# EVALUATION OF $F_1$ HYBRIDS IN SNAKEGOURD

*(Trichosanthes anguina L.)*

By

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**THESIS**

Submitted in partial fulfilment of the
requirement for the degree

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**1995**

## DECLARATION

I hereby declare that this thesis entitled '**Evaluation of $F_1$ hybrids in Snakegourd**' is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or any other similar title of any other University or Society.

Vellanikkara
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## CERTIFICATE

Certified that the thesis entitled '**Evaluation of $F_1$ hybrids in Snake-gourd**' is a record of research work done by **Mr.Sudevkumar, V.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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# Introduction

# INTRODUCTION

Vegetables occupy an important place in our daily food intake from time immemorial. Among different vegetables, those belonging to Cucurbitaceae family consist of the largest number of cultivated vegetable crops. Eventhough they are more adapted to tropical conditions, their performance is fairly good under temperate situations also. They assume importance not only as a source of food but their medicinal values are now greatly acknowledged in India and abroad. Both tender and mature fruits are consumed and relished equally.

Among different Cucurbitaceous vegetables cultivated, snakegourd (*Trichosanthes anguina* L.) occupies a pride of place which is valued for it's semi matured fruits in almost every part of the country. The crop is supposed to be a native of the Indian Archipelago. The edible portion constitutes 98 per cent of the fruit. Every 100 g of fruit contains 94.6 g of moisture, 0.5 of protein, 0.3 g of fat, 0.5 g of minerals, 0.8 g of fibre, 3.3 g of carbohydrate and 160.01 I.U. of vitamin A (Gopalan *et al.*, 1982).

In Kerala, the productivity of vegetables, in general, is low which is considered as one of the reasons for shortages of vegetables in the state which is far from the requirement. About fourty different vegetable crops are grown in the state. However high yielding varieties are very limited which can be attributed for the low productivity of vegetables. Snakegourd is no exception in which improved and high yielding varieties are very few. But we are blessed with an appreciable amount of variability existing in this crop in terms of fruit size, colour and yield potential. Research development in this crop has resulted in the evolution of a few high yielding varieties which have shown ample scope for further improvement. Heterosis breeding in the recent past have divulged the existence of high heterosis for yield and yield contributing characters which have triggered the evolution of a few $F_1$ hybrids. The $F_1$ hybrids developed in the Department of Olericulture of the College of Horticulture, Vellanikkara have been reported to be highly heterotic for various characters (Varghese, 1991). However the usefulness of these hybrids largely depends on its stability of performance over seasons and locations. The relative performance of these hybrids are important for recommending the better and ideal ones for cultivation. Another deciding factor for the cultivation of $F_1$ hybrids is the availability of hybrid seeds at reasonable price. So far no other techniques other than the manual method of $F_1$ seed production is available.

In this backdrop, the present study was taken up with the following objectives:

i) Evaluation of $F_1$ hybrids of snakegourd developed in the Department of Olericulture, College of Horticulture, Kerala Agricultural University, under different seasons

ii) Estimation of heterosis under different seasons

iii) Estimation of cost of production of $F_1$ hybrid seeds in snakegourd.

# Review of Literature

## REVIEW OF LITERATURE

The available information on various aspects of the research topic "Evaluation of $F_1$ hybrids in Snakegourd" are collected and the review is presented on the following heads:

### A. Heterosis

Heterosis breeding is one of the important tools of crop improvement, especially in cross-pollinated crops. The term heterosis refers to the phenomenon in which the $F_1$ obtained by crossing two genetically dissimilar gametes or individuals, shows increased or decreased vigour over the better parent or over the mid-parental value. The first suggestion about the exploitation of hybrid vigour in vegetable was by Hayes and Jones (1916) in cucurbits.

Pal and Singh (1946) studied the heterotic behaviour of five bittergourd lines and observed heterobeltiosis for number of male and female flowers, main vine length, fruit size and total yield/plant. Hybrids between small fruited varieties gave more number of fruits/plant than hybrids between long fruited varieties. Heterobeltiosis for yield was exhibited by almost all hybrids. In the cross between Delhi Local and Panipat Local, heterobeltiosis observed was even to the tune of 191.3 per cent in bittergourd. Performance of these hybrids was better in hot season than in rainy season. The hybrid between Panipat Local x Ambala Local showed consistently higher yields than other hybrids. Reciprocal crosses showed distinct differences for all characters. Aiyadurai (1951) noticed heterosis for earliness, fruits/plant, fruit size, fruit flesh thickness and total yield. The $F_1$s were intermediate for vine length.

Similarly Aggrawal *et al.* (1957) studied several crosses between wild bittergourd types and cultivated types and noticed intermediate performance for earliness, vine length, female flowers, fruits and yield/plant. Srivastava (1970) analysed the performance of 90 $F_1$ hybrids in bittergourd and found that 45 out of these 90 hybrids showed significant earliness for female flower production compared to the better parent. He could also observe 64.0 per cent heterobeltiosis for yield and significant increase for fruit length, fruit girth, fruit weight and fruits/plant in hybrids.

Kolhe (1972) studied the hybrid performance with respect of yield in 91 cross combinations obtained from 25 parents in bottlegourd and 57 cross combinations obtained from 16 parents in ridgegourd. He also analysed 16 combinations obtained from 12 parents in smoothgourd and six combinations obtained from 13 parents in bittergourd. It was found that only one cross combination in bottlegourd (Kalyanpur 9 x Malkapur 26), one ridgegourd (Baroda-24 x Mulshi-33) and one in smoothgourd (Indore-6 x M.P.-7) showed heterosis of considerable magnitude worth of practical exploitation. In bittergourd none of the cross combinations possessed standard heterosis.

Tyagi (1973) examined the hybrid behaviour in bottle gourd. He observed maximum heterobeltiosis for number of female flowers (69.06 %) in the cross 5414 x 6106, for number of fruits maximum relative heterosis (33.33 %) in the cross Type 1 x 6022. For weight of fruits maximum relative heterosis (38.29 %) and maximum heterobeltiosis (13.64 %) was manifested by the cross Type 1 x 6022. The number of seeds in hybrids showed a heterobeltiosis ranging from 1.10 to 2.10 per cent.

Lal *et al.* (1976) crossed bittergourd varieties viz. midget, Green Local, White Local and Bundelkhand Local in all possible combinations. All crosses which include midget as one of the parents were not successful. In hybrids Green Local x White Local and Green Local x Bundelkhand Local, heterosis was observed for vegetative characters like internodal length, leaf size, leaf length, number of primary branches, length of the main shoot, floral characters like days to flower (negative heterosis), number of inter node at which male flower emerged, sex ratio (negative heterosis) and fruit characters like number of fruits, fruit length, average fruit weight etc. In total yield, Green Local x White Local exhibited 139.1 per cent heterobeltiosis while Green Local x Bundelkhand Local showed 35.2 per cent heterobeltiosis.

Bowers *et al.* (1978) examined the yield of pickling cucumber hybrids (six named hybrids and 17 experimental hybrids) and reported 34 to 40 per cent heterosis. They also opined that heterosis in yield would not only involve a higher number of female flowers, but also a more vigorous vegetative phase to support higher yield.

Sirohi and Chaudhary (1978) made detailed studies on heterosis in 28 $F_1$ hybrids of bittergourd and opined that when either one or two of the parental lines have got high gca effects for yield and its component characters, the $F_1$ hybrid also showed high amount of positive heterosis. For yield and its component characters, heterobeltiosis was shown by the hybrids, Pusa Do Mausmi x S-144 (84.10 %), Pusa Do Mausmi x S-63 (72.00 %) and Coimbatore Long x S-63 (45.46 %).

Singh and Joshi (1979) in a 5 x 5 diallel cross in bittergourd, observed heterobeltiosis for vine length and for primary branches/plant. For number of fruits/plant, heterobeltiosis was shown by the hybrids BWMI x BWLI (13.7 %) and BWLI x BSI (34.4 %).

More and Seshadri (1980) made an extensive study on heterosis in muskmelon involving one monoecious female parent and 20 andro-monoecious male parents. For earliness maximum heterosis of 8.68 per cent was observed in the hybrid H-7 and for number of fruits/plants, it was H-24 (29.55 %). The highest heterobeltiosis for yield was shown by H-15 (109.44 %).

Kale and Seshadri (1981) conducted a 6 x 6 diallel analysis without reciprocals in watermelon and reported that the hybrids Pusa Rasaal x Asahi Yamato, Sugar Baby x Pusa Rasaal, Russian x Shakkarchini, Asahi Yamato x Russian and Sugar Baby x Asahi Yamato were superior. The percentage of heterobeltiosis was maximum for yield (80.00 %) followed by fruit weight (53.33 %) and number of fruits (33.33 %). They also noted that crosses showing good heterosis in $F_1$ showed good retention of heterosis in $F_2$ also.

Doijode and Sulladmath (1982) in pumpkin reported a relative heterosis for vine length ranging from -19.3 per cent (IHR-6 x Arka Chandan) to 59.00 per cent (IHR-83 x CM-12). Node at which first female formed showed the highest negative heterosis of -20.3 per cent in IHR-61 x IHR-8 over the mid-parental value. The cross IHR-83 x CM-12 showed the highest relative heterosis of 52.00 per cent for number of female flowers produced per plant.

Solanki *et al.* (1982) while studying the hybrid performance in cucumber, observed that characters like number of primary branches/plant, number of female flowers, number of fruits harvested/plant, average fruit weight and fruit yield showed pronounced heterobeltiosis to the tune of 25.26 per cent, 50.95 per cent, 42.12 per cent, 33.33 per cent and 83.80 per cent respectively.

Dixit and Kalloo (1983) evaluated 28 $F_1$ hybrids for different characters along with their parents. The extent of heterobeltiosis for yield/plant was 46.70 per cent in the cross Pusa Sharbati x Sarada melon, for number of fruits/plant, it was Punjab Sunehari x Sel-1 (54.30 %), for weight of fruits Arkajeet x Pusa Sharbati (39.70 %), for flesh thickness Pusa Sharbati x Sarada Melon (18.50 %) and for total soluble solids it was in Arkajeet x Sarada melon (26.10 %). For early hermaphrodite flower production, Durgapura Madhu x Sarada melon showed a high heterobeltiosis (-29.70 %). They recommended the crosses Pusa Sharbati x Punjab Sunehari and Pusa Sharbati x Sarada melon as $F_1$ hybrids for commercial vegetable production. Srivastava and Nath (1983) in an extensive study, analysed the performance of 90 hybrids in bittergourd. They reported significantly negative heterosis for days to opening of female flowers (0.3 to 16.7 %) and heterobeltiosis for vine length (0.4 to 27.10 %), fruits/plant (0.2 to 47.2 %) and yield.

Pal *et al.* (1984) crossed a small fruited and odd shaped bottlegourd line (45-1-1) with four other Varieties (No. 12, 30, 7 and 52). The $F_1$ hybrids and their reciprocals exhibited heterosis with regard to germination of seeds by 2-7 days. Fruit maturity was hastened by 10-11 days over better parent. Hybrids gave 20 per cent higher yield than parents and had a longer harvesting period of 65-71 days, than parents (55-65 days). Hybrids also gave 17-28 per cent higher flesh thickness than parents.

Chaudhary (1987) conducted a 11 x 11 diallel analysis in bittergourd. He observed heterosis for vine length (26.32 %), early female flower production (22.00 - 98.00 %), early harvest (19.26 %), fruit length (11.57 %), flesh thickness (16.18 %), fruits/plant (18.11 %), total yield/plant (25.32 %) and T.S.S. (11.87 %). Relative heterosis was also observed for yield/plant (276.43 %), fruits/plant (127.44 %), fruit weight (121.45 %) and flesh thickness (118.74 %). Heterobeltiosis was also noted for characters like yield/plant (235.94 %) fruit weight (85.7 %), flesh thickness (74.24 %) etc. The hybrid C-96 x Green bittergourd recorded a heterobeltiosis of 53.03 per cent for yield.

Janakiram and Sirohi (1987) studied 45 $F_1$ hybrids of bottlegourd in a diallel set involving ten parents (excluding reciprocals) and reported heterotic performance for characters like vine length, days to first harvest, fruits/plant, fruit weight and yield/plant. They suggested that the presence of dominant genes for most of the characters studied in parents which can be exploited by developing $F_1$ hybrids for commercial cultivation.

Reddy *et al.* (1987) evaluated six watermelon cultivars with their 15 $F_1$ hybrids in a diallel analysis (excluding reciprocals). The hybrid Durgapura Mitha x Arka Manik showed significant heterosis for yield/plant and T.S.S. content. Similarly significant heterosis was observed in sugar Baby x Tirupati local-4 for total number of fruits/plant, Durgapura Mitha x Tirupati Local-4 for average fruit weight and Asahi Yamato x Sugar Baby for edible flesh content. They summarised that heterosis breeding is an important tool for improving the yield and quality of water-melon.

Sirohi *et al.* (1987) investigated the manifestation of heterosis for yield and it's components in 66 $F_1$ hybrids of bottlegourd obtained from a diallel set involving 12 parents (excluding reciprocals). For yield the $F_1$s $P_4$ x $P_{10}$, $P_3$ x $P_9$ and $P_2$ x $P_{12}$ proved the best and gave 48.01, 34.61 and 29.03 per cent heterosis respectively over the check variety $P_{11}$. The high yield in three $F_1$s has been directly attributed to increased number of fruits/plant. The cross $P_4$ x $P_{10}$ was identified as the best for number of fruits and yield.

Lawande and Patel (1989) studied the heterosis for yield in 55 $F_1$ hybrids derived from crosses among 11 inbreds of bittergourd in a diallel fashion without reciprocals. Maximum and significant heterosis was observed for yield and fruit number/plant. Heterosis for fruit length was of low magnitude. Crosses between $CO_1$ Green x Hissar selection, Green Long x $CO_2$ White Long, $CO_1$ Green x Delhi Local, $CO_1$ Green x Priya White and Hissar selection x Green Long were found to be promising for characters like yield/plant, number of fruits, fruit weight etc.

Vahab (1989) investigated the heterosis in bitter gourd in a 10 x 10 diallel test and reported significant standard heterosis for earliness in crosses MC-66 x MC-49, MC-49 x MC-34 and Arka Harit x MC-82 to the tune of -11.97 per cent, -13.28 per cent and -11.67 per cent respectively. For percentage of female flowers Priya x MC-49 (7.91%) and MC-49 x MC-69 (7.1%) showed standard heterosis. Arka Harit x MC-79 showed high heterobeltiosis in first (117.7%) and second (43.09%) seasons. For the character, fruits/plant, in first season heterobeltiosis was shown by MC-78 x MC-49 (40.76%) and MC-49 x MC-34 (17.07%). In the second season it was MC-49 x MC-69 (37.83%) and Arka Harit x MC-79 (37.6%).

Varghese (1991) after conducting a 13 x 13 diallel analysis (excluding reciprocals) in snakegourd, reported heterobeltiosis, relative heterosis and standard heterosis for several characters in a number of hybrids. For days to first female flower opening, heterobeltiosis was the highest in $P_{10}$ x $P_4$ (-16.28 %) followed by $P_5$ x $P_4$ (-15.63 %) while standard heterosis was the maximum in $P_5$ x $P_4$ (-25.00 %) followed by $P_8$ x $P_1$ (-22.22 %). The hybrids $P_{12}$ x $P_5$, $P_9$ x $P_5$, $P_{12}$ X $P_4$, $P_5$ x $P_4$ and $P_4$ x $P_3$ showed high heterobeltiosis and relative heterosis for female flowers/plant. For days to first fruit picking maturity the maximum heterobeltiosis was recorded in $P_5$ x $P_3$ (-18.87 %) and standard heterosis in $P_{11}$ x $P_9$ (-25.68 %). Out of 51 hybrids evaluated, 46 expressed relative heterosis and 34 expressed heterobeltiosis for yield. Heterobeltiosis for yield was maximum in $P_{12}$ x $P_5$ (114.03 %) followed by $P_{12}$ x $P_8$ (113.68 %) and $P_4$ x $P_3$ (110.53 %). Standard heterosis for yield was maximum in $P_{12}$ x $P_8$ (212.50 %) followed by $P_{10}$ x $P_3$ (208.00 %) and $P_4$ x $P_3$ (200.00 %). Heterobeltiosis for fruits/plant was maximum in $P_{11}$ x $P_2$ (111.11 %) followed by $P_{12}$ x $P_5$ (105.36 %).

Janakiram and Sirohi (1992) presented the information on heterosis in ten $F_1$ crosses of bottleground involving 12 inbred lines. The highest yielding parents were S9-1 (8.13 kg/plant) and NC 59812-1 (7.69 kg/plant). Significant heterobeltiosis was reported and the best performing hybrids were S 36-1 x NC 59812-1 and S 39-1 x S 1-3 with 76.4 per cent and 58.1 per cent heterosis for yield for better parents respectively.

Ranpise *et al.* (1992) made heterosis studies for the yield contributing characters in a diallel fashion involving eight parents (without reciprocals). Appreciable heterosis was recorded for characters like yield/plant (93.69 %), flesh thickness (43.18 % ), number of fruits/plant (37.2 %), fruit weight (36.09 %), fruit length (26.02 %), number of internode at which first female flower appeared (-24.72 %), vine length (24.63 %), days to first female flowering (-5.4 %) and days to first harvest (-4.32 %). The mean of $F_1$ hybrids was greater than that of parents in all the characters except days to first harvest, days to first female flower opening and fruit length. In heterotic hybrids, heterobeltiosis for yield ranged from 19.21 per cent to 93.69 per cent.

Pitchaimuthu and Sirohi (1994) made a detailed study on heterosis in bottlegourd, by conducting a 10 x 10 diallel cross excluding reciprocals. Appreciable amount of heterosis was observed for all the characters under study except days to first fruit harvest. The $F_1$ hybrids Pusa Naveen x S.10 and Pusa Naveen x Pusa Summer Prolific Long were observed to be the best performing for yield and they showed 64.60 and 60.38 per cent heterosis for yield over top parent S.10. Heterobeltiosis for the characters like days to first male flower opening and first female flower opening ranged from -0.18 to -20.77 and from -0.77 to 019.81 respectively. Pusa Naveen x S.10 recorded the maximum standard heterosis of 30.60 per cent for number of fruits per plant followed by Pusa Naveen x Pusa Summer Prolific Long. The best performing hybrid of the study was Pusa Naveen x S.10, which recorded 64.62 per cent heterosis over the top parent and 78.30 per cent over Pusa Naveen, the commercial cultivar for total yield per plant.

**B. Hybrid seed production**

A good number of $F_1$ hybrids have been released in the country in cucurbitaceous vegetables and these have become popular among farmers. For the popularisation of new variety, especially a hybrid cultivar, production of quality seeds and it's extensive distribution at a resonable price are of prime importance. For this, it is necessary to estimate the time taken for emasculation, pollination etc. So as to compute the cost of production of $F_1$ hybrid seeds. Various aspects of this topic are reviewed hereunder.

Haften and Stevenson (1956) reported that in tomato plants, the time required for the pollination to produce 4000 seeds was 12 minutes for male sterile plants and 51 minutes for fertile plants. They also noted that the number of successful crosses was greater, the time required to emasculate and pollinate was less and the number of seeds/fruit was more when male sterile plants were used.

The report of F.A.O. (1961) says that in cucumber two women can bag and pollinate 100 flowers/hour. In tomato it was only 80 flowers/hour. In brinjal, the time required to complete emasculation and pollination of one flower was reported to be 50-60 seconds.

Lal (1977) conducted a detailed study on hybrid seed production in long fruited and round fruited brinjal varieties and it was revealed that 500 flowers in the long fruited brinjal and 400 flowers in the round fruited varieties were sufficient to give one kg of hybrid seed and the emasculation and pollination for this took 10 to 12.5 man hours.

Devadas and Ramadas (1993) carried out studies on the cost of production of $F_1$ hybrid seeds in bittergourd. They gathered the information from a 18 x 18 diallel experiment. Hand pollination was started from 51 days after sowing and seed extraction was started from 73 days after sowing. A total of 3,629 flowers were pollinated and 53,499 seeds were obtained. Further it was observed that 313 women hours were required for the whole operation starting from preparatory work for pollination to packing of the seeds extracted. Out of the total flowers pollinated, 66.19 per cent developed into ripe fruits fit for seed extraction. Approximately 36 flowers were pollinated per women hour and 530 seeds were produced per woman hour of pollination. When the entire process starting from preparatory work of bagging of flowers to packing of seeds was considered, about 171 seeds were produced per woman hour. The labour required to produce one kg hybrid seed was worked out to be 29.25 women hours, approximately.

# Materials and Methods

# MATERIALS AND METHODS

The research work was undertaken during the period from July 1992 to March 1994 in the research farm of the Department of Olericulture, College of Horticulture, Vellanikkara. The experimental site is located at an altitude of 22.5 m above M.S.L. between 70°32' N latitude and 75°16' E longitude. The area enjoys a warm humid tropical climate. The experimental location is having a loamy soil with a pH of 5.5. The whole experiment consisted of the following parts:

A. Selfing of parents, followed by crossing and production of hybrid seeds

B. Evaluation of the hybrids along with their parents, and estimation of heterosis

C. Estimation of cost of production of $F_1$ seeds

## A. Selfing of parents followed by crossing and production of hybrids seeds

Experimental materials

The experimental material consisted of 16 snakegourd genotypes used as parental lines. These genotypes were maintained in the Department of Olericulture, College of Horticulture and were earlier tested for the general and specific combining abilities. These 16 genotypes were crossed in different combinations to produce 10 hybrid combinations whose heterosis was evaluated for yield and other characters in the preliminary studies.

As the first step, the parental lines were raised during July 1992 to October 1992 for selfing. The selfing was repeated for the second season during

November 1992 to February 1993. These selfed seeds of the 16 genotypes were again used to raise a crop and crossed to produce 10 different combinations during May 1993 to June 1993. The cultural practices, plant protection measures and fertilizer applications were adopted according to the Package of Practices recommended by Kerala Agricultural University (1989).

The important morphological characters of the fruits which are used for identifying different lines are presented, for all the parental lines and hybrids, in Table 1.

The $F_1$ seeds produced were collected, processed and used for raising the crop for further evaluation.

**B. Evaluation of hybrids along with their parents**

The main part of the research work consisted of the evaluation of the 10 $F_1$ hybrids along with their parents, over different seasons.

a) Experimental materials

The experimental material consisted of 16 parental genotypes and 10 $F_1$ hybrid combinations derived from the 16 parental lines. The standard cultivar TA-19 was used as the check variety, thus making the total number of genotypes evaluated were 27.

