STABILITY STUDIES IN NEW SUNFLOWER (*Helianthus annuus* L.) HYBRIDS UNDER DIFFERENT AGRO CLIMATIC CONDITIONS

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CERTIFICATE

This is to certify that the thesis entitled, **"STABILITY STUDIES IN NEW SUNFLOWER (*Helianthus annuus* L.) HYBRIDS UNDER DIFFERENT AGRO CLIMATIC CONDITIONS"** submitted by **Mr. PANDURANGA Y.K.**, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **GENETICS AND PLANT BREEDING** to the University of Agricultural Sciences, GKVK, Bangalore, is a *bona-fide* research work carried out by him under my guidance and supervision and that no part of the thesis has been submitted for the award of any other degree, diploma, associateship, fellowship or other similar titles.

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INTRODUCTION

I. INTRODUCTION

Sunflower (*Helianthus annuus* L.) is the second most important oil seed crop in the world next to soybean. Its seed oil can be used for human consumption and also as a raw material for oleo chemistry. It can also be used as a substitute for mineral oil in various applications, such as a fuel, a lubricant or oil for hydraulic systems.

Due to its low to moderate production requirements, high oil quality, protein content and utilization of all plant parts it is grown in an area of 18.2 m.ha with an annual production of 22.5 m.tons world wide. The major sunflower growing countries are Soviet Union, Argentine, China, The United States, France, Spain, Romania, Turkey, Hungary and India.

In India prior to 1970's sunflower was mainly grown as ornamental plant, however, with the introduction of high yielding Russian varietal populations viz., 'VNIIMK' 8393 (EC, 68413), 'Pere dovik' (EC 68414), 'Armavirskii'. 3497 (EC 68415) and 'Cernianka-65' (Morden) upgraded its importance later as an oil seed crop. Since then this crop is becoming popular in view of its high yield potential, high oil content, short duration, low thermo and photosensitivity, wide adaptability and ability to withstand drought. Currently the crop is grown over an area of 3.0 m.ha with a production of 1.8 m. tons in the country. The major sunflower growing states in the country are Karnataka, Maharastra, Andra Pradesh, Tamil Nadu, Punjab, Haryana and Uttar Pradesh.

Sunflower, being highly cross pollinated crop is ideal for exploitation of heterosis. The discovery of cytoplasmic male sterility by Leclercq (1969) in France and the fertility restoration by Kinman (1970) in U.S.A. provided the required break through for heterosis breeding in sunflower. The development and release of the first ever sunflower hybrid in the country BSH-1 using male sterility system from Bangalore (Seetharam, 1980) gave a stimulus and renewed interest in the crop. Since then several hybrids have been developed and the area under hybrids have also been increasing.

Sunflower is grown in a wide range of environments, varying soil types, rainfall patterns, fertility levels, pests and disease complexes and cultural practices. Hence identification of stable genotypes across environments (locations) is important in plant breeding programme. Allard and Bradshaw (1964) suggested the selection of genotypes that show least interaction with the environments.

Success in plant breeding primarily depends on the magnitude of variation present for yield and yield components and the nature of association among them. The estimates of phenotypic correlation among the characters are useful in planning the selection strategies. Path coefficient analysis is helpful in partitioning the correlation coefficient into direct and indirect effects. So that the relative contribution of each component character to the end product yield could be assessed.

Realizing the importance for such studies in sunflower, the present investigation was carried out with following objectives.

1. To evaluate the newly developed hybrids for higher seed yield and oil content
2. To study the stability parameters for newly developed hybrids under different agro-climatic conditions
3. To estimate the extent of heterosis for newly developed hybrids.
4. To study the relationship between yield and yield components through correlation and path coefficient analysis.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

The literature pertaining to the present study has been reviewed under the following heads.

1. Heterosis
2. Genotype x environmental interactions and stability analysis
3. Correlation and path coefficient analysis.

2.1 Heterosis

Heterosis is the superiority or inferiority of the hybrid (F_1) over its parents. Generally, heterosis is manifested as an increase in vigour. The hybrid may be superior to the mid parent (average heterosis) or better parent (heterobeltosis) or a check variety or hybrid that is referred to as standard heterosis or economic or useful heterosis.

The utilization of hybrid vigour as a means of maximising the yield of agricultural crops has become one of the most important method in plant breeding. As sunflower is a highly cross pollinated crop, it is ideally suited for exploitation of hybrid vigour. The literature pertaining to heterosis on sunflower has been presented in Table 1.

2.2 Genotype x environment interactions and stability analysis

Genotype x environment interactions are of major importance to the plant breeders in the process of evolution of improved varieties. When varieties are grown at several locations for testing their performance, their relative rankings will usually differs. Genotype x environment interaction is present whether the varieties are purelines, single crosses, double crosses, top crosses, S_1 lines or any other material with which breeder is working (Eberhart and Russel, 1966).

Table 1: Review of literature pertaining to standard heterosis in sunflower hybrids

Character	No. of Crosses	Range of heterosis (%) (Standard heterosis)	References
Days to 50% flowering	19	1-5 days earlier	Neagu and Catrina (1963)
	66	-0.60 to 21.68	Shankara (1981)
	10	-5.00 to 17.73	Shivaraju (1984)
	10	-2.68 to 18.75	Shivaraju (1984)
	30	-12.97 to 0	Chidananda (1985)
	18	-5.88 to 1.68	Ibrahim (1985)
	24	-3.79 to 22.75	Naik (1985)
	60	-20.31 to 1.56	Govindaraju (1986)
	30	-6.11 to 8.33	Jahagirdhar (1986)
	32	-17.97 to -1.68	Manjunath (1986)
	18	-19.69 to -7.34	Wali (1987)
	40	-7.14 to 19.23	Uma (1987)
	30	-7.65 to -2.12	Shekar (1996)
Days to maturity			
	8	+ve significant	Seetharam *et al.* (1977)
	4	25.00 to 30.00	Skoric (1977)
	100	Upto -7.69	Chaudhary and Anand (1984)
	10	-5.00 to 17.73	Shivaraju (1984)
	12	-3.79 to 22.75	Naik (1985)
	32	-13.29 to 0.61	Manjunath (1986)
	21	+ve significant	Shivakumara (1989)
	25	-14.03 to 16.89	Bindu Madhava (1990)
	-	-ve significant	Chidambaram and Sundaram (1990)
	72	-22.39 to 15.10	Harini (1992)
Plant height			
	10	-24.52 to -5.19	Shivaraju (1984)
	10	-12.81 to 8.56	Shivaraju (1984)
	30	-46.73 to 0	Chidananda (1985)
	18	-40.72 to 10.85	Ibrahim (1985)
	24	26.21 to 128.09	Naik (1985)
	60	-6.01 to 32.61	Govindaraju (1986)
	30	-3.98 to 19.32	Jahagirdhar (1986)
	32	-35.15 to 16.25	Manjunath (1986)
	18	-9.30 to 17.55	Wali (1987)
	40	-23.62 to 1.81	Uma (1987)
	21	-12.84 to 5.99	Shivakumara (1989)
	72	-18.17 to 29.62	Harini (1992)
	2	2.77 to 20.62	Naresh (1993)
	30	-28.02 to 3.88	Shekar (1996)

Table 1: Review of literature pertaining to standard heterosis in sunflower hybrids (Contd.....)

