1507096.00	637281.80	2142433.00	1330203.00	1344872.00	85322.98	153078.50	32410.84	99
100	174164.50	158110.90	746524.50	189056.60	1210262.00	623847.80	633878.10	6165.09	1744.25	35520.48	100

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	41	42	43	44	45	46	47	48	49	50	
1	188786.30	96214.44	85452.62	371238.80	16219.43	461797.10	33225.62	505062.70	11198.64	151337.70	1
2	476314.90	315488.50	296104.50	123929.20	19287.79	873987.20	7014.43	929601.60	24057.96	411437.30	2
3	556775.60	384108.10	362483.80	90059.42	40137.82	982477.80	22016.48	1043523.00	44783.48	488935.10	3
4	2853064.00	2436703.00	2382007.00	420572.40	1294372.00	3741276.00	1170141.00	3857028.00	1329157.00	2690557.00	4
5	2957535.00	2533136.00	2477446.00	460827.20	1364686.00	3860695.00	1236898.00	3977725.00	1400523.00	2792211.00	5
6	154531.20	71676.22	62699.92	425324.60	28158.50	405840.00	49585.57	444797.80	22716.57	120635.60	6
7	417653.90	267730.30	249939.30	156729.10	8928.29	793589.70	1586.34	846391.40	12686.97	356531.70	7
8	13196.71	59122.39	67757.47	1334391.00	443247.40	17293.15	521529.90	27017.84	422934.40	27140.97	8
9	1212.13	11533.35	15298.46	1031196.00	277018.30	73826.62	339521.10	91627.62	260770.80	2067.14	9
10	47508.00	118548.70	130827.70	1580068.00	589167.50	1533.43	678799.50	4543.40	566606.00	70039.88	10
11	7106.46	44403.46	51913.82	1256872.00	399287.20	27886.32	473610.00	39243.78	379901.10	18272.22	11
12	3252.10	8435.39	11462.22	989206.60	255837.80	86216.36	315938.90	105409.60	239928.90	2575.83	12
13	287640.50	167473.60	153456.00	257576.00	1757.82	609805.20	6905.47	657035.60	959.18	239298.90	13
14	15880.98	64893.54	73919.60	1359248.00	457776.70	14778.32	537236.80	23958.43	436849.00	31488.74	14
15	1888.59	28640.70	34662.16	1165829.00	348644.30	42954.67	418410.30	57002.12	330502.40	8862.32	15
16	56179.73	12434.94	8886.36	649178.50	100334.00	231582.20	139213.10	261366.60	90684.59	36358.65	16
17	27137.31	2094.95	976.69	769724.10	150716.00	167550.60	197764.50	193660.20	138672.10	14349.31	17
18	50882.96	126023.00	138476.40	1604808.00	604497.30	498.42	695491.60	4443.82	580390.80	76050.08	18
19	91131.32	186076.20	201204.30	1804282.00	729199.60	3308.63	828733.50	2904.60	702530.50	124156.80	19
20	1020633.00	777744.50	747190.10	1803.46	210489.20	1575080.00	162159.60	1649307.00	224873.00	924997.30	20
21	4117.86	5894.47	8914.14	979113.80	250067.70	88999.18	309446.00	106838.30	236100.00	186.36	21
22	11073.95	52221.44	60541.73	1302761.00	424975.40	21529.45	501471.70	30847.14	406049.20	22416.27	22
23	15892.90	63712.28	72799.11	1356841.00	456147.30	14966.58	535332.10	23385.13	435967.10	30343.78	23
24	67845.10	150326.60	164170.40	1691019.00	657595.60	417.68	752033.70	864.76	633363.40	95369.61	24
25	181136.90	88478.05	78238.60	379548.10	16176.52	449454.10	33789.31	490439.20	12583.87	142050.20	25
26	81686.98	24552.57	19306.28	572371.80	71364.75	280995.60	104688.30	313242.10	63899.05	55791.39	26
27	1154.05	15277.05	19889.15	1074035.00	299108.80	63163.94	363827.50	78631.18	283480.20	2023.57	27
28	12123.62	853.42	1997.24	879928.20	201376.80	122456.90	255080.20	143706.30	188913.10	3037.47	28
29	1198.81	21234.24	26586.60	1120183.00	323673.00	52507.69	390940.40	66923.22	307206.30	4440.72	29
30	54153.07	11038.87	7616.76	655203.90	102458.40	227621.90	141791.60	257031.80	93050.97	33978.24	30
31	298272.50	173727.80	159463.10	246182.30	96.75	624991.50	3994.43	671796.30	1030.34	246486.90	31
32	277120.70	157782.10	144252.60	266482.60	904.75	593995.60	6994.51	639445.80	1088.04	227757.00	32
33	986439.80	749206.00	718938.00	3162.18	195767.20	1533483.00	149771.60	1608613.00	208755.50	893039.90	33
34	317841.10	189540.00	174467.80	228651.50	410.20	653888.40	2541.13	702938.90	1265.60	264871.80	34
35	1511103.00	1212067.00	1173728.00	35476.89	459020.80	2173369.00	386179.50	2260892.00	480122.80	1393696.00	35
36	844488.10	625621.10	598101.80	15465.41	135251.80	1354717.00	97344.18	1424620.00	146382.40	758009.00	36
37	856113.20	635456.80	607717.80	13803.31	139787.70	1369475.00	101158.30	1439693.00	151229.20	768801.50	37
38	3963.39	5467.02	8308.22	970670.70	245802.00	90995.28	304740.40	109564.00	231336.90	651.80	38
39	25199.28	945.47	355.94	785138.00	157329.90	160783.50	205083.30	184792.20	146176.70	11914.35	39
40	4048.77	34522.77	41296.53	1206767.00	370926.10	35637.44	442695.80	47699.03	353128.30	11422.38	40
41	0.00	17652.30	22170.30	1084887.00	305223.10	60252.84	370860.30	77522.90	287762.00	3544.34	41
42	17652.30	0.00	336.75	833432.90	179305.80	140079.80	230101.70	162534.50	167521.80	6524.89	42
43	22170.30	336.75	0.00	801730.00	164775.60	153300.60	213670.70	177137.60	153289.10	9566.26	43
44	1084887.00	833432.90	801730.00	0.00	239628.20	1654921.00	187817.70	1731065.00	255448.40	985053.60	44
45	305223.10	179305.80	164775.60	239628.20	0.00	635298.80	3236.61	682732.80	918.21	253143.40	45
46	60252.84	140079.80	153300.60	1654921.00	635298.80	0.00	728353.50	2291.36	610819.50	87159.26	46
47	370860.30	230101.70	213670.70	187817.70	3236.61	728353.50	0.00	778571.40	6163.54	312975.10	47
48	77522.90	162534.50	177137.60	1731065.00	682732.80	2291.36	778571.40	0.00	659123.80	105393.60	48
49	287762.00	167521.80	153289.10	255448.40	918.21	610819.50	6163.54	659123.80	0.00	238840.70	49
50	3544.34	6524.89	9566.26	985053.60	253143.40	87159.26	312975.10	105393.60	238840.70	0.00	50

Appendix I (Contd...)

	41	42	43	44	45	46	47	48	49	50	
51	32097.99	3583.24	1852.31	743952.10	139568.40	180037.70	185033.70	207483.30	127781.10	17901.67	51
52	1193.50	26634.83	32392.16	1153189.00	341721.00	45294.46	410884.70	59987.39	323669.40	7556.52	52
53	14034.15	62377.95	70989.60	1345116.00	449873.10	16399.61	528858.50	27174.10	428470.60	29514.34	53
54	10816.92	55211.23	63356.13	1310600.00	429986.60	20469.75	507206.50	31777.05	409105.60	24994.38	54
55	209829.60	110962.20	99346.72	342358.90	10788.66	494596.00	25108.43	539320.00	6581.89	169802.90	55
56	18253.52	573.01	479.26	822222.60	174294.80	144252.50	224661.00	168568.70	161544.30	7953.35	56
57	52520.49	10238.12	6988.66	661313.30	104865.50	224022.50	144564.80	253049.10	95423.22	32648.66	57
58	699646.00	502198.20	477438.20	42467.30	81633.21	1169804.00	53188.12	1235541.00	90126.78	620991.10	58
59	767803.10	560987.90	534725.10	28415.56	106583.60	1257685.00	73807.10	1326583.00	115619.20	686122.30	59
60	117900.80	224004.70	240511.70	1917777.00	802130.60	9929.68	906428.20	7576.72	773799.50	155493.90	60
61	736280.80	532846.80	507412.30	33832.13	94077.76	1216832.00	63112.55	1283338.00	103550.20	655198.50	61
62	139114.80	60139.73	51777.41	447376.20	32359.63	381574.50	55899.24	419355.00	27088.00	105468.80	62
63	1363.45	27680.28	33503.85	1159185.00	345062.80	44153.35	414572.50	58889.94	326742.20	8227.65	63
64	97328.19	195175.60	210607.30	1831622.00	746723.50	4689.22	847450.70	3917.44	719508.90	131689.30	64
65	38199.15	106352.60	117665.10	1529646.00	559018.70	2859.84	646657.90	9114.29	535184.20	61423.11	65
66	14291.83	3056.47	3321.18	855622.10	190965.70	132337.00	243598.40	157656.10	176092.50	7773.18	66
67	27123.66	85748.69	96162.94	1452315.00	512214.50	6674.61	596081.60	13303.14	490488.70	45834.60	67
68	185684.40	92728.19	82214.75	373538.60	15514.19	456908.80	32686.56	499014.80	11293.90	147309.80	68
69	9229.28	50407.04	58382.46	1290953.00	418388.00	22645.68	494525.70	33429.41	398623.60	21419.93	69
70	169092.60	291788.40	310738.00	2109686.00	927581.50	27692.70	1039422.00	20802.19	897829.20	212282.20	70
71	29107.78	3179.56	1687.09	759098.80	146364.30	172957.50	192902.00	200408.20	133966.70	16171.68	71
72	1125.95	10321.08	13804.32	1020109.00	271253.40	76607.85	333261.10	95194.57	255059.50	1283.14	72
73	36158.44	3997.24	2027.23	726026.50	131575.10	188818.10	175754.10	216012.60	120830.10	20010.50	73
74	297010.90	174069.90	159622.20	246705.70	397.73	624030.90	4585.85	672200.30	153.71	246809.10	74
75	150293.50	67050.13	58214.40	428067.80	27197.25	399760.80	49039.61	438027.90	22768.62	114591.50	75
76	28427.49	89123.14	99575.62	1463854.00	519307.40	5994.56	603864.40	13222.12	496790.00	48379.11	76
77	116751.90	45720.59	38500.52	490702.70	44740.87	343611.40	71760.25	379331.80	38531.87	86275.96	77
78	2722.93	6660.74	9434.71	980104.40	250778.40	88033.96	310545.90	107803.20	235246.40	821.09	78
79	87040.66	27999.61	22416.77	558232.00	66547.80	291053.60	98830.41	324046.40	58949.42	61062.94	79
80	232559.30	124866.60	112701.90	314073.30	5410.86	528298.00	16683.47	572193.60	4133.20	187039.30	80
81	521.78	14680.28	19038.74	1064018.00	293974.60	65145.32	358246.00	81777.13	277466.10	2562.92	81
82	1286.49	10347.78	13764.24	1016972.00	269777.60	77619.60	331617.40	96556.68	253318.80	1837.40	82
83	1598.22	29156.74	34927.59	1163009.00	347547.90	43930.47	417358.00	59361.98	328530.20	9469.26	83
84	14954.81	642.89	1041.83	846546.30	185609.30	134320.30	237430.90	157742.40	172410.70	6124.14	84
85	18077.84	69876.00	79135.38	1381823.00	470950.30	12465.63	551603.10	21594.10	449507.00	34679.41	85
86	42152.12	6817.93	4299.00	700603.40	121142.40	202424.90	163622.30	230755.20	110323.40	25565.74	86
87	76639.63	164303.60	178614.00	1736471.00	686149.40	1076.70	782742.30	1469.24	660854.00	106357.80	87
88	2155.77	28739.33	34892.47	1170185.00	350809.30	42061.70	420699.00	55374.14	333198.60	8418.54	88
89	113485.90	44106.58	36923.49	496991.80	46777.14	338468.60	74459.22	374585.40	40122.93	83625.85	89
90	188012.90	93532.11	83068.10	370313.60	14525.28	459976.40	31242.22	501317.30	11077.20	148461.00	90
91	577977.70	399103.00	377295.90	79621.46	43566.21	1009971.00	23380.70	1069587.00	50483.96	506365.10	91
92	89198.03	28931.90	23199.86	552876.40	64634.60	294989.40	96557.33	328132.10	57465.87	62170.22	92
93	276981.00	158140.70	144453.30	265703.30	735.15	594492.30	6920.26	640845.30	532.20	227773.10	93
94	428521.70	276482.00	258337.80	149892.40	10499.83	808798.00	2220.42	862374.60	14404.08	366589.40	94
95	15325.33	62756.16	71748.46	1352608.00	453682.30	15360.25	532720.00	24059.63	433521.60	29562.04	95
96	26978.90	1083.62	314.88	775965.30	153229.10	165095.20	200338.10	189266.00	142457.80	12709.47	96
97	91969.62	31298.68	25297.32	545324.00	62322.15	300513.00	93742.38	334802.50	54499.01	65605.32	97
98	8100.89	2238.77	3720.00	906423.50	214213.70	111909.90	269694.50	133753.10	199883.30	2530.67	98
99	55056.88	133058.70	145778.20	1628305.00	619119.10	364.72	711151.80	4106.13	594274.70	81863.21	99
100	16722.21	1191.61	1180.37	832590.80	179390.60	140263.00	230508.00	165023.10	165922.70	7577.64	100