The $F_1$ hybrids along with their parents and check variety were grown for two seasons, the first during August 1993 to November 1993 and the second during December 1993 to March 1994. All the genotypes were grown in a randomized block design with two replications. Each replication consisted of three

Table 1. Morphological description of 16 parental lines and 10 hybrids of snakegourd

| Sl. No. | Line or hybrid number | Fruit colour | Fruit size |
|---|---|---|---|
| 1 | $P_3$ | Green with white stripes | Medium |
| 2 | $P_4$ | White | Short |
| 3 | $P_5$ | White, palegreen colour at stylar end | Long |
| 4 | $P_8$ | White | Short |
| 5 | $P_9$ | Green with white stripes | Medium to long |
| 6 | $P_{10}$ | White | Short |
| 7 | $P_{12}$ | Green with white stripes | Medium |
| 8 | $P_{13}$ | White with short pale green stripes | Medium |
| 9 | DFH 15 | White with green strips | Medium |
| 10 | DFH 16 | White | Medium |
| 11 | DFH 33 | Green with white lines | Short to medium |
| 12 | DFH 39 | Green with white strips | Short |
| 13 | DFH 41 | Green with white lines | Medium to long |
| 14 | DFH 50 | Ashy white | |
| 15 | DFH 57 | White | Long |
| 16 | DFH 58 | Green with white lines | Short to medium |
| 17 | $P_4 \times P_3$ | Green with white stripes | Medium |
| 18 | $P_9 \times P_5$ | Green with white strips | Medium |
| 19 | $P_{10} \times P_3$ | White with green strips | Medium |
| 20 | $P_{12} \times P_8$ | Green with white lines | Medium |
| 21 | $P_{13} \times P_4$ | Ashy white | Short to medium |
| 22 | DFH 15 x DFH 58 | Green with white lines | Short to medium |
| 23 | DFH 33 x DFH 16 | White with green lines | Medium |
| 24 | DFH 39 x DFH 57 | White | Short to medium |
| 25 | DFH 41 x DFH 50 | White | Medium |
| 26 | DFH 58 x DFH 16 | Green with white strips | Medium |

pits/treatment and one plant/pit. The spacing adopted was 2.0 x 2.0 m. The cultural practices and plant protection measures were adopted according to the Package of Practices recommended by the Kerala Agricultural University (1989).

b) Observations recorded

Different quantitative as well as qualitative characters were taken for the evaluation of the hybrids. All the plants in a replication were considered for observations.

i) Days to first male flower opening

The number of days were counted from the date of germination to the date when the first male flower opened.

ii) Days to first female flower opening

The number of days were counted from the date of germination to the date of opening of the first female flower.

iii) Days to first fruit picking maturity

The number of days taken for the first fruit to mature, was counted starting from the date of germination up to the first harvest of fruits.

iv) Number of fruits/plant

The number of fruits in each plant per treatment was counted as and when harvested and at the end of the crop, added together to reach at the total number of fruits per plant.

v) Average fruit weight (g)

The weight of each and every fruit harvested was recorded and finally the average was worked out for each plant.

vi) Yield/plant (g)

The weights of all the harvested fruits from each plant were recorded and added up to get the total yield/plant.

vii) Fruit length (cm)

The length of all the harvested fruits were measured and the average was worked out.

viii) Fruit girth (cm)

Girth at the middle part of all the harvested fruits were measured and average was worked out.

ix) Flesh thickness (cm)

First six fruit harvested from each plant were used for this purpose. Each fruit was cut in the middle, across the length of the fruit and flesh thickness was measured with a common scale.

x) Number of seeds/fruit

Number of seeds was counted from the first six fruits harvested from each plant and the average was worked out.

xi) 100 seed weight (g)

Weight of 100 seeds from each plant was recorded.

xii) Seed weight/fruit (g)

Last six fruits harvested were used for this purpose. The seeds were extracted, cleaned and seed weight/fruit were recorded. Finally average was worked out for each plant.

xiii) Total crop duration (days)

The number of days were counted starting from the date of germination to the date of final harvest, for each plant and averages were reached at.

xiv) Number of fruits affected by fruit flies

The total number of fruits damaged by fruit flies, even after adopting standard control measures, were recorded for each plant.

Following chemical constituents of the fruit also were estimated. For this purpose, two fruits per plant were taken at the time the second harvest.

xv) Crude fibre content of the fruit (%)

From a sample of dried and powdered flesh, one gram was taken and was extracted with 1.25 per cent $H_2SO_4$ and then with 1.25 per cent NaOH. The residue was then washed with acetone to estimate the crude fibre content (Chopra and Kanwar, 1976).

xvi) Crude protein content (%)

Nitrogen content was estimated by microkjeldahl method. A sample of 0.1 g of dried and powdered flesh was taken for analysis. The protein content was calculated by multiplying the value of nitrogen by 6.25 and the resulting value was expressed in gram per 100 g of fruit on dry weight basis (Jackson, 1958).

xvii) Ash content of fruit (%)

Total ash content of fruit was determined by dry ashing. A 3 g sample of fruit tissue was collected so as to be free of dust and placed in a weighed porcelain crucible, dried at 100°C for 10 hours and weighed. Approximately 2 ml of pure olive oil is added to the tissue and crucible was heated slowly at a low flame to prevent ignition. The crucible was then placed in a muffle furnace and heated to 525°C for 45 minutes until the ash is nearly white (Jackson, 1958).

## C. Estimation of cost of production of $F_1$ seeds

The aim was to calculate the human labour required to produce one kilograme of $F_1$ seeds of snakegourd. The cost of production was limited to the labour requirement for the actual hybridization work only. For this purpose, a fixed number of male and female flowers were bagged on the previous evening. The female flowers were crossed by taking pollen from male plants. The female flowers were bagged again and labelled after crossing. Time taken for bagging, crossing, bagging after crossing and labelling were recorded. The mature fruits of ripe stage were harvested. The seeds were collected and processed. The seed number per fruit from each day of crossing were noted and weight of seeds was estimated.

## D. Statistical analysis

The performance of different genotypes for each season was evaluated using the ANOVA technique. In order to get an overall comparison of genotypes, independent of seasons, analysis of variance was applied to the pooled data obtained by combining the observations of the two seasons. Performance of hybrids over parents was evaluated in terms of amount of heterosis and statistical significance of the estimated heterosis was tested by the students 't' test.

### i) Analysis of variance

Analysis of variance of different characters was done, in a randomised block design, as described by Panse and Sukhatme (1978), for each season separately. The break-up of the total variance is given in the following table.

Analysis of variance of the design

| Source of variation | df | M.S. observed | M.S. expected |
|---|---|---|---|
| Total | 53 | | |
| Replications | 1 | $M_1$ | |
| Genotypes | 26 | $M_2$ | Error variance + (number of replications and genotypic variance) |
| Error | 26 | $M_3$ | Error variance |

### ii) Analysis of variance using data pooled over seasons

The data for each character, were pooled over seasons, wherever possible and the analysis of variance was conducted. For this, first step was testing the homogeneity of error variance of the same character in both the seasons. This was done using Bartlett's test of homogeneity of variances. Here, the quantity

$$\chi^2 = \left\{ \left(\sum_{1}^{n} K_r\right) \log_e \overline{S^2} - \sum_{1}^{n} K_r \log_e \overline{S_r^2} \right\}$$

was calculated where,

$n$ = total number of mean squares

$K$ = degrees of freedom

$\overline{S_r^2}$ = Error variance

$\overline{S^2}$ = Pooled estimate of error variance

$$\overline{S^2} = \frac{\left(\sum_{1}^{n} K_r S_r^2\right)}{\sum_{1}^{n} K_r}$$

Based on the significance of the $\chi^2$ value, homogeneity of variances was determined.

After that, combined analysis of variance of different characters in both the seasons, was done, wherever possible. All the analysis were done as described by Panse and Sukhatme (1978). The break-up of the total variance is given in the following table.

| Source of variation | df | | M.S. observed | M.S. expected |
|---|---|---|---|---|
| Seasons | 1 | | $M_1$ | - |
| Genotype | | | | |
| Between parents | 15 | 26 | $M_2$ | $\sigma e^2 + r\sigma m^2 + rp\sigma v^2$ |
| Between hybrids | 9 | | | |
| Hybrids vs parents | 1 | | | |
| Check vs others | 1 | | | |
| Genotype and season | 26 | | $M_3$ | $\sigma e^2 + r\sigma m^2$ |
| Pooled Error | 52 | | $M_4$ | $\sigma e^2$ |
| Total | 107 | | | |

where,

r = number of replications

p = number of seasons

$\sigma e^2$ = error variance

$\sigma v^2$ = variance due to varietal effects

$\sigma m^2$ = variance due to genotype x season interaction

iii) Estimation of heterosis

The magnitude of heterosis showed by the hybrids was estimated by using three different parameters, namely, Relative heterosis (Heterosis over mid-parental values), Heterobeltiosis (Heterosis over better parent) and standard heterosis (heterosis over a standard check variety), as described by Briggle (1963) and Hayes *et al.* (1965).

a) RH $= \dfrac{\overline{F_1} - \overline{MP}}{MP}$

where,

RH = Relative heterosis

$\overline{F_1}$ = Average performance of the $F_1$

$\overline{MP}$ = Mid-parental value

b) HB $= \dfrac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$

where,

HB = Heterobeltiosis

$\overline{BP}$ = Average performance of the better parent

c) Standard heterosis $= \dfrac{\overline{F_1} - \text{Check variety value}}{\text{Check variety value}} \times 100$

Check variety value denotes the average performance of the check variety, TA-19

For testing relative heterosis,

$$SE = \sqrt{\frac{3 \times EMS}{2 \times r}}$$

$CD_{(0.05)}$ = SE x $t_e$

$t_{e\ (0.05)}$ = table value of students 't' at error degrees of freedom and 5 % level significance and for testing heterobeltiosis and standard heterosis,

$$SE = \sqrt{\frac{2\ EMS}{r}}$$

$$CD_{(0.05)} = SE \times t_e$$

where

SE = Standard Error of difference between two means

CD = Critical difference

EMS = Error Mean Square, in RBD

r = Number of replications

# Results

# RESULTS

The data collected were analysed using the Analysis of variance technique for season I, season II and pooled over seasons. Heterosis was also estimated in different seasons for different characters. The results are discussed under the following heads:

## 1 Evaluation of hybrids

All the ten hybrids were evaluated for different characters which are described below.

### 1.1 Days to first male flower anthesis

During the first season, the cross $P_9$ x $P_5$ recorded the lowest number of days to male flower opening (30.58) followed by DFH 15 x DFH 58 (31.40) and the highest was for DFH 58 x DFH 16 (39.00) (Table 2). Analysis of variance revealed that hybrids in general have significant superiority over parents (parental mean was 41.84 days and hybrid mean was 35.02 days) and also they differed significantly among themselves. The crosses $P_9$ x $P_5$ (30.58 days) DFH 15 x DFH 58 (31.40 days) and $P_{13}$ x $P_4$ (33.59 days) showed statistically significant result for earliness male flower anthesis.

In the second season also crosses were found to be superior over their parents with a hybrid mean of 34.67 days and parental mean of 41.33 days. Among the crosses the number of days varied from 29.28 days in $P_4$ x $P_3$ followed by 31.53 in DFH 15 x DFH 58 and 32.19 in $P_9$ x $P_5$ and 39.00 in DFH 39 x DFH 57.

Since the experimental errors of both the seasons were found to be homogeneous in Chi-square test, the observations were pooled over seasons and analysed. $P_9$ x $P_5$ (31.38 days), DFH 15 x DFH 58 (31.46 days) and $P_4$ x $P_3$ (31.73 days) recorded significant superiority over other crosses. The highest value was recorded in DFH 39 x DFH 57 (38.79 days).

1.2 Days to first female flower opening

For this character, crosses differed significantly from their parents and among themselves in both the seasons and in pooled analysis. Results are presented in Table 2.

In the first season, minimum number of days was recorded for female flower opening in $P_9$ x $P_5$ (37.25), followed by DFH 15 x DFH 58 (37.43) and the maximum was in DFH 58 x DFH 16 (44.17). During the second season minimum was observed in $P_4$ x $P_3$ (34.89) followed by $P_9$ x $P_5$ (36.11), DFH 15 x DFH 58 (36.18) and the maximum was in DFH 58 x DFH 16 (45.39).

On pooled analysis $P_4$ x $P_3$ (36.64), $P_9$ x $P_5$ (36.68) and DFH 15 x DFH 58 (30.81) were significantly superior over other crosses. Maximum value was recorded in DFH 58 x DFH 16 (44.78).

1.3 Days to first fruit picking maturity

Results are presented in Table 3. During the first season, crosses differed significantly from parents (Parental mean was 60.70 days and hybrid mean 52.18 days) but no significant difference was observed between crosses.

Table 2. Mean performance of 16 parents and 10 $F_1$ hyrbids for days to first male and female flower opening

| Parents/crosses | Days to first male flower opening | | | Days to first female flower opening | | |
|---|---|---|---|---|---|---|
| | Season I | Season 2 | Pooled mean | Season 1 | Season 2 | Pooled mean |
| $P_3$ | 45.81 | 43.88 | 44.84 | 49.63 | 48.96 | 49.29 |
| $P_4$ | 43.46 | 42.77 | 43.12 | 50.11 | 47.00 | 48.55 |
| $P_5$ | 40.25 | 40.84 | 40.54 | 48.71 | 47.44 | 48.08 |
| $P_8$ | 41.56 | 39.28 | 40.42 | 46.50 | 44.31 | 45.40 |
| $P_9$ | 34.71 | 33.46 | 34.09 | 41.68 | 42.71 | 42.20 |
| $P_{10}$ | 40.69 | 40.50 | 40.60 | 46.63 | 44.14 | 45.39 |
| $P_{12}$ | 41.21 | 41.63 | 41.42 | 51.12 | 46.94 | 49.03 |
| $P_{13}$ | 39.89 | 41.42 | 40.65 | 47.31 | 46.17 | 40.74 |
| DFH 15 | 41.57 | 41.52 | 41.54 | 51.19 | 49.07 | 50.13 |
| DFH 16 | 45:27 | 42.53 | 43.90 | 52.67 | 46.71 | 49.69 |
| DFH 33 | 43.42 | 42.38 | 42.90 | 47.19 | 48.71 | 45.95 |
| DFH 39 | 44.46 | 43.46 | 43.96 | 49.03 | 49.19 | 49.11 |
| DFH 41 | 42.27 | 45.83 | 44.05 | 46.83 | 47.28 | 47.05 |
| DFH 50 | 41.14 | 40.64 | 40.89 | 47.84 | 47.34 | 47.59 |
| DFH 57 | 40.31 | 38.92 | 39.61 | 44.69 | 42.83 | 43.76 |
| DFH 58 | 43.42 | 42.25 | 42.83 | 46.50 | 46.94 | 46.72 |
| $P_4$ x $P_3$ | 34.19 | 29.28 | 31.73 | 38.39 | 34.89 | 36.64 |
| $P_9$ x $P_5$ | 30.58 | 32.19 | 31.38 | 37.25 | 36.11 | 36.68 |
| $P_{10}$ x $P_3$ | 36.88 | 35.50 | 36.19 | 37.88 | 42.34 | 40.11 |
| $P_{12}$ x $P_8$ | 36.00 | 35.31 | 35.66 | 41.13 | 40.03 | 40.58 |
| $P_{13}$ x $P_4$ | 33.59 | 37.25 | 35.42 | 40.59 | 40.18 | 40.38 |
| DFH 15 x DFH 58 | 31.40 | 31.53 | 31.46 | 37.43 | 36.18 | 30.81 |
| DFH 33 x DFH 16 | 34.07 | 34.01 | 34.04 | 39.82 | 38.59 | 39.20 |
| DFH 39 x DFH 57 | 38.58 | 39.00 | 38.79 | 43.62 | 44.11 | 43.86 |
| DFH 58 x DFH 50 | 35.92 | 35.13 | 35.52 | 39.50 | 38.92 | 39.21 |
| DFH 58 x DFH 16 | 39.00 | 37.50 | 38.25 | 44.17 | 45.39 | 44.78 |
| Mean of parents | 41.84 | 41.33 | 41.59 | 47.98 | 46.61 | 48.29 |
| Mean of hybrids | 35.02 | 34.67 | 34.85 | 39.98 | 39.67 | 39.83 |
| CD (P=0.05) | 1.96 | 2.17 | 1.44 | 2.66 | 2.63 | 1.44 |
| CD (P=0.01) | 2.85 | 3.16 | 2.04 | 3.86 | 3.82 | 2.04 |

The earliest time taken was in DFH 15 x DFH 58 (49.56 days) followed by $P_9$ x $P_5$ (51.13 days) and the maximum was in DFH 39 x DFH 57 (54.59 days). During the second season the hybrids differed significantly, the earliest being DFH 15 x DFH 58 (48.75 days) followed by $P_9$ x $P_5$ (49.00 days). Maximum number of days was recorded in DFH 39 x DFH 57 (54.21). Pooled analysis showed the significant superiority of DFH 15 x DFH 58 (49.16 days), $P_9$ x $P_5$ (50.06 days) and $P_4$ x $P_3$ (50.99 days). Maximum number of days was recorded in DFH 39 x DFH 57 (54.40 days).

1.4 Number of fruits/plant

All the hybrids showed significant difference over the parents as well as among themselves during both the seasons. The results are presented in Table 3.

During the first season, the highest number of fruits was produced in $P_9$ x $P_5$ (36.00) and in DFH 15 x DFH 58 (36.00) followed by $P_4$ x $P_3$ (33.50) and the lowest was in $P_{12}$ x $P_8$ (22.00). The first three showed significant superiority over other hybrids for this character. Second season data also maintained almost similar trends, with the maximum value recorded in $P_9$ x $P_5$ (37.50) followed by $P_4$ x $P_3$ (37.00) and DFH 15 x DFH 58 (35.00) and the minimum was in $P_{12}$ x $P_8$ (20.50). In the pooled analysis the highest fruit number was recorded in $P_9$ x $P_5$ (36.75) followed by DFH 15 x DFH 58 (35.50) and $P_4$ x $P_3$ (35.25) and these three differed significantly from other crosses. The minimum was recorded in $P_{12}$ x $P_8$ (21.25).

Table 3. Mean performance of 16 parents and 10 $F_1$ hybrids for first fruit picking maturity and number of fruits

| Parents/crosses | Days of first fruit picking - maturity | | | No. of fruits/plant | | |
|---|---|---|---|---|---|---|
| | Season 1 | Season 2 | Pooled mean | Season 1 | Season 2 | Pooled mean |
| $P_3$ | 59.50 | 57.42 | 58.46 | 15.00 | 14.50 | 14.75 |
| $P_4$ | 61.13 | 58.69 | 59.91 | 20.50 | 16.50 | 18.50 |
| $P_5$ | 61.16 | 58.56 | 59.86 | 13.00 | 11.50 | 12.25 |
| $P_8$ | 59.63 | 56.08 | 57.85 | 11.00 | 12.50 | 11.75 |
| $P_9$ | 54.44 | 55.38 | 54.91 | 10.50 | 13.50 | 12.00 |
| $P_{10}$ | 61.14 | 57.25 | 59.26 | 12.00 | 15.50 | 13.75 |
| $P_{12}$ | 63.06 | 60.69 | 61.87 | 14.50 | 14.50 | 14.50 |
| $P_{13}$ | 60.50 | 60.59 | 60.54 | 12.50 | 16.00 | 14.25 |
| DFH 15 | 62.19 | 61.88 | 62.03 | 18.00 | 16.50 | 17.25 |
| DFH 16 | 63.57 | 61.44 | 62.30 | 17.50 | 14.00 | 15.75 |
| DFH 33 | 62.34 | 61.45 | 61.89 | 13.00 | 14.00 | 13.50 |
| DFH 39 | 62.61 | 59.59 | 61.10 | 16.00 | 16.00 | 16.00 |
| DFH 41 | 59.56 | 58.88 | 59.22 | 11.00 | 12.50 | 11.75 |
| DFH 50 | 61.09 | 61.63 | 61.36 | 9.00 | 9.50 | 9.25 |
| DFH 51 | 58.46 | 55.59 | 57.02 | 15.00 | 14.00 | 14.50 |
| DFH 58 | 60.75 | 60.03 | 60.39 | 25.00 | 25.50 | 25.25 |
| $P_4 \times P_3$ | 51.92 | 50.06 | 50.99 | 33.50 | 37.00 | 35.25 |
| $P_9 \times P_5$ | 51.13 | 49.00 | 50.06 | 36.00 | 37.50 | 36.75 |
| $P_{10} \times P_3$ | 52.69 | 53.03 | 52.86 | 30.00 | 31.50 | 30.75 |
| $P_{12} \times P_8$ | 52.30 | 53.08 | 52.73 | 22.00 | 20.50 | 21.25 |
| $P_{13} \times P_4$ | 53.00 | 50.88 | 51.94 | 31.00 | 30.00 | 30.30 |
| DFH 15 x DFH 58 | 49.56 | 48.75 | 49.16 | 36.00 | 35.00 | 35.50 |
| DFH 33 x DFH 16 | 51.88 | 52.57 | 52.22 | 23.50 | 27.00 | 25.25 |
| DFH 39 x DFH 57 | 54.59 | 54.21 | 54.40 | 29.50 | 31.00 | 30.25 |
| DFH 41 x DFH 50 | 52.67 | 50.94 | 51.81 | 28.00 | 27.50 | 27.15 |
| DFH 58 x DFH 16 | 52.07 | 52.54 | 52.30 | 24.00 | 27.00 | 25.50 |
| Mean of parents | 60.70 | 59.07 | 59.87 | 14.59 | 14.78 | 14.69 |
| Mean of hybrids | 52.18 | 51.50 | 51.85 | 29.35 | 30.40 | 29.86 |
| CD (P=0.05) | 2.72 | 2.74 | 1.28 | 3.88 | 3.02 | 1.67 |
| CD (P=0.01) | 3.96 | 3.98 | 1.81 | 5.64 | 4.39 | 2.37 |

1.5 Average fruit weight

Table 4 depicts the details of this character. In the first season hybrids did not differ significantly from their parents. The values ranged from 463.52 g ($P_{12}$ x $P_8$) to 292.73 g (DFH 39 x DFH 57) for the hybrids. During the second season, the crosses showed significant variations from parents as well as among themselves. The highest was recorded in $P_{12}$ x $P_8$ (568.17 g) and the lowest was in DFH 39 x DFH 57 (322.95 g).

The Bartlett's Chi-Square test for homogeniety of errors showed that the experimental errors of both the seasons were heterogeneous.

1.6 Yield/plant

Yield per plant showed significant superiority over parents, and difference among the crosses during both the seasons. Details are presented in Table 4.

During the first season, maximum yield was recorded in DFH 15 x DFH 58 (12664 g) followed by $P_{13}$ x $P_4$ (12473 g) and $P_4$ x $P_3$ (12414.50 g). These three recorded statistically significant difference from other crosses. The lowest was recorded in DFH 39 x DFH 57 (8620.50 g). In the second season, $P_4$ x $P_3$ outyielded all the other crosses (13632 g) followed by $P_9$ x $P_5$ (13094 g), $P_{13}$ x $P_4$ (12138 g) and DFH 15 x DFH 58 (12029 g) while DFH 39 x DFH 57 (10031.50 g) registered the lowest yield. In the pooled analysis it was revealed that $P_4$ x $P_3$ (13023.25 g) was the highest yielder followed by DFH 15 x DFH 58 (12746.50 g) and $P_{13}$ x $P_4$ (12305.50 g) while DFH 39 x DFH 57 registered the lowest yield (9326 g).