Character	No. of Crosses	Range of heterosis (%) (Standard heterosis)	References
Head diameter			
	66	-29.35 to -4.35	Shankara (1981)
	10	3.84 to 38.41	Shivaraju (1984)
	10	-5.46 to 30.91	Shivaraju (1984)
	30	-52.18 to 0	Chidananda (1985)
	18	-15.5 to 15.39	Ibrahim (1985)
	24	5.34 to 79.21	Naik (1985)
	30	-17.33 to 10.39	Jahagirdhar (1986)
	32	-26.46 to 8.67	Manjunath (1986)
	18	-13.54 to 40.08	Wali (1987)
	21	-6.55 to 45.07	Shivakumara (1989)
	72	-17.66 to 37.82	Harini (1992)
	24	0.47 to 23.80	Naresh (1993)
	30	2.26 to 29.47	Shekar (1996)
Stem diameter			
	66	-34.01 to -9.72	Shankara (1981)
	10	-6.56 to 32.05	Shivaraju (1984)
	10	4.00 to 28.00	Shivaraju (1984)
	30	-38.00 to 0.00	Chidananda (1995)
	18	-98.86 to 98.30	Govindaraju (1986)
	30	-12.55 to 12.17	Jahagirdhar (1986)
	32	-22.82 to 8.15	Manjunath (1986)
	18	-26.77 to 16.16	Wali (1987)
	40	-18.3 to 24.01	Uma (1987)
	21	-2.65 to 29.63	Shivakumara (1989)
	72	-18.96 to 91.71	Harini (1992)
	24	17.1	Naresh (1993
	30	-5.66 to -31.48	Shekar (1996)
Seed yield			
	-	54	Grebenjuk (1967)
	27	9 to 28.8	Vranceanu (1967)
	118	35	Vuple (1967)
	-	30	Gundeav (1968)
	7	24	Vranceanu and Stonenescu (1969)
	35	118 to 245	Neagu (1970)
	-	12.00 to 40.00	Leclercq (1971)
	-	24	Vicentini (1971)
	15	8 to 44	Vranceanu *et al.* (1973)
	-	18.00 to 30.00	Voskoboinik and Soldatov (1975)
	320	10.7 to 33.8	Voskoboinik (1977)
	66	-54.94 to 3.66	Shankara (1981)
	1	40.00 to 50.00	Seetharam (1984)
	10	-28.75 to 37.82	Shivaraju (1984)

Table 1: Review of literature pertaining to standard heterosis in hybrids sunflower (Contd.....)

Character	No. of Crosses	Range of heterosis (% (Standard heterosis)	References
	10	-23.21 to 38.99	Shivaraju (1984)
	30	-65.04 to 0	Chidananda (1985)
	18	-42.37 to 48.03	Ibrahim (1985)
	24	-14.37 to 143.01	Naik (1985)
	60	-27.63 to 9.38	Govindaraju (1986)
	30	-56.24 to 40.33	Jahagirdhar (1986)
	32	-19.49 to 37.01	Manjunath (1986)
	18	56.71 to 248.12	Wali (1987)
	40	-38.43 to 34.02	Uma (1987)
	21	-65.09 to 297.44	Shivakumara (1989)
	72	-29.62 to 88.70	Harini (1992)
	24	-5.66 to -19.21	Naresh (1993)
	30	-0.22 to -56.90	Shekar (1996)
100 seed weight			
	66	-38.33 to 2.83	Shankara (1983)
	10	-30.52 to 71.63	Shivaraju (1984)
	10	-10.52 to 94.76	Shivaraju (1984)
	30	-45.53 to 0	Chidananda (1985)
	18	-16.38 to 46.55	Ibrahim (1985)
	24	-31.07 to 15.32	Naik (1985)
	60	-20.76 to 9.98	Govindaraju (1986)
	30	-24.87 to 23.69	Jahagrdhar (1986)
	32	-37.45 to 8.56	Manjunath (1986)
	18	-17.86 to 25.63	Wali (1987)
	40	-14.58 to 23.83	Uma (1987)
	21	-15.03 to 44.41	Shivakumara (1989)
	72	-32.59 to 47.95	Harini (1992)
	24	-0.61 to -29.26	Naresh (1993)
	30	-0.76 to -9.19	Shekar (1996)
Percent seed filling			
	10	-14.45 to 7.17	Shivaraju (1984)
	10	-8.28 to 9.10	Shivaraju (1984)
	18	-19.08 to 60.86	Ibrahim (1985)
	18	-2.68 to 74.99	Wali (1987)
	21	-22.47 to 5.47	Shivakumara (1989)
	72	-15.49 to 4.07	Harini (1992)
	24	-1.00 to -9.11	Naresh (1993)

Table 1: Review of literature pertaining to standard heterosis in hybrids (Contd.....)

Character	No. of Crosses	Range of heterosis (% (Standard heterosis)	References
Oil content			
	27	3.2	Vranceanu (1967)
	-	40	Gundeav (1968)
	7	31	Vranceanu and Stonenescu (1969)
	15	13.0 to 44.0	Vranceanu *et al.* (1973)
	-	Significant	Vranceanu and Stonenescu (1975)
	-	13	Voskoboinik and Soldatov (1975)
	66	-27.73 to 4.11	Shankara (1981)
	7	26.4	Vranceanu (1981)
	-	10.0 to 24.0	Buchuchanu *et al.* (1984)
	10	-32.06 to 0.21	Shivaraju (1984)
	10	-25.16 to 4.66	Shivaraju (1984)
	30	-22.17 to 0	Chidananda (1985)
	18	-22.07 to 6.67	Ibrahim (1985)
	24	-15.51 to 13.57	Naik (1985)
	60	13.80 to -1.87	Govindaraju (1986)
	30	-2.18 to 11.08	Jahagirdhar (1986)
	32	-9.26 to 18.75	Manjunath (1986)
	18	2.74 to 17.47	Wali (1987)
	40	-4.20 to 15.15	Uma (1987)
	21	-1.43 to 15.57	Shivakumara (1989)
	72	-14.71 to 32.67	Harini (1992)
	24	-0.33 to -15.32	Naresh (1993)
	30	17.40 to 104.45	Shekar (1996)

Johanson (1909) explained the meaning of phenotype, which he described as the appearance or form arising as a result of interaction of genotype and environment. He was well ahead of others in realizing the importance of environment in developing processes. However the existence of genotype x environment interaction was first reported by Fisher and Mackenzie (1923) from the results of a varietal trail on potatoes. The break through came when Fisher (1926) presented the analysis of variance for factorial designs in field experimentation. This was used by Immer *et al.* (1934) to analyse the yield data obtained from a barley trial.

Sprague and Federer (1951) explained how variance components could be compartmented into effects of genotypes, environments and their interaction in equating the observed mean squares in ANOVA to their expectations on random model.

Allard (1961) pointed out that there is a relationship between genetic diversity and consistency in performance in different environments. According to him mixed populations were more stable than pure lines, owing to higher buffering.

Comstock and Moll (1963) demonstrated the significant effect of genotype x environment interactions in slowing the progress from selection.

Finlay and Wilkinson (1963) used regression as a quantitative measure of phenotypic stability to describe the varietal adaptability over a range of environments. According to them, absolute phenotypic stability could be expressed by b=0 and the ideal variety in respect of adaptation would be the one having maximum yield potential in most favourable environment and maximum phenotypic stability.