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	51	52	53	54	55	56	57	58	59	60	
1	65583.56	218040.70	304885.20	288443.90	658.09	90588.81	43779.61	163164.10	196324.40	604012.30	1
2	261248.50	521614.70	653319.20	629114.10	55172.74	308390.20	213098.30	22268.30	36043.20	1067659.00	2
3	321882.50	606039.50	746449.30	720501.80	83205.23	374604.80	269360.10	9825.38	18227.85	1185921.00	3
4	2280314.00	2964059.00	3266258.00	3212839.00	1517652.00	2416497.00	2135272.00	727159.70	661217.90	4130622.00	4
5	2373725.00	3070253.00	3377945.00	3323327.00	1593726.00	2512602.00	2225393.00	780265.90	711886.10	4256103.00	5
6	46568.97	180333.70	260515.10	244878.10	5780.22	67435.68	27948.24	200789.60	237738.50	540213.60	6
7	218353.10	460098.70	584323.30	561568.80	37196.17	261491.40	174346.20	37247.34	54691.91	978878.80	7
8	85967.94	6718.40	425.38	520.62	327432.60	61768.50	117031.60	903091.50	980599.80	52992.78	8
9	23844.75	3597.55	21301.06	16950.19	186925.00	12190.45	41098.73	657252.60	723475.80	136864.60	9
10	156647.50	34406.19	10997.38	14362.27	455807.20	123181.30	197433.50	1107499.00	1193607.00	17796.28	10
11	67540.97	2537.48	2255.03	968.88	289447.00	46462.94	94996.18	839826.30	914480.40	70258.94	11
12	18330.13	6960.54	28184.91	23062.49	169173.00	8622.60	33456.48	623935.40	688264.00	153272.50	12
13	128031.50	322934.50	427933.40	408020.30	7084.40	161615.40	95227.33	92297.85	117879.50	772602.70	13
14	92441.74	8585.62	441.62	641.99	339337.40	67403.58	124488.20	923610.70	1001762.00	48247.44	14
15	47565.80	138.18	6809.67	4466.98	246615.50	30169.87	71128.23	765524.00	836907.50	93419.12	15
16	3708.11	72157.37	125886.20	115231.90	50006.37	10615.62	279.13	361292.80	410893.30	335862.40	16
17	365.97	38668.67	79910.88	71606.29	86677.32	990.62	4261.58	452162.20	507407.90	257660.60	17
18	163643.00	37381.75	11683.96	15300.43	467136.90	129697.50	205988.50	1127417.00	1213624.00	14113.14	18
19	231306.70	72660.72	33835.23	39601.68	577112.80	190578.60	281144.50	1295579.00	1387744.00	1791.04	19
20	691045.50	1086589.00	1273121.00	1239075.00	306194.00	766577.30	611338.90	31356.14	19500.98	1831408.00	20
21	17413.08	8118.59	30818.34	25991.55	167612.70	7565.84	31535.70	616601.80	681582.10	158007.30	21
22	78854.06	5282.75	1800.56	1489.90	313477.20	55567.72	107967.30	877871.40	954773.70	60556.30	22
23	92106.11	8583.89	890.57	1153.65	339245.80	66895.63	123703.90	922068.50	1000545.00	49068.45	23
24	192580.60	51716.98	20830.76	25196.04	515354.40	155298.60	237433.10	1200751.00	1290072.00	7984.28	24
25	60838.82	209671.50	295764.60	279799.40	2180.36	84528.85	38995.94	169201.10	203921.80	591105.50	25
26	11674.71	101005.50	163263.00	151491.70	31676.46	22731.12	3379.49	304758.90	350891.40	395313.60	26
27	31263.12	2215.67	16741.19	13382.81	207484.80	17330.32	50174.57	692096.20	760708.10	122840.90	27
28	6965.85	19672.49	51061.53	44909.74	128581.40	1761.64	16304.91	538261.50	599134.50	201526.50	28
29	39218.73	882.29	11554.32	8869.98	227602.70	23385.76	60425.99	729039.00	799321.20	107731.20	29
30	3046.29	69976.53	123090.30	112798.00	52111.22	9544.66	56.05	365735.20	415895.30	331361.90	30
31	134971.20	334321.70	441412.50	421761.10	10099.87	169037.20	100764.20	85697.09	111288.30	790712.20	31
32	120924.00	311654.70	415424.50	396099.00	6710.29	153232.00	88517.19	97920.25	124978.00	755686.60	32
33	662843.10	1051964.00	1234967.00	1201957.00	287015.00	737308.50	585860.50	24720.62	13818.16	1785994.00	33
34	148136.30	355451.50	465227.20	445266.50	12860.52	184020.20	112785.60	74867.66	98724.96	822726.30	34
35	1102928.00	1591585.00	1815541.00	1775265.00	596133.30	1198046.00	1002074.00	154581.80	125313.80	2472744.00	35
36	547515.80	904924.80	1075491.00	1044467.00	213263.20	615157.00	477253.90	7224.25	2408.82	1592951.00	36
37	556906.00	917038.10	1088716.00	1057552.00	219287.40	625037.10	486017.20	8197.05	2946.05	1608999.00	37
38	15791.74	8196.38	31397.79	26251.26	162967.10	6531.93	29637.21	609650.10	673933.10	160497.40	38
39	1451.22	35751.10	76121.66	67966.33	93517.69	948.56	5439.37	464905.60	521434.70	249880.70	39
40	56464.57	1096.36	4849.59	3302.81	267101.30	37098.39	81585.15	799180.40	872595.20	82951.60	40
41	32097.99	1193.50	14034.15	10816.92	209829.60	18253.52	52520.49	699646.00	767803.10	117900.80	41
42	3583.24	26634.83	62377.95	55211.23	110962.20	573.01	10238.12	502198.20	560987.90	224004.70	42
43	1852.31	32392.16	70989.60	63356.13	99346.72	479.26	6988.66	477438.20	534725.10	240511.70	43
44	743952.10	1153189.00	1345116.00	1310600.00	342358.90	822222.60	661313.30	42467.30	28415.56	1917777.00	44
45	139568.40	341721.00	449873.10	429986.60	10788.66	174294.80	104865.50	81633.21	106583.60	802130.60	45
46	180037.70	45294.46	16399.61	20469.75	494596.00	144252.50	224022.50	1169804.00	1257685.00	9929.68	46
47	185033.70	410884.70	528858.50	507206.50	25108.43	224661.00	144564.80	53188.12	73807.10	906428.20	47
48	207483.30	59987.39	27174.10	31777.05	539320.00	168568.70	253049.10	1235541.00	1326583.00	7576.72	48
49	127781.10	323669.40	428470.60	409105.60	6581.89	161544.30	95423.22	90126.78	115619.20	773799.50	49
50	17901.67	7556.52	29514.34	24994.38	169802.90	7953.35	32648.66	620991.10	686122.30	155493.90	50