Table 4. Mean performance of 16 parents and 10 $F_1$ hybrids for average fruit weight and yield per plant

| Parents/crosses | Average fruit weight (g) | | | Yield/plant (g) | | |
|---|---|---|---|---|---|---|
| | Season 1 | Season 2 | Pooled mean | Season 1 | Season 2 | Pooled mean |
| $P_3$ | 326.14 | 334.95 | 330.54 | 4891.50 | 4858.00 | 4874.75 |
| $P_4$ | 291.91 | 332.83 | 312.37 | 5979.00 | 5443.50 | 5711.25 |
| $P_5$ | 389.44 | 493.84 | 441.64 | 5235.00 | 5694.00 | 5464.50 |
| $P_8$ | 635.49 | 620.38 | 627.93 | 6995.00 | 7749.50 | 7372.15 |
| $P_9$ | 530.57 | 519.70 | 515.13 | 5579.50 | 7130.00 | 6354.75 |
| $P_{10}$ | 402.05 | 400.94 | 401.50 | 4824.50 | 6212.00 | 5518.25 |
| $P_{12}$ | 390.46 | 393.48 | 391.97 | 5659.00 | 5693.50 | 5676.25 |
| $P_{13}$ | 405.04 | 412.84 | 408.94 | 5070.50 | 6603.00 | 5836.75 |
| DFH 15 | 294.30 | 329.08 | 311.69 | 5454.50 | 5415.50 | 5435.00 |
| DFH 16 | 336.16 | 377.45 | 356.80 | 5886.00 | 5268.00 | 5577.00 |
| DFH 39 | 323.79 | 329.90 | 326.84 | 4223.50 | 4561.00 | 4392.25 |
| DFH 39 | 240.25 | 302.66 | 271.46 | 3768.50 | 4075.50 | 4322.00 |
| DFH 41 | 460.37 | 462.88 | 461.63 | 5054.50 | 5785.00 | 5419.75 |
| DFH 50 | 529.77 | 593.55 | 561.66 | 4679.00 | 5633.50 | 5156.25 |
| DFH 57 | 311.45 | 337.04 | 324.24 | 4671.50 | 4713.50 | 4692.50 |
| DFH 58 | 222.76 | 227.96 | 225.46 | 5558.50 | 5810.00 | 5684.25 |
| $P_4 \times P_3$ | 320.65 | 368.27 | 344.46 | 12414.50 | 13632.00 | 13023.25 |
| $P_9 \times P_5$ | 317.33 | 348.93 | 333.13 | 11394.00 | 13094.00 | 12244.00 |
| $P_{10} \times P_3$ | 329.40 | 323.90 | 326.65 | 9841.50 | 10194.00 | 10017.75 |
| $P_{12} \times P_8$ | 463.52 | 568.17 | 515.84 | 9822.50 | 11666.00 | 10744.25 |
| $P_{13} \times P_4$ | 402.40 | 404.95 | 403.68 | 12473.00 | 12138.00 | 12305.50 |
| DFH 15 x DFH 58 | 352.04 | 366.73 | 359.38 | 12664.00 | 12029.00 | 12746.50 |
| DFH 33 x DFH 16 | 450.18 | 427.88 | 439.03 | 10554.00 | 11529.50 | 11041.75 |
| DFH 39 x DFH 57 | 292.73 | 322.95 | 307.84 | 8620.50 | 10031.50 | 9326.00 |
| DFH 41 x DFH 50 | 393.88 | 395.23 | 394.56 | 11020.50 | 10859.00 | 10939.75 |
| DFH 58 x DFH 16 | 430.06 | 396.08 | 413.07 | 10298.50 | 10679.00 | 10488.75 |
| Mean for parents | 380.62 | 404.34 | - | 5220.63 | 5677.85 | 5467.78 |
| Mean for hybrids | 375.22 | 392.03 | - | 10910.30 | 11585.20 | 11287.75 |
| CD (P=0.05) | 71.57 | 3.59 | - | 1046.28 | 1203.82 | 557.17 |
| CD (P=0.01) | 104.00 | 48.81 | - | 1520.35 | 1749.27 | 788.20 |

## 1.7 Fruit length

The crosses differed significantly from parents and among themselves in both the seasons and in pooled analysis (Table 5).

In the first season, fruit length varied from 28.00 cm (DFH 39 x DFH 57) to 45.89 cm (DFH 58 x DFH 16). During the second season, the values ranged from 27.76 cm (DFH 39 x DFH 57) to 54.11 cm ($P_{12}$ x $P_8$). On pooled analysis, the shortest fruit length was recorded in DFH 39 x DFH 57 (27.88 cm) and the longest in $P_{12}$ x $P_8$ (46.86 cm).

## 1.8 Fruit girth

The results in this character are given in Table 5. During the first season, the values for the crosses did not differ from the parents, but they showed significant variation among themselves. It varied from 15.52 cm in $P_4$ x $P_3$ to 20.70 cm in $P_{13}$ x $P_4$. However, in the second season, the crosses exhibited significant variation from parents with the highest value being 19.29 cm ($P_{12}$ x $P_8$) and the lowest (16.83 cm) in DFH 39 x DFH 57. In the pooled analysis, the difference of hybrids from the parents found insignificant. The maximum girth was recorded in $P_{12}$ x $P_8$ (19.66 cm) and the minimum in $P_4$ x $P_3$ (16.37 cm).

## 1.9 Flesh thickness

For this character the crosses exhibited significant variation from their parents as well as among themselves, during season I and season II as is evident from Table 6.

Table 5. Mean performance of 16 parents and 10 $F_1$ hybrids for fruit length and fruit girth

| Parents/crosses | Fruit length (cm) | | | Fruit girth (cm) | | |
|---|---|---|---|---|---|---|
| | Season 1 | Season 2 | Pooled mean | Season 1 | Season 2 | Pooled mean |
| $P_3$ | 47.47 | 30.23 | 38.85 | 15.54 | 17.08 | 16.31 |
| $P_4$ | 37.90 | 35.02 | 36.46 | 16.05 | 18.47 | 17.26 |
| $P_5$ | 59.74 | 68.37 | 64.05 | 14.10 | 15.26 | 14.68 |
| $P_8$ | 50.89 | 50.55 | 50.72 | 21.95 | 21.12 | 21.54 |
| $P_9$ | 50.57 | 52.74 | 51.65 | 18.91 | 18.22 | 18.56 |
| $P_{10}$ | 47.29 | 46.96 | 47.12 | 17.99 | 19.06 | 18.53 |
| $P_{12}$ | 50.87 | 55.89 | 53.38 | 16.82 | 17.75 | 17.29 |
| $P_{13}$ | 42.48 | 45.50 | 43.79 | 19.44 | 19.56 | 19.50 |
| DFH 15 | 40.89 | 44.09 | 42.49 | 15.37 | 18.89 | 17.30 |
| DFH 16 | 28.80 | 33.88 | 31.34 | 20.33 | 18.84 | 19.58 |
| DFH 33 | 33.26 | 34.44 | 33.85 | 17.65 | 22.63 | 20.14 |
| DFH 39 | 25.32 | 37.23 | 31.29 | 17.01 | 18.63 | 17.83 |
| DFH 41 | 49.91 | 55.18 | 52.54 | 17.19 | 17.22 | 17.22 |
| DFH 50 | 60.61 | 53.81 | 57.21 | 21.18 | 19.03 | 20.10 |
| DFH 57 | 28.71 | 35.36 | 32.03 | 21.72 | 20.73 | 21.22 |
| DFH 58 | 30.33 | 28.90 | 29.61 | 14.92 | 16.35 | 15.64 |
| $P_4$ x $P_3$ | 35.00 | 33.56 | 34.28 | 15.52 | 17.23 | 16.37 |
| $P_9$ x $P_5$ | 43.91 | 42.65 | 43.28 | 17.83 | 17.55 | 17.69 |
| $P_{10}$ x $P_3$ | 38.29 | 39.05 | 38.67 | 18.52 | 17.18 | 17.85 |
| $P_{12}$ x $P_8$ | 39.61 | 54.11 | 46.86 | 19.63 | 19.29 | 19.66 |
| $P_{13}$ x $P_4$ | 30.06 | 35.30 | 32.68 | 20.70 | 18.13 | 19.41 |
| DFH 15 x DFH 58 | 30.05 | 32.59 | 31.32 | 19.54 | 18.65 | 19.10 |
| DFH 33 x DFH 16 | 40.96 | 43.56 | 42.26 | 18.50 | 17.70 | 18.10 |
| DFH 39 x DFH 57 | 28.00 | 27.76 | 27.88 | 18.05 | 16.83 | 17.44 |
| DFH 41 x DFH 50 | 36.32 | 35.44 | 35.88 | 17.37 | 18.02 | 17.69 |
| DFH 58 x DFH 16 | 45.89 | 45.54 | 45.71 | 16.92 | 16.83 | 16.88 |
| Mean of parents | 42.82 | 44.23 | 43.56 | 17.88 | 18.68 | 18.28 |
| Mean of hybrids | 36.80 | 38.96 | 37.88 | 18.26 | 17.74 | 17.99 |
| CD (P=0.05) | 4.18 | 5.91 | 5.05 | 1.91 | 1.61 | 1.76 |
| CD (P=0.01) | 6.07 | 8.59 | 7.37 | 2.78 | 2.34 | 2.53 |

During the first season, flesh thickness varied from 0.63 cm ($P_{10}$ x $P_3$) to 0.78 cm (DFH 33 x DFH 16). In the second season, it varied from 0.60 cm (DFH 58 x DFH 16) to 0.77 cm (DFH 33 x DFH 16). On pooled analysis, the lowest was 0.63 cm ($P_{10}$ x $P_3$) while the highest was 0.77 cm (DFH 33 x DFH 16).

1.10 Number of seeds/fruit

The hybrids on the whole showed significant variations, from their parents for this character during the first season and in pooled analysis while they were not significantly varying during the second season. Details are presented in Table 6.

In the first season, minimum number of seeds was observed in $P_9$ x $P_5$ (41.42) while maximum was in $P_{13}$ x $P_4$ (65.34). In the second season it varied from 44.82 ($P_9$ x $P_5$) to 56.50 ($P_{12}$ x $P_8$). The pooled data gave a minimum value of 43.12 ($P_9$ x $P_5$) and the maximum of 59.37 ($P_{10}$ x $P_3$).

1.11 100 seed weight

In both the seasons, this character exhibited significant difference between hybrids and parents as well as among crosses. A heterogeneity in experimental errors during the seasons did not favour a pooled analysis. Details are presented in Table 7.

In the first season, 100 seed weight varied from 22.58 g ($P_{12}$ x $P_8$) to 30.25 (DFH 58 x DFH 16) while in the second season it ranged from 22.65 g ($P_{12}$ x $P_8$) to 30.50 g (DFH 58 x DFH 16).

Table 6. Mean performance of 16 parents and 10 $F_1$ hybrids for flesh thickness and number of seeds per fruit

| Parents/crosses | Flesh thickness (cm) | | | No. of seeds/fruit | | |
|---|---|---|---|---|---|---|
| | Season 1 | Season 2 | Pooled mean | Season 1 | Season 2 | Pooled mean |
| $P_3$ | 0.69 | 0.65 | 0.67 | 46.47 | 49.92 | 48.19 |
| $P_4$ | 0.68 | 0.62 | 0.65 | 51.64 | 49.80 | 50.72 |
| $P_5$ | 0.41 | 0.44 | 0.43 | 43.40 | 42.34 | 42.87 |
| $P_8$ | 0.73 | 0.75 | 0.74 | 62.80 | 55.48 | 59.14 |
| $P_9$ | 0.66 | 0.81 | 0.74 | 55.20 | 63.16 | 59.18 |
| $P_{10}$ | 0.67 | 0.71 | 0.69 | 60.80 | 48.58 | 54.69 |
| $P_{12}$ | 0.87 | 0.78 | 0.83 | 51.93 | 54.50 | 53.32 |
| $P_{13}$ | 0.71 | 0.71 | 0.71 | 55.79 | 54.61 | 55.20 |
| DFH 15 | 0.72 | 0.73 | 0.72 | 44.84 | 46.59 | 45.72 |
| DFH 16 | 0.63 | 0.72 | 0.67 | 53.00 | 52.68 | 52.84 |
| DFH 33 | 0.66 | 0.72 | 0.69 | 54.50 | 48.62 | 51.56 |
| DFH 39 | 0.63 | 0.68 | 0.65 | 43.30 | 39.02 | 41.16 |
| DFH 41 | 0.70 | 0.70 | 0.70 | 55.95 | 50.68 | 53.30 |
| DFH 50 | 0.73 | 0.66 | 0.69 | 46.96 | 51.44 | 49.20 |
| DFH 57 | 0.61 | 0.73 | 0.67 | 52.62 | 42.50 | 47.50 |
| DFH 58 | 0.65 | 0.66 | 0.66 | 42.08 | 43.30 | 42.67 |
| $P_4 \times P_3$ | 0.70 | 0.66 | 0.68 | 43.92 | 52.65 | 48.89 |
| $P_9 \times P_5$ | 0.68 | 0.67 | 0.68 | 41.42 | 44.82 | 43.12 |
| $P_{10} \times P_3$ | 0.63 | 0.63 | 0.63 | 63.62 | 55.13 | 59.37 |
| $P_{12} \times P_8$ | 0.64 | 0.65 | 0.65 | 57.09 | 56.50 | 56.79 |
| $P_{13} \times P_4$ | 0.77 | 0.73 | 0.75 | 65.34 | 49.84 | 57.59 |
| DFH 15 x DFH 58 | 0.74 | 0.70 | 0.72 | 55.11 | 54.50 | 54.80 |
| DFH 33 x DFH 16 | 0.78 | 0.77 | 0.77 | 59.17 | 50.15 | 54.66 |
| DFH 39 x DFH 57 | 0.69 | 0.66 | 0.67 | 61.43 | 50.20 | 55.82 |
| DFH 41 x DFH 50 | 0.66 | 0.67 | 0.67 | 46.37 | 45.19 | 45.78 |
| DFH 58 x DFH 16 | 0.67 | 0.60 | 0.64 | 53.41 | 46.68 | 50.04 |
| Mean of parents | 0.67 | 0.69 | 0.68 | 51.59 | 49.58 | 50.43 |
| Mean of hybrids | 0.70 | 0.67 | 0.69 | 54.68 | 50.56 | 52.63 |
| CD (P=0.05) | 0.05 | 0.07 | 0.07 | 8.18 | 6.84 | 7.55 |

1.12 Seed weight/fruit

The crosses did not exhibit significant variation from parents during first season for this character. But in the second season and in pooled analysis the difference was significant. The data on this character are presented in Table 7.

Seed weight per fruit showed the range of value from 11.17 g ($P_9$ x $P_5$) to 16.72 g (DFH 33 x DFH 16) in the first season. In the second season, the maximum was in DFH 58 x DFH 16 (14.21 g) while the minimum in $P_9$ x $P_5$ (10.72 g). In pooled analysis the maximum seed weight was noticed in DFH 33 x DFH 16 (15.29 g) while the minimum in $P_9$ x $P_5$ (10.94 g).

1.13 Total crop duration

In the first season, crosses did not differ significantly among themselves, but differed from parents in the second season and in pooled analysis they recorded significant variation from parents as well as among themselves (Table 8).

During the first season, it varied from 124 days (DFH 15 x DFH 58) to 131 days (DFH 58 x DFH 16) while in the second season, the duration was comparatively less which ranged from 117 days ($P_4$ x $P_3$) to 129 days (DFH 39 x DFH 57). The pooled analysis showed that the maximum duration was in DFH 39 x DFH 57 (129 days) and the minimum in $P_9$ x $P_5$ and $P_4$ x $P_3$ (121.75 days each).

1.14 Fruit fly incidence (%)

Results on fruit fly infestation on fruits are presented in Table 8. The hybrids on the whole did not exhibit increased or decreased susceptibility to fruit flies when compared with parents or among themselves during both the seasons.

Table 7. Mean performance of 16 parents and 10 $F_1$ hybrids for 100 seed weight and seed weight per fruit

| Parents/crosses | 100 seed weight (g) | | | Seed weight/fruit (g) | | |
|---|---|---|---|---|---|---|
| | Season 1 | Season 2 | Pooled mean | Season 1 | Season 2 | Pooled mean |
| $P_3$ | 33.03 | 32.64 | 32.64 | 15.36 | 16.10 | 15.73 |
| $P_4$ | 26.60 | 26.70 | 26.70 | 13.73 | 13.36 | 13.55 |
| $P_5$ | 29.30 | 28.80 | 28.80 | 12.72 | 11.98 | 12.35 |
| $P_8$ | 31.90 | 31.40 | 31.40 | 20.02 | 17.14 | 18.58 |
| $P_9$ | 27.55 | 27.60 | 27.60 | 15.25 | 17.48 | 16.36 |
| $P_{10}$ | 27.53 | 27.28 | 27.28 | 16.75 | 13.14 | 14.95 |
| $P_{12}$ | 28.88 | 29.34 | 29.34 | 15.01 | 16.24 | 15.65 |
| $P_{13}$ | 33.35 | 33.33 | 33.33 | 18.62 | 18.17 | 18.39 |
| DFH 15 | 27.47 | 27.43 | 27.45 | 12.31 | 12.78 | 12.51 |
| DFH 16 | 30.60 | 29.45 | 30.03 | 16.23 | 15.33 | 15.88 |
| DFH 33 | 25.90 | 23.85 | 24.88 | 14.15 | 11.59 | 12.85 |
| DFH 39 | 28.18 | 28.40 | 28.29 | 12.21 | 11.08 | 11.65 |
| DFH 41 | 29.10 | 28.60 | 28.85 | 16.30 | 14.48 | 15.39 |
| DFH 50 | 31.93 | 32.45 | 32.19 | 15.00 | 16.82 | 15.90 |
| DFH 57 | 31.30 | 32.58 | 31.94 | 18.19 | 13.82 | 16.01 |
| DFH 58 | 22.72 | 24.35 | 23.54 | 9.59 | 10.55 | 10.07 |
| $P_4 \times 3$ | 29.50 | 29.90 | 29.70 | 12.97 | 12.06 | 12.50 |
| $P_9 \times P_5$ | 26.83 | 23.95 | 25.40 | 11.17 | 10.72 | 10.94 |
| $P_{10} \times P_3$ | 25.43 | 25.25 | 25.34 | 16.21 | 13.99 | 15.10 |
| $P_{12} \times P_8$ | 22.58 | 22.65 | 22.62 | 12.92 | 12.79 | 12.86 |
| $P_{13} \times P_4$ | 25.45 | 24.20 | 24.83 | 16.60 | 12.10 | 14.35 |
| DFH 15 x DFH 58 | 23.50 | 23.60 | 23.55 | 12.93 | 12.90 | 12.92 |
| DFH 33 x DFH 16 | 28.23 | 27.65 | 27.94 | 16.72 | 13.86 | 15.29 |
| DFH 39 x DFH 57 | 26.33 | 25.93 | 26.13 | 16.21 | 13.00 | 14.61 |
| DFH 41 x DFH 50 | 29.25 | 28.95 | 29.10 | 13.54 | 13.09 | 13.31 |
| DFH 58 x DFH 16 | 30.25 | 30.50 | 30.38 | 16.13 | 14.21 | 15.17 |
| Mean of parents | 29.08 | 29.01 | - | 15.09 | 14.38 | 14.74 |
| Mean of hybrids | 26.76 | 26.26 | - | 14.54 | 12.87 | 13.75 |
| CD (P=0.05) | 1.97 | 1.21 | - | 2.74 | 2.45 | 2.60 |
| CD (P=0.01) | 2.86 | 1.76 | - | 3.99 | 3.56 | 3.77 |

Table 8. Mean performance of 16 parents and 10 $F_1$ hybrids for total crop duration and fruit fly infestation

| Parents/Crosses | Total crop duration (days) | | | No. of fruits attacked by fruit flies | | |
|---|---|---|---|---|---|---|
| | Season I | Season 2 | Pooled | Season I | Season 2 | Pooled |
| $P_3$ | 127.00 | 125.00 | 126.00 | 1.50 | 1.50 | 1.50 |
| $P_4$ | 107.25 | 106.00 | 106.63 | 5.00 | 2.50 | 3.75 |
| $P_5$ | 106.25 | 105.50 | 105.88 | 2.50 | 2.00 | 2.25 |
| $P_8$ | 111.50 | 108.00 | 109.75 | 1.00 | 1.00 | 1.00 |
| $P_9$ | 125.00 | 124.50 | 124.75 | 5.50 | 1.50 | 3.50 |
| $P_{10}$ | 126.00 | 123.00 | 124.50 | 1.00 | 2.00 | 1.50 |
| $P_{12}$ | 128.00 | 127.50 | 127.75 | 2.00 | 2.50 | 2.25 |
| $P_{13}$ | 126.00 | 121.00 | 123.50 | 1.50 | 2.50 | 2.00 |
| DFH 15 | 123.75 | 117.00 | 120.38 | 1.50 | 2.50 | 2.00 |
| DFH 16 | 125.50 | 124.00 | 124.75 | 2.00 | 1.50 | 1.75 |
| DFH 33 | 127.25 | 125.50 | 126.38 | 4.00 | 2.00 | 3.00 |
| DFH 39 | 123.00 | 122.00 | 122.50 | 3.50 | 1.00 | 2.25 |
| DFH 41 | 125.00 | 118.00 | 121.50 | 1.00 | 1.50 | 1.25 |
| DFH 50 | 127.50 | 126.00 | 126.75 | 1.50 | 2.00 | 1.75 |
| DFH 57 | 127.00 | 125.00 | 126.00 | 1.50 | 2.50 | 2.00 |
| DFH 58 | 121.00 | 120.00 | 120.50 | 1.00 | 3.00 | 2.00 |
| $P_4 \times P_3$ | 126.40 | 117.00 | 121.75 | 2.50 | 2.00 | 2.25 |
| $P_9 \times P_5$ | 125.50 | 118.00 | 121.75 | 1.50 | 2.00 | 1.75 |
| $P_{10} \times P_3$ | 127.50 | 123.50 | 125.50 | 3.50 | 2.50 | 3.00 |
| $P_{12} \times P_8$ | 127.50 | 125.00 | 126.25 | 2.50 | 2.00 | 2.25 |
| $P_{13} \times P_4$ | 126.00 | 124.00 | 123.00 | 1.00 | 1.50 | 1.25 |
| DFH 15 x DFH 58 | 124.00 | 121.50 | 122.75 | 1.50 | 1.00 | 1.25 |
| DFH 33 x DFH 16 | 129.50 | 120.50 | 125.00 | 2.00 | 2.50 | 2.25 |
| DFH 39 x DFH 57 | 129.00 | 129.00 | 129.00 | 1.50 | 1.00 | 1.25 |
| DFH 41 x DFH 50 | 130.00 | 127.00 | 128.50 | 1.00 | 1.00 | 1.00 |
| DFH 58 x DFH 16 | 131.00 | 126.00 | 128.50 | 2.50 | 1.50 | 2.00 |
| Mean of parents | 122.35 | 119.88 | 121.11 | 2.25 | 1.97 | - |
| Mean of hybrids | 127.64 | 123.14 | 125.20 | 1.95 | 1.70 | - |
| CD (P=0.05) | 4.89 | 6.05 | 5.50 | 1.38 | 1.52 | - |
| CD (P=0.0) | 7.10 | 8.80 | 7.99 | 2.01 | 2.22 | - |

During first season, the number of fruits attacked by fruit flies varied from 1.00 ($P_{13}$ x $P_4$ and DFH 41 x DFH 50) to 3.5 ($P_{10}$ x $P_3$) while during second season, it ranged from 1.00 (DFH 15 x DFH 58, DFH 39 x DFH 57 and DFH 41 x DFH 50) to 2.5 (DFH 33 x DFH 16 and $P_{10}$ x $P_3$). In the pooled analysis, the number of fruits attacked by fruit flies was the lowest in DFH 41 x DFH 50 (1.00) and the highest in $P_{10}$ x $P_3$ (3.00).

1.15 Crude fibre content of fruit

Since the observations were in percentages, the data were transformed and are presented in Table 9.

In the first season there was a significant difference among the crosses, as well as between crosses and parents. Among the crosses, crude fibre content of fruit was the highest in DFH 15 x DFH 58 (48.5%) and the lowest in $P_{10}$ x $P_3$ (30.50%). In the second season observations revealed that there was no significant difference between the crosses and the parents, but hybrids differed significantly among themselves. The cross with the maximum value for crude fibre content was DFH 39 x DFH 57 (45.00%) while the minimum value was in $P_{10}$ x $P_3$ (20.5%). The pooled analysis data showed that crosses were not significantly differing from parents. Among crosses, crude fibre content was the highest in DFH 15 x DFH 58 (45.25%) while it was the lowest in $P_{10}$ x $P_3$ (25.50%).