According to Eberhart and Russel (1966) in addition to mean and regression, deviation from regression should be given importance. Perkins and Jinks (1968) proposed that a regression of genotype x environmental interaction on environmental index had to be obtained rather than regression of mean performance as done in the Eberhart and Russel's model.

Luthra and Singh (1974) concluded after comparing some stability models and parameters that the relative rankings of the genotype in Eberhart and Russel's and Perkin and Jink's model would be same.

Paroda *et al.* (1973) were of opinion that minimum of three contrasting environments would be quite sufficient in order to select most stable genotypes as well as to predict their mean performance.

Allard and Bradshaw (1964) suggested selection of stable genotype that interact less with the environments in which they are to be grown with a view to reduce the genotype x environmental interaction to a considerable extent.

Literature on stability analysis in sunflower is rather limited and the available information on which are presented below.

In a study on stability of yield in sunflower, Sharma and Chopde (!979) indicated that the differences in stability were mainly due to linear regression. The strain EC 68414 had high mean with bi = 1.17 which is not significantly different from unity indicating average stability. EC 68415 with high mean showed specificity towards most unfavourable environment. In general they reported that the mean performance as inversely proportion to stability.

Nuthan (1980) in his experiment to study heterosis and stability index on sunflower with ten hybrids, seven parents with check variety EC 68415 reported that hybrids were generally more stable than their parents over a range of environments.

Seetharam *et al.* (1980) evaluated eight sunflower hybrids developed using four cytoplasmic male sterile lines and two restorers, along with a check variety EC 68415 in three different environments to study the phenotypic stability of seed yield. Three hybrids showed very high phenotypic index but they had regression coefficient value exceeding unity. The results indicated that the mean performance was inversely proportional to stability. In general the hybrids had greater specificity of adaptability to favourable environments.

Dua and Yadava (1981) evaluated twelve sunflower lines and the hybrids from their 66 crosses in seven environments over two seasons to study the phenotypic stability. They reported that EC 69874 had given high achene yields with high oil content. Among hybrids, EC 85819 x EC 66877 and EC 77195 x EC 68413 were the most stable and gave higher than average achene yields and oil percentages.

Eight Romanian commercial hybrid varieties and the variety Record were evaluated by Filipescu and Poparlan (1982) for oil content at 18 sites for 5 years. They reported that average oil content over all sites ranged from 48.1 per cent in Ramsun 52 to 50.3 per cent in Record. Over the whole period, Record surpassed all others in Dobrogea, Baragan and forest sleppe zone of Muntenia and Ottenia. But Ramsun 90 was superior in western ghatts. However, in Moldavia, Record was surpassed by the midearly hybrids Ramsun 90, Ramsun 301 and Floram 305. In three years out of five, the mean oil content over all sites was highest in Ramsun 90, but Ramsun 59 showed most responsive to favourable conditions, attaining 53.5 per cent in the best years.

Javirsingh and Yadava (1982) grown 36 forms of sunflower in seven environments during rabi and kharif seasons to study stability for oil content. They recorded highest oil content in EC 93613 but it showed poor stability. Where as EC 69874, EC 68414, Ramsun, Record and EC 68415 showed more stability. The results indicated that mean performance with respect to oil content was inversely related to stability.

From data recorded with respect to seed yield, oil yield, oil percentage and also flowering on seven single cross hybrids and two open pollinated cultivars grown in ten environments in each of three years, George (1983) noticed high seed yield in hybrids than the cultivars. Among the hybrids, 'Hysun 31' and 'Sunking' recorded higher seed yield than the others. Finally he suggested that difference were due to location interaction with genotypes.

Javirsingh and Yadava (1983) conducted stability studies to assess the magnitude and nature of G x E interaction in 36 genotypes of sunflower grown in seven different environments. The linear component of G x E interaction was significant for all the characters except for percentage of filled seeds. Non linear component was also found to be significant for all the characters. The magnitude of linear component was higher for 100 seed weight and yield of filled seeds. However, magnitude of non linear component was higher for only percentage of filled seeds indicating that prediction across the environment could not possible for this character. Stability analysis revealed that genotype EC 68414, Ramsun, Record and EC 69874 were stable for yield and for most of the component characters.

Pathak and Dixit (1984) reported that the sunflower varieties performed differently in varying environments. EC 68415 had high mean seed yield and showed specific adaptation to favourable environments and a nonsignificant deviation from linear regression. EC 68414 and EC 69874 were stable where as Sunrise was unstable. Further, they correlated stability parameters $\bar{X}$ and bi which showed significant positive correlation.

Five sunflower genotypes tested under ten different environments by Rangaswamy *et al.* (1986) indicated that all the genotypes had unit regression coefficient with S^2di not different from zero. The most superior genotype for grain yield and oil content was EC 68415 followed by EC 68414. High stability was shown by SUF-2.

Seetharam (1984) reported that the sunflower hybrid BSH-1 (CMS 234A x RHA-274) out yielded the standard check EC 68415 by 40 to 50 per cent in trials over locations. The hybrid was shorter than EC 68415, had higher self fertility and possessed greater resistance to rust and alternaria leaf spot.

Sen *et al.* (1985) evaluated seven varieties of sunflower over five seasons for yield stability. Significant differences were observed in variety, environment and interaction between variety and environment. The linear component of variety x environment was also significant. Stability analysis indicated that Swedish II was the most stable variety over seasons. Gor 33 and 5697/97 were identical in stability but low yielders. While Swedish I and Viniimk 8331 were also identical in stability but were high yielder. The variety viniimk 8931 was considered most stable over three rabi seasons, whereas, DS-I showed highest degree of sensitivity to environment over all growing seasons.

Chaudhary and Anand (1988) from their study of 30 exotic collections of sunflower over three seasons namely, kharif, rabi and spring for 14 quantitative characters revealed considerable amount of variability for all the characters except seedling dry matter weight in kharif. The genetic advance was consistently high for seed yield in all the three seasons.

Giriraj *et al.*(1988) evaluated a set of fifteen sunflower genotypes comprising inbreds, populations, single, three way and double crosses in replicated trial for stability of seed yield over four environments. The results of the study indicated that the inbreds were low in stability as against the populations which had a high level of stability and wider adaptability. The single cross and double cross hybrids were considered as the most stable group for seed yield which had combined high mean with regression equal to unity and least deviation from regression.

Singh *et al.* (1989) obtained data from three sets of triple test crosses using open pollinated varieties and indicated the importance of epistatic and additive gene action for all the traits under study. Additive effects interacted with environment for seed yield, while dominance effect showed significant interaction for seed yield, plant height, head diameter, 100 seed weight and per cent shelling.

Swamy Gowda and Giriraj (1989) reported that there was significant influence of season on genotypes in their study on evaluation of sunflower inbreds, hybrids and populations for self incompatibility over seasons. All genotypes, in general, recorded higher seed yield, number of filled seeds, seed set, autogamy and self incompatibility during summer as compared to monsoon season. They concluded based on the mean seed yield and seed filling over season that the hybrids were more self compatible than inbreds and populations.