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	51	52	53	54	55	56	57	58	59	60	
51	0.00	44812.34	88425.34	79854.19	78094.46	2065.54	2776.98	432173.70	486184.70	272959.40	51
52	44812.34	0.00	7572.99	5185.47	240752.00	27978.92	68043.44	755063.50	825982.90	96830.35	52
53	88425.34	7572.99	0.00	332.56	331671.20	64205.06	120545.30	911307.90	988688.60	50724.61	53
54	79854.19	5185.47	332.56	0.00	314616.00	56903.23	110328.40	883105.00	959297.40	57722.30	54
55	78094.46	240752.00	331671.20	314616.00	0.00	105158.10	53975.53	144085.20	175397.10	641548.80	55
56	2065.54	27978.92	64205.06	56903.23	105158.10	0.00	8901.42	492585.80	550315.70	228666.20	56
57	2776.98	68043.44	120545.30	110328.40	53975.53	8901.42	0.00	370470.90	420950.70	327113.50	57
58	432173.70	755063.50	911307.90	883105.00	144085.20	492585.80	370470.90	0.00	1760.20	1391766.00	58
59	486184.70	825982.90	988688.60	959297.40	175397.10	550315.70	420950.70	1760.20	0.00	1487031.00	59
60	272959.40	96830.35	50724.61	57722.30	641548.80	228666.20	327113.50	1391766.00	1487031.00	0.00	60
61	461081.70	792975.50	953092.20	924169.90	161135.50	523277.10	396954.90	543.80	713.41	1443225.00	61
62	37652.90	164075.80	241206.90	226672.90	8159.74	56718.92	20916.77	215452.90	254309.80	512826.40	62
63	46001.72	41.80	7039.93	4725.42	243282.20	28946.02	69566.15	759830.80	830859.90	95032.46	63
64	241077.10	78198.15	37581.93	43604.26	592231.00	199554.90	292061.30	1318590.00	1411439.00	1019.53	64
65	140189.70	26706.61	5986.53	8502.93	426159.80	109094.50	179846.30	1064281.00	1147739.00	21962.87	65
66	4451.78	23214.26	55714.37	48879.66	115826.90	1332.29	13837.18	517799.20	576078.10	212378.60	66
67	117779.50	17354.06	2574.25	4138.46	387185.30	89109.99	153664.10	1000645.00	1082193.00	32641.37	67
68	63494.07	214606.40	301323.20	285048.00	1006.40	87944.05	41475.98	164891.40	198740.10	599113.10	68
69	75150.90	3918.41	898.62	386.84	305998.80	52716.32	104375.60	867415.00	943403.60	62075.21	69
70	348374.60	143586.80	86100.28	95294.16	755452.50	297871.70	408940.30	1556249.00	1657281.00	4877.68	70
71	152.63	41388.30	83328.65	75038.04	82717.91	1514.63	3958.60	443539.70	498040.00	263958.00	71
72	21818.69	4125.31	22559.26	18334.40	182128.20	10751.94	38908.85	648042.70	713845.10	140670.90	72
73	375.85	49399.15	95101.96	86235.64	73320.30	3055.45	1696.15	418976.50	472531.40	284167.50	73
74	133924.10	333279.00	439785.80	420099.30	8265.80	168327.20	100459.00	85176.40	110206.20	788921.50	74
75	43635.50	176210.50	255973.00	241095.50	6500.96	63833.14	25348.81	202286.00	240223.70	534085.10	75
76	120780.40	18539.71	2625.42	4378.21	392287.60	91937.62	157560.40	1009754.00	1091346.00	30657.15	76
77	26632.07	139564.60	211363.00	197630.80	14622.30	42803.85	12830.09	245987.30	287353.60	468655.70	77
78	16345.22	7118.57	28977.10	24175.03	165610.30	6946.54	31486.21	616212.30	680451.30	155976.70	78
79	13626.76	106838.80	170658.90	158352.20	27708.89	25660.54	4442.37	294363.30	339479.70	406955.60	79
80	92196.82	264782.90	360707.20	343248.60	3091.13	120681.40	64798.94	126845.20	157482.00	681234.50	80
81	28965.70	1899.94	16894.28	13100.82	201355.10	15777.66	47708.60	683598.50	751238.40	125167.10	81
82	21483.76	4414.62	23027.66	18611.38	180444.80	10564.38	38413.77	645509.60	710969.30	141780.90	82
83	46788.82	305.23	6755.05	4468.13	244330.40	29835.40	70880.88	762575.40	833387.90	94127.99	83
84	3526.24	23700.72	57678.72	50653.24	113828.30	257.42	11528.33	511566.80	570303.80	216107.60	84
85	98107.80	10375.59	393.55	1067.53	350414.90	72298.43	131458.90	941868.50	1020731.00	43886.31	85
86	893.25	56244.55	104481.50	94860.34	64610.05	5133.68	807.98	399620.50	451634.40	300426.70	86
87	207665.30	59709.85	25509.41	30570.78	539850.00	169003.10	254743.70	1238506.00	1328970.00	4873.18	87
88	48563.63	262.45	6815.50	4652.49	249505.60	30800.32	72166.91	769304.40	841218.80	92461.38	88
89	24910.04	136219.80	207036.40	193645.70	15305.70	40876.51	11994.46	249989.70	291605.40	462458.40	89
90	64872.21	216845.60	304268.40	287955.20	1652.85	89362.61	42118.71	163247.90	197261.00	603184.60	90
91	337878.00	627805.30	771555.10	745154.50	92654.26	391172.80	282756.40	6747.13	14917.67	1217357.00	91
92	14464.59	109351.80	173814.00	161671.00	27112.78	26773.67	5031.70	290431.50	335488.60	411788.90	92
93	120649.20	311929.50	415460.20	396393.90	6168.66	153178.90	88728.47	96836.81	123711.70	756061.40	93
94	226232.20	471707.20	597308.80	574368.80	40329.02	270092.00	181569.90	33742.54	50479.61	995645.40	94
95	90896.02	8214.87	775.56	1067.67	337079.50	65866.90	122447.30	918438.40	996775.00	49778.98	95
96	1392.97	37984.30	79274.58	71096.88	90954.69	1260.50	4868.85	457948.40	514222.20	255372.60	96
97	15483.40	112584.40	177582.50	165142.70	24419.28	28446.64	5814.83	284628.20	328813.80	417859.80	97
98	8135.92	14867.93	43264.16	37266.05	136198.50	2092.07	19422.41	558180.70	619388.80	187334.50	98
99	171126.40	40975.59	13609.24	17315.45	479195.70	136465.70	214547.90	1146938.00	1233633.00	11854.49	99
100	2503.39	26245.07	61229.97	54167.24	108273.30	175.61	10274.62	500246.20	558154.70	223299.60	100

Appendix I (Contd...)

	61	62	63	64	65	66	67	68	69	70	
1	181241.50	4826.50	220453.10	556167.60	395665.00	100202.20	358308.00	376.84	280321.00	714864.50	1
2	28833.97	100658.50	525664.50	1003527.00	783588.30	329142.90	728549.30	67545.15	615531.50	1212260.00	2
3	14432.76	140330.60	610200.00	1118409.00	885162.60	394903.60	828287.20	99640.54	707199.80	1339227.00	3
4	691034.90	1733953.00	2973552.00	4003927.00	3550654.00	2471482.00	3433547.00	1584363.00	3182798.00	4410354.00	4
5	742708.50	1815169.00	3079928.00	4127407.00	3666951.00	2568544.00	3547901.00	1661999.00	3292828.00	4540272.00	5
6	220331.90	1634.50	182569.90	494880.40	344525.70	76268.25	309152.30	2605.85	237109.30	645282.60	6
7	45603.58	74717.41	463968.20	917555.30	707950.50	281205.90	655353.10	46907.89	548478.20	1117225.00	7
8	944455.60	236669.00	6290.65	39466.73	7019.79	54547.97	2509.73	296814.70	419.50	88506.06	8
9	692561.70	120241.40	3913.76	114491.90	49340.06	9238.01	36361.06	163923.80	14806.31	191804.20	9
10	1153158.00	346667.10	33578.60	10618.68	2084.39	113714.50	3163.72	419208.90	15279.70	38749.99	10
11	879613.80	204658.60	2292.43	54511.87	14010.49	39935.76	7567.82	260657.20	562.11	110934.60	11
12	658286.70	106437.70	7314.62	129599.80	59435.94	5903.80	45403.00	147437.40	20858.99	211444.00	12
13	105558.70	27251.15	326002.50	718255.00	534203.10	175844.50	489584.70	11574.30	397737.60	897023.60	13
14	965392.60	247098.20	8063.81	35386.43	5337.34	59250.19	1799.11	308238.50	1033.50	82761.00	14
15	803593.50	168868.60	122.71	75116.07	24996.46	25156.58	15955.72	220074.80	3301.34	139522.60	15
16	387487.20	18843.10	73637.06	300324.10	186219.30	15112.25	159976.80	38202.11	109526.80	419201.00	16
17	481567.70	43499.81	39758.55	226680.00	129296.40	2938.23	107665.20	71131.10	67110.60	331160.50	17
18	1173696.00	357748.20	36340.58	7691.61	1221.91	118264.80	4003.52	430653.30	17239.98	34550.46	18
19	1345155.00	454983.00	71143.26	177.64	11505.76	176204.10	19238.92	536663.30	43013.78	12071.86	19
20	24033.59	406453.30	1092275.00	1747175.00	1452490.00	797932.00	1377618.00	335947.90	1220469.00	2019794.00	20
21	650556.60	103584.40	8763.26	133950.20	63026.94	7650.69	47059.71	145198.40	22305.50	215252.40	21
22	918380.80	223881.80	5055.86	46114.95	10604.62	50045.58	4387.49	282991.80	567.05	97382.35	22
23	963666.60	246279.90	8148.25	36116.20	5992.79	59799.03	1725.99	307798.30	1020.24	83155.35	23
24	1248190.00	399195.90	50552.06	3534.03	5081.69	143662.90	9197.27	476544.10	27208.57	23586.12	24
25	187289.20	2925.17	212232.20	543712.10	385452.90	96176.94	347063.90	486.92	270629.70	699589.90	25
26	328818.80	7999.97	102865.00	356710.80	231321.30	30094.11	201341.30	22163.96	144364.20	484480.60	26
27	728149.40	135717.30	2591.78	101762.90	41753.78	15577.41	28897.74	182669.70	10582.24	173780.70	27
28	570094.10	73401.12	20631.61	174282.80	91315.96	3692.00	72164.71	108994.80	40309.74	265591.10	28
29	766085.60	152269.60	1135.57	88064.25	33169.88	20676.92	21845.87	201682.00	6533.66	155768.10	29
30	392143.50	19833.09	71519.86	296054.60	182951.50	14546.70	156607.20	39920.03	106784.80	413688.30	30
31	98361.21	30257.66	337644.20	735717.10	549591.80	185794.70	502982.80	14329.39	410126.50	915097.10	31
32	111407.40	23717.05	314808.70	701872.20	520367.00	168890.10	475176.00	9970.38	384982.20	877751.40	32
33	18537.18	385443.00	1057559.00	1702971.00	1412018.00	767365.10	1338913.00	316407.00	1183936.00	1972096.00	33
34	86981.62	36850.23	358824.20	766711.40	576251.10	200804.40	529026.40	18471.06	433634.20	949667.00	34
35	137925.80	733717.00	1598544.00	2374794.00	2028886.00	1237185.00	1940279.00	637717.40	1752877.00	2690573.00	35
36	4002.90	298515.50	910099.10	1514554.00	1241014.00	643060.30	1172178.00	238372.20	1027549.00	1768945.00	36
37	4685.44	305491.40	922251.10	1530228.00	1255222.00	653402.60	1185861.00	244698.30	1040442.00	1785692.00	37
38	643454.60	100327.40	8798.76	136220.00	64193.74	5805.35	48550.12	141038.10	23023.44	218920.70	38
39	494399.60	47487.16	36950.07	219313.40	124176.80	3896.60	102134.10	76790.46	62921.89	321665.90	39
40	837946.50	185031.60	1111.09	65811.79	20271.55	32839.34	11557.40	239037.10	1746.37	125673.50	40
41	736280.80	139114.80	1363.45	97328.19	38199.15	14291.83	27123.66	185684.40	9229.28	169092.60	41
42	532846.80	60139.73	27680.28	195175.60	106352.60	3056.47	85748.69	92728.19	50407.04	291788.40	42
43	507412.30	51777.41	33503.85	210607.30	117665.10	3321.18	96162.94	82214.75	58382.46	310738.00	43
44	33832.13	447376.20	1159185.00	1831622.00	1529646.00	855622.10	1452315.00	373538.60	1290953.00	2109686.00	44
45	94077.76	32359.63	345062.80	746723.50	559018.70	190965.70	512214.50	15514.19	418388.00	927581.50	45
46	1216832.00	381574.50	44153.35	4689.22	2859.84	132337.00	6674.61	456908.80	22645.68	27692.70	46
47	63112.55	55899.24	414572.50	847450.70	646657.90	243598.40	596081.60	32686.56	494525.70	1039422.00	47
48	1283338.00	419355.00	58889.94	3917.44	9114.29	157656.10	13303.14	499014.80	33429.41	20802.19	48
49	103550.20	27088.00	326742.20	719508.90	535184.20	176092.50	490488.70	11293.90	398623.60	897829.20	49
50	655198.50	105468.80	8227.65	131689.30	61423.11	7773.18	45834.60	147309.80	21419.93	212282.20	50

Appendix I (Contd...)