1.16 Crude protein content of fruit

There was significant difference between crosses and parents for this

Table 9. Mean performance of 16 parents and 10 $F_1$ hybrids for crude fibre and crude protein (transformed data)

| Parents/Crosses | Crude fibre content of fruit* | | | Crude protein content of fruit* | | |
|---|---|---|---|---|---|---|
| | Season I | Season 2 | Pooled mean | Season 1 | Season 2 | Pooled mean |
| $P_3$ | 0.35 (34.50) | 0.33 (32.00) | 0.34 (33.25) | 0.16 (15.53) | 0.21 (20.63) | 0.18 (18.08) |
| $P_4$ | 0.40 (39.00) | 0.40 (39.00) | 0.40 (39.00) | 0.14 (13.90) | 0.15 (14.45) | 0.14 (14.18) |
| $P_5$ | 0.32 (31.50) | 0.34 (33.00) | 0.33 (32.25) | 0.27 (26.89) | 0.24 (23.50) | 0.26 (25.19) |
| $P_8$ | 0.55 (52.00) | 0.53 (50.50) | 0.54 (51.25) | 0.29 928.49) | 0.26 (26.04) | 0.28 (27.27) |
| $P_9$ | 0.42 (40.50) | 0.40 (39.00) | 0.41 (39.75) | 0.25 (24.54) | 0.22 (21.33) | 0.23 (22.93) |
| $P_{10}$ | 0.45 (43.00) | 0.43 (42.00) | 0.44 (42.50) | 0.21 (21.24) | 0.20 (20.20) | 0.21 (20.72) |
| $P_{12}$ | 0.37 (36.00) | 0.36 (35.50) | 0.37 (35.75) | 0.16 (15.45) | 0.16 (16.21) | 0.16 (15.83) |
| $P_{13}$ | 0.34 (33.50) | 0.38 (37.50) | 0.37 (35.50) | 0.23 (23.00) | 0.21 (20.54) | 0.22 (21.77) |
| DFH 15 | 0.31 (30.00) | 0.31 (30.50) | 0.31 (30.25) | 0.29 (28.90) | 0.25 (24.75) | 0.27 (26.83) |
| DFH 16 | 0.41 (40.00) | 0.40 (39.00) | 0.40 (39.50) | 0.24 (23.83) | 0.23 (22.83) | 0.24 (23.33) |
| DFH 33 | 0.38 (36.50) | 0.37 (36.00) | 0.37 (36.25) | 0.36 (33.83) | 0.32 (31.85) | 0.33 (32.84) |
| DFH 39 | 0.62 (58.00) | 0.59 (56.00) | 0.61 (57.00) | 0.14 (13.82) | 0.15 (14.40) | 0.14 (14.11) |
| DFH 41 | 0.47 (45.50) | 0.43 (41.50) | 0.45 (43.50) | 0.37 (36.30) | 0.34 (33.70) | 0.36 (35.00) |
| DFH 50 | 0.34 (33.00) | 0.45 (43.00) | 0.39 (38.00) | 0.28 (27.35) | 0.26 (25.69) | 0.27 (26.52) |
| DFH 57 | 0.29 (28.50) | 0.33 (32.500 | 0.31 (30.50) | 0.25 (25.03) | 0.24 (23.24) | 0.24 (24.13) |
| DFH 58 | 0.36 (35.00) | 0.34 (33.50) | 0.35 (34.25) | 0.17 (16.45) | 0.15 (14.49) | 0.16 (15.47) |
| $P_4$ x $P_3$ | 0.37 (36.00) | 0.34 (33.50) | 0.36 (34.75) | 0.13 (13.25) | 0.14 (14.25) | 0.14 (13.75) |
| $P_9$ x $P_5$ | 0.48 (46.00) | 0.46 (44.00) | 0.47 (45.00) | 0.14 (14.34) | 0.15 (15.10) | 0.15 (14.72) |
| $P_{10}$ x $P_3$ | 0.31 (30.50) | 0.29 (20.50) | 0.26 (25.50) | 0.22 (22.08) | 0.19 (19.20) | 0.21 (20.64) |
| $P_{12}$ x $P_8$ | 0.35 (34.50) | 0.35 (34.50) | 0.36 (34.50) | 0.18 (18.08) | 0.19 (18.85) | 0.19 (28.46) |
| $P_{13}$ x $P_4$ | 0.38 (37.00) | 0.38 (37.00) | 0.38 (37.00) | 0.15 (14.90) | 0.14 (13.50) | 0.14 (14.20) |
| DFH 15 x DFH 58 | 0.51 (48.50) | 0.43 (42.00) | 0.47 (45.25) | 0.17 (16.92) | 0.15 (15.30) | 0.16 (16.15) |
| DFH 33 x DFH 16 | 0.43 (42.00) | 0.42 (41.00) | 0.43 (41.50) | 0.17 (16.90) | 0.17 (16.78) | 0.17 (16.84) |
| DFH 39 x DFH 57 | 0.46 (44.00) | 0.47 (45.00) | 0.46 (44.50) | 0.29 (28.30) | 0.25 (24.35) | 0.26 (26.33) |
| DFH 41 x DHF 50 | 0.43 (42.00) | 0.45 (43.00) | 0.44 (42.50) | 0.27 (23.95) | 0.25 (24.58) | 0.26 (25.26) |
| DFH 58 x DFH 16 | 0.37 (36.00) | 0.38 (37.50) | 0.38 (37.00) | 0.21 (21.02) | 0.24 (23.72) | 0.23 (22.37) |
| Mean of parents | 38.53 | 38.78 | 38.66 | 23.40 | 22.12 | 22.76 |
| Mean of hybrids | 39.65 | 37.80 | 39.15 | 18.97 | 18.56 | 18.87 |
| CD (P = 0.05) | 0.05 | 0.05 | 0.04 | 0.05 | 0.05 | 0.04 |
| CD (P = 0.01) | 0.08 | 0.08 | 0.07 | 0.08 | 0.08 | 0.07 |

character and the crosses registered a significant difference among themselves in season 1, season 2 and in pooled analysis, results are presented in Table 9.

In the first season, among the crosses, the maximum crude protein content was observed in DFH 39 x DFH 57 (28.30%) and the minimum in $P_4$ x $P_3$ (13.25%) while in the second season maximum was in DFH 41 x DFH 50 (24.58%) and the minimum in $P_{13}$ x $P_4$ (13.50%). In pooled analysis the highest valaue was in DFH 39 x DFH 57 (26.33%) and the lowest in $P_4$ x $P_3$ (13.75%).

1.17 Ash content of fruit

For this character the crosses differed significantly from parents as well as among themselves during season 1, season 2 and in pooled analysis. Details are presented in Table 10. In the first season, DFH 58 x DFH 16 recorded the highest ash content (16.03%) while DFH 15 x DFH 58 had the lowest value (8.60%). During the second season, the maximum was in DFH 39 x DFH 57 (14.67%) and the minimum in DFH 15 x DFH 58 (9.84%). In pooled analysis, it ranged from the highest value of 15.32 per cent (DFH 58 x DFH 16) to a lowest value of 9.22 per cent (DFH 15 x DFH 58).

## 2 Estimation of heterosis

The heterotic behaviour of all the ten hybrids was studied by analysing the data separately for season I. Season II and also data pooled over seasons, for each character. Heterosis was estimated in terms of Relative heterosis (RH). Heterobeltiosis (HB) and standard heterosis (SH). The values are presented characterwise hereunder.

Table 10. Mean performance of 16 parents and 10 $F_1$ hybrids for ash content of fruit (Transformed data)

| Parents/crosses | Ash content of fruit* | | |
|---|---|---|---|
| | Season 1 | Season 2 | Pooled mean |
| $P_3$ | 0.11 (10.83 | 0.11 (10.73) | 0.11 (10.78 |
| $P_4$ | 0.10 (10.34) | 0.10 ( 9.90) | 0.10 (10.12) |
| $P_5$ | 0.12 (11.91) | 0.11 (11.33) | 0.11 (11.62) |
| $P_8$ | 0.11 (10.75) | 0.11 (10.94) | 0.11 (10.84) |
| $P_9$ | 0.11 (11.39) | 0.11 (10.84) | 0.11 (11.12) |
| $P_{10}$ | 0.10 (10.17) | 0.10 ( 9.98) | 0.10 (10.07) |
| $P_{12}$ | 0.11 (10.55) | 0.11 (10.53) | 0.11 (10.54) |
| $P_{13}$ | 0.11 (10.93) | 0.11 (11.00) | 0.11 (10.99) |
| DFH 15 | 0.11 (11.34) | 0.13 (12.44) | 0.12 (11.89) |
| DFH 16 | 0.12 (12.33) | 0.12 (12.00) | 0.12 (12.16) |
| DFH 33 | 0.11 (11.11) | 0.12 (12.33) | 0.12 (11.73) |
| DFH 39 | 0.10 ( 9.67) | 0.10 (10.23) | 0.10 ( 9.95) |
| DFH 41 | 0.11 (11.19) | 0.12 (11.55) | 0.11 (11.37) |
| DFH 50 | 0.12 (11.57) | 0.12 (11.54) | 0.12 (11.56) |
| DFH 57 | 0.12 (12.36) | 0.12 (12.12) | 0.12 (12.24) |
| DFH 58 | 0.11 (11.12) | 0.11 (10.83) | 0.11 (10.97) |
| $P_4$ x $P_3$ | 0.12 (11.84) | 0.13 (12.80) | 0.13 (12.32) |
| $P_9$ x $P_5$ | 0.10 (10.24) | 0.11 (10.80) | 0.11 (10.52) |
| $P_{10}$ x $P_3$ | 0.13 (13.24) | 0.13 (12.93) | 0.13 (13.09) |
| $P_{12}$ x $P_8$ | 0.11 (11.30) | 0.13 (13.25) | 0.13 (12.31) |
| $P_{13}$ x $P_4$ | 0.10 ( 9.27) | 0.11 (10.85) | 0.10 (10.06) |
| DFH 15 x DFH 58 | 0.09 ( 8.60) | 0.10 ( 9.84) | 0.09 ( 9.22) |
| DFH 33 x DFH16 | 0.10 (10.47) | 0.01 ( 9.92) | 0.10 (10.20) |
| DFH 39 x DFH 57 | 0.15 (15.24) | 0.15 (14.67) | 0.15 (14.96) |
| DFH 41 x DFH 50 | 0.15 (15.19) | 0.14 (14.02) | 0.15 (14.60) |
| DFH 58 x DFH 16 | 0.16 (16.03) | 0.15 (14.60) | 0.15 (15.32) |
| Mean of parents | 11.01 | 11.14 | 11.12 |
| Mean of hybrids | 12.14 | 12.37 | 12.26 |
| CD (P = 0.05) | 0.05 | 0.05 | 0.04 |
| CD (P = 0.01) | 0.08 | 0.08 | 0.08 |

2.1 Days to first male flower opening

The statistical analysis of heterosis revealed that all the 10 hybrids studied, were having significant heterosis for earliness in terms of days taken for first male flower anthesis. Details are presented in Table 11.

The highest relative heterosis of -26.17 per cent was observed in the cross DFH 15 x DFH 58 followed by $P_4$ x $P_3$ (-23.41%) and DFH 33 x SFH 16 (-23.18%) and the lowest was in DFH 39 x DFH 57 (-8.99%). All the ten hybrids exhibited statistically significant heterobeltiosis, the highest value being in the cross DFH 15 x DFH 58 (-27.68%) and the lowest in DFH 39 x DFH 57 (-13.23%). Significant standard heterosis over the standard check variety TA-19 was also observed which ranged from the highest value of -27.31% in $P_9$ x $P_5$ [followed by DFH 15 x DFH 58 (-25.36%)] to the lowest value of -7.30 per cent in DFH 58 x DFH 16.

During the second season also all the ten hybrids exhibited significant heterosis. The highest relative heterosis was shown by $P_4$ x $P_3$ (-32.43%) followed by DFH 15 x DFH 58 (-24.73%) and the lowest was in DFH 39 x DFH 57 (-5.32%). The heterobeltiosis varied from a highest value of -33.27 per cent in $P_4$ x $P_3$ followed by -25.37 per cent in DFH 15 x DFH 58, to the lowest value of -10.26 per cent in DFH 39 x DFH 57. Similarly the highest standard heterosis was noticed in the cross $P_4$ x $P_3$ (-28.83%) followed by DFH 15 x DFH 58 (-23.36%) and the lowest was in DFH 39 x DFH 57 (-5.20%).

Table 11. Mean performance of hybrids, better parents, mid-parents and heterosis for days to first male flower opening

| Crosses | $F_1$ | | | MP | | | BP | | | RH (%) | | | HB (%) | | | SH (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool |
| $P_4 \times P_3$ | 34.19 | 29.28 | 31.73 | 44.64 | 43.33 | 43.98 | 45.81 | 43.88 | 44.84 | -23.41** | -32.43** | -27.85** | -25.37** | -33.27** | -29.24** | -18.73** | -28.83** | -23.74** |
| $P_9 \times P_5$ | 30.58 | 32.19 | 31.38 | 37.48 | 37.15 | 37.30 | 40.25 | 40.84 | 40.50 | -18.41** | -13.35** | -15.87** | -24.02** | -21.18** | -22.52** | -27.31** | -21.75** | -24.59** |
| $P_{10} \times P_3$ | 36.88 | 35.50 | 36.19 | 43.25 | 42.19 | 42.72 | 45.81 | 43.88 | 44.84 | -14.73** | -15.86** | -15.29** | -19.49** | -19.10** | -19.29** | -12.34** | -13.71** | -13.03** |
| $P_{12} \times P_8$ | 36.00 | 35.31 | 35.66 | 41.39 | 40.46 | 40.92 | 41.56 | 41.63 | 41.42 | -13.02** | -12.73** | -12.85** | -13.38** | -15.18** | -13.91** | -14.43** | -14.17** | -14.30** |
| $P_{13} \times P_4$ | 33.59 | 37.25 | 35.42 | 41.68 | 42.10 | 41.89 | 43.46 | 42.77 | 43.12 | -19.41** | -11.52** | -15.45** | -22.71** | -12.91** | -17.86** | -20.16** | -9.46** | -14.88** |
| DFH 15 x DFH 58 | 31.40 | 31.53 | 31.46 | 42.50 | 41.89 | 42.19 | 43.42 | 42.25 | 42.83 | -26.17** | -24.73** | -25.43** | -27.68** | -25.37** | -25.55** | -25.36** | -23.36** | -24.39** |
| DFH 33 x DFH 16 | 34.07 | 34.01 | 34.04 | 44.35 | 42.46 | 43.40 | 45.27 | 42.53 | 43.90 | -23.18** | -19.90** | -21.57** | -24.74** | -20.03** | -22.46** | -19.02** | -17.33** | -18.19** |
| DFH 39 x DFH 57 | 38.58 | 39.00 | 38.79 | 42.39 | 41.19 | 41.79 | 44.46 | 43.46 | 43.96 | -8.99** | -5.32* | -7.18** | -13.23** | -10.26** | -11.76** | -8.30** | -5.20** | -6.78** |
| DFH 41 x DFH 50 | 35.92 | 35.13 | 35.52 | 41.71 | 43.24 | 42.49 | 42.27 | 45.83 | 44.05 | -13.88** | -18.76** | -16.40** | -15.02** | -23.25** | -19.36** | -14.62** | -14.62** | -14.64** |
| DFH 58 x DFH 16 | 39.00 | 37.50 | 38.25 | 44.35 | 42.39 | 43.37 | 45.27 | 42.53 | 43.90 | -12.06** | -11.54** | -11.81** | -13.85** | -11.83** | -12.87** | -7.30** | -8.85** | -8.07** |

| | | $S_1$ | $S_2$ | Pool |
|---|---|---|---|---|
| Mean performance of standard check variety | = | 42.07 | 41.14 | 41.61 |
| CD for RH ($F_1$ vs MP) | P = 0.05 = | 1.71 | 1.88 | 1.25 |
| | P = 0.01 = | 2.47 | 2.73 | 1.76 |
| CD for HB ($F_1$ vs BP) | P = 0.05 = | 1.96 | 2.17 | 1.44 |
| | P = 0.01 = | 2.85 | 3.16 | 2.04 |
| CD for SH ($F_1$ vs CD) | P = 0.05 = | 1.96 | 2.17 | 1.44 |
| | P = 0.01 = | 2.85 | 3.16 | 2.04 |

$S_1$ = Mean for season-1, $S_2$ = Mean for season-2, Pool = Pooled mean
* = 0.05; ** = 0.01

The pooled analysis of the data showed that relative heterosis was maximum in $P_4$ x $P_3$ (-27.85%) followed by DFH 15 x DFH 58 (-25.43%) and minimum in DFH 39 x DFH 57 (-7.18%). Significant heterobeltiosis was observed in all the hybrids with a maximum value -29.24 per cent in $P_4$ x $P_3$ and minimum value of -11.76 per cent in DFH 39 x DFH 57. Standard heterosis expressed by the hybrids were -24.59 per cent in $P_9$ x $P_5$, -24.39 per cent in DFH 15 x DFH 58 and -6.78 in DFH 39 x DFH 57.

2.2 Days to female flower opening

For this character all the ten hybrids were showing significant heterosis. Details are shown in Table 12.

In the first season all the hybrids were significantly heterotic; the relative heterosis was maximum in the cross DFH 15 x DFH 58 (-23.38%), followed by $P_4$ x $P_3$ (-23.02%) and the lowest in DFH 39 x DFH 57 (-6.91%). Heterobeltiosis was ranging from -26.88 per cent in DFH 15 x DFH 58 to -11.03 per cent in DFH 39 x DFH 57. For standard heterosis, the maximum value was -25.07 per cent in $P_9$ x $P_5$ followed by -24.70 per cent in DFH 15 x DFH 58, and the minimum was -11.14 per cent in DFH 58 x DFH 16.

During the second season, the test hybrids showed almost similar heterotic behaviour. Relative heterosis was the highest in $P_4$ x $P_3$ (-27.28%) and the lowest in DFH 58 x DFH 16 (-3.07%) which was not statistically significant. Heterobeltiosis was the highest in $P_4$ x $P_3$ (-28.74%) and the lowest in DFH 58 x DFH 16 (-3.30%). Heterosis expressed by DFH 58 x DFH 16 and DFH 41 x DFH 50 were non-significant. For standard heterosis maximum was recorded in $P_4$ x $P_3$

Table 12. Mean performance of hybrids, better parents, mid-parents and heterosis for days to first female flower opening

| Crosses | $F_1$ | | | MP | | | BP | | | RH (%) | | | HB (%) | | | SH (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool |
| $P_4 \times P_3$ | 38.39 | 34.89 | 36.64 | 49.87 | 47.98 | 48.92 | 50.11 | 48.96 | 49.29 | -23.02** | -27.28** | -25.10** | -23.39** | -28.74** | -25.66** | -22.77** | -28.43** | -25.57** |
| $P_9 \times P_5$ | 37.25 | 36.11 | 36.68 | 45.20 | 45.08 | 45.14 | 48.71 | 47.49 | 48.08 | -17.57** | -19.90** | -18.74** | -23.53** | -23.88** | -23.71** | -25.07** | -25.93** | -25.19** |
| $P_{10} \times P_3$ | 37.88 | 42.34 | 40.11 | 48.13 | 46.55 | 43.34 | 49.63 | 48.96 | 49.29 | -21.30** | -9.04** | -15.27** | -23.68** | -13.52** | -18.62** | -23.80** | -13.15** | -18.53** |
| $P_{12} \times P_8$ | 41.13 | 40.03 | 40.58 | 48.81 | 45.63 | 47.22 | 51.12 | 46.94 | 49.03 | -15.75** | -12.27** | -14.06** | -19.56** | -14.72** | -17.23** | -17.28** | -17.89** | -17.57** |
| $P_{13} \times P_4$ | 40.59 | 40.18 | 40.38 | 48.81 | 46.59 | 47.65 | 50.11 | 47.00 | 48.55 | -16.84** | -13.76** | -15.26** | -19.00** | -14.51** | -16.83** | -18.35** | -17.58** | -17.98** |
| DFH 15 x DFH 58 | 37.43 | 36.18 | 36.81 | 48.85 | 48.01 | 48.43 | 51.19 | 49.07 | 50.13 | -23.38** | -24.64** | -23.99** | -26.88** | -26.27** | -26.57** | -24.70** | -25.78** | -25.23** |
| DFH 33 x DFH 16 | 39.82 | 38.59 | 39.26 | 49.93 | 47.71 | 48.82 | 52.67 | 48.71 | 49.69 | -20.25** | -19.12** | -19.71** | -24.40** | -20.78** | -21.11** | -19.90** | -20.84** | -20.37** |
| DFH 39 x DFH 57 | 43.62 | 44.11 | 43.86 | 46.86 | 46.01 | 46.44 | 49.03 | 49.19 | 49.11 | -6.91* | -4.13 | -5.56** | -11.03** | -10.33** | -10.69** | -12.25** | -9.52** | -10.91** |
| DFH 41 x DFH 50 | 39.50 | 38.92 | 39.21 | 47.34 | 47.31 | 47.32 | 47.84 | 47.34 | 47.59 | -16.56** | -17.73** | -17.14** | -17.43** | -4.23 | -17.60** | -20.54** | -20.16** | -20.35** |
| DFH 58 x DFH 16 | 44.17 | 45.39 | 44.78 | 49.59 | 46.83 | 48.71 | 52.67 | 46.94 | 49.69 | -10.93** | -3.07 | -8.07** | -16.14** | -3.30 | -9.88** | -11.14** | -6.89* | -9.04** |

| | | $S_1$ | $S_2$ | Pool |
|---|---|---|---|---|
| Mean performance of standard check variety | | 49.71 | 48.75 | 49.23 |
| CD for RH ($F_1$ vs MP) | P = 0.05 = | 2.30 | 2.28 | 1.25 |
| | P = 0.01 = | 3.35 | 3.31 | 1.76 |
| CD for HB ($F_1$ vs BP) | P = 0.05 = | 2.66 | 2.63 | 1.44 |
| | P = 0.01 = | 3.86 | 3.82 | 2.04 |
| CD for SH ($F_1$ vs CP) | P = 0.05 = | 2.66 | 2.63 | 1.44 |
| | P = 0.01 = | 3.86 | 3.82 | 2.04 |

$S_1$ = Mean for season 1, $S_2$ - Mean for season 2, Pool = Pooled mean
* P = 0.05, ** P = 0.01

(-28.43%) followed by $P_9$ x $P_5$ (-25.93%) and the lowest was in DFH 58 x DFH 16 (-6.89%).

In the pooled analysis all the ten hybrids were found to be significantly superior over their parents. The cross $P_4$ x $P_3$ showed a maximum relative heterosis of -25.10 per cent followed by DFH 15 x DFH 58 (-23.99%) and the lowest was in DFH 39 x DFH 57 (-5.56%). Significant heterobeltiosis was observed in the hybrids, the highest being in DFH 15 x DFH 58 (-26.57%) followed by $P_4$ x $P_3$ (-25.66%) and the lowest in DFH 58 x DFH 16 (-9.88%). Similar trend was noticed in the case of standard heterosis also with the highest in $P_4$ x $P_3$ (-25.57%) followed by DFH 15 x DFH 58 (-25.23%) and the lowest in DFH 58 x DFH 16 (-9.04%).

2.3 Days to first fruit picking maturity

During the first season all the hybrids showed statistically significant heterosis in terms of relative heterosis, heterobeltiosis and standard heterosis. Data are presented in Table 13. The cross DFH 15 x DFH 58 expressed maximum relative heterosis of -19.38 per cent and DFH 39 x DFH 57 evinced the lowest (-9.83%). Heterobeltiosis was maximum in DFH 15 x DFH 58 (-18.42%) and the minimum value recorded was -6.08 per cent ($P_9$ x $P_5$). The standard heterosis was also highest in DFH 15 x DFH 58 (-18.67%) and the minimum in DFH 39 x DFH 57 (-10.42%).

The analysis of the second season data showed that the cross DFH 15 x DFH 58 was having the highest amount of relative heterosis, heterobeltiosis and standard heterosis (-20.03%, -18.79% and -21.09%, respectively) and DFH 39 x DFH 57 showed the lowest values (-5.87%, -2.48% and -12.23%, respectively).