Velazquez-cagal *et al.* (1990) evaluated 30 genotypes at three locations in the valley of Mexico (Chapingo, Santiago Tepetitlan and San Juan Ixtilmaco) for their response to the environmental variations of this region and to select for stability, and high achene yield, oil content and oil yield. They indicated that genotype x environment interaction was important for achene yield, oil yield, oil content, kernel and hull percentage. Stable performance for achene yield, oil yield and oil content were observed for seven varieties, two hybrids and one synthetic lines, with Talinay, Peredovic and Viniimk 1646 being particularly stable. Cernianka was earliest and best genotype in poor environments. The hybrid Sungrow, although unstable, gave highest achene yield and oil yield.

Gross and Hanzel (1991) reported that development of bird resistant varieties would provide economical and environmentally safe methods of contending with the problem. Morphological traits that confer resistance to depredations by birds have been identified. These traits include long involucral bracts, horizontally oriented heads, concave heads and long head to stem distance. Genotype, Environment and G x E effects were all significant ($P < 0.05$). Results of this study indicated that performance of hybrids possessing these characterstics can be expected to be stable over a wide geographical area.

From the evaluation of 24 single cross hybrids over the seasons, Giriraj and Virupakshappa (1992) observed lowest average heterosis for days to flowering and highest for seed yield. A similar trend for each season implied that heterosis was stable over environments. Hybrids CMS851 x RHA 274 and CMS 234 x NDRL 56 yielded high in all the three seasons.

Naidu *et al.* (1992) synthesized 200-250 new hybrids using 20 CMS and 60 restorer lines of both early and medium maturity and were compared with the commercial controls MSFH-8 and MSFH-17. Among them, 38 hybrids were superior for seed yield in monsoon season, 52 in summer and 11 in both the seasons.

Shinde *et al.* (1992) evaluated 15 promising genotypes of sunflower for 10 yield components during kharif, rabi and summer seasons. They observed significant environmental effects and genotype x environment interactions for all the characters. Kharif (E_1) season was favourable for stem girth, diameter of head, number of filled seeds, yield per cent and oil percentage, while rabi (E_2) was found favourable for days to 50 per cent flowering and days for maturity. Summer (E_3) revealed as a favourable environment for plant height, total number of seeds and number of leaves. Further they concluded that kharif environment was most suitable for development of the yield contributing characters and yield.

Jutharat Sonnoey (1993) compared the composite population with some hybrid varieties using three methods of stability analysis (Francis and Kannenberg, Finlay and Wilkinson and Eberhart and Russel model) on 11 characteristics in five environments. They reported that the composite population had the highest stability and adaptation for all the three methods of analysis with respect to all the characteristics, while the hybrid variety HYSIN 44 gave the highest yields in all environments. The XF-452 variety showed the highest oil content (47 %). But, this was found only under optimum environment. The HYSUN 33 gave the highest oil content in all environments ranging from 33 to 66 per cent.

Boujghagh (1993) studied the effects of winter (15 November – 15 December) versus spring (end of February – end of March) sowing on the behaviour of early and late maturing genotypes. Yield of the late genotypes were five times higher in winter sowing than spring sowing, where as, yield of the early genotypes were higher in spring sowings. This indicates, late cultivars may be adapted to winter and early cultivars to spring sowings, while both types could be used for intermediate (January) sowing dates.

Fourty hybrids along with female and 10 male parents were evaluated in kharif, rabi and summer seasons by Madrap *et al.* (1994). There was significant differences between seasons, in general, seed yield being greater in rabi and summer seasons. Among the female parents, CMS 338A gave consistently high yield in all seasons followed by CMS 234A, KSP-1 in kharif and 7-11 in rabi and summer were best among male parents. CMS 234A x RHA-300 was the highest yielding hybrid in the kharif and CMS 338A x KSP-1 in rabi season.

Jaipurkar *et al.* (1994) compared the performance of seven sunflower hybrids with two cultivars in rainfed conditions during kharif. They recorded the yield ranging from 1.26 t per ha in CV. Morden to 2.27 t in hybrid PKVSH 28. They attributed the high yield of this hybrid to low transpiration, average leaf area, high leaf proline and chlorophyll contents and high leaf turgor.

In a series of variety trails at 16 Spanish locations to study the effect of G x E interaction on yield, Moro *et al.* (1994) revealed that days to flowering x latitude and days to flowering x mean temperature did show a significant influence on G x E interaction.

In an international trials with sunflower hybrids growing in areas of Europe and North America, Vranceanu and Craiciu (1994) reported that there was great variation in respect of environmental adaptability, genetic yield potential and oil content. A group of hybrids showed satisfactory stability over many sites in both years. Some hybrids were better differentiated only in a limited number of areas.

From the yield stability studies on two groups of varieties using two controls 'Isabel' (hybrid variety) and 'Cavissos' (open pollinated variety), Xanthopoulos (1994) indicated that only two varieties (hybrids) were stable for achene yield across the environments. Both the controls showed an unstable performance. Most varieties showed linear response to the environmental effects, but the unpredictable component of GE interaction (S^2di) showed wide variation and was important than the predictable environment.

Twenty one sunflower hybrids were evaluated for stability parameters with respect to seed yield and its components in three environments (Pillai *et al.*, 1995). Five hybrids (85121, 85131, 85137, 85144 and 85151) were stable for all four characters viz., plant height, head diameter, days to 50 per cent flowering and single plant yield and bi, the mean regression of the genotypes on the environmental index. This indicated that the seed yielding ability and capacity to respond to environmental variation were closely associated.

Yield stability was evaluated in twelve promising sunflower hybrids and varieties in three different saline environments (Uma *et al.*, 1995). The genotype x environment interaction was non significant for seed yield. In general, all varieties showed better performance in low saline environments. Genotypes MSFH-17 and EC 310377 were stable with high mean seed yield and average responses to environmental changes.

Laishram and Singh (1997) evaluated eleven genotypes in three artificially created environments (differing in NPK fertilizer dose) for two seasons. Observations were recorded on plant height, days to 50 per cent flowering and maturity, head diameter, 100 seed weight, per cent seed set, seed yield per plant and oil content. Genotype x environment interaction was significant for all the characters studied. Both linear and non-linear components were important for all characters, except plant height and seed filling in which non-linear components were predominant.

2.3 Correlations and path coefficient analysis

Knowledge of phenotypic correlation between yield and its components has been immense help in the selection of suitable plant types. The association of characters may be due to either genetic linkage or pleiotrophy (Harland, 1939). A knowledge of correlation that exists among important characters may facilitate in the interpretation of results and provide a basis for planning more efficient breeding programme.

Ross (1939) stated that the yield showed negative correlation with days to blooming, number of leaves and branches. He also found a positive relationship of yield with plant height and oil percentage. Finally he concluded that selection for taller, non-branching types would lead to production of varieties with high yield and oil content.

Putt (1943) and Russel (1952) observed a positive correlation between yield and other characters viz., days to maturity, plant height, head diameter and stem diameter. They also observed a strong positive association between oil and Kernel content of the seed, thus giving an indirect approach to selection for oil content.

Frakes *et al.* (1961) demonstrated utility of path analysis in plant selection in Alfalfa and affirmed that the analysis helps in measuring direct and indirect effects of different variables on yield.

Schuster (1964) reported significant positive correlation of seed yield with head diameter and height, while a negative correlation was noticed between seed yield and length of the growing period.