	61	62	63	64	65	66	67	68	69	70	
51	461081.70	37652.90	46001.72	241077.10	140189.70	4451.78	117779.50	63494.07	75150.90	348374.60	51
52	792975.50	164075.80	41.80	78198.15	26706.61	23214.26	17354.06	214606.40	3918.41	143586.80	52
53	953092.20	241206.90	7039.93	37581.93	5986.53	55714.37	2574.25	301323.20	898.62	86100.28	53
54	924169.90	226672.90	4725.42	43604.26	8502.93	48879.66	4138.46	285048.00	386.84	95294.16	54
55	161135.50	8159.74	243282.20	592231.00	426159.80	115826.90	387185.30	1006.40	305998.80	755452.50	55
56	523277.10	56718.92	28946.02	199554.90	109094.50	1332.29	89109.99	87944.05	52716.32	297871.70	56
57	396954.90	20916.77	69566.15	292061.30	179846.30	13837.18	153664.10	41475.98	104375.60	408940.30	57
58	543.80	215452.90	759830.80	1318590.00	1064281.00	517799.20	1000645.00	164891.40	867415.00	1556249.00	58
59	713.41	254309.80	830859.90	1411439.00	1147739.00	576078.10	1082193.00	198740.10	943403.60	1657281.00	59
60	1443225.00	512826.40	95032.46	1019.53	21962.87	212378.60	32641.37	599113.10	62075.21	4877.68	60
61	0.00	235789.30	797879.50	1368694.00	1109385.00	549570.60	1044134.00	182873.40	907986.80	1610552.00	61
62	235789.30	0.00	166376.40	468715.40	322736.40	66304.15	287766.50	3598.86	218482.30	614405.10	62
63	797879.50	166376.40	0.00	76592.01	25712.54	23864.31	16679.99	217123.60	3636.81	141519.80	63
64	1368694.00	468715.40	76592.01	0.00	13640.84	184482.70	22240.98	551429.10	47325.63	10118.53	64
65	1109385.00	322736.40	25712.54	13640.84	0.00	97811.52	1476.95	391759.60	10437.46	47014.99	65
66	549570.60	66304.15	23864.31	184482.70	97811.52	0.00	80296.29	98618.81	46045.48	280180.20	66
67	1044134.00	287766.50	16679.99	22240.98	1476.95	80296.29	0.00	353789.70	4806.24	61331.66	67
68	182873.40	3598.86	217123.60	551429.10	391759.60	98618.81	353789.70	0.00	276385.00	708993.10	68
69	907986.80	218482.30	3636.81	47325.63	10437.46	46045.48	4806.24	276385.00	0.00	100256.70	69
70	1610552.00	614405.10	141519.80	10118.53	47014.99	280180.20	61331.66	708993.10	100256.70	0.00	70
71	472877.20	41254.37	42441.65	232666.80	133728.70	3191.43	112138.40	67887.48	70704.23	338368.80	71
72	683274.90	116441.00	4522.10	118009.10	51589.42	8099.20	38322.01	159489.60	16017.03	196101.30	72
73	447255.70	33813.73	50690.95	251600.80	148447.60	6719.03	124737.90	58878.71	80890.37	360530.20	73
74	98152.69	29755.77	336457.00	734018.00	547789.10	183605.30	502227.00	13200.39	409212.30	913952.80	74
75	221964.30	370.27	178625.10	489036.80	339756.20	74531.73	303488.90	2556.66	232343.50	637256.10	75
76	1053616.00	292827.50	17773.60	20602.73	813.12	82177.48	199.73	359020.10	5521.71	59045.35	76
77	267633.30	1104.22	141629.50	426495.10	287904.10	51263.64	254875.50	8398.31	190003.60	566034.50	77
78	650562.20	103299.80	7584.38	132099.20	61026.29	5147.79	46430.68	144085.90	21499.38	213992.20	78
79	318043.40	6188.39	108688.30	367728.40	240039.00	32587.43	209898.20	18931.26	151450.20	497950.70	79
80	142503.50	12665.40	267793.90	630311.30	459099.10	135166.60	416658.20	4114.44	332653.00	796719.00	80
81	719546.40	131609.10	2155.11	103836.10	42496.97	12674.13	30288.95	177334.80	11053.20	177682.30	81
82	680630.50	115433.10	4719.51	119073.50	52198.44	7509.48	39094.46	158076.40	16574.19	197740.40	82
83	800846.00	167933.40	193.04	75820.91	25171.77	23867.29	16808.52	218463.80	3820.31	140821.50	83
84	542787.70	63208.76	24538.65	187798.50	100441.00	960.26	81332.96	95935.86	46766.63	283667.40	84
85	984237.10	256804.50	9784.75	31649.30	3838.08	63722.98	1051.91	319011.70	1634.29	76972.90	85
86	427266.70	28323.90	57583.30	266894.10	160052.70	8395.15	135951.00	51227.39	89760.83	379532.60	86
87	1286896.00	421374.70	58401.49	1602.84	7114.77	156286.30	12737.55	500463.90	33123.67	18199.15	87
88	807419.30	170680.80	342.70	74251.53	24743.29	26621.51	15283.25	222546.20	3057.66	137753.60	88
89	272045.40	1405.21	138284.40	420585.40	282986.30	48932.96	250492.40	9063.51	186143.90	559208.30	89
90	180935.90	3754.39	219473.20	555284.00	395193.60	100930.10	356464.10	282.82	278791.50	713023.40	90
91	10224.32	150090.30	632211.30	1148853.00	912544.10	414311.50	853113.40	108799.30	730474.30	1371548.00	91
92	314015.10	5796.34	111311.60	372335.90	243889.70	34424.86	213213.70	18366.72	154346.30	502800.80	92
93	110500.50	23665.91	315105.30	702320.80	520622.80	168641.10	475691.70	9694.02	385404.50	878098.40	93
94	41811.41	79487.68	475578.70	933817.90	722205.90	290132.50	669107.80	50675.98	561156.00	1135044.00	94
95	960025.40	244483.60	7794.26	36717.25	6175.79	58852.14	1814.61	305782.70	872.57	84031.19	95
96	487224.10	45522.34	39241.15	224494.70	128193.40	4870.11	105562.90	74417.60	65749.68	327532.00	96
97	308068.10	4939.38	114416.00	378162.80	248350.60	35193.81	218045.20	16414.77	158363.70	510166.70	97
98	590819.90	80278.43	15542.63	161081.90	81153.80	1560.21	64170.35	116636.00	33982.42	250587.30	98
99	1193707.00	368853.20	39792.76	5987.63	1568.90	124084.40	5330.48	442570.70	19760.36	31436.24	99
100	531357.60	59534.75	27135.42	194558.10	105297.60	664.39	86127.59	91092.71	50369.97	292007.70	100

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	71	72	73	74	75	76	77	78	79	80	
1	69827.03	162470.20	61475.79	13260.62	4056.94	363107.50	9769.04	147066.90	20623.24	5427.15	1
2	270383.10	433488.40	250827.80	21212.63	91843.24	736689.00	121642.90	407738.60	156373.50	44604.10	2
3	331555.00	510621.10	311523.30	41468.26	130701.30	835957.10	164923.50	482954.70	204874.10	73661.54	3
4	2306295.00	2747968.00	2249561.00	1309894.00	1695828.00	3450510.00	1818640.00	2681948.00	1946542.00	1459131.00	4
5	2400299.00	2850305.00	2342426.00	1380615.00	1776371.00	3565184.00	1901658.00	2783205.00	2032460.00	1534315.00	5
6	50347.26	130434.70	42990.50	25084.03	2171.54	314047.90	3468.24	116916.30	10407.08	12261.23	6
7	226803.20	377613.50	208613.10	10554.63	67058.03	663243.00	93044.57	353604.60	123627.10	27907.93	7
8	81133.10	21283.48	91943.38	433869.50	250957.00	3115.90	206938.20	27379.18	166637.10	354709.40	8
9	21421.40	286.15	27300.56	269313.00	130854.20	38099.67	99239.52	1055.71	72047.98	208827.00	9
10	150308.10	61990.18	164165.60	579081.60	363423.50	3231.63	310670.80	71990.00	260780.00	485686.70	10
11	63353.11	12765.86	73141.75	390172.10	218394.70	8388.19	176943.30	17799.89	139896.90	316411.60	11
12	16183.76	957.40	21552.73	248171.40	116687.40	47218.35	86661.91	986.37	61514.76	191083.20	12
13	134323.40	254630.10	121294.60	902.51	23404.09	495947.10	38272.40	235162.30	58657.85	5929.17	13
14	87392.13	24525.55	98939.15	447987.70	262050.70	2145.81	216617.80	31247.37	175370.30	368306.20	14
15	44041.28	5046.04	52256.13	340136.00	181287.00	17138.57	143872.70	8360.12	110645.20	271270.50	15
16	4896.11	42065.89	2762.58	95652.66	23335.71	163736.70	11102.96	34413.90	3486.45	61753.19	16
17	275.60	17668.07	937.46	144960.30	49987.84	110659.50	31374.61	12828.73	17023.57	101645.60	17
18	156811.60	66133.90	172118.70	593386.40	375375.40	3351.42	321179.50	76733.57	270419.90	500027.00	18
19	223114.80	111219.80	241436.20	716845.80	474898.50	17842.85	413426.60	124851.60	355583.20	614132.20	19
20	705541.10	957643.40	674155.80	216637.80	388550.30	1388680.00	447397.40	919110.10	512106.20	281453.50	20
21	15745.13	1576.73	19281.36	243890.30	112589.90	49807.35	84328.02	929.95	59461.95	184690.40	21
22	74511.23	18182.06	83984.59	416507.00	237429.80	5618.08	195010.50	23631.06	155974.00	338293.40	22
23	87250.54	24465.10	98081.62	446922.30	260805.00	2483.60	215839.30	30974.79	174661.40	366481.80	23
24	185417.80	84923.91	201249.50	646577.00	417589.80	8753.52	360200.10	96838.96	306357.40	548747.40	24
25	65305.78	155284.00	55728.60	14404.17	1523.13	352694.00	7361.45	139852.80	17378.82	3557.62	25
26	13851.96	64631.67	9173.76	67963.53	10488.69	205903.90	3541.57	54746.41	412.57	38830.69	26
27	28741.85	1629.34	34205.19	292140.50	146117.50	31099.70	113556.90	2863.10	84297.08	227013.40	27
28	6149.27	6471.48	7777.51	195921.80	80805.81	75312.56	57607.96	3702.44	37488.68	142846.30	28
29	36280.26	3105.18	42721.15	316292.00	163385.20	23742.49	128772.80	5240.19	97435.89	248448.40	29
30	4269.30	40329.22	1926.55	98038.38	24118.84	160479.90	12013.37	32725.56	3957.65	62766.93	30
31	141713.10	264706.20	126954.20	577.87	25166.19	510150.80	42206.17	244454.30	63408.96	4517.74	31
32	127286.30	244636.60	113471.20	902.77	19443.57	482103.50	34187.54	225301.80	53597.85	3063.32	32
33	676825.90	924898.50	646742.40	201208.60	368041.60	1349256.00	425880.80	886979.90	488901.30	263435.30	33
34	154984.00	283431.20	140014.50	775.39	31272.80	536017.50	50161.00	262362.70	73006.08	6909.15	34
35	1121180.00	1434486.00	1081531.00	468300.00	709284.00	1953273.00	788873.70	1387104.00	873970.50	560265.50	35
36	560339.30	787490.80	532673.40	139923.10	283216.10	1182148.00	333976.10	752518.50	390146.20	192872.20	36
37	569837.20	798818.30	541781.50	144669.90	289856.00	1195976.00	341361.70	763462.50	398113.30	198101.80	37
38	14102.18	1101.90	18085.05	239180.00	109691.60	51016.12	81283.53	544.07	56854.47	181600.70	38
39	1538.24	15993.32	1624.85	152243.50	53939.51	105606.20	34721.59	11501.47	19529.64	107131.50	39
40	52830.64	8446.92	60888.38	362904.80	197421.30	13038.57	158962.30	12264.00	123886.40	290255.50	40
41	29107.78	1125.95	36158.44	297010.90	150293.50	28427.49	116751.90	2722.93	87040.66	232559.30	41
42	3179.56	10321.08	3997.24	174069.90	67050.13	89123.14	45720.59	6660.74	27999.61	124866.60	42
43	1687.09	13804.32	2027.23	159622.20	58214.40	99575.62	38500.52	9434.71	22416.77	112701.90	43
44	759098.80	1020109.00	726026.50	246705.70	428067.80	1463854.00	490702.70	980104.40	558232.00	314073.30	44
45	146364.30	271253.40	131575.10	397.73	27197.25	519307.40	44740.87	250778.40	66547.80	5410.86	45
46	172957.50	76607.85	188818.10	624030.90	399760.80	5994.56	343611.40	88033.96	291053.60	528298.00	46
47	192902.00	333261.10	175754.10	4585.85	49039.61	603864.40	71760.25	310545.90	98830.41	16683.47	47
48	200408.20	95194.57	216012.60	672200.30	438027.90	13222.12	379331.80	107803.20	324046.40	572193.60	48
49	133966.70	255059.50	120830.10	153.71	22768.62	496790.00	38531.87	235246.40	58949.42	4133.20	49
50	16171.68	1283.14	20010.50	246809.10	114591.50	48379.11	86275.96	821.09	61062.94	187039.30	50

Appendix I (Contd...)