Table 13. Mean performance of hybrids, better parents, mid-parents and heterosis for days to first fruit picking maturity

| Crosses | $F_1$ | | | MP | | | BP | | | RH (%) | | | HB (%) | | | SH (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool |
| $P_4 \times P_3$ | 51.92 | 50.06 | 50.99 | 60.32 | 58.06 | 59.19 | 59.50 | 57.42 | 58.46 | -13.93** | -13.78** | -13.85** | -12.74** | -12.82** | -12.78** | -14.80** | -18.97** | -16.90** |
| $P_9 \times P_5$ | 51.13 | 49.00 | 50.06 | 57.80 | 56.97 | 57.39 | 54.44 | 55.38 | 54.91 | -11.54** | -13.99** | -12.77** | -6.08* | -11.52** | -8.83** | -16.10** | -20.69** | -18.42** |
| $P_{10} \times P_3$ | 52.69 | 53.03 | 52.86 | 60.32 | 57.34 | 58.86 | 59.50 | 57.25 | 58.46 | -12.65** | -7.52** | -10.19** | -11.45** | -7.37** | -9.59** | -13.54** | -14.16** | -13.85** |
| $P_{12} \times P_8$ | 52.30 | 53.08 | 52.73 | 61.35 | 58.39 | 59.86 | 59.63 | 56.08 | 57.85 | -14.75** | -9.09** | -11.91** | -12.29** | -5.35* | -8.85** | -14.18** | -14.08** | -14.06** |
| $P_{13} \times P_4$ | 53.00 | 50.88 | 51.94 | 60.82 | 59.64 | 60.23 | 60.50 | 58.69 | 59.91 | -12.86** | -14.69** | -13.76** | -12.40** | -13.31** | -13.30** | -13.03** | -17.64** | -15.35** |
| DFH 15 x DFH 58 | 49.56 | 48.75 | 49.16 | 61.47 | 60.96 | 61.21 | 60.75 | 60.03 | 60.39 | -19.38** | -20.03** | -19.69** | -18.42** | -18.79** | -18.60** | -18.67** | -21.09** | -19.88** |
| DFH 33 x DFH 16 | 51.88 | 52.57 | 52.22 | 62.96 | 61.45 | 62.10 | 62.34 | 61.44 | 61.89 | -17.60** | -14.45** | -15.91** | -16.78** | -14.44** | -14.24** | -14.87** | -14.91** | -14.90** |
| DFH 39 x DFH 57 | 54.59 | 54.21 | 54.40 | 60.54 | 57.59 | 59.06 | 58.46 | 55.59 | 57.02 | -9.83** | -5.87* | -7.89** | -6.62* | -2.48 | -4.59* | -10.42** | -12.23** | -11.34** |
| DFH 41 x DFH 50 | 52.67 | 50.94 | 51.81 | 60.33 | 60.26 | 60.29 | 59.56 | 58.88 | 59.22 | -12.70** | -15.47** | -14.07** | -11.57** | -13.49** | -12.51** | -13.57** | -17.55** | -15.50** |
| DFH 58 x DFH 16 | 52.07 | 52.54 | 52.30 | 62.16 | 60.74 | 61.35 | 60.75 | 60.03 | 60.39 | -16.23** | -13.50** | -14.75** | -14.29** | -12.48** | -13.40** | -14.56** | -14.96** | -14.77** |

| | | $S_1$ | $S_2$ | Pool |
|---|---|---|---|---|
| Mean performance of standard check variety | | 60.94 | 61.78 | 61.36 |
| CD for RH ($F_1$ vs MP) | P = 0.05 = | 2.36 | 2.37 | 1.11 |
| | P = 0.01 = | 3.43 | 3.45 | 1.57 |
| CD for HB ($F_1$ vs BP) | P = 0.05 = | 2.72 | 2.74 | 1.28 |
| | P = 0.01 = | 3.96 | 3.98 | 1.81 |
| CD for SH ($F_1$ vs CP) | P = 0.05 = | 2.72 | 2.74 | 1.28 |
| | P = 0.01 = | 3.96 | 3.98 | 1.81 |

$S_1$ = Mean for season 1, $S_2$ = Mean for season 2, Pool = Pooled mean

* P = 0.05, ** P = 0.01

The values were statistically nonsignificant in the case of heterobeltiosis.

In the pooled analysis all the hybrids were found to be significantly superior to their respective parents. The cross DFH 15 x DFH 58 found to effect the highest relative heterosis, heterobeltiosis and standard heterosis (-19.69%, -18.60% and -19.88%, respectively) while the cross DFH 39 x DFH 57 was having the lowest values for the above parameters (-7.89%, -4.59% and -11.34%, respectively).

2.4 Number of fruits/plant

The first season data revealed significant heterosis for total number of fruits in all the hybrids except in DFH 58 x DFH 16 (Table 14). The relative heterosis ranged from 206.38% in $P_9$ x $P_5$ to 12.94% in DFH 58 x DFH 16. Heterobeltiosis was maximum in the cross $P_9$ x $P_5$ (176.92%) followed by DFH 41 x DFH 50 (154.55%). The minimum value recorded in DFH 58 x DFH 16 (-4.00%). Considerable improvement was observed when the hybrids were compared with the standard check variety in all the cases. The maximum was in $P_9$ x $P_5$ and DFH 15 x DFH 58 (140% each) followed by $P_4$ x $P_3$ (123.33%) and the minimum value was recorded by $P_{12}$ x $P_8$ (46.67%).

During the second season $P_9$ x $P_5$ recorded the maximum relative heterosis (200%) and heterobeltiosis (177.78%) while DFH 58 x DFH 16 showed the lowest values of 36.71 per cent and 5.06 per cent, respectively. The standard heterosis was maximum in $P_9$ x $P_5$ (141.94%) and the minimum in $P_{12}$ x $P_8$ (32.26%).

In pooled analysis $P_9$ x $P_5$ expressed the highest amount of relative heterosis, heterobeltiosis and standard heterosis (202.97%, 177.35% and 140.98%,

Table 14. Mean performance of hybrids, better parents, mid-parents and heterosis for number of fruits per plant

| Crosses | F1 | | | MP | | | BP | | | RH (%) | | | HB (%) | | | SH (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool |
| $P_4 \times P_3$ | 33.50 | 37.00 | 35.27 | 17.75 | 15.50 | 16.63 | 20.50 | 16.50 | 18.50 | 88.73** | 138.71** | 111.97** | 63.41** | 124.24** | 90.54** | 123.33** | 138.71** | 131.15** |
| $P_9 \times P_5$ | 36.00 | 37.50 | 36.75 | 11.75 | 12.50 | 12.13 | 13.00 | 13.50 | 13.25 | 206.38** | 200.00** | 202.97** | 176.92** | 177.78** | 177.35** | 140.00** | 141.94** | 140.98** |
| $P_{10} \times P_3$ | 30.00 | 31.50 | 30.75 | 13.50 | 15.00 | 14.25 | 14.00 | 15.50 | 14.75 | 122.22** | 110.00** | 115.79** | 100.00** | 103.23** | 108.47** | 100.00** | 103.23** | 101.64** |
| $P_{12} \times P_8$ | 22.00 | 20.50 | 21.25 | 12.75 | 13.50 | 13.13 | 14.50 | 14.50 | 14.50 | 72.55** | 51.85** | 61.84** | 51.72** | 41.38** | 46.55** | 46.67** | 32.26** | 39.34** |
| $P_{13} \times P_4$ | 31.00 | 30.00 | 30.50 | 16.50 | 16.25 | 16.38 | 20.50 | 16.00 | 18.25 | 87.88** | 84.62** | 84.98** | 51.22** | 87.50** | 63.78** | 106.67** | 93.55** | 98.69** |
| DFH 15 x DFH 58 | 36.00 | 35.00 | 35.50 | 21.50 | 21.00 | 21.25 | 25.00 | 25.50 | 25.25 | 67.44** | 66.67** | 67.06** | 44.00** | 37.25** | 40.59** | 140.00** | 125.81** | 132.79** |
| DFH 33 x DFH 16 | 23.50 | 27.00 | 25.25 | 15.25 | 14.00 | 14.63 | 17.50 | 14.00 | 15.75 | 54.10** | 92.86** | 72.59** | 34.29** | 92.86** | 60.32** | 56.67** | 74.19** | 65.57** |
| DFH 39 x DFH 57 | 29.50 | 31.00 | 30.25 | 15.50 | 22.00 | 18.25 | 16.00 | 16.00 | 16.00 | 90.32** | 40.91** | 98.36** | 84.38** | 93.75** | 89.06** | 96.67** | 100.00** | 98.36** |
| DFH 41 x DFH 50 | 28.00 | 27.50 | 27.75 | 10.00 | 11.00 | 10.50 | 11.00 | 12.50 | 11.75 | 166.67** | 150.00** | 164.29** | 154.55** | 120.00** | 136.17** | 86.67** | 77.42** | 81.97** |
| DFH 58 x DFH 16 | 24.00 | 27.00 | 25.50 | 21.25 | 19.75 | 20.50 | 25.00 | 25.50 | 25.25 | 12.94 | 36.71** | 24.39** | -4.00 | -5.06 | 0.99 | 60.00** | 74.19** | 67.21** |

| | | $S_1$ | $S_2$ | Pool |
|---|---|---|---|---|
| Mean performance of standard check variety | | 15.00 | 15.50 | 15.25 |
| CD for RH ($F_1$ vs MP) | P = 0.05 = | 3.36 | 2.61 | 1.45 |
| | P = 0.01 = | 4.89 | 3.80 | 2.05 |
| CD for HB ($F_1$ vs BP) | P = 0.05 = | 3.88 | 3.02 | 1.67 |
| | P = 0.01 = | 5.64 | 4.39 | 2.37 |
| CD for SH ($F_1$ vs CP) | P = 0.05 = | 3.88 | 3.02 | 1.67 |
| | P = 0.01 = | 5.64 | 4.39 | 2.37 |

$S_1$ = Mean for season 1, $S_2$ = Mean for season 2, Pool = Pooled mean

* P = 0.05, ** P = 0.01

respectively), followed by DFH 41 x DFH 50 (164.29%, 136.17% and 81.97%, respectively). The crosses $P_4$ x $P_3$ and DFH 15 x DFH 58 exhibited high degree of standard heterosis (131.15% and 132.79%, respectively).

### 2.5 Average fruit weight

This character recorded a wide range of values (Table 15). During the first season out of ten hybrids evaluated, only three showed significant improvement over their respective midparental values. They were DFH 15 x DFH 58 (36.17%), DFH 33 x DFH 16 (36.43%) and DFH 58 x DFH 16 (53.89%). DFH 33 x DFH 16 (33.92%) and DFH 58 x DFH 16 (27.93%) showed significant heterobeltiosis while none of the crosses showed superior performance over the standard check variety.

During the second season six crosses exhibited significant relative heterosis with the maximum value in DFH 15 x DFH 58 (31.67%) followed by DFH 58 x DFH 16 (30.84%) and the minimum in $P_{13}$ x $P_4$ (8.61%). Significant heterobeltiosis was observed in DFH 33 x DFH 16 (13.36%) and DFH 15 x DFH 58 (11.44%). $P_{12}$ x $P_8$ was the only cross which showed a positive significant standard heterosis (15.69%).

Since the experimental errors during Season I and Season II were heterogeneous, pooled analysis was not taken into account.

### 2.6 Yield/plant

The data are presented in Table 16. All the ten hybrids showed statistically significant relative heterosis during the first season, with the highest value in DFH 15 x DFH 58 (129.98%) followed by $P_4$ x $P_3$ (128.41%) and DFH 41 x DFH 50

Table 15. Mean performance of hybrids, better parents, mid-parents and heterosis for average fruit weight (g)

| Crosses | $F_1$ | | | MP | | | BP | | | RH (%) | | | HB (%) | | | SH (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool |
| $P_4 \times P_3$ | 320.65 | 368.27 | 344.46 | 309.03 | 333.89 | 321.46 | 326.14 | 334.95 | 330.54 | 3.76 | 10.30 | 7.15* | -1.68 | 9.95* | 4.21 | -36.89 | -25.01 | -31.05 |
| $P_9 \times P_5$ | 317.33 | 348.93 | 333.13 | 460.01 | 525.14 | 483.39 | 530.57 | 519.70 | 525.13 | -31.02 | -33.55 | -31.08 | -40.19 | -32.86 | -36.56 | -37.54 | -28.95 | -33.32 |
| $P_{10} \times P_3$ | 329.40 | 323.90 | 326.65 | 364.10 | 366.89 | 366.02 | 402.05 | 400.94 | 401.50 | -9.53 | -11.72 | -10.76 | -18.07 | -19.21 | -18.64 | -35.16 | -34.05 | -34.62 |
| $P_{12} \times P_8$ | 463.52 | 568.17 | 515.84 | 512.98 | 506.93 | 509.95 | 635.49 | 620.38 | 627.93 | -9.64 | 12.08** | 1.16 | -27.06 | -8.42 | -17.85 | -8.76 | 15.69** | 3.25 |
| $P_{13} \times P_4$ | 402.40 | 404.95 | 403.68 | 348.18 | 372.84 | 360.66 | 405.04 | 412.84 | 408.94 | 15.47 | 8.61* | 11.93 | -0.65 | -1.91 | -1.29 | -20.80 | -17.54 | -19.20 |
| DFH 15 x DFH 58 | 352.04 | 366.73 | 354.38 | 258.53 | 278.52 | 268.58 | 294.30 | 329.08 | 311.69 | 36.17** | 31.67** | 33.81** | 19.62 | 11.44** | 15.30 | -30.71 | -25.33 | -28.06 |
| DFH 33 x DFH 16 | 450.18 | 427.88 | 439.03 | 329.98 | 353.68 | 341.82 | 336.16 | 377.45 | 356.80 | 36.43** | 20.98** | 28.44** | 33.92** | 13.36** | 23.05** | -11.39 | -12.87 | -12.12 |
| DFH 39 x DFH 57 | 292.73 | 322.95 | 307.84 | 275.85 | 319.85 | 297.85 | 311.45 | 337.04 | 324.24 | 6.12 | 0.97 | 3.36 | -6.01 | -4.18 | -5.06 | -42.38 | -34.24 | -38.38 |
| DFH 41 x DFH 50 | 393.88 | 395.23 | 394.56 | 495.07 | 528.22 | 511.65 | 529.77 | 593.55 | 561.66 | -20.44 | -25.18 | -22.88 | -25.65 | -33.41 | -29.75 | -22.47 | -19.52 | -21.02 |
| DFH 58 x DFH 16 | 430.06 | 396.08 | 413.07 | 279.46 | 302.71 | 291.13 | 336.16 | 377.45 | 356.80 | 53.89** | 30.84** | 41.89** | 27.93** | 4.94 | 15.77 | -15.35 | -19.35 | -17.32 |

| | | $S_1$ | $S_2$ | Pool |
|---|---|---|---|---|
| Mean performance of standard check variety | | 508.05 | 491.11 | 499.58 |
| CD for RH ($F_1$ vs MP) | P = 0.05 = | 61.98 | 29.09 | 61.98 |
| | P = 0.01 = | 90.06 | 42.27 | 90.06 |
| CD for HB ($F_1$ vs BP) | P = 0.05 = | 71.57 | 33.59 | 71.57 |
| | P = 0.01 = | 104.00 | 48.81 | 104.00 |
| CD for SH ($F_1$ vs CP) | P = 0.05 = | 71.57 | 33.59 | 71.57 |
| | P = 0.01 = | 104.00 | 48.81 | 104.00 |

$S_1$ = Mean for season 1, $S_2$ = Mean for season 2, Pool = Pooled mean

* P = 0.05, ** P = 0.01

Table 16. Mean performance of hybrids, better parents, mid-parents and heterosis for yield per plant (g)

| Crosses | $F_1$ | | | MP | | | BP | | | RH (%) | | | HB(%) | | | SH (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool |
| $P_4 \times P_3$ | 12414.50 | 13632.00 | 13023.25 | 5435.25 | 5150.75 | 5293.00 | 5979.00 | 5443.50 | 5711.25 | 128.41** | 164.66** | 146.05** | 107.64** | 150.43** | 128.03** | 62.85** | 79.17** | 71.00** |
| $P_9 \times P_5$ | 11394.00 | 13094.00 | 12244.00 | 5407.25 | 6412.00 | 5909.63 | 5579.50 | 7130.00 | 6354.75 | 110.72** | 104.21** | 107.19** | 104.21** | 83.65** | 92.67** | 49.46** | 72.10** | 60.77** |
| $P_{10} \times P_3$ | 9841.50 | 10194.00 | 10017.75 | 4858.00 | 5535.00 | 5196.50 | 4891.50 | 6212.00 | 5518.25 | 102.58** | 84.17** | 92.78** | 101.20** | 64.10** | 81.54** | 29.09** | 33.98** | 31.54** |
| $P_{12} \times P_8$ | 9822.50 | 11666.00 | 10744.25 | 6327.00 | 6721.50 | 6524.25 | 6995.00 | 7749.50 | 7372.25 | 55.25** | 73.50** | 64.68** | 40.42** | 50.54** | 45.74** | 28.85** | 53.33** | 41.07** |
| $P_{13} \times P_4$ | 12473.00 | 12138.00 | 12305.50 | 5524.75 | 6023.25 | 5774.00 | 5979.00 | 6603.00 | 5836.75 | 125.77** | 101.52** | 113.12** | 108.61** | 83.83** | 110.83** | 63.61** | 59.53** | 61.57** |
| DFH 15 x DFH 58 | 12664.00 | 12029.00 | 12746.50 | 5506.50 | 5612.75 | 5559.63 | 5558.50 | 5810.00 | 5684.25 | 129.98** | 114.32** | 129.27** | 127.83** | 107.04** | 124.24** | 66.12** | 58.10** | 67.36** |
| DFH 33 x DFH 16 | 10554.00 | 11529.00 | 11041.75 | 5054.75 | 4914.50 | 4984.63 | 5887.00 | 5268.00 | 5577.00 | 108.79** | 134.60** | 121.52** | 79.31** | 118.86** | 97.99** | 38.44** | 51.53** | 44.98** |
| DFH 39 x DFH 57 | 8620.50 | 10031.50 | 9326.00 | 4220.00 | 4394.50 | 4500.25 | 4671.50 | 4713.50 | 4692.50 | 104.28** | 128.30** | 106.91** | 84.53** | 112.82** | 98.74** | 13.08** | 31.85** | 22.45** |
| DFH 41 x DFH 50 | 11020.50 | 10859.00 | 10939.75 | 4866.75 | 5709.25 | 5288.00 | 5054.50 | 5785.00 | 5419.75 | 126.44** | 90.20** | 106.88** | 118.03** | 87.71** | 101.85** | 44.56** | 42.72** | 43.64** |
| DFH 58 x DFH 16 | 10298.50 | 10679.00 | 10486.75 | 5722.25 | 5539.00 | 5630.63 | 5886.00 | 5810.00 | 5684.25 | 79.97** | 92.80** | 86.28** | 74.97** | 21.21** | 84.52** | 35.09** | 40.36** | 37.72** |

| | | $S_1$ | $S_2$ | Pool |
|---|---|---|---|---|
| Mean performance of standard check variety | | 7623.50 | 7608.00 | 7616.00 |
| CD for RH ($F_1$ vs MP) | P = 0.05 = | 906.10 | 1042.54 | 482.53 |
| | P = 0.01 = | 1316.66 | 1514.96 | 682.60 |
| CD for HB ($F_1$ vs BP) | P = 0.05 = | 1046.28 | 1203.80 | 557.17 |
| | P = 0.01 = | 1520.35 | 1749.27 | 788.20 |
| CD for SH ($F_1$ vs CP) | P = 0.05 = | 1046.28 | 1203.80 | 557.17 |
| | P = 0.01 = | 1520.35 | 1749.27 | 788.20 |

$S_1$ = Mean for season 1, $S_2$ = Mean for season 2, Pool = Pooled mean

* P = 0.05, ** P = 0.01

(126.44%) and the lowest was recorded in $P_{12}$ x $P_8$ (55.25%). Heterobeltiosis was the highest in DFH 15 x DFH 58 (127.83%) followed by DFH 41 x DFH 50 (118.03%), $P_{13}$ x $P_4$ (108.61%), $P_4$ x $P_3$ (107.64%) and the lowest in $P_{12}$ x $P_8$ (40.42%). Standard heterosis was 66.12 per cent in DFH 15 x DFH 58, 63.61 per cent in $P_{13}$ x $P_4$, 62.85 per cent in $P_4$ x $P_3$ while the lowest was recorded in DFH 39 x DFH 57 (13.08%).

Observations during the second season showed that the maximum relative heterosis of 164.66 per cent was recorded in $P_4$ x $P_3$ followed by 134.60 per cent in DFH 33 x DFH 16 and the lowest value of 73.50 per cent in $P_{12}$ x $P_8$. Heterobeltiosis was maximum in $P_4$ x $P_3$ (150.43%) followed by DFH 33 x DFH 16 (118.86%) and the minimum in $P_{12}$ x $P_8$ (50.54%). Standard heterosis was maximum in $P_4$ x $P_3$ (79.17%) followed by $P_9$ x $P_5$ (72.10%), $P_{13}$ x $P_4$ (59.53%), DFH 15 x DFH 58 (58.10%) and the minimum was in DFH 39 x DFH 57 (31.85%).

In pooled analysis the cross $P_4$ x $P_3$ recorded the highest relative heterosis, heterobeltiosis and standard heterosis (146.05%, 128.03% and 71%, respectively). Other hybrids which showed high amount of relative heterosis were DFH 15 x DFH 58 (129.27%), DFH 33 x DFH 16 (121.52%), $P_9$ x $P_5$ (107.19%) and the lowest value in $P_{12}$ x $P_8$ (64.68%). High heterobeltiosis was recorded in $P_4$ x $P_3$ (128.03%), DFH 15 x DFH 58 (124.24%) and DFH 41 x DFH 50 (101.85%) while the lowest was in $P_{12}$ x $P_8$ (45.74%). Standard heterosis was high in DFH 15 x DFH 58 (67.36%), $P_{13}$ x $P_4$ (61.57%) and in $P_9$ x $P_5$ (60.77%) while the lowest value was in $P_{10}$ x $P_3$ (31.54%).

2.7 Fruit length

A detailed account of the heterosis observed for this character is given in Table 17. Seven out of ten cross combinations showed significant relative heterosis, with the highest value being -34.27 per cent in DFH 41 x DFH 50 followed by $P_{13}$ x $P_4$ (-25.21%), $P_{12}$ x $P_8$ (-22.15%) and the lowest in DFH 58 x DFH 16 (55.19%). Heterobeltiosis was the maximum in DFH 41 x DFH 50 (-40.08%) followed by $P_{13}$ x $P_4$ (-29.24%) and DFH 15 x DFH 58 (-26.51%) and a minimum of 51.30 per cent was recorded in DFH 58 x DFH 16. All the ten hybrids showed significant standard heterosis, with the maximum value being - 56.17 per cent in DFH 39 x DFH 57 and a minimum of -29.31 per cent in DFH 58 x DFH 16.

In the second season only four combinations were significantly superior over their midparental values. They were DFH 41 x DFH 50 (-34.91%), $P_9$ x $P_5$ (-33.42%), DFH 39 x DFH 57 (-23.53%) and $P_{13}$ x $P_4$ (-11.88%). At the same time, six combinations exhibited significant heterobeltiosis with the maximum value in $P_9$ x $P_5$ (-37.62%) followed by DFH 41 x DFH 50 (-35.77%) and DFH 15 x DFH 58 (-26.08%) and the minimum being 26.48 per cent in DFH 33 x DFH 16.