D'Jakov (1966, 1969) observed that the yield of kernels had a positive correlation with their oil content. Further, he observed that variation from high oil and low yield to low oil and high yield was chiefly environmental, while variation in the reverse direction was largely hereditary.

Natali and Shaikh (1970) observed that seed yield was strongly correlated with the number of flowers. Head diameter was negatively correlated with yield. They also reported positive and multiple correlation coefficient of seed yield with plant height, number of flowers, growth period and 1000 seed weight.

D'Jakov (1971) observed a positive correlation between yield and oil content, but the correlation was negative between yield and husk percentage. He concluded that these two characters are inherited independent of each other.

Khanna (1972) observed a significant negative correlation between the percentage of seed set and diameter of capitalum and stem. The joint interaction of stem and head diameter appeared to be important in determining seed set.

The studies made by Fick *et al.* (1974) on open pollinated and hybrid varieties indicated a positive correlation between seed oil content, days to 50 per cent flowering, plant height and test weight. But the oil content in the inbred lines was found to be negatively correlated with seed weight.

The significant positive correlation between plant height and number of days to flowering was reported by Oka and Campas (1974).

Shabana (1975) observed significant positive relationship between yiėld and yield components like number of seeds, days to flowering, plant height, leaf area and number of leaves. He also found negative correlation between yield and oil content. This studies also revealed that oil content was positively correlated with plant height, number of leaves per plant, number of seeds per head and hundred seed weight.

Pathak (1975) reported that seed yield per plant had a highly significant and positive correlation with total dry matter, head diameter, 100 seed weight, plant height and stem diameter. Where as, Baldzhi (1976) found a positive correlation between percentage of filled seeds and seed yield per head.

Ayyaswamy *et al.* (1977) noticed that the diameter of head and stem girth had a close bearing on seed yield.

From a study of correlation, Chandra and Anand (1977) revealed that yield was positively correlated both phenotypically and genotypically with plant height, stem diameter and 100 seed weight. Stem diameter at mid height had a strong positive effect on yield as indicated by the path coefficient analysis. However, the height, stem diameter below the fourth leaf and 100 per cent flowering showed negative direct association with yield. While, Singh *et al.* (1977) emphasized more on seed weight and head diameter selection for increased yield as they were positively associated with yield.

Varshney and Singh (1977) reported a positive correlation of seed yield with days to 75 per cent maturity, plant height, head diameter and 1000 seed weight. A study of path analysis revealed that plant height, head diameter and seed filling directly affected seed yield, while maturity and 1000 seed weight affected yield indirectly via. plant height.

From his studies, Lakshmanaiah (1978) reported that seed yield was positively and significantly associated with capitalum diameter, 100 seed weight, seed number per capitalum, stem girth, plant height, seed filling, seed volume weight and oil content. He also noticed through the path analysis that the component characters, head diameter depicted maximum positive direct effect and also indirect effect viz., seed weight, stem girth, seed number, plant height, seed filling and oil content on seed yield.

Giriraj *et al.* (1979) in their study on 362 elite progeny lines indicated that achene weight, plant height and head diameter affected the achene yield directly, while the characters positively associated with yield were leaf number and oil content.

Omran *et al.* (1979) reported that seed yield per plant was positively correlated with capitulum diameter and 100 seed weight. The variety Giza-I recorded higher correlation values than Mujak for these two characters from both March and April sowings but oil content was higher in Mujak.

While studying thirty varieties of sunflower, Anand and Chandra (1980) reported a positive correlation of yield and oil content with head diameter, 100 seed weight, seed filling, plant height, stem girth, seed number per capitulum and seed weight. In a study of path analysis they noticed that head diameter had the greatest positive direct effect on yield.

Alba and Greco (1980) recorded positive correlation and direct effect of capitalum diameter and plant height with seed yield. While, Srinivasa (1980) indicated in his studies that yield per plant was negatively correlated with 100 seed weight and oil content and positively correlated with head diameter, plant height and stem girth.

The studies of Srinivasa (1980) revealed that yield per plant was negatively correlated with 100 seed weight and oil content and positively correlated with head diameter, plant height and stem girth.

Velkov (1980) worked out correlation between yield and yield components in Soviet and Bulgarian varieties and observed a high positive correlation between yield and head diameter, while a moderate correlation between head size and achene weight. Path coefficient analysis indicated that head diameter had direct effect on achene yield. 100 achene weight had high indirect effect via. head diameter.

Dedio (1982) deduced negative association of husk percentage with seed yield, oil content and 100 achene weight in his study with thirty five hybrids and seven parental lines.

Lakshman Rao (1983) reported that seed yield was positively and significantly correlated with head diameter, kernel oil content, seed filling, 100 seed weight, total dry matter and harvest index. A negative correlation was found with days to maturity and husk percentage. Path analysis revealed that harvest index had the highest positive direct effect on yield.

Pathak *et al.* (1983) reported that achene per plant and 100 achene weight had the highest positive direct effect on yield, while, Rao (1983) reported positive correlation between yield and head diameter, oil content, filling percentage, 100 seed weight, total dry matter and harvest index. He also reported a strong positive correlation between 100 seed weight and total dry matter, oil content and seed yield per plant.

Rao (1983) reported positive correlation between yield and head diameter, oil content, filling percentage, 100 seed weight, total dry matter and harvest index. He also reported a strong positive correlation between 100 seed weight and total dry matter, oil content and seed yield per plant.

While studying seven cultivars, Caylak and Eimirgolu (1984) reported that, head yield was strongly correlated with height, stem thickness, head diameter and 1000 achene weight

In a study involving thirty collections of sunflower, Chaudhary and Anand (1985) indicated significant positive association between seed yield and fresh weight and dry matter weight of seedlings, number of leaves, plant height at flowering and maturity, stem diameter and head diameter. The results also revealed that days to flowering and plant height at flowering had maximum direct effects on seed yield. Hence, while formulating selection indices for seed yield, they have suggested to give maximum weightage for days to flowering, head diameter along with fresh and dry seedling weight.

Mishra *et al.* (1985) reported that head diameter, per cent filled seeds and 100 seed weight were positively correlated with seed yield per plant and had high positive direct effect on it as revealed by path analysis.

From a study comprising of 36 genotypes, Singh *et al.* (1985) indicated that head diameter, percentage of filled seeds and 100 seed weight were positively correlated with seed yield per plant.

Sivaram (1986) from a path coefficient analysis, showed that yield per plant had the strongest direct effect on plot yield, followed by percentage achene set,while, head diameter and 1000 achene weight had negative and low direct effects on yield per plant.

Abdel-Gawad *et al.* (1987) observed highly significant phenotypic correlation of oil yield per plant with seed yield, 100 seed weight, number of leaves and plant height. They also found significant correlation of seed yield with number of seeds per capitalum, capitalum diameter, 100 seed weight, number of leaves per plant and plant height.

Alam *et al.* (1987) reported that seed yield was positively and significantly correlated with capitalum diameter (r=0.71) and number of seeds per head (r=0.63), where as, Sheriff *et al.* (1987) reported a close association of stem diameter, dry matter content, capitalum diameter and seed number per capitalum with seed yield.

Sherief *et al.* (1987) reported a close association of stem diameter, drymatter content, capitalum diameter and seed number per capitalum with seed yield.