	71	72	73	74	75	76	77	78	79	80	
51	152.63	21818.69	375.85	133924.10	43635.50	120780.40	26632.07	16345.22	13626.76	92196.82	51
52	41388.30	4125.31	49399.15	333279.00	176210.50	18539.71	139564.60	7118.57	106838.80	264782.90	52
53	83328.65	22559.26	95101.96	439785.80	255973.00	2625.42	211363.00	28977.10	170658.90	360707.20	53
54	75038.04	18334.40	86235.64	420099.30	241095.50	4378.21	197630.80	24175.03	158352.20	343248.60	54
55	82717.91	182128.20	73320.30	8265.80	6500.96	392287.60	14622.30	165610.30	27708.89	3091.13	55
56	1514.63	10751.94	3055.45	168327.20	63833.14	91937.62	42803.85	6946.54	25660.54	120681.40	56
57	3958.60	38908.85	1696.15	100459.00	25348.81	157560.40	12830.09	31486.21	4442.37	64798.94	57
58	443539.70	648042.70	418976.50	85176.40	202286.00	1009754.00	245987.30	616212.30	294363.30	126845.20	58
59	498040.00	713845.10	472531.40	110206.20	240223.70	1091346.00	287353.60	680451.30	339479.70	157482.00	59
60	263958.00	140670.90	284167.50	788921.50	534085.10	30657.15	468655.70	155976.70	406955.60	681234.50	60
61	472877.20	683274.90	447255.70	98152.69	221964.30	1053616.00	267633.30	650562.20	318043.40	142503.50	61
62	41254.37	116441.00	33813.73	29755.77	370.27	292827.50	1104.22	103299.80	6188.39	12665.40	62
63	42441.65	4522.10	50690.95	336457.00	178625.10	17773.60	141629.50	7584.38	108688.30	267793.90	63
64	232666.80	118009.10	251600.80	734018.00	489036.80	20602.73	426495.10	132099.20	367728.40	630311.30	64
65	133728.70	51589.42	148447.60	547789.10	339756.20	813.12	287904.10	61026.29	240039.00	459099.10	65
66	3191.43	8099.20	6719.03	183605.30	74531.73	82177.48	51263.64	5147.79	32587.43	135166.60	66
67	112138.40	38322.01	124737.90	502227.00	303488.90	199.73	254875.50	46430.68	209898.20	416658.20	67
68	67887.48	159489.60	58878.71	13200.39	2556.66	359020.10	8398.31	144085.90	18931.26	4114.44	68
69	70704.23	16017.03	80890.37	409212.30	232343.50	5521.71	190003.60	21499.38	151450.20	332653.00	69
70	338368.80	196101.30	360530.20	913952.80	637256.10	59045.35	566034.50	213992.20	497950.70	796719.00	70
71	0.00	19491.91	808.20	140378.20	47550.60	114912.90	29657.46	14299.48	15884.85	97776.31	71
72	19491.91	0.00	25195.46	263612.70	126741.70	40018.87	96034.93	505.19	69261.65	203267.40	72
73	808.20	25195.46	0.00	126616.30	39157.77	128241.40	23356.90	19130.30	11308.29	85523.29	73
74	140378.20	263612.70	126616.30	0.00	25104.97	508799.70	41683.43	243494.00	62879.93	4901.76	74
75	47550.60	126741.70	39157.77	25104.97	0.00	308919.90	2372.90	112849.40	8791.56	9215.02	75
76	114912.90	40018.87	128241.40	508799.70	308919.90	0.00	259725.20	48394.97	214320.40	423091.20	76
77	29657.46	96034.93	23356.90	41683.43	2372.90	259725.20	0.00	84093.31	2199.52	20791.89	77
78	14299.48	505.19	19130.30	243494.00	112849.40	48394.97	84093.31	0.00	59202.38	185396.90	78
79	15884.85	69261.65	11308.29	62879.93	8791.56	214320.40	2199.52	59202.38	0.00	35933.17	79
80	97776.31	203267.40	85523.29	4901.76	9215.02	423091.20	20791.89	185396.90	35933.17	0.00	80
81	26313.26	675.16	32547.82	286256.60	142518.50	32025.79	109615.40	1991.51	80897.19	223325.90	81
82	19041.73	152.40	24930.93	261933.90	125841.40	40713.11	94984.85	546.85	68432.78	202309.40	82
83	43066.14	4900.87	51938.31	338433.60	180507.10	17542.58	143134.00	8142.71	110062.60	270192.20	83
84	2709.93	8205.62	4807.37	179384.30	70794.83	84045.68	48299.54	4967.02	29975.05	130415.40	84
85	92830.86	27468.79	104846.30	460905.20	271896.00	1198.30	225808.00	34466.78	183632.60	379654.90	85
86	1542.07	30097.85	748.01	115907.10	33757.32	139280.60	18758.68	23714.63	8170.58	77928.26	86
87	200036.00	95060.02	216893.00	674575.00	440271.80	11867.06	381424.30	107569.90	325924.30	574451.70	87
88	45180.54	5454.15	52905.70	342728.50	182775.40	16756.79	145607.90	8701.70	112119.20	272688.20	88
89	27813.80	93116.15	21926.26	43456.62	2789.78	255081.90	231.81	81381.56	1948.36	21805.25	89
90	69520.28	161441.60	59869.08	12734.06	2484.17	362054.50	8706.61	146021.20	19457.21	3550.67	90
91	348168.90	530790.80	325966.30	46457.82	139261.40	861946.60	175415.80	502182.20	216706.00	78900.05	91
92	16872.97	71253.32	11842.89	61306.88	7993.50	217787.60	2241.69	60949.09	290.49	33933.03	92
93	126954.60	244728.20	113360.20	548.99	19297.75	482406.30	34433.88	225292.20	53818.01	2376.96	93
94	234746.80	388132.60	216210.40	12194.86	71373.38	677092.80	98308.19	363563.90	129691.50	30330.04	94
95	86048.02	23832.54	96821.01	444473.30	258883.40	2561.85	214211.90	30227.77	173175.00	364072.00	95
96	1622.35	17545.59	1218.92	148420.20	51533.11	109246.40	33115.89	12686.91	18381.07	103381.10	96
97	17752.30	73818.00	13194.12	58471.19	7338.61	222320.50	1578.08	63367.21	203.80	32738.71	97
98	6745.14	3434.27	10163.01	207468.40	88837.38	66496.07	63454.53	1487.68	42116.91	154412.60	98
99	164033.60	70906.54	180055.50	607488.60	386914.90	4408.12	331528.90	81875.90	279976.50	513577.70	99
100	1748.46	9610.28	3957.65	172947.50	66980.28	88603.53	45349.99	6122.57	27689.50	124956.60	100

Appendix I (Contd...)

	81	82	83	84	85	86	87	88	89	90	
1	180625.70	160820.60	221303.80	98546.44	322871.70	53120.74	505693.00	226500.60	10290.87	1142.85	1
2	462114.40	431397.80	528233.30	323175.00	678791.10	235497.50	933703.90	533139.60	124948.10	66062.00	2
3	542143.70	507906.70	611859.10	390748.00	774242.90	293227.60	1046033.00	619491.30	168267.40	98916.46	3
4	2820708.00	2742873.00	2978877.00	2458452.00	3324081.00	2204768.00	3863187.00	2991909.00	1829746.00	1578774.00	4
5	2924110.00	2844955.00	3085269.00	2555194.00	3436577.00	2296151.00	3984675.00	3098597.00	1913291.00	1656237.00	5
6	145968.50	128776.20	183611.30	73871.29	276614.70	35494.15	447244.30	187661.10	4372.78	2993.73	6
7	404329.20	375792.70	466612.00	275210.70	608431.20	194946.30	850520.10	470764.80	95987.26	45364.80	7
8	15449.68	21859.07	6511.78	55317.85	528.46	101631.80	26476.02	5505.07	202950.30	299325.30	8
9	334.15	205.25	4277.97	9246.18	25842.44	31955.02	92058.74	4816.94	96663.06	165842.60	9
10	51826.38	63355.16	34038.14	114286.50	7715.16	177831.80	4087.22	31081.44	305703.00	421749.40	10
11	8125.15	12985.58	2367.92	40657.63	3377.33	80856.55	39555.10	2028.49	173573.40	262999.60	11
12	1761.98	548.41	7543.28	6066.99	33461.97	25112.24	105963.00	8694.45	84458.74	149324.90	12
13	276401.80	252550.50	327646.10	172042.60	448616.50	109728.00	660102.80	332449.80	40442.97	11275.58	13
14	18085.51	24903.75	8000.85	60493.45	256.98	108278.90	23553.36	7421.46	212718.10	310887.70	14
15	2365.32	5230.07	353.77	25579.46	9331.30	59034.01	57107.85	286.70	140678.80	222245.40	15
16	51107.35	41265.27	74677.50	13270.07	137049.00	1063.01	262910.00	76665.10	10424.67	39107.80	16
17	23874.14	17222.25	40552.48	1883.52	88954.49	1692.65	194310.20	42099.86	29810.22	72458.90	17
18	55758.10	67119.82	36069.73	120413.30	8522.92	185218.40	2741.82	34614.42	315968.60	433824.90	18
19	97407.35	112281.00	70561.37	179141.50	28216.02	256649.50	817.25	68740.35	407690.00	540300.10	19
20	999771.60	954115.20	1095631.00	789618.50	1308684.00	648619.70	1654957.00	1103353.00	453829.60	333109.60	20
21	2650.48	1969.60	10131.33	5631.30	35821.23	24641.02	108361.10	8886.21	82011.35	146271.00	21
22	12667.52	18935.82	5851.34	49554.29	2091.51	93778.93	31464.22	3774.26	191415.40	284872.50	22
23	17924.86	25073.93	8553.16	60111.58	533.59	108047.90	23602.08	6989.02	212069.10	310036.10	23
24	72540.25	86043.96	50628.99	144922.40	16132.87	215479.00	527.51	47889.90	355220.80	479343.70	24
25	172791.50	154174.50	214095.10	92504.05	313055.70	49111.53	492404.20	217017.00	8055.38	367.22	25
26	75970.41	64108.93	104560.40	27012.97	175926.30	7096.03	315042.40	105856.50	3085.32	22501.64	26
27	807.19	2179.08	3722.24	14191.59	20357.36	40985.69	79591.29	2340.24	110705.80	184072.10	27
28	10063.53	6849.34	22143.86	1396.17	57848.46	11878.14	144931.00	21309.65	55446.51	109914.30	28
29	1415.30	3706.46	2100.37	19690.83	14535.48	50072.06	67560.87	763.79	125644.00	203308.40	29
30	49416.89	39876.10	72802.91	12316.95	134121.60	981.21	258509.10	74193.57	11066.00	40668.52	30
31	287069.90	263312.60	340267.30	180189.80	462246.20	116935.90	675409.80	343159.00	44266.95	13182.44	31
32	265901.90	243071.40	317201.50	163602.80	435478.80	103492.40	643306.60	320269.40	36298.23	9013.67	32
33	967227.10	921688.40	1060484.00	760355.20	1270587.00	622070.20	1612174.00	1068962.00	431263.40	314209.50	33
34	307014.30	281983.50	361234.50	195848.40	486946.20	129564.00	705339.00	364922.50	51944.71	17682.24	34
35	1486534.00	1430520.00	1602575.00	1227251.00	1858302.00	1049795.00	2266826.00	1611902.00	796787.20	633925.80	35
36	826112.50	784379.80	913052.30	636016.00	1108504.00	510189.80	1428832.00	920461.20	339218.60	236178.80	36
37	837717.80	795723.90	925345.40	646135.90	1121908.00	519375.70	1443873.00	932588.70	346648.40	242467.00	37
38	2294.60	1177.59	9751.77	4525.13	36716.85	22468.09	110949.10	9415.73	79117.25	142309.40	38
39	21440.57	15821.41	38272.24	1589.27	84481.62	2991.54	186922.70	38455.01	33434.55	77518.97	39
40	4966.81	9106.74	1885.11	32270.71	6587.74	69267.53	48282.05	391.01	155554.90	240851.10	40
41	521.78	1286.49	1598.22	14954.81	18077.84	42152.12	76639.63	2155.77	113485.90	188012.90	41
42	14680.28	10347.78	29156.74	642.89	69876.00	6817.93	164303.60	28739.33	44106.58	93532.11	42
43	19038.74	13764.24	34927.59	1041.83	79135.38	4299.00	178614.00	34892.47	36923.49	83068.10	43
44	1064018.00	1016972.00	1163009.00	846546.30	1381823.00	700603.40	1736471.00	1170185.00	496991.80	370313.60	44
45	293974.60	269777.60	347547.90	185609.30	470950.30	121142.40	686149.40	350809.30	46777.14	14525.28	45
46	65145.32	77619.60	43930.47	134320.30	12465.63	202424.90	1076.70	42061.70	338468.60	459976.40	46
47	358246.00	331617.40	417358.00	237430.90	551603.10	163622.30	782742.30	420699.00	74459.22	31242.22	47
48	81777.13	96556.68	59361.98	157742.40	21594.10	230755.20	1469.24	55374.14	374585.40	501317.30	48
49	277466.10	253318.80	328530.20	172410.70	449507.00	110323.40	660854.00	333198.60	40122.93	11077.20	49
50	2562.92	1837.40	9469.26	6124.14	34679.41	25565.74	106357.80	8418.54	83625.85	148461.00	50