Pooled analysis revealed that significant relative heterosis was manifested in eight combinations, with the maximum value in DFH 41 x DFH 50 (-34.62%) followed by $P_9$ x $P_5$ (-25.19%) and the minimum in DFH 58 x DFH 16 (49.97%). DFH 41 x DFH 50 (-37.28%) showed the highest heterobeltiosis followed by $P_9$ x $P_5$ (-32.43%) and DFH 15 x DFH 58 (-26.29%), while the lowest was in DFH 58 x DFH 16 (45.85%). All the crosses showed significant standard heterosis, the highest being -57.60 per cent in DFH 39 x DFH 57 followed by -52.37 per cent in

Table 17. Mean performance of hybrids, better parents, mid-parents and heterosis for fruit length (cm)

| Crosses | $F_1$ | | | MP | | | BP | | | RH (%) | | | HB (%) | | | SH (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool |
| $P_4 \times P_3$ | 35.00 | 33.56 | 34.28 | 42.69 | 32.63 | 37.67 | 47.47 | 35.02 | 38.85 | -18.01** | 2.85 | -9.00** | -26.27** | -4.17 | -29.83** | -46.09** | -49.61** | -47.87** |
| $P_9 \times P_5$ | 43.91 | 42.65 | 43.28 | 55.16 | 69.06 | 57.85 | 59.74 | 68.37 | 64.05 | -20.40** | -33.42** | -25.19** | -26.50** | -37.62** | -32.43** | -32.36** | -35.96** | -34.18** |
| $P_{10} \times P_3$ | 38.29 | 39.05 | 38.67 | 47.38 | 38.60 | 42.99 | 47.47 | 46.96 | 47.12 | -19.19** | 1.17 | -10.05** | -19.34** | -16.84* | -17.93** | -41.02** | -41.37** | -41.20** |
| $P_{12} \times P_8$ | 39.61 | 54.11 | 46.86 | 50.88 | 53.22 | 52.05 | 50.89 | 55.89 | 53.38 | -22.15** | 1.67 | -9.97** | -22.17** | -3.18 | -12.21** | -38.99** | -18.75** | -28.74** |
| $P_{13} \times P_4$ | 30.06 | 35.30 | 32.68 | 40.19 | 40.06 | 40.13 | 42.48 | 45.10 | 43.79 | -25.21** | -11.88* | -18.56** | -29.24** | -21.73** | -25.37** | -53.70** | -47.00** | -50.30** |
| DFH 15 x DFH 58 | 30.05 | 32.54 | 31.32 | 35.61 | 36.50 | 36.05 | 40.89 | 44.09 | 42.49 | -15.61** | -10.71 | -13.12** | -26.51** | -26.08** | -26.29** | -53.71** | -51.07** | -52.37** |
| DFH 33 x DFH 16 | 40.96 | 43.56 | 42.26 | 31.03 | 34.16 | 32.60 | 33.26 | 34.44 | 33.85 | 32.00 | 27.52 | 29.63 | 23.15 | 26.48 | 24.84 | -36.91** | -34.59** | -35.74** |
| DFH 39 x DFH 57 | 28.00 | 27.76 | 27.88 | 27.02 | 36.30 | 31.66 | 28.71 | 37.23 | 32.03 | 3.63 | -23.53** | -11.94** | -2.47 | -25.44** | -12.96** | -56.87** | -58.32** | -57.60** |
| DFH 41 x DFH 50 | 36.37 | 35.44 | 35.88 | 55.26 | 54.50 | 54.88 | 60.61 | 55.18 | 57.21 | -34.27** | -34.91** | -34.62** | -40.08** | -35.77** | -37.28** | -44.05** | -46.79** | -45.44** |
| DFH 58 x DFH 16 | 45.89 | 45.54 | 45.71 | 29.57 | 31.39 | 30.48 | 30.33 | 33.88 | 31.34 | 55.19 | 45.08 | 49.97 | 51.30 | 34.42 | 45.85 | -29.31** | -31.62** | -30.49** |

| | | $S_1$ | $S_2$ | Pool |
|---|---|---|---|---|
| Mean performance of standard check variety | | 64.92 | 66.60 | 65.76 |
| CD for RH ($F_1$ vs MP) | P = 0.05 = | 3.62 | 5.12 | 2.97 |
| | P = 0.01 = | 5.26 | 7.44 | 4.20 |
| CD for HB ($F_1$ vs BP) | P = 0.05 = | 4.18 | 5.91 | 3.43 |
| | P = 0.01 = | 6.07 | 8.59 | 4.85 |
| CD for SH ($F_1$ vs CP) | P = 0.05 = | 4.18 | 5.91 | 3.43 |
| | P = 0.01 = | 6.07 | 8.59 | 4.85 |

$S_1$ = Mean for season 1, $S_2$ = Mean for season 2, Pool = Pooled mean

*P = 0.05, ** P = 0.01

DFH 15 x DFH 58 and -50.30 per cent in $P_{13}$ x $P_4$, with the lowest value in $P_{12}$ x $P_8$ (-28.74%).

2.8 Fruit girth

Data are presented in Table 18. Out of the ten cross combinations, during the first season only four recorded significant relative heterosis. They were DFH 15 x DFH 58 (28.93%), $P_{13}$ x $P_4$ (16.62%), $P_{10}$ x $P_3$ (10.44%) and $P_9$ x $P_5$ (8%). DFH 15 x DFH 58 turned out to be the only one cross showing a significant heterobeltiosis of 27.13 per cent. None of the combinations could perform better than the standard check variety, for this character.

During the second season, only one combination DFH 15 x DFH 58 (5.85%) could give significant improvement over the mid parental value. None of the crosses showed significant heterobeltiosis or standard heterosis, for this character.

In pooled analysis only one cross, DFH 15 x DFH 58 could give significant improvement over midparental values (16.53%) and better parental value (11.50%). None of the other combinations could perform better than the check variety.

2.9 Seed weight/fruit

According to the data shown in Table 19. During the first season all the hybrids except DFH 58 x DFH 16 failed to give a significant improvement over mid-parental value or over better parent. DFH 58 x DFH 16 exhibited a relative heterosis of 24.94 per cent. Six hybrids showed significant standard heterosis, the

Table 18. Mean performance of hybrids, better parents, mid-parents and heterosis for fruit girth (cm)

| Crosses | $F_1$ | | | MP | | | BP | | | RH (%) | | | HB (%) | | | SH (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool |
| $P_4$ x $P_3$ | 15.52 | 17.23 | 16.37 | 15.80 | 17.78 | 16.79 | 16.05 | 18.47 | 17.26 | -1.77 | -3.09 | -2.50 | -3.30 | -6.71 | -5.16 | -26.55 | -12.80 | -19.95 |
| $P_9$ x $P_5$ | 17.83 | 17.55 | 17.69 | 16.51 | 16.74 | 16.62 | 18.91 | 18.22 | 18.56 | 8.00* | 4.84 | 6.44 | -5.71 | -3.68 | -4.69 | -15.62 | -11.18 | -13.50 |
| $P_{10}$ x $P_3$ | 18.52 | 17.18 | 17.85 | 16.77 | 18.07 | 17.42 | 17.99 | 19.04 | 18.53 | 10.44* | -4.93 | 2.47 | 2.95 | -9.86 | -3.67 | -12.35 | -13.06 | -12.71 |
| $P_{12}$ x $P_8$ | 19.63 | 19.29 | 19.46 | 19.39 | 19.44 | 19.42 | 21.95 | 21.12 | 21.54 | 1.24 | -0.77 | 0.21 | -10.57 | -8.68 | -9.66 | -7.10 | -2.38 | -4.84 |
| $P_{13}$ x $P_4$ | 20.70 | 18.13 | 19.41 | 17.75 | 19.02 | 18.38 | 19.44 | 19.56 | 19.50 | 16.62** | -4.68 | 5.60 | 6.48 | -7.31 | -0.46 | -2.04 | -8.25 | -5.09 |
| DFH 15 x DFH 58 | 19.54 | 18.65 | 19.10 | 15.15 | 17.62 | 16.39 | 15.37 | 18.89 | 17.13 | 28.93** | 5.85* | 16.53** | 27.13* | -1.27 | 11.50* | -7.52 | -5.62 | -6.60 |
| DFH 33 x DFH 16 | 18.50 | 17.70 | 18.10 | 18.99 | 20.74 | 19.86 | 20.33 | 22.63 | 20.14 | -2.58 | -14.66 | -8.86 | -9.00 | -21.79 | -10.13 | -12.45 | -10.43 | -11.49 |
| DFH 39 x DFH 57 | 18.05 | 16.83 | 17.44 | 19.37 | 19.68 | 19.53 | 21.72 | 20.73 | 21.22 | -6.81 | -14.48 | -10.70 | -16.90 | -18.81 | -17.81 | -14.58 | -14.83 | -14.72 |
| DFH 41 x DFH 50 | 17.37 | 18.02 | 17.69 | 19.19 | 18.13 | 18.65 | 21.18 | 19.03 | 20.10 | -9.48 | -0.61 | -5.15 | -17.99 | -5.31 | -11.99 | -17.79 | -8.81 | -13.50 |
| DFH 58 x DFH 16 | 16.92 | 16.83 | 16.88 | 17.63 | 17.60 | 17.61 | 20.33 | 18.84 | 19.58 | -4.03 | -4.38 | -7.55 | -16.77 | -10.67 | -16.85 | -19.92 | -14.83 | -20.39 |

| | | $S_1$ | $S_2$ | Pool |
|---|---|---|---|---|
| Mean performance of standard check variety | | 21.13 | 19.76 | 20.45 |
| CD for RH ($F_1$ vs MP) | P = 0.05 = | 1.66 | 1.39 | 1.22 |
| | P = 0.01 = | 2.41 | 2.03 | 1.73 |
| CD for HB ($F_1$ vs BP) | P = 0.05 = | 1.91 | 1.61 | 1.41 |
| | P = 0.01 = | 2.78 | 2.34 | 2.00 |
| CD for SH ($F_1$ vs CP) | P = 0.05 = | 1.91 | 1.61 | 1.41 |
| | P = 0.01 = | 2.78 | 2.34 | 2.00 |

$S_1$ = Mean for season 1, $S_2$ = Mean for season 2, Pool = Pooled mean

* P = 0.05, ** P = 0.01

Table 19. Mean performance of hybrids, better parents, mid-parents and heterosis for seed weight/fruit (g)

| Crosses | $F_1$ | | | MP | | | BP | | | RH (%) | | | HB (%) | | | SH (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool |
| $P_4 \times P_3$ | 12.97 | 12.06 | 12.51 | 14.54 | 14.73 | 14.64 | 15.36 | 16.10 | 15.73 | -10.80 | -18.13 | -14.55 | -15.56 | -25.09 | -20.47 | 18.23 | 5.33 | 11.60 |
| $P_9 \times P_5$ | 11.17 | 10.72 | 10.94 | 13.98 | 14.73 | 14.35 | 15.25 | 17.48 | 16.36 | -20.10 | -27.22 | -23.76 | -26.75 | -38.67 | -33.13 | 1.82** | -6.38* | -2.41** |
| $P_{10} \times P_3$ | 16.21 | 13.99 | 15.10 | 16.06 | 14.62 | 15.34 | 16.75 | 15.10 | 15.93 | 0.93 | -4.31 | -1.56 | -3.22 | -8.81 | -3.91 | 47.77 | 22.18 | 34.70* |
| $P_{12} \times P_8$ | 12.92 | 12.79 | 12.86 | 17.52 | 16.69 | 17.10 | 20.02 | 17.14 | 18.58 | -26.26 | -23.37 | -24.80 | -35.46 | -25.38 | -30.79 | 17.78** | 11.70 | 14.72** |
| $P_{13} \times P_4$ | 16.60 | 12.10 | 14.35 | 16.18 | 15.76 | 15.97 | 18.62 | 18.17 | 18.39 | 2.60 | -23.32 | -10.14 | -10.85 | -33.41 | -21.47 | 51.32 | 5.68 | 28.01* |
| DFH 15 x DFH 58 | 12.93 | 12.90 | 12.92 | 10.95 | 11.66 | 11.30 | 12.31 | 12.78 | 12.54 | 18.08 | 10.63 | 14.34 | 5.04 | 0.94 | 3.03 | 17.87** | 12.66* | 15.25** |
| DFH 33 x DFH 16 | 16.72 | 13.86 | 15.29 | 15.19 | 13.46 | 14.38 | 16.23 | 15.33 | 15.88 | 10.07 | 2.97 | 6.33 | 3.02 | -9.59 | -3.72 | 52.42** | 21.05 | 36.40** |
| DFH 39 x DFH 57 | 16.21 | 13.00 | 14.61 | 15.20 | 12.45 | 13.83 | 18.19 | 13.82 | 16.01 | 6.64 | 4.42 | 5.64 | -10.89 | -5.93 | -8.74 | 47.77** | 13.54 | 30.33** |
| DFH 41 x DFH 50 | 13.54 | 13.09 | 13.31 | 15.65 | 15.65 | 15.65 | 16.30 | 16.82 | 16.56 | -13.48* | 6.36 | -14.95** | -16.93 | -22.18 | -24.32 | 23.43** | 14.32* | 18.78** |
| DFH 58 x DFH 16 | 16.13 | 14.21 | 15.17 | 12.91 | 12.94 | 12.98 | 16.23 | 15.33 | 15.88 | 24.94 | 9.81 | 21.03 | -0.62 | -7.31 | -1.07 | 47.04 | 24.10 | 40.14 |

| | | $S_1$ | $S_2$ | Pool |
|---|---|---|---|---|
| Mean performance of standard check variety | | 10.97 | 11.45 | 11.21 |
| CD for RH ($F_1$ vs MP) | P = 0.05 = | 2.38 | 2.12 | 1.15 |
| | P = 0.01 = | 3.45 | 3.08 | 1.63 |
| CD for HB ($F_1$ vs BP) | P = 0.05 = | 2.74 | 2.45 | 1.33 |
| | P = 0.01 = | 3.99 | 3.56 | 1.88 |
| CD for SH ($F_1$ vs CP) | P = 0.05 = | 2.74 | 2.45 | 1.33 |
| | P = 0.01 = | 3.94 | 3.56 | 1.88 |

$S_1$ = Mean for season 1, $S_2$ = Mean for season 2, Pool = Pooled mean

* P = 0.05, ** P = 0.01

maximum being in DFH 33 x DFH 16 (52.42%) followed by $P_{13}$ x $P_4$ (51.32%) and the minimum value in $P_9$ x $P_5$ (1.82%).

During the second season none of the hybrids could outyield mid-parent or better parent for this character. Significant standard heterosis was noticed in only three hybrids. They were DFH 58 x DFH 16 (24.10%), $P_{10}$ x $P_3$ (22.18%) and DFH 33 x DFH 16 (21.05%).

Pooled analysis revealed a significant heterotic reaction in DFH 58 x DFH 16 (21.03%) and in DFH 15 x DFH 58 (14.34%) in terms of relative heterosis. None of the hybrids showed significant heterobeltiosis. Eight out of ten crosses exhibited statistically significant standard heterosis. The combinations DFH 58 x DFH 16 (40.14%), DFH 33 x DFH 16 (36.40%) and $P_{10}$ x $P_3$ (34.70%) showed higher values.

2.10 Total crop duration

As shown in Table 20, all the crosses, during the first season recorded increase in crop duration, but only five showed significant relative heterosis. $P_9$ x $P_5$ (8.54%) gave the maximum followed by $P_{13}$ x $P_4$ (8.03%) and $P_4$ x $P_3$ (7.91%). $P_{10}$ x $P_3$ gave the lowest value (0.79%). None of the combinations could perform better than the better parent. Even though the crosses showed marginal standard heterosis, none of them was significantly superior.

During the second season, four combinations showed significant relative heterosis. They were $P_{13}$ x $P_4$ (9.25%), $P_{12}$ x $P_8$ (6.16%), DFH 39 x DFH 57 (4.45%) and DFH 41 x DFH 50 (4.10%). Significant heterobeltiosis was shown by none of the crosses. Standard heterosis was significant in the case of DFH 39 x

Table 20. Mean performance of hybrids, better parents, mid-parents and heterosis for total crop duration (days)

| Crosses | $F_1$ | | | MP | | | BP | | | RH (%) | | | HB (%) | | | SH (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_2$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool |
| $P_4 \times P_3$ | 126.40 | 117.00 | 121.75 | 117.13 | 115.50 | 116.32 | 127.00 | 125.00 | 126.00 | 7.91** | 1.30 | 4.67** | -0.47 | -6.40 | -3.37 | 0.72 | -1.68 | -0.41 |
| $P_9 \times P_5$ | 125.50 | 118.00 | 121.75 | 115.63 | 115.00 | 115.32 | 125.00 | 124.50 | 124.75 | 8.54** | 2.61 | 5.58** | 0.40 | -5.22 | -2.40 | 0.00 | -0.84 | -0.41 |
| $P_{10} \times P_3$ | 127.50 | 123.50 | 125.50 | 126.50 | 124.00 | 125.25 | 127.00 | 125.00 | 126.00 | 0.79 | -0.40 | 0.20 | 0.30 | -1.20 | -0.39 | 1.59 | 3.78 | 2.66* |
| $P_{12} \times P_8$ | 127.50 | 125.00 | 126.25 | 119.75 | 117.75 | 118.75 | 128.00 | 127.50 | 127.75 | 6.47** | 6.16* | 6.32** | -0.39 | 1.96 | -1.17 | 1.59 | 5.04* | 3.27* |
| $P_{13} \times P_4$ | 126.00 | 124.00 | 125.00 | 116.63 | 113.50 | 115.06 | 126.00 | 121.00 | 123.50 | 8.03** | 9.25** | 3.20* | 0.00 | 2.48 | -0.46 | 0.40 | 4.20 | 0.61 |
| DFH 15 x DFH 58 | 124.00 | 121.50 | 122.75 | 122.38 | 118.50 | 120.44 | 123.75 | 120.00 | 121.88 | 1.32 | 2.53 | 0.75 | 0.20 | 1.25 | 1.87 | -1.20 | 2.10 | 0.41 |
| DFH 33 x DFH 16 | 129.50 | 120.50 | 125.00 | 126.38 | 124.75 | 125.56 | 127.25 | 125.50 | 126.38 | 2.47 | -3.41 | 0.45 | 1.77 | -3.98 | -1.09 | 3.19 | 1.26 | 2.25* |
| DFH 39 x DFH 57 | 129.00 | 129.00 | 129.00 | 125.00 | 123.50 | 124.25 | 127.00 | 125.00 | 126.00 | 3.20 | 4.45* | 3.82** | 1.57 | 3.20 | 2.38 | 2.79 | 8.40** | 5.52** |
| DFH 41 x DFH 50 | 130.00 | 127.00 | 128.50 | 126.25 | 122.00 | 124.13 | 127.50 | 126.00 | 126.75 | 2.97 | 4.10* | 3.52** | 1.96 | 0.79 | 1.38 | 3.59 | 6.72* | 5.11** |
| DFH 58 x DFH 16 | 131.00 | 126.00 | 128.50 | 123.25 | 122.00 | 122.62 | 125.50 | 124.00 | 124.75 | 6.29** | 3.28 | 4.80** | 4.38 | 1.61 | 3.01** | 4.38 | 5.88* | 5.11** |

| | | $S_1$ | $S_2$ | Pool |
|---|---|---|---|---|
| Mean performance of standard check variety | | 125.50 | 119.00 | 122.25 |
| CD for RH ($F_1$ vs MP) | P = 0.05 = | 4.23 | 5.24 | 2.17 |
| | P = 0.01 = | 6.15 | 7.62 | 3.07 |
| CD for HB ($F_1$ vs BP) | P = 0.05 = | 4.89 | 6.05 | 2.51 |
| | P = 0.01 = | 7.10 | 8.80 | 3.55 |
| CD for SH ($F_1$ vs CP) | P = 0.05 = | 4.89 | 6.05 | 2.51 |
| | P = 0.01 = | 7.10 | 8.80 | 3.35 |

$S_1$ = Mean for season 1, $S_2$ = Mean for seasons 1, Pooled = Pooled mean

* P = 0.05, ** P = 0.01

DFH 57 (8.40%), DFH 41 x DFH 50 (6.72%), DFH 58 x DFH 16 (5.88%) and $P_{12}$ x $P_8$ (5.04%).

In the pooled analysis it was revealed that eight crosses were significantly superior over the mid parent, with a maximum value exhibited by $P_{12}$ x $P_8$ (6.32%) followed by $P_9$ x $P_5$ (5.58%) and the minimum was exhibited by DFH 33 x DFH 16 (0.45%). DFH 58 x DFH 16 showed significant heterobeltiosis of 3.01%. Six crosses gave significant improvement over the standard check variety, with a maximum value of 5.52 per cent in DFH 39 x DFH 57, followed by 5.11 per cent in both DFH 41 x DFH 50 and DFH 58 x DFH 16, and the minimum was in $P_4$ x $P_3$ and $P_9$ x $P_5$ (-0.41% each).

2.11 Crude protein content of fruit

The extent of heterosis for this character was very marginal (Table 21). In the first season only DFH 39 x DFH 57 showed a significant relative heterosis (45.65%). None of the combinations showed significant heterobeltiosis or standard heterosis.

Only two crosses, viz. DFH 39 x DFH 57 and DFH 58 x DFH 16 exhibited significant relative heterosis (29.38% and 27.12% respectively) during the second season.

When the data were pooled over seasons DFH 39 x DFH 57 recorded a significant relative heterosis (37.71%) and heterobeltiosis (9.12%). DFH 58 x DFH 16 also showed relative heterosis of 15.31 per cent. None of the other crosses was significantly heterotic.

Table 21. Mean performance of hybrids, better parents, mid-parents and heterosis for crude protein content of fruit (%)

| Crosses | $f_1$ | | | mp | | | BP | | | RH (%) | | | HB (%) | | | SH (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool |
| $P_4 \times P_3$ | 13.25 | 14.25 | 13.75 | 14.72 | 17.54 | 16.13 | 15.53 | 20.63 | 18.08 | -9.99 | -18.76 | -14.76 | -14.68 | -30.93 | -23.95 | -50.37 | -39.62 | -45.33 |
| $P_9 \times P_5$ | 14.34 | 15.10 | 14.72 | 25.72 | 22.42 | 24.06 | 26.89 | 23.50 | 25.19 | -44.25 | -32.65 | -38.82 | -46.67 | -35.74 | -41.56 | -46.29 | -36.02 | -41.47 |
| $P_{10} \times P_3$ | 22.08 | 19.20 | 20.64 | 18.39 | 20.42 | 19.40 | 21.24 | 20.63 | 20.72 | 20.07 | -5.97 | 6.39 | 3.95 | -6.93 | -0.39 | -17.30 | -18.64 | -17.93 |
| $P_{12} \times P_8$ | 18.08 | 18.85 | 18.46 | 21.97 | 21.13 | 21.55 | 28.49 | 26.04 | 27.27 | -17.71 | -10.79 | -14.34 | -36.54 | -27.61 | -32.31 | -32.28 | -20.13 | -26.60 |
| $P_{13} \times P_4$ | 14.90 | 13.50 | 14.20 | 18.46 | 17.50 | 17.98 | 23.00 | 20.54 | 21.77 | -19.28 | -22.86 | -21.02 | -35.22 | -34.27 | -34.77 | -44.19 | -42.80 | -43.54 |
| DFH 15 x DFH 58 | 16.92 | 15.30 | 16.15 | 22.68 | 19.62 | 21.15 | 28.90 | 24.75 | 26.83 | -25.40 | -22.02 | -23.64 | -41.45 | 3.73 | -34.81 | -36.63 | -35.17 | -35.79 |
| DFH 33 x DFH 16 | 16.90 | 16.78 | 16.84 | 28.83 | 27.34 | 28.09 | 33.83 | 31.85 | 32.84 | -41.38 | -38.62 | -40.05 | -50.04 | -47.32 | -48.72 | -36.70 | -28.90 | -33.04 |
| DFH 39 x DFH 57 | 28.30 | 24.35 | 26.33 | 19.43 | 18.82 | 19.12 | 25.03 | 23.24 | 24.13 | 45.65** | 29.38* | 37.71** | 13.06 | 4.78 | 9.12* | 5.99 | 3.18 | 4.69 |
| DFH 41 x DFH 50 | 23.95 | 24.58 | 25.26 | 31.83 | 29.70 | 30.76 | 36.30 | 33.70 | 35.00 | -24.76 | -17.24 | -17.88 | -34.02 | -27.06 | -27.83 | -10.30 | 4.15 | 0.44 |
| DFH 58 x DFH 16 | 21.02 | 23.72 | 22.37 | 20.14 | 18.66 | 19.40 | 23.83 | 22.83 | 23.33 | 4.37 | 27.12* | 15.31* | -11.79 | 3.90 | -4.11 | -21.27 | 0.51 | -11.05 |

| | | $S_1$ | $S_2$ | Pool |
|---|---|---|---|---|
| Mean performance of standard check variety | | 26.70 | 23.60 | 25.15 |
| CD for RH ($F_1$ vs MP) | P = 0.05 = | 4.46 | 4.38 | 1.95 |
| | P = 0.01 = | 6.48 | 6.37 | 2.75 |
| CD for HB ($F_1$ vs BP) | P = 0.05 = | 5.15 | 5.06 | 2.65 |
| | P = 0.01 = | 7.49 | 7.35 | 3.18 |
| CD for SH ($F_1$ vs CP) | P = 0.05 = | 5.15 | 5.06 | 2.65 |
| | P = 0.01 = | 7.49 | 7.35 | 3.18 |

$S_1$ = Mean for season 1, $S_2$ = Mean for season 2, Pool - Pooled mean

* P = 0.05, ** P = 0.01

2.12 Ash content of fruit

During the first season four crosses showed significant relative heterosis for this character (Table 22). They were DFH 39 x DFH 57 (38.29%), DFH 58 x DFH 16 (36.66%), DFH 41 x DFH 50 (33.48%) and $P_{10}$ x $P_3$ (26.10%). Similarly, significant heterobeltiosis was observed in DFH 41 x DFH 50 (31.29%), DFH 58 x DFH 16 (30.01%), DFH 39 x DFH 57 (23.30%) and $P_{10}$ x $P_3$ (22.25%). All the crosses except DFH 58 x DFH 16 (16.41%) failed to give significant standard heterosis.