Wali (1987) reported that seed yield had significant positive correlation with days to 50 per cent flowering, plant height, 100 seed weight, oil content and strong positive correlation with number of filled seeds per head and diameter. However, the oil content showed a positive and significant association with plant height, head diameter, number of filled seeds per head and 100 seed weight.

Vanishree *et al.* (1988) found highly significant correlation of head diameter, stem diameter, 100 seed weight, number of leaves per plant and plant height with seed yield.

Niranjan murthy and Shambulingappa (1989) suggested that yield could be increased by increasing seed filling percentage capitalum diameter, 100 seed weight and stem circumference.

Janimu and Ado (1989) indicated that capitalum diameter had direct positive correlation with yield, while stem diameter had negatively correlated with yield. They also reported that yield could be improved by selection for capitalum diameter and number of leaves.

Chervet and Vear (1990) reported that leaf number had significant correlation with emergence to flowering and emergence to maturity. In contrast yield was significantly correlated with head and stem diameter and plant height.

From the studies with 37 diverse sunflower varieties, Pathak and Dixit (1990) reported that seed yield per plant was significantly and positively correlated with stem girth, head weight, shelling percentage and 100 seed weight. Path coefficient analysis revealed the maximum direct effect of head diameter followed head weight, days to flowering, days to maturity and 100 seed weight on seed yield per plant. They also reported that plant height, stem girth, leaves per plant and shelling percentage were influenced the yield through other characters.

In the field trails involving nine sunflower hybrids and a control cultivar Suncorn-110, Khan and Raja Zamier Ul Islam (1991) reported positive correlation between yield and yield components such as plant height, head diameter and hundred seed weight.

Harini (1992) observed that seed yield was positively associated with 100 seed weight, head diameter and oil per cent in addition to its strong association with plant height, stem girth and oil yield, while oil content had significant positive correlation with seed filling per cent, seed yield and oil yield.

Tariq *et al.* (1992) reported that most of the characters showed positive correlation with yield except 100 seed weight and days to maturity which were negatively correlated with yield.

In a study of correlation and path coefficient analysis in F_1 and F_2 generation in sunflower by Chaudhary and Anand (1993) reported that seed yield was significantly and positively correlated with number of leaves per plant, plant height, head diameter and 1000 seed weight in both the F_1 and F_2 while oil content exhibited a positive significant association with seed yield only in the F_2.

Pallikondaperumal and Rajashekaran (1993) reported that 100 seed weight, diameter of head and plant height had high genotypic correlation with seed yield. In a path coefficient analysis they observed that 100 seed weight had the maximum direct effect on seed yield, while plant height and days to maturity showed their effect on seed yield through other related character.

Patil (1993) reported that seed yield was positively and significantly associated with all the characters studied except days to 50 per cent flowering. Seed yield had highest positive association with number of seeds per head followed by total weight of the head and plant height both at genotypic and phenotypic level. Path coefficient analysis indicated that number of seeds per head was the chief contributing character for seed yield and influenced indirectly through 100 seed weight and total weight of the head.

Suma (1993) observed highly significant positive correlation of seed yield per plant with number of filled seeds per plant, seed filling percentage and head diameter. Path analysis revealed that the number of filled seeds per plant exerted maximum direct effects on yield.

Jayarame Gowda (1994) observed highly significant positive correlation of seed yield per plant with number of filled seeds per plant followed by test weight, head diameter and oil content. Oil yield per plant was significantly and positively associated with seed yield and number of filled seeds per plant. Path analysis indicated that number of filled seeds per plant and test weight exerted maximum direct effect on seed yield.

In a correlation studies involving 63 genotypes Punia and Gill (1994) showed that seed yield per plant was significantly correlated with number of seeds per head, head diameter and stem diameter. Path analysis indicated that number of filled seeds per head, 100 seed weight and head diameter were the most important traits for seed yield per plant.

Kalaiselvan and Monohararan (1994) observed significant and positive correlation of yield with plant height and head diameter. Grain number was also showed positive but not significantly correlated with yield. However, 100 seed weight exhibited a week negative association with yield. The interacorrelations revelaed that plant height was significantly and positively correlated with grains number, head diameter and 100 grain weight. Head diameter was also positively associated with grain number.

The studies made by Suma and Virupakashappa (1994) on 196 germplasm accessions revealed highest correlation of seed yield with number of seeds per plant, seed filling percentage and head diameter, while oil yield was highly and positively correlated with seed yield per plant and number of filled seeds per plant. Path coefficient analysis indicated that number of filled seeds per plant exhibited maximum direct effect on seed yield, head diameter also showed considerable effect on seed yield. Finally, they concluded the importance of number of seeds per plant, head diameter and 1000 seed weight for yield improvement.

Evaluation of 324 germplasm accessions for yield contributing characters and their association with seed yield by Gangappa and Virupakshappa (1994) showed that seed yield was positively and significantly associated with all the characters they studied except days to 50 per cent flowering. Among these characters the highest positive correlation was with total head weight, followed by stem diameter, harvest index and head diameter. Path coefficient analysis revealed that total head weight had the highest direct effect on yield.

Mogali and Virupakshappa (1994) reported in the evaluation of 196 accessions that seed yield was positively correlated both at genotypic and phenotypic levels with number of filled seeds per plant, stem diameter, head diameter, test weight and seed filling percentage. Plant height was positively correlated with all the characters studied except seed filling percentage, while oil content was negatively correlated with seed yield at genotypic level. Path analysis indicated that number of filled seeds per plant had the maximum direct effects on seed yield. However, seed yield had the highest direct effect on oil yield followed by seed filling percentage, oil content and head diameter. Number of filled seeds per plant had the highest indirect effect via seed yield per plant, while plant height, stem diameter, head diameter and 1000 seed weight had the greater indirect effect via seed yield.

Gallegos and Escobedo (1996) indicated that head diameter showed high contribution to yield in direct way, while physiological maturity considering the end of flowering showed indirect contribution to yield. They also suggested that high residual factors are to be included.

Patil *et al.* (1996) reported that number of seeds per head was highly correlated with yield, followed by weight of head, plant height and stem diameter, while days to 50 per cent flowering showed non significant association with all most all character including seed yield and oil content except number of seeds per head. However, oil content was negatively correlated with all growth and yield components. Path analysis studies indicated that number of seeds per head showed maximum direct effect followed by 100 seed weight and weight of head in respect of both seed yield and oil yield. The maximum indirect effect for any character was through seeds per plant.

Correlation analysis conducted by Haile-Kefene *et al.* (1996) revealed that oil yield was highly and significantly correlated with seed yield per plant, number and percentage of filled seeds per head, seed oil content, 1000 seed weight, total above ground dry matter and stem diameter and significantly with harvest index. Path analysis indicated that seed yield per plant and oil content exerted the highest direct and indirect effects on oil yield followed by number of filled seeds per head and 1000 seed weight. Finally they concluded that oil yield in sunflower is largely determined by seed yield per plant and seed content.

MATERIALS AND METHODS

III MATERIAL AND METHODS

The material used and methods followed during the course of investigation have been described in this chapter.

The present study to produce hybrids in sunflower was undertaken during rabi-summer 1996-97 at Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore. Then the synthesized hybrids were evaluated over three different locations/environments during kharif 1997.