Appendix I (Contd...)

	81	82	83	84	85	86	87	88	89	90	
51	28965.70	21483.76	46788.82	3526.24	98107.80	893.25	207665.30	48563.63	24910.04	64872.21	51
52	1899.94	4414.62	305.23	23700.72	10375.59	56244.55	59709.85	262.45	136219.80	216845.60	52
53	16894.28	23027.66	6755.05	57678.72	393.55	104481.50	25509.41	6815.50	207036.40	304268.40	53
54	13100.82	18611.38	4468.13	50653.24	1067.53	94860.34	30570.78	4652.49	193645.70	287955.20	54
55	201355.10	180444.80	244330.40	113828.30	350414.90	64610.05	539850.00	249505.60	15305.70	1652.85	55
56	15777.66	10564.38	29835.40	257.42	72298.43	5133.68	169003.10	30800.32	40876.51	89362.61	56
57	47708.60	38413.77	70880.88	11528.33	131458.90	807.98	254743.70	72166.91	11994.46	42118.71	57
58	683598.50	645509.60	762575.40	511566.80	941868.50	399620.50	1238506.00	769304.40	249989.70	163247.90	58
59	751238.40	710969.30	833387.90	570303.80	1020731.00	451634.40	1328970.00	841218.80	291605.40	197261.00	59
60	125167.10	141780.90	94127.99	216107.60	43886.31	300426.70	4873.18	92461.38	462458.40	603184.60	60
61	719546.40	680630.50	800846.00	542787.70	984237.10	427266.70	1286896.00	807419.30	272045.40	180935.90	61
62	131609.10	115433.10	167933.40	63208.76	256804.50	28323.90	421374.70	170680.80	1405.21	3754.39	62
63	2155.11	4719.51	193.04	24538.65	9784.75	57583.30	58401.49	342.70	138284.40	219473.20	63
64	103836.10	119073.50	75820.91	187798.50	31649.30	266894.10	1602.84	74251.53	420585.40	555284.00	64
65	42496.97	52198.44	25171.77	100441.00	3838.08	160052.70	7114.77	24743.29	282986.30	395193.60	65
66	12674.13	7509.48	23867.29	960.26	63722.98	8395.15	156286.30	26621.51	48932.96	100930.10	66
67	30288.95	39094.46	16808.52	81332.96	1051.91	135951.00	12737.55	15283.25	250492.40	356464.10	67
68	177334.80	158076.40	218463.80	95935.86	319011.70	51227.39	500463.90	222546.20	9063.51	282.82	68
69	11053.20	16574.19	3820.31	46766.63	1634.29	89760.83	33123.67	3057.66	186143.90	278791.50	69
70	177682.30	197740.40	140821.50	283667.40	76972.90	379532.60	18199.15	137753.60	559208.30	713023.40	70
71	26313.26	19041.73	43066.14	2709.93	92830.86	1542.07	200036.00	45180.54	27813.80	69520.28	71
72	675.16	152.40	4900.87	8205.62	27468.79	30097.85	95060.02	5454.15	93116.15	161441.60	72
73	32547.82	24930.93	51938.31	4807.37	104846.30	748.01	216893.00	52905.70	21926.26	59869.08	73
74	286256.60	261933.90	338433.60	179384.30	460905.20	115907.10	674575.00	342728.50	43456.62	12734.06	74
75	142518.50	125841.40	180507.10	70794.83	271896.00	33757.32	440271.80	182775.40	2789.78	2484.17	75
76	32025.79	40713.11	17542.58	84045.68	1198.30	139280.60	11867.06	16756.79	255081.90	362054.50	76
77	109615.40	94984.85	143134.00	48299.54	225808.00	18758.68	381424.30	145607.90	231.81	8706.61	77
78	1991.51	546.85	8142.71	4967.02	34466.78	23714.63	107569.90	8701.70	81381.56	146021.20	78
79	80897.19	68432.78	110062.60	29975.05	183632.60	8170.58	325924.30	112119.20	1948.36	19457.21	79
80	223325.90	202309.40	270192.20	130415.40	379654.90	77928.26	574451.70	272688.20	21805.25	3550.67	80
81	0.00	727.40	2653.54	12482.81	20897.49	38013.92	82272.78	2703.55	106922.70	179190.70	81
82	727.40	0.00	4958.48	7920.93	28011.72	29489.12	96235.14	5940.96	92261.43	160213.00	82
83	2653.54	4958.48	0.00	25348.98	9656.06	58427.94	58219.38	943.46	139611.10	221160.10	83
84	12482.81	7920.93	25348.98	0.00	65269.01	7087.26	158312.10	26326.02	46426.62	97405.28	84
85	20897.49	28011.72	9656.06	65269.01	0.00	114793.00	20490.97	9115.11	221522.00	321880.60	85
86	38013.92	29489.12	58427.94	7087.26	114793.00	0.00	231779.20	60369.76	17590.76	52413.47	86
87	82272.78	96235.14	58219.38	158312.10	20490.97	231779.20	0.00	55864.74	375944.60	503720.10	87
88	2703.55	5940.96	943.46	26326.02	9115.11	60369.76	55864.74	0.00	142348.70	224455.30	88
89	106922.70	92261.43	139611.10	46426.62	221522.00	17590.76	375944.60	142348.70	0.00	9600.68	89
90	179190.70	160213.00	221160.10	97405.28	321880.60	52413.47	503720.10	224455.30	9600.68	0.00	90
91	562297.30	528313.50	634984.10	407763.20	799202.10	308417.60	1074061.00	640452.60	179476.40	107043.40	91
92	83304.66	70750.85	112918.70	31430.49	186922.40	9220.50	329879.50	114493.60	1739.32	18732.89	92
93	266455.30	243317.70	317380.20	163833.10	435835.40	103662.90	643740.30	320730.20	36132.46	8966.75	93
94	415296.30	386275.80	478297.50	284106.20	621678.00	202625.70	866072.90	482483.00	101224.70	49262.25	94
95	17497.68	24504.43	8204.51	59199.97	505.81	106894.40	24037.01	6654.75	210318.00	308075.60	95
96	23276.17	17507.54	40794.85	2166.87	87775.53	2939.31	191398.20	40566.42	31809.14	75004.61	96
97	86047.78	72908.83	115627.80	33055.36	191059.00	9816.26	335933.80	118233.80	1207.60	17137.04	97
98	6453.63	3270.88	16182.97	1059.08	49952.53	13403.03	133904.30	17077.45	61189.42	118330.10	98
99	60083.28	71705.13	39249.05	126788.60	10137.81	193013.40	2094.83	38268.22	326285.40	446102.50	99
100	14652.65	9409.94	27709.70	297.91	69357.57	5982.79	164761.10	29262.30	43136.75	92793.47	100

Appendix I (Contd...)