In the second season six combinations recorded significant superiority over mid parent with the maximum value observed in DFH 39 x DFH 57 (31.22%) followed by DFH 58 x DFH 16 (27.85%) and the minimum in DFH 33 x DFH 16 (-18.49%). Heterobeltiosis was noticed in DFH 41 x DFH 50 (21.90%), followed by DFH 58 x DFH 16 (21.67%) and the minimum in DFH 15 x DFH 58 (-20.90%). No significant standard heterosis was observed in any of the crosses.

Pooled analysis revealed that six combinations were significantly superior over their mid-parental values, the highest value being recorded in DFH 39 x DFH 57 (48.12%) followed by DFH 58 x DFH 16 (32.41%) and the lowest was in DFH 15 x DFH 58 (-19.34%). The maximum amount of heterobeltiosis was observed in DFH 41 x DFH 50 (26.30%) followed by DFH 58 x DFH 16 (25.99%) and the minimum in DFH 15 x DFH 58 (-22.46%). The combinations which were significantly superior over the check variety were DFH 58 x DFH 16 (13.31%), DFH 39 x DFH 57 (10.65%) and DFH 41 x DFH 50 (7.99%).

Table 22. Mean performance of hybrids, better parents, mid-parents and heterosis for ash content of fruit (%)

| Crosses | $F_1$ | | | MP | | | BP | | | RH (%) | | | HB (%) | | | SH (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool | $S_1$ | $S_2$ | Pool |
| $P_4 \times P_3$ | 11.84 | 12.80 | 12.32 | 10.62 | 10.32 | 10.45 | 10.83 | 10.73 | 10.78 | 11.49 | 24.03** | 17.89** | 9.33 | 19.29* | 14.29** | -14.02 | -2.07 | -8.88 |
| $P_9 \times P_5$ | 10.24 | 10.80 | 10.52 | 11.65 | 10.09 | 11.37 | 11.91 | 11.33 | 11.62 | 12.10 | -2.61 | -7.48 | -14.02 | -4.68 | -9.47 | -25.64 | -17.37 | -22.19 |
| $P_{10} \times P_3$ | 13.24 | 12.93 | 13.09 | 10.50 | 10.36 | 10.43 | 10.83 | 10.73 | 10.78 | 26.10** | 24.81** | 25.50** | 22.25 | 20.50* | 21.43** | -3.85 | -1.07 | -3.18 |
| $P_{12} \times P_8$ | 11.30 | 13.25 | 12.31 | 10.65 | 10.74 | 10.69 | 10.75 | 10.94 | 10.84 | 6.10 | 23.37** | 15.15** | 5.12 | 21.12* | 13.56** | -17.94 | 1.38 | -8.95 |
| $P_{13} \times P_4$ | 9.27 | 10.85 | 10.06 | 10.64 | 10.48 | 10.56 | 10.93 | 11.06 | 10.99 | -12.88 | 3.53 | -4.73 | -15.19 | -1.90 | -8.46 | -32.68 | -16.99 | -25.59 |
| DFH 15 x DFH 58 | 8.60 | 9.84 | 9.22 | 11.23 | 11.64 | 11.43 | 11.34 | 12.44 | 11.89 | -23.42 | -15.46 | -19.34 | -24.16 | -20.90 | -22.46 | -37.55 | -24.71 | -31.80 |
| DFH 33 x DFH 16 | 10.47 | 9.92 | 10.20 | 11.72 | 12.17 | 11.95 | 12.33 | 12.33 | 12.16 | -10.67 | -18.49 | -14.66 | -15.09 | -19.55 | -16.12 | -23.97 | -24.10 | -24.56 |
| DFH 39 x DFH 57 | 15.24 | 14.67 | 14.96 | 11.02 | 11.18 | 10.10 | 12.36 | 12.12 | 12.24 | 38.29** | 31.22** | 48.12** | 23.30* | 21.04* | 22.22** | 10.68 | -12.24 | 10.65** |
| DFH 41 x DFH 50 | 15.19 | 14.02 | 14.60 | 11.38 | 11.55 | 11.47 | 11.57 | 11.55 | 11.56 | 33.48** | 21.90** | 27.29** | 31.29** | 21.90* | 26.30** | 10.31 | 7.73 | 7.99** |
| DFH 58 x DFH 16 | 16.63 | 14.60 | 15.32 | 11.73 | 11.42 | 11.57 | 12.33 | 12.00 | 12.16 | 36.66** | 27.85** | 32.41** | 30.01** | 21.67* | 25.99** | 16.41* | 11.71 | 13.31** |

| | | $S_1$ | $S_2$ | Pool |
|---|---|---|---|---|
| Mean performance of standard check variety | | 13.77 | 13.07 | 13.52 |
| CD for RH ($F_1$ vs MP) | P = 0.05 = | 1.82 | 1.66 | 0.48 |
| | P = 0.01 = | 2.65 | 2.40 | 0.68 |
| CD for HB ($F_1$ vs BP) | P = 0.05 = | 2.10 | 1.91 | 0.56 |
| | P = 0.01 = | 3.06 | 2.78 | 0.79 |
| CD for SH ($F_1$ vs CP) | P = 0.05 = | 2.10 | 1.91 | 0.56 |
| | P = 0.01 = | 3.06 | 2.78 | 0.79 |

$S_1$ = Mean for season 1, $S_2$ = Mean for season 2, Pool = Pooled mean

* P = 0.05, ** P = 0.05

### 3 Estimation of cost of production of $F_1$ seeds

The details on the crossing work to produce $F_1$ seeds are presented in Table 23. A total of 13 fruits were obtained out of 13 flowers crossed. Time taken for preparatory operations like bagging and labelling and crossing of 13 flowers recorded as 99 minutes. From these 13 fruits 633 seeds weighing 161.00 g were obtained, with an average yield of 12.4 g seeds/fruit. From this data, the cost of production of one kg $F_1$ seeds of snakegourd was estimated as shown below.

Cost of production of one kg $F_1$ seed:-

Number of fruits required for 1 kg of seed $= \frac{1000}{12.4}$

$= 80.6 \approx \underline{\underline{81}}$

Total time takenfor crossing 13 fruits =99 minutes

Average time taken for crossing one fruit $= \frac{99}{13}$

= 7.62 minutes

Time required for crossing 81 fruits = 81 x 7.62

= 617.22 minutes

= 10.29 hrs

Labour charges/day (8 hours duration) = Rs.80/-

Labour requirement for 1 kg seed $= \frac{\text{Total time required for producing one kg of } F_1 \text{ seed}}{\text{Total man hour/day}}$

$= \frac{10.29}{8} = 1.29$

Table 23. Crossing operation to produce $F_1$ seeds in snakegourd

| Sl. No. | Number of flowers bagged | | Time taken for bagging | | Time taken for crossing (minutes) | Total time taken (minutes) | No. of fruits obtained | No. of seeds obtained |
|---|---|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | | | | |
| 1 | 2 | 2 | 5 | 5 | 8 | 18 | 2 | 98 |
| 2 | 4 | 4 | 10 | 10 | 15 | 35 | 4 | 193 |
| 3 | 3 | 3 | 8 | 5 | 6 | 19 | 3 | 144 |
| 4 | 1 | 1 | 3 | 2 | 3 | 8 | 1 | 48 |
| 5 | 2 | 2 | 3 | 3 | 5 | 11 | 2 | 98 |
| 6 | 1 | 1 | 3 | 3 | 2 | 8 | 1 | 52 |
| Total | | 13 | 32 | 28 | 39 | 99 | 13 | 633 |
| Total weight of seeds obtained | | | | | | | | 161 g |
| Average seed weight/fruit (161/13) | | | | | | | | 12.4 g |

Cost of producing 1 kg of seed = Total number of labourers required x wage/day

= 1.29 x 80 = Rs.103/-

The cost of production thus worked out pertains exclusively of the additional cost involved in the hybridization work to produce $F_1$ seeds of snakegourd.

# Discussion

# DISCUSSION

Cucurbitaceous crops are widely cultivated all over India, for tender as well as for mature fruits. Snakegourd (*Trichosanthes anguina* L.) is a common cucurbitaceous vegetable cultivated for it's semi matured fruits and relished by many people in our country. Fibre, minerals and other nutrients are richly available in this vegetable. Besides, it has been found to be useful for medicinal purposes also. Cucurbitaceous crops, being cross pollinated in nature, offer good scope for the exploitation of heterosis and development of high yielding hybrid varieties. But surprisingly for this crop, the number of improved varieties released in our country is very less and the number of $F_1$ hybrids is practically nil. This is a major limiting factor for the wide range adoption of this vegetable and to ensure high productivity eventhough the yield/unit area is comparable to any other Cucurbitaceous vegetable. Use of $F_1$ hybrids has been proved an effective tool to bring about high productivity and uniformity of crop. Equally important is the high adaptability with respect to season and location. In this backdrop the present study was undertaken to evaluate the performance of a few $F_1$ hybrids developed in the Department of Olericulture, College of Horticulture. The imperative need for assessing the cost of production of $F_1$ hybrid seeds was also looked into. The various information collected in the study are discussed below.

## 1. Evaluation of $F_1$ hybrids

Among the 17 characters selected for evaluating ten hybrids it was unambiguously proved that these hybrids exhibited significant superiority over their parents for thirteen characters in the first season and for fourteen characters in the second season. The characters like average fruit weight, fruit girth, seed weight/fruit and number of fruits attacked by fruit flies during first season and number of seeds per fruit, number of fruits attacked by fruit flies and crude fibre content of the fruit during the second season were not significantly different among the hybrids. Similarly, out of fourteen characters selected for pooled analysis, the hybrids proved their superiority in all the characters barring fruit girth, number of fruit attacked by fruit flies and crude fibre content of the fruit.

The earliness can be evaluated from factors like days taken for the first male flower opening, female flower opening and fruit picking maturity. For these three characters, hybrids took longer time during the first season (mean hybrid performance were 35.02, 39.98 and 52.18 days respectively) than in the second season (34.67, 39.67 and 51.50 days respectively). But these differences were found to be non-significant. But as revealed from the data, $P_4$ x $P_3$ (31.73, 36.64 and 50.99 days respectively) DFH 15 x DFH 58 (31.46, 36.81 and 49.16 days respectively) and $P_9$ x $P_5$ (31.38, 36.68 and 50.06 days respectively) were found to be superior to other hybrids with respect to earliness. Further on comparing the hybrid means with the parental means, the hybrids evinced earliness by 6-8 days.

Earliness in hybrids is a proven fact in plant breeding and the present findings also endorse the same fact as evidenced by the pooled analysis. Similar observation have been made by Lal *et al.* (1976) in bittergourd, More and Seshadri (1980) in muskmelon, Pal *et al.* (1984) in bottlegourd, Varghese (1991) in snakegourd, Ranpise *et al.* (1992) and Pitchaimuthu and Sirohi (1994).

In snakegourd, since the useful part is the fruit, fruit characters have a direct bearing on the total marketable yield.

The total number of fruits per plant and average fruit weight collectively and severally contribute to the total yield. In the present investigation, the mean hybrid performance was not significantly different between seasons (29.35 fruits in season 1 and 30.4 fruits in season 2), but they were superior to their parents by a margin of 14-16 fruits/plant in both the seasons and in pooled analysis. The pooled data indicated a parental average of 14.69 fruits while a hybrid mean was 29.86 fruits/plant. $P_9$ x $P_5$ (36.75), DFH 15 x DFH 58 (35.50), $P_4$ x $P_3$ (35.25) and $P_{13}$ x $P_4$ (30.30) topped the list for this character. The number of fruits harvested varied significantly among the best hybrids also. Average fruit weight was found to be higher in hybrids in the second season (375.22 g in first season and 392.03 g in second season). Similarly average fruit weight was less in hybrids than in parents. In both the seasons, $P_{12}$ x $P_8$ produced fruits with maximum weight (463.52 g and 568.17 g, respectively) followed by DFH 33 x DFH 16 (450.18 g and 427.88 g, respectively).

Yield per plant, which is one of the important considerations in any breeding programme showed wide variations among hybrids. Hybrids outyielded parents with highly significant margins (hybrid mean was 11287.75 g and parental mean was 5467.98 g). Similarly, hybrids produced significantly better yield during the second season compared to first season (hybrid mean of 11585.20 g and 10910.30 g respectively. The pooled analysis revealed that the top perfomers were $P_4$ x $P_3$ (13.02 kg), DFH 15 x DFH 58 (12.75 kg), $P_{13}$ x $P_4$ (12.31 kg) and $P_9$ x $P_5$ (12.24 kg). The first two were statistically at par and the second two were statistically similar. This findings reaffirms the reports made by Varghese (1991) after conducting the preliminary studies using the same experimental material.

Further, it is to be noted that all the four top performers mentioned above produced medium sized fruits only (344.46 g, 359.38 g, 403.68 g and 333.13 g per fruit, respectively). But these crosses also produced the highest number of fruits per plant. Similar observations were noted earlier by Sharma *et al.* (1983) and Sirohi *et al.* (1987) in bottlegourd, and Lawande and Patel (1989) in bittergourd. Sirohi *et al.* (1987) opined that the high yield recorded in three $F_1$s in bottlegourd was directly due to the increased number of fruits/plant.

Fruit length and fruit girth are two important fruit characteristics. The performance of hybrids was significant different from parents in both the seasons. They produced shorter fruits than parents (37.88 cm and 43.56 cm, respectively). Lawande and Patel (1989) and Varghese (1991) observed similar trends in bittergourd and snakegourd respectively. Fruit girth did not show any appreciable change over seasons. For these two characters the impact of season on hybrids is not much pronounced.

Flesh thickness was found more in hybrids as showed by the data (parental mean was 0.68 cm and hybrid mean was 0.69 cm). Comparable findings were made by Pal *et al.* (1984) in bittergourd, Reddy *et al.* (1987) in watermelon and Ranpise *et al.* (1992) in bittergourd. It was high in DFH 33 x DFH 16 (0.77 cm) and $P_{13}$ x $P_4$ (0.75 cm). $P_4$ was reported to be a good combiner for this character as reported by Varghese (1991).

Number of seeds/fruit, 100 seed weight and seed weight/fruit are interrelated characters to determine the seed yield per hectare. The number of seeds/fruit was found to be fewer in hybrids in the second season compared to first season

(50.56 and 54.68 respectively), while the seed number in hybrids was comparable to that of parents in both the seasons. Since snakegourd is a cross pollinated crop this is quite rational and it draws parallels from the reports of Tyagi (1973) in bottlegourd and Chaudhary (1987) in bittergourd. At the same time 100 seed weight was found to be less in hybrids compared to parents, but there was not much seasonal difference in this character. Seed weight/fruit was also found to be higher in parents than in hybrids (means of 14.74 g and 13.70 g, respectively).

Hybrids showed significant difference between the seasons (14.54 g and 12.87 g in season 1 and 2 respectively). This difference in seed characters can be attributed to the genotypic difference and seasonal variation as the second crop season coincided with the summer months. Pooled data revealed that DFH 33 x DFH 16 (15.29 g) and $P_{10}$ x $P_3$ (15.10 g) were performing better for this character.

Total crop duration significantly differed between seasons for hybrids (127.64 days in season 1 and 123.14 days in season 2). This is true because the hybrids remained in the field for a longer period than the parents (125.50 days and 121.11 days). Similar observations were made by Pal *et al.* (1984) in bottlegourd and Varghese (1991) in snakegourd.

Number of fruits attacked by fruit flies did not show much variation. $P_{10}$ x $P_3$ recorded the maximum number of damaged fruits in season 1, season 2 (3.5 and 2.5, respectively). The hybrids were not resistant to fruitfly attack.

Crude fibre content, crude protein content and ash content of fruit describe the qualitative aspects of the fruits. Crude fibre content was low in crosses like $P_{10}$ x $P_3$ (25.50%), $P_{12}$ x $P_8$ (34.50%) and $P_4$ x $P_3$ (34.75%). Here, another point to be noted is that $P_{10}$ x $P_3$ had consistently the lowest fibre content in season 1 and 2 and also on pooling (30.50%, 20.50% and 25.50% respectively). This can be one of the reasons for $P_{10}$ x $P_3$ becomes more susceptible to fruit fly attack in both the seasons. The fruit fly attack may be having a direct bearing on the fibre content of the fruit. Crude protein content was comparatively lesser in hybrids than parents (18.87% and 22.76% respectively). In the case of ash content the pooled data showed that DFH 39 x DFH 57 (14.96%) and DFH 41 x DFH 50 (14.60%) were having high ash content which were in turn having comparatively higher crude fibre content also (44.50% and 42.50%, respectively). This shows the quality parameters of the hybrids are not the same but varying to a greater extent.

## 2 Estimation of heterosis

The evaluation of the *per se* performance of hybrids will be incomplete unless and until it is being supplemented with the information on the heterotic behaviour of these hybrids for various characters which are discussed below:

Days to first male flower opening, registered a highly significant relative heterosis, heterobeltiosis and standard heterosis, in all the ten test hybrids, in both the seasons and in pooled analysis. During the first season, high relative heterosis, heterobeltiosis and standard heterosis were recorded by DFH 15 x DFH 58 (-26.17%, -27.68% and -25.36%, respectively) followed by $P_4$ x $P_3$ (-23.41%, -25.37% and -18.73%, respectively). During the second season also $P_4$ x $P_3$ was the first (-32.43%, -33.27% and -28.83%, respectively) followed by DFH 15 x DFH 58 (-24.73%, -25.37% and -23.36%, respectively). Pooled analysis also revealed the highly heterotic behaviour of $P_4$ x $P_3$ (-27.85%, -29.24% and -23.74%, respectively) closely followed by DFH 15 x DFH 58 (-25.43%, -25.55% and -24.39%, respectively).

Days to first female flower opening was another character where all the ten hybrids showed significant relative heterosis, heterobeltiosis and standard heterosis in both the seasons and in pooled analysis. During the first season, DFH 15 x DFH 58 (-23.38, -26.88% and -24.70%, respectively), $P_4$ x $P_3$ (-23.02%, -23.39% and -22.77%, respectively) and $P_9$ x $P_5$ (-17.57%, -23.53% and -25.07%, respectively) were the top performers. During second season $P_4$ x $P_3$ (-27.28%, -28.74% and -28.43%, respectively) and DFH 15 x DFH 58 (-24.64%, -26.27% and -25.78%, respectively) were found to be superior. Pooled analysis also proved the superiority of $P_4$ x $P_3$ and DFH 15 x DFH 58. For days to first fruit picking maturity, all the crosses except DFH 58 x DFH 16 showed significant relative heterosis, heterobeltiosis and standard heterosis. During the first season DFH 15 x DFH 58 (-19.38%, -18.42% and -18.67%, respectively) and DFH 33 x DFH 16 (-17.60%, -16.78% and 14.87%, respectively) were found to be superior, while in the second season again DFH 15 x DFH 58 (-20.03%, 18.79% and -21.09%, respectively) and $P_9$ x $P_5$ (13.99%, -11.52% and -20.69%) recorded high values. Pooled analysis also showed the superiority of DFH 15 x DFH 58.

The crosses DFH 15 x DFH 58, $P_4$ x $P_3$ and $P_9$ x $P_5$ turn out to be the most promising hybrids for earliness as evidenced by the results of the days to first male flower opening, female flower opening and fruit picking maturity, which are considered as important criteria in determining the earliness. And it is also to be noted that these crosses were having high *per se* performance also. The present observations corroborate the earlier report of Varghese (1991) while using the same experimental material.

The significant level of heterosis showed by all the ten hybrids forcefully justifies the selection of these crosses for exploitation of heterosis. This findings draw parallels from the reports of Lal *et al.* (1976) in bittergourd. More and Seshadri (1980) in muskmelon, solanki *et al.* (1982) in cucumber, Chaudhary (1987), Janakiram and Sirohi (1987), Vahab (1989) and Ranpise (1992) in bittergourd and Pitchaimuthu and Sirohi (1994) in bottlegourd.

Number of fruits per plant was another character wherein all the hybrids except DFH 58 x DFH 16 showed significant relative heterosis, heterobeltiosis and standard heterosis. During the first season, $P_9$ x $P_5$ (206.38%, 176.92% and 140.00%, respectively) and DFH 41 x DFH 50 (166.67%, 154.55% and 86.67%, respectively) showed very high heterosis. During the second season, $P_9$ x $P_5$ (200.00%, 177.78% and 141.94%, respectively) and $P_4$ x $P_3$ (138.71%, 124.24% and 138.71%, respectively) were found to be performing well over other crosses, while pooled analysis again confirmed the superiority of $P_9$ x $P_5$ (202.97%, 200.00% and 140.98%, respectively. The superiority of $P_9$ x $P_5$ and $P_4$ x $P_3$ has been earlier indicated by Varghese (1991). Heterosis for number of fruits/plant is an important aspect in crop improvement and poductivity. Similar instances have been reported by Lal *et al.* (1976), Chaudhary (1987) in bittergourd, Sirohi *et al.* (1987) in bottlegourd, Lawande and Patel (1989) and Vahab (1989) in bittergourd and Janakiram and Sirohi (1992) in bottlegourd.

For average fruit weight, during first season, significant relative heterosis and heterobeltiosis were shown by DFH 33 x DFH 16 (36.43% and 33.92%) and DFH 58 x DFH 16 (53.89% and 27.93%) only. DFH 15 x DFH 58 (31.67% and 11.44%) and DFH 33 x DFH 16 (20.98% and 13.36%) showed significant relative heterosis and heterobeltiosis. On pooled analysis again, DFH 15 x DFH 58 and DFH 33 x DFH 16 recorded significant relative heterosis and heterobeltiosis. None of the crosses except $P_{12}$ x $P_8$ during second season could give significant standard heterosis.