3.1 Materials

The base material for the present study consisted of 10 inbred lines and 7 fertility restorer lines (R-lines). Materials were obtained from project coordinating unit (sunflower), University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bangalore. Ten inbred lines, which were used as female parent, are IB101, IB102, IB103, IB105, IB106, IB107, IB108, IB109, IB110 and IB111. Seven restorer lines, which were used as male parent are 83R-6, 6D-1, R-274, RHA-586, RHA-587, 3376R and PZ8R. Four checks viz., KBSH-1, MSFH-17, Morden and Sungene-85 were included in the study for meaningful comparison.

3.2 Methods

3.2.1 Crossing programme

In order to synthesize single cross hybrids, seeds of inbred lines and restorers were sown at the Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore during rabi-summer seasons of 1996-97. Male sterility was induced for the ten inbreds lines by the application of gibberelic acid (GA) at the star bud stage of the crop at 100 ppm concentration (Seetharam and Kusumakumari, 1975). Three to four drops of GA was applied successively for four to five days resulted in hundred per cent male sterility.

At the time of flowering all the plants of inbred and restorer lines were bagged. The pollen from seven restorer lines was collected separately in petriplates early morning hours and pollinated to each of the ten male sterile lines separately. Pollination was done till the complete blooming of capitalum. When plants attains physiological maturity, crop was harvested and threshed. Out of 70 hybrids obtained, 36 hybrids were selected for evaluation over three different environments. The list of hybrids selected for evaluation are mentioned in the Table 2.

3.2.2 Locations/Environments

The experimental material was sown for evaluation in three different locations i.e., at three different research stations of University of Agricultural Sciences, Bangalore, representing different agroclimatic zones of Karnataka. The locations were Regional Research Station (RRS), GKVK Farm, Bangalore, Agricultural Research Station (ARS), Babbur Farm, Hiriyur, and Agricultural Research Station (ARS), Katthalgere. The zonal details and the geographical description of the above mentioned three locations are given in Table 3. The data on the weather parameters viz., maximum and minimum temperature, rainfall and relative humidity prevailed at all the locations during the cropping period are given in Table 4.

3.2.3 Layout and management

The experimental material consisting of 36 newly developed hybrids and four checks were sown in three different environments during kharif season.

The experiment was laid out in a randomised complete block design (RCBD) consisting of three replications, each replication contained two rows of each of hybrids. The row length in all the locations was 3.0 m. The inter and intra row spacings given were 60 cm and 30 cm respectively. Two to three seeds were dibbled per hill. After ten days, only one seedling per hill was retained.

Table 2 : List of newly synthesized hybrids and checks involved in the present investigation

Sl.No.	Hybrids	Sl.No.	Hybrids
1	IB101 x R-274	21	IB106 x PZ8R
2	IB101 x 3376R	22	IB106 x RHA 586
3	IB101 x PZ8R	23	IB107 x PZ8R
4	IB102 x R-274	24	IB107 x 6D-1
5	IB102 x RHA 587	25	IB108 x RHA 587
6	IB102 x 3376R	26	IB108 x PZ8R
7	IB102 x PZ8R	27	IB109 x R-274
8	IB102 x 6D-1	28	IB109 x RHA 587
9	IB102 x RHA 586	29	IB109 x PZ8R
10	IB103 x RHA 587	30	IB110 x RHA 587
11	IB103 x PZ8R	31	IB110 x 3376R
12	IB103 x 83R-6	32	IB110 x PZ8R
13	IB103 x 6D-1	33	IB111 x RHA 587
14	IB103 x RHA 586	34	IB111 x 3376R
15	IB105 x R-274	35	IB111 x PZ8R
16	IB105 x RHA 587	36	IB111 x RHA 586
17	IB105 x 3376R		**CHECKS**
18	IB105 x RHA 586	37	KBSH-1
19	IB106 x RHA 587	38	MSFH-17
20	IB106 x 3376R	39	Morden
		40	Sungene-85

Table 3 : Geographical position of the three environments involved in the present investigation

Location	Zone	Soil type	Altitude (m)	Latitude	Longitude	Annual rainfall (mm)
Reginoal Research Station, GKVK Farm, Bangalore	Eastern dry zone (zone 5)	Red sandy soil	899.00	13°00' N	77°57' E	830.50
Agricultural Research Station, Babbur farm, Hiriyur	Central dry zone (zone 4)	Black soil	606.10	13°57' N	70°37'38" E	580.00
Agricultural Research Station, Katthalgere	Southern transitional zone (zone 7)	Red sandy soil	623.30	14°37'00" N	75°49'00" E	650.00

Table 4 : Weather data prevailed at different environments during cropping period

Environments	Weather components	Year 1997			
		June	July	August	September
RRS, Bangalore	Temperature (°C)				
	(a) Maximum	28.50	28.90	28.00	28.50
	(b) Minimum	19.90	20.00	19.80	19.40
	Total rainfall (mm)	16.80	30.40	67.80	264.90
	Average RH(%)	72.00	70.50	71.50	73.50
		August	September	October	November
ARS, Hiriyur	Temperature (°C)				
	(a) Maximum	29.50	31.80	32.10	28.20
	(b) Minimum	15.60	15.60	16.20	14.60
	Total rainfall (mm)	20.50	85.50	56.60	0.00
	Average RH(%)	36.60	85.00	85.10	85.10
		August	September	October	November
ARS, Katthalger	Temperature (°C)				
	(a) Maximum	30.10	30.20	30.30	28.90
	(b) Minimum	19.50	20.60	19.30	18.60
	Total rainfall (mm)	0.00	6.20	175.11	82.40
	Average RH(%)	86.00	85.50	84.80	82.60

In Bangalore and Katthalgere environments the crop was raised under irrigated conditions where as in Hiriyur the crop was raised under protective irrigation. Recommended package of practices were followed in each environment separately for crop improvement. The experimental details in different environments are presented in Table 5.

3.2.4 Sampling and collection of data

Observations were recorded on 12 characters in all the three environments. Five random plants were tagged in each entry in each replication for recording observations. Mean of five plants was used for statistical analysis. The procedure of data collection for 12 different characters is given below.

1. Days to 50 per cent flowering

This was recorded in terms of number of days taken from the date of sowing to the opening of the ray florets in fifty per cent of the plants in each entry.

2. Days to maturity

The number of days taken from the date of sowing to physiological maturity as evidenced by the change of colour in back of the head from green to lemon yellow was recorded as days to maturity.

3. Number of leaves per plant

Total number of leaves per plant was counted and recorded at maturity.

4. Plant height (cm)

Plant height was measured in centimeter at maturity from the base of the plant to the point of attachment of the capitalum.

5. Head diameter (cm)

Head diameter in centimeter was recorded at the maximum width of the

Table 5 : Sowing date, spacing and plot size, followed in different environments (Locations)

Sl.No.	Location / Environment	Date of sowing	Spacing (cm^2)	Plot size (m^2)
1	Regional Research Station, GKVK Farm, Bangalore	27th June, 1997	60 x 30	3.0 x 1.2
2	Agricultural Research Station Babbur Farm, Hiriyur	5th August, 1997	60 x 30	3.0 x 1.2
3	Agricultural Research Station Katthalgere	28th August, 1997	60 x 30	3.0 x 1.2

head at the time of harvesting.