	91	92	93	94	95	96	97	98	99	100	
1	107784.30	20397.48	10370.80	50675.44	310257.70	77682.13	17819.59	119390.40	446860.30	93381.81	1
2	4973.76	153911.20	27113.34	1520.77	658509.30	280453.00	149745.20	360631.00	854643.80	314795.80	2
3	1784.75	202667.30	50497.53	10816.98	754027.30	345491.70	196744.60	431555.80	960915.60	380790.30	3
4	865605.70	1936005.00	1353743.00	1071993.00	3279606.00	2337889.00	1921636.00	2559436.00	3700367.00	2433439.00	4
5	922672.20	2022090.00	1425740.00	1136044.00	3391373.00	2432271.00	2007232.00	2658216.00	3819113.00	2529949.00	5
6	137026.80	11033.06	20355.59	71468.06	264480.40	55705.88	8946.93	92251.33	392277.80	70202.06	6
7	13257.19	121251.10	14547.07	236.25	588940.10	235571.30	117815.50	309806.80	775485.10	267554.10	7
8	763350.60	169601.20	409292.90	589889.10	142.69	75758.03	173848.10	41334.99	14821.46	59283.54	8
9	538361.80	74526.35	250320.00	395015.70	22286.64	19072.71	76900.53	4254.72	68253.18	11118.10	9
10	952360.00	263802.70	550063.60	756754.80	9182.21	141735.20	269937.80	93813.52	1702.61	119904.60	10
11	704407.20	143248.10	367156.20	538920.10	2355.55	58684.18	146705.30	28936.38	24611.70	44305.91	11
12	507960.70	64240.77	230207.60	369443.30	29575.76	14584.54	65970.48	2444.73	80099.76	7698.25	12
13	50882.89	58035.90	1445.97	15533.78	432698.70	142281.10	54643.01	199620.50	593266.50	166106.30	13
14	781762.40	178879.60	423268.50	606573.00	388.98	82134.13	182813.10	45845.21	12404.75	64698.46	14
15	636896.60	113449.20	318629.90	479832.50	7287.35	40353.85	116615.80	16434.16	38820.64	28423.90	15
16	274496.70	4454.90	84558.78	175414.90	128221.20	6555.71	4698.57	21677.12	221620.20	11926.97	16
17	354960.80	18240.36	131134.30	240450.70	81986.65	858.66	19318.12	5620.81	159052.40	1400.76	17
18	971133.90	274049.80	564673.80	773974.10	11123.38	149871.00	279384.40	99158.72	295.20	125803.00	18
19	1127338.00	360014.90	685351.30	914255.80	32790.34	214766.20	365871.90	153057.20	4600.70	185820.20	19
20	62616.49	507882.70	234921.60	127161.50	1280658.00	722185.30	499887.70	847616.10	1548797.00	776486.60	20
21	501820.90	60792.32	224952.60	362912.30	30466.17	11879.15	64139.59	2367.23	83673.01	7401.63	21
22	739768.00	158557.20	391919.20	568896.70	617.90	67943.85	163237.90	36541.63	19342.57	53666.19	22
23	780239.30	177790.80	421778.90	604804.40	37.06	80888.12	182248.10	45594.24	12990.58	64529.15	23
24	1038147.00	310363.30	616229.00	834018.00	18900.17	176214.90	316354.50	121748.00	1383.92	151482.50	24
25	112308.60	16362.13	10178.91	52477.23	299287.70	70534.62	15097.71	112951.50	435673.80	87967.60	25
26	226107.00	237.41	58166.07	136480.20	165297.20	15609.05	753.26	38523.88	270401.40	24831.42	26
27	570380.30	85924.64	271497.60	421529.30	16301.66	24279.89	89692.50	7879.73	58733.23	16546.01	27
28	432034.20	38112.59	178890.10	303679.00	51281.55	3613.57	41110.66	1314.97	116002.10	2079.92	28
29	604078.50	99229.38	294897.80	450613.60	11165.23	31677.70	103168.20	11918.92	48437.74	22288.17	29
30	278826.30	4425.85	86491.88	178385.70	125118.60	5445.63	5219.55	20438.94	217946.30	10896.55	30
31	46547.96	61453.11	507.45	11942.77	444918.00	148052.20	59336.14	208404.90	609137.30	174164.50	31
32	55076.09	52252.02	323.61	16805.67	418828.40	133327.70	50006.13	190640.20	578400.60	158110.90	32
33	55348.85	484164.10	219094.20	115802.90	1243633.00	694900.20	476400.00	816954.30	1507096.00	746524.50	33
34	39516.59	70698.13	1609.65	8505.33	469614.10	162838.90	68264.31	225045.80	637281.80	189056.60	34
35	220478.40	867626.60	494783.40	330810.60	1824906.00	1142548.00	857694.50	1299105.00	2142433.00	1210262.00	35
36	25525.05	386235.80	154812.40	70491.50	1082964.00	575972.50	379196.30	688033.50	1330203.00	623847.80	36
37	27625.09	394007.00	159681.60	73735.60	1096076.00	585441.60	387031.50	698556.50	1344872.00	633878.10	37
38	495177.70	58718.44	220803.90	357729.60	31727.62	11085.22	61383.60	1491.84	85322.98	6165.09	38
39	365488.30	20637.31	137555.70	249005.60	76948.13	197.58	22439.19	4921.34	153078.50	1744.25	39
40	667887.40	126129.50	340052.10	506082.40	4268.57	47499.78	130328.20	21942.22	32410.84	35520.48	40
41	577977.70	89198.03	276981.00	428521.70	15325.33	26978.90	91969.62	8100.89	55056.88	16722.21	41
42	399103.00	28931.90	158140.70	276482.00	62756.16	1083.62	31298.68	2238.77	133058.70	1191.61	42
43	377295.90	23199.86	144453.30	258337.80	71748.46	314.88	25297.32	3720.00	145778.20	1180.37	43
44	79621.46	552876.40	265703.30	149892.40	1352608.00	775965.30	545324.00	906423.50	1628305.00	832590.80	44
45	43566.21	64634.60	735.15	10499.83	453682.30	153229.10	62322.15	214213.70	619119.10	179390.60	45
46	1009971.00	294989.40	594492.30	808798.00	15360.25	165095.20	300513.00	111909.90	364.72	140263.00	46
47	23380.70	96557.33	6920.26	2220.42	532720.00	200338.10	93742.38	269694.50	711151.80	230508.00	47
48	1069587.00	328132.10	640845.30	862374.60	24059.63	189266.00	334802.50	133753.10	4106.13	165023.10	48
49	50483.96	57465.87	532.20	14404.08	433521.60	142457.80	54499.01	199883.30	594274.70	165922.70	49
50	506365.10	62170.22	227773.10	366589.40	29562.04	12709.47	65605.32	2530.67	81863.21	7577.64	50

Appendix I (Contd...)

	91	92	93	94	95	96	97	98	99	100	
51	337878.00	14464.59	120649.20	226232.20	90896.02	1392.97	15483.40	8135.92	171126.40	2503.39	51
52	627805.30	109351.80	311929.50	471707.20	8214.87	37984.30	112584.40	14867.93	40975.59	26245.07	52
53	771555.10	173814.00	415460.20	597308.80	775.56	79274.58	177582.50	43264.16	13609.24	61229.97	53
54	745154.50	161671.00	396393.90	574368.80	1067.67	71096.88	165142.70	37266.05	17315.45	54167.24	54
55	92654.26	27112.78	6168.66	40329.02	337079.50	90954.69	24419.28	136198.50	479195.70	108273.30	55
56	391172.80	26773.67	153178.90	270092.00	65866.90	1260.50	28446.64	2092.07	136465.70	175.61	56
57	282756.40	5031.70	88728.47	181569.90	122447.30	4868.85	5814.83	19422.41	214547.90	10274.62	57
58	6747.13	290431.50	96836.81	33742.54	918438.40	457948.40	284628.20	558180.70	1146938.00	500246.20	58
59	14917.67	335488.60	123711.70	50479.61	996775.00	514222.20	328813.80	619388.80	1233633.00	558154.70	59
60	1217357.00	411788.90	756061.40	995645.40	49778.98	255372.60	417859.80	187334.50	11854.49	223299.60	60
61	10224.32	314015.10	110500.50	41811.41	960025.40	487224.10	308068.10	590819.90	1193707.00	531357.60	61
62	150090.30	5796.34	23665.91	79487.68	244483.60	45522.34	4939.38	80278.43	368853.20	59534.75	62
63	632211.30	111311.60	315105.30	475578.70	7794.26	39241.15	114416.00	15542.63	39792.76	27135.42	63
64	1148853.00	372335.90	702320.80	933817.90	36717.25	224494.70	378162.80	161081.90	5987.63	194558.10	64
65	912544.10	243889.70	520622.80	722205.90	6175.79	128193.40	248350.60	81153.80	1568.90	105297.60	65
66	414311.50	34424.86	168641.10	290132.50	58852.14	4870.11	35193.81	1560.21	124084.40	664.39	66
67	853113.40	213213.70	475691.70	669107.80	1814.61	105562.90	218045.20	64170.35	5330.48	86127.59	67
68	108799.30	18366.72	9694.02	50675.98	305782.70	74417.60	16414.77	116636.00	442570.70	91092.71	68
69	730474.30	154346.30	385404.50	561156.00	872.57	65749.68	158363.70	33982.42	19760.36	50369.97	69
70	1371548.00	502800.80	878098.40	1135044.00	84031.19	327532.00	510166.70	250587.30	31436.24	292007.70	70
71	348168.90	16872.97	126954.60	234746.80	86048.02	1622.35	17752.30	6745.14	164033.60	1748.46	71
72	530790.80	71253.32	244728.20	388132.60	23832.54	17545.59	73818.00	3434.27	70906.54	9610.28	72
73	325966.30	11842.89	113360.20	216210.40	96821.01	1218.92	13194.12	10163.01	180055.50	3957.65	73
74	46457.82	61306.88	548.99	12194.86	444473.30	148420.20	58471.19	207468.40	607488.60	172947.50	74
75	139261.40	7993.50	19297.75	71373.38	258883.40	51533.11	7338.61	88837.38	386914.90	66980.28	75
76	861946.60	217787.60	482406.30	677092.80	2561.85	109246.40	222320.50	66496.07	4408.12	88603.53	76
77	175415.80	2241.69	34433.88	98308.19	214211.90	33115.89	1578.08	63454.53	331528.90	45349.99	77
78	502182.20	60949.09	225292.20	363563.90	30227.77	12686.91	63367.21	1487.68	81875.90	6122.57	78
79	216706.00	290.49	53818.01	129691.50	173175.00	18381.07	203.80	42116.91	279976.50	27689.50	79
80	78900.05	33933.03	2376.96	30330.04	364072.00	103381.10	32738.71	154412.60	513577.70	124956.60	80
81	562297.30	83304.66	266455.30	415296.30	17497.68	23276.17	86047.78	6453.63	60083.28	14652.65	81
82	528313.50	70750.85	243317.70	386275.80	24504.43	17507.54	72908.83	3270.88	71705.13	9409.94	82
83	634984.10	112918.70	317380.20	478297.50	8204.51	40794.85	115627.80	16182.97	39249.05	27709.70	83
84	407763.20	31430.49	163833.10	284106.20	59199.97	2166.87	33055.36	1059.08	126788.60	297.91	84
85	799202.10	186922.40	435835.40	621678.00	505.81	87775.53	191059.00	49952.53	10137.81	69357.57	85
86	308417.60	9220.50	103662.90	202625.70	106894.40	2939.31	9816.26	13403.03	193013.40	5982.79	86
87	1074061.00	329879.50	643740.30	866072.90	24037.01	191398.20	335933.80	133904.30	2094.83	164761.10	87
88	640452.60	114493.60	320730.20	482483.00	6654.75	40566.42	118233.80	17077.45	38268.22	29262.30	88
89	179476.40	1739.32	36132.46	101224.70	210318.00	31809.14	1207.60	61189.42	326285.40	43136.75	89
90	107043.40	18732.89	8966.75	49262.25	308075.60	75004.61	17137.04	118330.10	446102.50	92793.47	90
91	0.00	213892.00	55046.56	11451.38	777165.80	359603.10	208872.40	449711.60	989114.60	398410.00	91
92	213892.00	0.00	52098.70	127092.80	176147.10	19139.43	391.28	43735.65	284015.10	28902.72	92
93	55046.56	52098.70	0.00	16481.37	419385.40	133686.20	49905.09	190741.70	578721.40	157851.90	93
94	11451.38	127092.80	16481.37	0.00	601970.40	243822.50	123598.10	319253.50	790383.00	276244.40	94
95	777165.80	176147.10	419385.40	601970.40	0.00	79849.00	180668.10	44771.09	13301.36	63477.10	95
96	359603.10	19139.43	133686.20	243822.50	79849.00	0.00	21155.47	5837.03	157430.40	2213.03	96
97	208872.40	391.28	49905.09	123598.10	180668.10	21155.47	0.00	45676.89	289037.50	30365.19	97
98	449711.60	43735.65	190741.70	319253.50	44771.09	5837.03	45676.89	0.00	105004.60	1712.19	98
99	989114.60	284015.10	578721.40	790383.00	13301.36	157430.40	289037.50	105004.60	0.00	132322.30	99
100	398410.00	28902.72	157851.90	276244.40	63477.10	2213.03	30365.19	1712.19	132322.30	0.00	100