All the ten crosses showed statistically significant relative heterosis, heterobeltiosis and standard heterosis during both the seasons and in pooled analysis for total yield per plant. During the first season DFH 15 x DFH 58, $P_4$ x $P_3$ and $P_{13}$ x $P_4$ were the better yielders, while in the second seasons $P_4$ x $P_3$ and DFH 33 x DFH 16 have excelled. Pooled analysis, established the superiority of $P_4$ x $P_3$ (146.05%, 128.03% and 71.00%, respectively), DFH 15 x DFH 58 (129.27%, 124.25% and 67.36%, respectively) and $P_{13}$ x $p_4$ (113.12%, 110.83% and 61.57%, respectively). $P_4$ x $P_3$ and $P_{13}$ x $P_4$ have been found to be heterotic in preliminary studies also (Varghese, 1991). When we consider the extent of heterosis present and *per se* performance of hybrids, $P_4$ x $P_3$, DFH 15 x DFH 58, $P_9$ x $P_5$ and $P_{13}$ x $P_4$ could be named as promising, in terms of yield. Heterosis for yield was reported in other cucurbitaceous vegetables by Reddy *et al.* (1987) in watermelon, Srivastava and Nath (1983), Chaudhary (1987), Lawande and Patel (1989), Vahab (1989) and Ranpise (1992) in bittergourd, Janakiram and Sirohi (1992) and Pitchaimuthu and Sirohi (1994) in bottlegourd.

The fruit length was appreciably reduced in DFH 41 x DFH 50 and $P_{13}$ x $P_4$ during the first season and in DFH 41 x DFH 50 and $P_9$ x $P_5$ in the second season. The negative heterosis recorded for this trait turned out to be the most ideal so far as fruit length is concerned. In the pooled analysis also DFH 41 x DFH 40 and $P_9$ x $P_5$ established the same trend. The negative heterosis for this character has been reported desirable by earlier workers such as Lawande and Patel (1989) in bittergourd, Varghese (1991) in snakegourd and Ranpise (1992) in bittergourd.

For fruit girth the hybrid DFH 15 x DFH 58 exhibited significant relative heterosis (16.53%) and heterobeltiosis (11.50%). None of the crosses performed better than the check variety.

For seed weight per fruit the cross DFH 58 x DFH 16 recorded significant relative heterosis in the first season, second season and in pooled analysis (34.94% and 34.10% and 21.03%, respectively). During the second season $P_{10}$ x $P_3$ (22.18%) and DFH 33 x DFH 15 (21.05%) also evinced significant standard heterosis. And DFH 33 x DFH 16 (36.40%) and $P_{10}$ x $P_3$ (34.70%) gave significantly higher standard herterosis. Heterosis for seed weight per fruit as recorded in the above crosses are further vindication of earlier reports made by Chaudhary (1987) in bittergourd and Varghese (1991) in snakegourd.

For total crop duration relative heterosis was significant for $P_9$ x $P_5$ (8.5%), $P_{13}$ x $P_4$ (8.03%) and $P_4$ x $P_3$ (7.91%) during first season. During the second season also relative heterosis was highly significant for $P_{13}$ x $P_4$ (9.25%). There was corresponding high heterosis for yield for these crosses viz. $P_4$ x $P_3$ (RH being 128.41% and 164.66%), $P_{13}$ x $P_4$ (125.77% and 113.12%) which justify these hybrids having long duration.

In the case of crude protein content of fruit the cross DFH 39 x DFH 57 was significant to manifest heterosis during first season (45.65% relative heterosis) and during second season (29.38%). The cross DFH 58 x DFH 16 also gave significant relative heterosis (27.12%) during the second season. This shows that $F_1$ hybrids vary in their qualitative parameters.

For ash content of fruit, heterobeltiosis was shown by four hybrids; the high values being recorded by DFH 41 x DFH 50 (31.29%) and DFH 58 x DFH 16 (30.01%). During second season six combination showed relative heterosis. Pooling of data further confirmed the heterotic behaviour of DFH 41 x DFH 50 and DFH 58 x DFH 16.

From the foregoing discussion, it can be concluded that, when we consider the factors of earliness and total yield, the hybrids which could get through the evaluation process with outstanding performance are $P_4$ x $P_3$, DFH 15 x DFH 58, $P_{13}$ x $P_4$ and $P_9$ x $P_5$, in the descending order of superiority. They could give consistently higher yields. The pooled means these hybrids were respectively 13.02 kg, 12.75 kg, 12.31 kg and 12.24 kg, respectively). In addition to their good *per se* performance, they registered high amount of heterobeltiosis also. In pooled analysis relative heterosis for yield was 146.05 per cent, 129.27 per cent, 113.12 per cent and 107.19 per cent, respectively. Heterobeltiosis was 128.03 per cent, 124.24 per cent, 110.83 per cent and 92.67 per cent, respectively and standard heterosis was 71.00 per cent, 67.36 per cent, 61.57 per cent and 60.77 per cent, respectively. Fruit length recorded in $P_4$ x $P_3$ (34.28 cn), DFH 15 x DFH 58 (31.32 cm),

$P_9$ x $P_5$ (43.28 cm) and $P_{13}$ x $P_4$ (32.68 cm) were found to be medium, which is considered favourabe to fetch more market preference.

### 3. Estimation of cost of production of $F_1$ seeds

Once a hybrid or variety is identified as superior, it has to be popularised. Production and distribution of $F_1$ hybrids are of utmost importance in the population of any $F_1$ varieties. But compared to the production of seeds open pollinated varieties $F_1$ hybrid seed production involves more human labour and thus more expensive. And it was imperative to assess the cost factor in the production of $F_1$ seeds of snakegourd. Hence this part of the study was undertaken and the results are discussed hereunder:

Selfing and crossing were done manually and actual cost for this operation was worked out. The average number of seeds per fruit was 48.7 and average seed weight was 12.4 g per fruit. A total number of 81 fruits were required to get one kg of $F_1$ seeds and the average time taken for getting one fruit was 7.62 minutes. This means a total of 10.29 man hours were required for the production of one kg $F_1$ seeds, which involves a labour cost of Rs.103/- considering the wage rate of Rs.80/- per day. In contrast to this one kg of $F_1$ seeds of bittergourd took 29.25 hours as reported by Devadas and Ramadas (1993). As reported by Haften and Stevenson (1956) and Avdeev (1986) use of marker characters and male sterility might be very much helpful to cut short the cost of $F_1$ seed production. However,the $F_1$ seed production by manual means for the time being is still a worthwhile proposition especially in snakegourd. Another important observation noted was that artificial pollination will ensure increased fruit set and improved seed recovery which can be recommended whenever there is poor fruitset and seed filling.

Promising $F_1$ hybrids


Plate 1. $P_4 \times P_3$


Plate 3. $P_9 \times P_5$

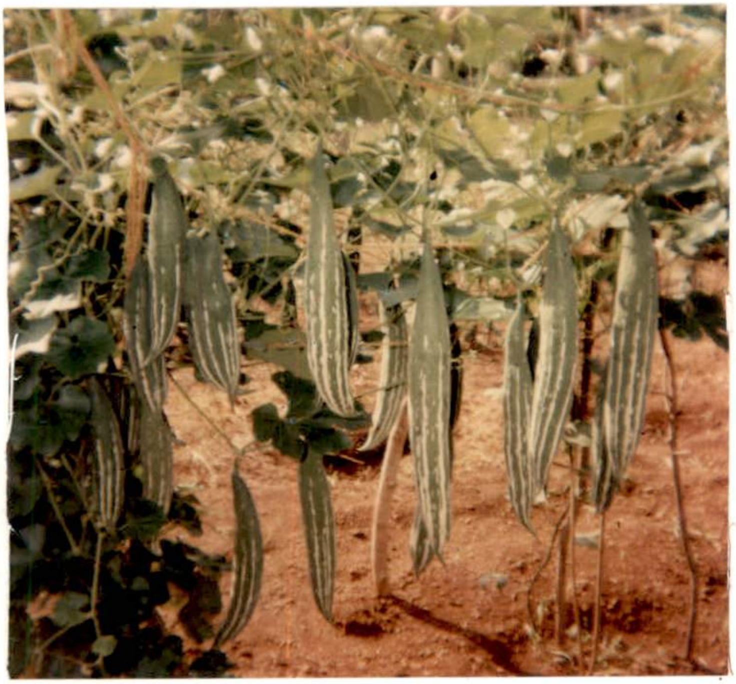

Plate 2. DFH 15 x DFH 58

# Summary

# SUMMARY


A study was undertaken with the objective of "Evaluation of $F_1$ hybrids in snakegourd" at the College of Horticulture, Vellanikkara during the period from 1992-1994. The investigation was to evaluate the performance of selected $F_1$ hybrids over seasons and to estimate the heterosis and cost of production of $F_1$ hybrid seeds.

A total of ten hybrids were evaluated along with their 16 parents and one standard check variety, TA-19, over two seasons. The hybrids were evaluated based on 17 characters. Hybrids exhibited significant variations among themselves as well as between parents. Heterosis was also prominent in all the hybrids for characters like earliness, yield etc.

The earliness was measured by days taken for first male flower opening, female flower opening and fruit picking maturity. The hybrids $P_4$ x $P_3$, DFH 15 x DFH 58 and $P_9$ x $P_5$ exhibited earliness for days to first male flower opening (31.73 days, 31.46 days and 31.38 days respectively). For days to first female flower opening and for first fruit picking maturity again $P_4$ x $P_3$ (36.64 and 50.99 days, respectively), DFH 15 x DFH 58 (36.81 and 49.16 days, respectively) and $P_9$ x $P_5$ (36.68 and 50.06 days, respectively) showed earliness. Earliness to the extent of 6-8 days was recorded by these hybrids.

In the case of number of fruits/plant, hybrids excelled in the production of more number of fruits compared to their parents. The hybrids $P_9$ x $p_5$ (36.75), DFH 15 x DFH 58 (35.50), $P_4$ x $P_5$ (35.58) and $P_{13}$ x $p_4$ (30.30) topped in the list. Average fruit weight was found to be lower in hybrids than parents. The highest

fruit weight was produced by $P_{12}$ x $p_8$ (463.52 g and 568.17 g in season 1 and season 2, respectively) followed by DFH 33 x DFH 16 (450.18 g and 427.88 g, respectively). [illegible] For fruit length, hybrids produced shorter fruits than parents. In the case of fruit girth $P_{12}$ x $P_8$, $P_{13}$ x $P_4$ and DFH 15 x DFH 58 had desirable girth (19.46 cm, 19.41 cm and 19.10 cm respectively). Flesh thickness registered an improvement from 0.68 cm (parental mean) to 0.69 cm (hybrid mean). The number of seeds/fruit was maximum in $P_{10}$ x $P_3$ (59.34) followed by $P_{13}$ x $P_4$ (57.59). For seed weight per fruit DFH 33 x DFH 16 (15.79 g) and $P_{10}$ x $P_3$ (15.10 g) had higher values compared to other hybrids. Hybrids with longer duration were DFH 39 x DFH 57 (129 days), DFH 41 x DFH 50 and DFH 58 x DFH 16 (both 128.50 days). Crude fibre content was low in crosses like $P_{10}$ x $P_3$ (25.50%), $P_{15}$ x $P_8$ (34.50%) and $P_4$ x $P_3$ (34.75%). Crude protein content was comparatively lesser in hybrids than parents (hybrid mean of 18.87% and parental mean of 22.76%). Ash content was higher in DFH 39 x DFH 57 (14.96%) and DFH 41 x DFH 50 (14.60%) among hybrids.

Heterosis for days to first male flower opening was high for $P_4$ x $P_3$ as evidenced by relative heterosis, heterobeltiosis and standard heterosis (-27.85%, -29.24% and -23.74%, respectively) followed by DFH 15 x DFH 58 (-25.43%, -25.55% and -24.39% for relative heterosis, heterobeltiosis and standard heterosis respectively). For days to first female flower opening $P_4$ x $P_3$ (-25.10%, -25.66% and -25.57%, respectively) and DFH 15 x DFH 58 (-23.99%, -26.57% and -25.23%, respectively) recorded higher negative heterosis. Days taken to first fruit picking maturity was the lowest in DFH 15 x DFH 58 (-19.69%, -18.60% and -19.88% for relative heterosis, heterobeltiosis and standard heterosis respectively).

For number of fruits/plant maximum heterosis was expressed by $P_9$ x $P_5$ (202.97%, 200.00% and 140.98% for relative heterosis, heterobeltiosis and standard heterosis respectively). For average fruit weight, significant relative heterosis and heterobeltiosis were shown by DFH 15 x DFH 58 (33.81% and 15.30%, respectively) and DFH 33 x DFH 16 (28.44% and 23.05%, respectively). All the 10 hybrids showed significant heterosis for yield/plant. In terms of relative heterosis, heterobeltiosis and standard heterosis, $P_4$ x $P_3$ (146.05%, 128.03% and 71.00%, respectively), DFH 15 x DFH 58 (129.27%, 124.24% and 67.36%, respectively) and $P_{13}$ x $P_4$ (113.12%, 110.83% and 61.57%, respectively) found as better performers. For fruit length, DFH 41 x DFH 50 (-34.62%, -37.28% and -45.44% for relative heterosis, heterobeltiosis and standard heterosis respectively) and $P_9$ x $P_5$ (-25.29%, -32.43% and -34.18% for relative heterosis, heterobeltiosis and standard heterosis respectively) showed high negative heterosis. For fruit girth, only DFH 15 x DFH 58 showed significant relative heterosis (16.53%) and heterobeltiosis (11.50%).

In the case of seed weight/fruit, DFH 58 x DFH 16 and DFH 15 x DFH 58 gave significant relative heterosis (21.03% and 14.34% respectively) and DFH 33 x DFH 16 (36.40%) and $P_{10}$ x $P_3$ (34.70%) showed significantly higher standard heterosis. For total crop duration, DFH 58 x DFH 16 manifested significant relative heterosis, heterobeltiosis and standard heterosis (4.80%, 3.01% and 5.11%, respectively. DFH 39 x DFH 57 recorded significant relative heterosis (37.71%) and heterobeltiosis (9.12%) for crude protein content of fruit. For ash content of fruit $P_4$ x $P_3$, $P_{10}$ x $P_3$, $P_{12}$ x $P_8$, DFH 58 x DFH 16 and DFH 41 x DFH 50 were found to be heterotic.

The cost of production of $F_1$ seeds production was worked out based on the cost factor involved in the manual operation of crossing work. The average time taken for crossing one fruit including all the preliminary operations was 7.62 minutes, the average yield of seeds per fruit was 12.40 g and to get one kg of seed 10.29 hours were required. Considering the labour charge at the rate of Rs.80/- per day (for 8 hour duration) the expenditure for producing one kg of hybrid seed had come to Rs.103/-. This pertains to the additional cost involved by way of crossing work.

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* Originals not seen

# Appendices

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# Appendix-1
## Analysis of variance for different characters - Season-1

| Characters | Variance due to replication df=1 | Mean squares due to genotypes | | | | Mean squares due to error df=26 |
|---|---|---|---|---|---|---|
| | | Parents df=15 | Hybrids df=9 | Hybrids vs parents df=1 | Check vs others df=1 | |
| Days to male flower opening | 0.71 | 13.87** | 15.62** | 572.66** | 15.63** | 1.32 |
| Days to female flower opening | 0.19 | 14.69** | 11.91** | 742.24** | 89.58** | 2.43 |
| Days to first picking maturity | 0.001 | 0.49** | 3.36 | 890.75** | 23.84** | 2.54 |
| Number of fruits/plant | 1.19 | 34.08** | 50.56** | 2679.96** | 53.47 | 5.19 |
| Average fruit weight (g) | 872.58 | 25349.42** | 739.76 | 361.16 | 32297.64** | 1760.03 |
| Yield/plant (g) | 388282.00 | 17338971.00** | 32192595.00** | 29674084.00** | 30169400.00** | 376121.00 |
| Fruit length (cm) | 18.74 | 248.26** | 73.89** | 443.97** | 1148.25** | 5.99 |
| Fruit girth (cm) | 1.59 | 12.30** | 4.42** | 1.70 | 18.61** | 1.26 |
| Flesh thickness (cm) | 0.00 | 0.017** | 0.005** | 0.008** | 0.002 | 0.001 |
| Number of seeds/fruit | 0.91 | 78.54** | 139.43** | 138.25* | 54.59 | 23.05 |
| 100 seed weight (g) | 3.20 | 16.26** | 13.30** | 67.84** | 47.76** | 1.36 |
| Seed weight/fruit | 0.04 | 14.22** | 8.25** | 3.71 | 29.47** | 2.59 |
| Total crop duration (days) | 90.74** | 104.73** | 9.78 | 350.64** | 2.47 | 8.21 |
| Number fruits attacked by fruit flies | 2.24 | 4.28** | 1.27 | 1.11 | 1.44 | 0.66 |
| Crude fibre content of fruit (%) | 0.001 | 0.016** | 0.008** | 0.008** | 0.002 | 0.001 |
| Crude protein content of fruit (%) | 0.002 | 4.27** | 1.27** | 1.11** | 1.44** | 0.001 |
| Ash content of fruit (%) | 0.001** | 0.01** | 0.005** | 0.022** | 0.007** | 0.0001 |

* P = 0.05
** P = 0.01

# APPENDIX-II
## Analysis of variance for different characters - Season -II

| Characters | Variance due to replication df=1 | Mean square due to genotypes | | | | Mean square due to error df=26 |
|---|---|---|---|---|---|---|
| | | Parents df=15 | Hybrids df=9 | Hybrids vs parents df=1 | Check vs other df=1 | |
| Days to male flower opening | 0.21 | 14.69** | 16.68** | 581.50** | 17.45** | 1.65 |
| Days to female flower opening | 6.45 | 8.76** | 24.30** | 591.71** | 44.55** | 2.88 |
| Days to first fruit picking maturity | 6.07 | 9.73** | 6.88** | 704.33** | 60.73** | 2.58 |
| Number of fruits/plant | 14.52* | 23.60** | 87.64** | 1806.40** | 953.86** | 3.13 |
| Average fruit weight (g) | 2027.88* | 23367.11** | 9995.24** | 1781.41* | 160888.00** | 387.73 |
| Yield/plant (g) | 189392.00 | 1511411.50 | 3102691.00 | 43570200.00 | 3008961.00 | 497923.00 |
| Fruit length (cm) | 0.59 | 252.96** | 117.43** | 342.79** | 1145.90** | 12.00 |
| Fruit girth (cm) | 4.46* | 6.65** | 1.28 | 10.85** | 4.01* | 0.89 |
| Flesh thickness (cm) | 0.00 | 0.014** | 0.005* | 0.025** | 0.001 | 0.002 |
| Number of seeds/fruit | 0.04 | 73.00** | 34.16 | 11.29 | 1.19 | 16.00 |
| 100 seed weight (g) | 16.12** | 14.71** | 13.60** | 158.92** | 14.59** | 0.41 |
| Seed weight/fruit (g) | 7.41 | 11.95** | 2.21 | 28.37** | 10.67* | 2.06 |
| Total crop duration (days) | 28.17 | 104.77** | 30.12* | 132.01** | 8.78 | 12.56 |
| Number of fruits attacked by by fruit flies | 0.30 | 0.70 | 0.69 | 0.89 | 0.78 | 0.80 |
| Crude fibre content of fruit (%) | 0.00 | 0.012** | 0.007** | 0.00009 | 0.00003 | 0.001 |
| Crude protein content of fruit(%) | 0.003 | 0.007** | 0.004** | 0.017** | 0.001 | 0.001 |
| Ash content of fruit(%) | 0.00 | 0.01** | 0.0007** | 0.012** | 0.004** | 0.002 |

* P = 0.05
** P = 0.01

## Appendix-III
### Analysis of variance for different characters - Pooled over seasons

| Characters | Mean squares due to season df=1 | Mean squares due to genotypes | | | | Mean squares due to error | |
|---|---|---|---|---|---|---|---|
| | | Parents df=15 | Hybrids df=9 | Hybrids vs partents df=1 | Check vs others df=1 | Inter-action | Pooled |
| Days to male flower opening | 5.81 | 26.19** | 28.55** | 118.76** | 26.28** | 3.09 | 1.47 |
| Days to female flower opening | 24.81** | 19.52** | 31.86** | 1372.00** | 89.16** | 4.04 | 2.65 |
| Days to first fruit picking maturity | 38.00** | 17.07** | 8.81** | 1590.04** | 80.04** | 2.14 | 2.50 |
| Number of fruits/plant | 7.26 | 52.82** | 101.57** | 5677.80** | 107.32** | 4.28 | 4.16 |
| Yield/plant (g) | 8840192.00** | 2196458.00** | 6074522.00** | 833705152.00** | 37666.70 | 511035.00 | 43703.30 |
| Fruit length (cm) | 77.94 | 455.84** | 168.00** | 782.72** | 2290.83** | 34.54 | 9.00 |
| Fruit girth (cm) | 1.41 | 15.45** | 4.36** | 3.00 | 19.90** | 2.99 | 1.07 |
| Number of seeds/fruit | 167.00** | 121.59** | 119.70** | 116.06** | 31.94 | 38.14 | 19.58 |
| 100 seed weight/ fruit (g) | 27.78** | 22.40** | 8.15* | 26.22** | 37.92** | 3.29 | 2.32 |
| Total crop duration (days) | 303.25** | 204.53** | 29.73* | 464.78** | 1.14 | 7.46 | 10.40 |
| Number of fruits attacked by fruit flies | 2.08 | 2.27** | 1.54 | 2.36 | 2.43 | 1.68 | 0.73 |
| Crude fibre content of fruit (%) | 0.011 | 0.21** | 0.12** | 0.006 | 0.001 | 0.001 | 0.005 |
| Crude protein content of fruit (%) | 0.03 | 0.16** | 0.085** | 0.38** | 0.05** | 0.005 | 0.008 |
| Ash content of fruit (%) | 0.00 | 0.002 | 0.02** | 0.14** | 0.06** | 0.001 | 0.001 |

* P = 0.05
** P = 0.01

# EVALUATION OF $F_1$ HYBRIDS IN SNAKEGOURD

(*Trichosanthes anguina* L.)

By

**V. SUDEVKUMAR**

## ABSTRACT OF A THESIS

Submitted in partial fulfilment of the
requirement for the degree

**Master of Science in Horticulture**

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# ABSTRACT

An investigation on "Evaluation of $F_1$ hybrids in Snakegourd" was conducted at College of Horticulture, Kerala Agricultural University, Vellanikkara, during 1992-1994. Ten $F_1$ hybrids were evaluated along with their parents and a standard check variety TA-19 for two seasons.

Heterosis was estimated in different seasons for different characters like days to first male flower anthesis, days to first female flower opening, days to first fruit picking maturity, number of fruits per plant, average fruit weight, yield per plant, fruit length, fruit girth, flesh thickness, number of seeds per fruit, hundred seed weight, seed weight/fruit, total crop duration, fruit fly incidence, crude fibre content of fruit, crude protein content of fruit and ash content of fruit. The heterotic behaviour of all the ten hybrids was studied for season I, season II and pooled over seasons for each character. Heterosis was estimated in terms of relative heterosis, heterobeltiosis and standard heterosis. Cost of production of $F_1$ seeds of snakegourd was also worked out.

All the ten hybrids recorded significant heterosis in terms of relative heterosis, heterobeltiosis and standard heterosis for characters like days to first male flower opening, days to first female flower opening, days to first fruit picking maturity, number of fruits/plant and total yield/plant in both the seasons. The number of days taken for flower opening, fruit picking maturity as well as the total crop duration were found to be lower in second season (summer). Seasonal variation was significant in number of days taken to first fruit picking maturity, total yield, number of seeds/fruit, seed weight/fruit and total crop duration.

The hybrids which exhibited high heterosis for yield in terms of relative heterosis, heterobeltiosis and standard heterosis were $P_4$ x $P_3$ (146.05%, 128.03% and 71.00% respectively), DFH 15 x DFH 58 (124.27%, 124.24% and 67.36% respectively) and $P_{13}$ x $p_4$ (113.10%, 110.83% and 61.57% respectively). The *per se* performance for yield was high for $P_4$ x $P_3$ (13.02 kg), DFH 15 x DFH 58 (12.75 kg), $P_{13}$ x $P_4$ (12.31 kg) and $P_9$ x $P_5$ (12.24 kg). Earliness for 6-8 days was also manifested by $P_4$ x $P_3$, DFH 15 x DFh 58 and $P_9$ x $P_5$.

The time taken for production of one kg of $F_1$ hybrid seed was 10.29 hours for preparatory operations and crossing work and the cost incurred was Rs.103/kg of seed.