Appendix II

Analysis for combining ability for vegetative characters

	Character	Mean squares		
		GCA	SCA	Error
1.	Plant height	50.647*	68.590**	16.430
2.	Internode length	2.980	2.210	1.240
3.	Days from emergence to maturity of leaves	4.050	4.070*	1.950
4.	Number of leaves	0.062	7.510	0.050
5.	Length of leaf blade	20.330**	68.770**	0.500
6.	Width of leaf blade	45.120**	14.990**	0.170
7.	Leaf size/leaf area	49405.430**	38144.080**	237.300
8.	Suckering ability	0.859**	0.159**	0.056

* Significant at 5 per cent level

** Significant at 1 per cent level

Appendix III

Analysis of variance for combining ability for floral characters

Sl. No.	Character	Mean squares		
		GCA	SCA	Error
1.	Time taken for first flowering	0.537**	0.107	0.057
2.	Days from emergence to maturity of inflorescence	6.32	19.70**	2.93
3.	Length of spathe	5.82**	4.18**	0.25
4.	Width of spathe	2.81**	4.16**	0.18
5.	Number of spadices/plant	9.83	0.194**	0.04
6.	Candle length	2.40**	3.44**	0.035
7.	Position of candle	555.90**	304.71**	0.28
8.	Number of flowers/candle	8382.14**	6291.50**	20.34
9.	Life of spadix	119.81**	64.35**	19.35
10.	Days to intiation of female phase	0.929**	1.15**	0.13
11.	Duration of female phase	2.97**	2.67**	0.53
12.	Days of interphase	1.82**	1.12**	0.31
13.	Duration of male phase	0.72*	2.58**	0.24
14.	Pollen fertility	78.25**	15.43**	0.40
15.	Total anthocyanin content	14066.64**	2645.93**	0.53
16.	Total carotene content	9.01**	4.01**	0.22

* Significant at 5 per cent level

** Significant at 1 per cent level

Appendix IV

Probable genotypes of the ten F_1 hybrids of *A. andreanum* in Experiment No. II

(1) (P_1) **HR x P** (P_2)

Genotypes MmOO x MmOo

Gametes MO, mO MO, Mo, mO, mo

		F1 genotypes	F1 phenotypes	
MO	MO	MMOO	Dark Maroon	
	Mo	MMOo	Dark Red	→ Hybrid No. 1
	mO	MmOO	Red	
	mo	MmOo	Pink	
mO	MO	MmOO	Red	
	Mo	MmOo	Pink	
	mO	mmOO	Orange	
	mo	mmOo	Coral	

(2) (P_1) **HR x LR** (P_2)

Genotypes MmOO x MMOO

Gametes MO, mO MO

	F1 genotypes	F1 phenotypes	
MO - MO	MMOO	Dark Maroon	
mO - MO	MmOO	Red	→ Hybrid No. 2

(3) (P_1) **HR x KR** (P_2)

Genotypes MmOO x MMOo

Gametes MO, mO MO, Mo

		F_1 genotypes	F_1 phenotypes	
MO	MO	MMOO	Maroon	
	Mo	MMOo	Dark Red	→ Hybrid No. 3
mO	MO	MmOO	Red	
	Mo	MmOo	Pink	

(4) (P_1) **HR x CR** (P_2)

Genotypes MmOO x MMOo

Gametes MO, mO MO, Mo

		F_1 genotypes	F_1 phenotypes	
MO	MO	MMOO	Maroon	
	Mo	MMOo	Dark Red	
mO	MO	MmOO	Red	→ Hybrid No. 4
	Mo	MmOo	Pink	

(5) (P_1) **P x LR** (P_2)

Genotypes MmOo x MMOO

Gametes MO, Mo, mO, mo MO

		F1 genotypes	F1 phenotypes	
MO — MO		MMOO	– Maroon	
Mo — MO		MMOo	– Dark Red	
mO — MO		MmOO	– Red	→ Hybrid No. 5
mo — MO		MmOo	– Pink	

(6) (P_1) **P x KR** (P_2)

Genotypes MmOo x MMOo

Gametes MO, Mo, mO, mo MO, Mo

		F1 genotypes	F1 phenotypes	
MO	MO	– MMOO	- Maroon	
	Mo	– MMOo	- Dark Red	
Mo	MO	– MMOo	- Dark Red	
	Mo	– MMoo	- White	
mO	MO	– MmOO	- Red	
	Mo	– MmOo	- Pink	→ Hybrid No. 6
mo	MO	– MmOo	- Pink	
	Mo	– Mmoo	- White	

(7) (P_1) **P x CR** (P_2)

Genotypes MmOo x MMOo

Gametes MO, Mo, mO, mo MO, Mo

		F₁ genotypes	F₁ phenotypes
MO	MO	MMOO	Maroon
	Mo	MMOo	Dark Red
Mo	MO	MMOo	Dark Red
	Mo	MMoo	White
mO	MO	MmOO	Red
	Mo	**MmOo**	**Pink**
mo	MO	**MmOo**	**Pink**
	Mo	Mmoo	White

(MmOo - Pink) → Either can be Hybrid No. 7

(8) (P_1) **LR x KR** (P_2)

Genotypes MMOO x MMOo

Gametes MO MO, Mo

	F_1 genotypes	F_1 phenotypes	
MO - MO	**MMOO**	**Maroon**	→ Hybrid No. 8
MO - Mo	MMOo	Dark Red	

(9) (P_1) **LR x CR** (P_2)

Genotypes MMOO x MMOo

Gametes MO MO, Mo

		F_1 genotypes		F_1 phenotypes	
MO - MO	–	MMOO	-	Maroon	→ Hybrid No. 9
MO - Mo	–	MMOo	-	Dark Red	

(10) (P_1) **KR x CR** (P_2)

Genotypes MMOo x MMOo

Gametes MO, Mo MO, Mo

			F_1 genotypes		F_1 phenotypes	
MO	MO	–	MMOO	-	Maroon	→ Hybrid No. 10
	Mo	–	MMOo	-	Dark Red	
Mo	MO	–	MMOo	-	Dark Red	
	Mo	–	MMoo	-	White	

GENETIC DIVERGENCE
IN
Anthurium andreanum Linden

By

MAYA DEVI P.

ABSTRACT OF THE THESIS

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ABSTRACT

Genetic divergence studies were conducted on 100 different genotypes of *Anthurium andreanum* Linden, comprising of 20 varieties and 80 F_1 hybrids generated from a previous hybridization programme in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani. As the parental varieties themselves had a long history of hybridization in their background, the entire material was highly heterozygous.

Significant genotypic differences were observed among the hundred genotypes for all the ten characters namely plant height, spathe length, spathe width, number of suckers per plant, length of leaf blade, width of leaf blade, candle length, inclination of candle with the spathe, number of spadices per plant per year and leaf area. Except for number of spadices/plant/year, all the characters were highly influenced by genotypic variation. High heritability with a good genetic advance was found for all the characters studied, except for number of spadices/plant/year which exhibited medium heritability and low genetic advance. These results indicate that selection of plants which are phenotypically superior with respect to nine of the characters studied will certainly result in a significant improvement in the next generation. Environmental correlation was absent for all the characters except for number of spadices/plant/year indicating the influence of environment on this character suggesting

the possibility of improving productivity (of flowers) of the crop by manipulating the environment.

The 100 genotypes of *Anthurium* were grouped into seventeen clusters using Mahalanobis D^2 statistic. Three hybrid genotypes (Honeymoon Red x Lady Jane [HR x LJ(1)], Ordinary Orange x Kalympong Red [OO x KR(3)] and OO x KR(8)), could not be grouped with others and so are kept as independent as clusters C_{15}, C_{16} and C_{17}. The cluster C_{11} was found to have maximum intercluster distance with eleven of the seventeen clusters formed. This was followed by C_{17} which showed maximum divergence between five out of the seventeen clusters. The results suggest that selection of parents from these divergent clusters will be effective in future hybridization programmes. Leaf area and suckering ability were found to be the two characters that contributed maximum for the divergence of the genotypes. So both at phenotypic and cluster levels, these two characters can be considered as potential contributors of differentiation in *Anthurium*.

Gene action was studied based on 24 characters in a diallel fashion using five parents and their ten hybrids. Dominance (over dominance) gene action was responsible for all the characters in their expression. Standardised Yr^1 - $(Wr + Vr)^1$ graph revealed that for almost for all the characters except for plant height, the selected parents possessed most of the dominant genes with positive effects. Of the 24 characters studied, the parent 'Pink' carried maximum dominant alleles (over dominance) for six characters, 'Chilli Red', 'Liver Red' and 'Kalympong Red' for five characters each and 'Honeymoon Red' for three characters.

Based on the gca and sca effects, the parent 'Honeymoon Red' was found to be the best general combiner for several traits like plant height, width of leaf blade, length of spathe, number of spadices/plant/year, duration of female phase, days of interphase, life of spadix and carotene content. For the characters, length and width of leaf blade, leaf area, time taken for first flowering, inclination of candle, days to intiation of female phase, duration of male phase, duration of female phase, total anthocyanin content and total carotenoids, the best general combiner was 'Kalympong Red'. For the characters, plant height, length and width of leaf blade, suckering ability, the best general combiner was 'Pink'. The parent 'Chilli Red' was the best general combiner for characters viz., days from emergence to maturity of leaves, length and width of leaf blade, leaf area, candle length, inclination of candle, number of flowers/candle, total anthocyanin content and days of interphase. The parent 'Liver Red' was the best general combiner for characters namely candle length, inclination of candle, internode length, length and width of leaf blade, leaf area, suckering ability, number of flowers/candle, pollen fertility, total anthocyanin content and total carotenoids.

The heterosis of F_1's over parent 'Liver Red', which is the most acceptable semi-commercial variety under the study, was worked out. Most of the F_1 hybrids registered negative heterosis, for characters such as plant height, length and width of leaf blade, days from emergence to maturity of leaves, leaf area, time taken for first flowering and inclination of candle. This is highly desirable in the case of *Anthurium*, because, the best commercial varieties of *Anthurium* should have medium plant height with medium sized leaves for accommodation of more plants within a unit green house area, earliness to maturity of leaves and shorter time taken for first flowering for enhancing the number of leaves and flowers/ plant/year and a reduced inclination of candle for accommodating more flowers at the time of packing for transportation.

Based on the anthocyanin contents, the probable spathe colour genotypes of five selected parents and their 10 F_1 hybrids of the present study have been worked out for the first time in *Anthurium* by correlating the total average anthocyanin content of the spathe of each variety to the incremental effect of the two anthocyanin producing genes, M and O.

To sum up, this pioneering study, the first of its kind in *Anthurium*, indicates that hybridisation is the easiest and sure method for achieving genetic improvement in this export oriented cutflower crop. Reductions in plant height, leaf size, leaf area, days to maturity of leaves, days to first flowering and inclination of candle observed in the hybrids when compared with the parents are highly desirable attributes of commercial hybrids. The fact that the character number of spadices/plant/year is controlled by the environment indicates that flower productivity can be enhanced by judicial manipulations of environmental conditions. Spathe colour genotypes of five parents and their ten hybrids have been determined for the first time based on the anthocyanin pigment assay of their spathes. The study highlights the feasibility of producing commercially viable indigenous anthurium hybrids for commercial cultivation in Kerala.