6. Stem diameter (cm)

Stem diameter or stem girth was measured at the first basal node with the help of vernier calipers in centimeter.

7. Seed yield per plant (g)

The filled seeds obtained after threshing were dried and their weight was recorded in grams.

8. Hundred seed weight (g)

One hundred filled seeds were randomly picked from each treatment and its weight was recorded in grams.

9. Seed filling percentage/per cent seed filling

The number of filled and unfilled seeds were counted and the filling percentage was calculated as follows :

$$\text{Seed filling percentage (\%)} = \frac{\text{Number of filled seeds}}{\text{Total number of seeds (filled + un filled)}} \times 100$$

10. Kernel weight (g)

Fifty seeds were dehusked in each treatment by hand and weight of the kernel was recorded in grams.

11. Husk content (%)

Fifty seeds were dehusked by hand and the ratio of the husk to the total seed was expressed in percentage.

12. Oil content (%)

Fifteen grams of seeds were taken from each treatment and the oil content (%) was determined using NMR (Nuclear Magnetic Resonance) Spectrometer available at the Directorate of oil seeds Research, Rajendranagar, Hyderabad.

3.3 Statistical analysis

The data on mean values for all the characters were analysed.

3.3.1 Analysis of variance (ANOVA)

Analysis of variance for each of the 12 characters was carried out separately by Fisher's method as outlined by Sundararaj *et al.* (1972). The structure of ANOVA table is as follows :

Source	df	SS	MSS	Calculated F
Replications	(r-1)	SSr	MSSr	MSSr/MSSe
Treatments	(t-1)	SSt	MSSt	MSSt/MSSe
Error	(r-1) (t-1)	SSe	MSSe	

Where, r = number of replications

t = number of treatments

SSr, SSt and SSe = Sum of squares due to replications, treatments and error respectively

MSSr, MSSt and MSSe = Mean sum of squares due to replication, treatments and error respectively.

Only when the mean sum of square due to treatments found significant when tested against error mean sum of square, the data would be subjected to subsequent analysis Standard error of mean (SEm ±) was worked out using the formula.

$$SEm \pm = \sqrt{\frac{MSSe}{r}}$$

Critical difference (CD) and coefficient of variation (CV.) were worked out using following formulae.

$$CD = \sqrt{\frac{2MSSe}{r}} \times \text{table 't' at error df}$$

$$CV(\%) = \frac{\sqrt{MSSe}}{\bar{x}} \times 100$$

3.3.2 Genotype x environment interactions

3.3.2.1 Pooled analysis of variance

The data obtained for twelve characters from genotypes over three environments were subjected to pooled analysis of variance for interaction as outlined by Perkins and Jinks (1968) to know the difference among the genotypes, environments and to reveal the existence of genotypes x environment interaction for each characters as indicated below.

Source	d.f	MS	F
Genotypes	(g-1)	M_1	M_1/M_3
Environments	(n-1)		
Genotype x Environment	(g-1) (n-1)	M_2	M_2/M_3
Pooled error	n(g-1)(r-1)	M_3	

Where, g = Number of genotypes

n = Number of environments

r = Number of replications

M_1, M_2 and M_3 = Mean sum of squares due to genotypes, genotype x environment and pooled error respectively.

Only when mean square due to genotype x environment was found significant in pooled analysis of variance, the stability analysis was carried out.

3.3.2.2 Stability analysis

To analyze the data over three environments the stability model proposed by Eberhart and Russel (1966) was adopted. This model involves the estimation of three parameters which are defined by a mathematical formula.

$$Y_{ij} = \mu_i + \beta_i I_j + S_{ij}$$

Where, Y_{ij} = Mean of the i^{th} variety at the j^{th} environment

μ_i = Mean of i^{th} variety over all environments

β_i = The regression coefficient that measure the response of i^{th} variety to varying environments.

S_{ij} = The deviation from regression of the i^{th} variety at the j^{th} environment and

I_j = The environmental index obtained by subtracting the grand mean from the mean of all varieties at the j^{th} environment.

These parameters were calculated as follows :

a) Environmental Index :

$$I_j = \frac{\sum_j Y_{ij}}{t} - \frac{\sum_i \sum_j Y_{ij}}{t.s}$$

Where, t = Number of varieties

s = Number of environments

with $\sum_j I_j = 0$

b) The regression coefficient for each variety (bi)

$$bi = \frac{\sum_j Y_{ij} I_j}{\sum_j I^2_j}$$

(c) Deviation from regression

$$S^2di = \frac{\sum_j \delta^2_{ij}}{S-2} - \frac{S^2_e}{r}$$

Where, S^2e/r = Mean square for (estimate of) pooled error

(d) Predicated performance of the genotypes

$$Y_{ij} = \bar{X}_i + b_i I_j$$

Where, $\bar{X}_i$ is the estimate of μ_i

In this model, the variance due to environments and genotype x environment are portioned into environment (linear), genotype x environment (linear) and deviations from the regression coefficient.

ANOVA for stability

Source	df	SS	MSS	F-value
Genotypes (G)	(g-1)	$\sum_i \sum_j y_{ij}^2$ - CF	MS_1	MS_1/MS_3
Environment(E)	(n-1)	$1/n \sum_j Yi^2$ - CF		
G x E	(g-1) (n-1)	$\sum_i \sum_j y_{ij}^2 - 1/n \sum_j Yi^2$		
Env. (linear)	1	$1/g (\sum_j Y_j - Ij)^2 \sum_j Ij^2$		
Geno. x Env. (linear)	(g-1)	$\sum_j [(\sum Yij\ Ij)^2 / \sum_j ij^2]$- Env. (linear) SS	MS_2	MS_2/MS_3
Pooled deviation	g(n-2)	$\sum_i \sum_j d^2ij^2$	MS_3	MS_3/MS_4
Genotype 1	(n-2)	$[\sum_j Yij^2 - Yi.^2/n]$ - $[\sum_j Yij\ Ij]^2 / \sum_j Ij^2$		
Genotype g	(n-2)	$[\sum_j Ygj^2 - Yg.^2/n]$ - $[\sum_j Ygj\ Ij]^2 / \sum_j Ij^2$		
Pooled error	n(g-1) (r-1)		MS_4	
Total	(ng-1)	$\sum_i \sum_j Yij^2$ - CF	TSS	

Where, n = Number of environments, r = Number of replications
g = Number of genotypes CF = Correction factor

a) To test the significance of pooled deviation mean square against the pooled error mean square.

$$F = \frac{MS_3}{MS_4}$$

If pooled deviation mean square found significant then it would be the appropriate denominator to test the significance of all components including genotypes, genotype x environment (linear). Other wise pooled error mean square is appropriate denominator.

b) To test the significance of the differences among the means of genotypes.

$$F = \frac{MS_1}{MS_3}$$

c) To test that genotypes do not differ for their regression on environmental index.

$$F = \frac{MS_2}{MS_3}$$

Further 't' test is used to test the significance of deviation of 'bi' from unity

$$t = \frac{1\text{-}bi}{S.E\,(bi)}$$

Where,

$$SEbi = \sqrt{\frac{\sum_j \delta^2 ij/n\text{-}2}{\sum_j I^2 j}}$$

Where, δ^2ij is the deviation of i^{th} variety in j^{th} environment from regression.

d) To test individual deviation from linear regression.

$$F = \left[\frac{\sum_j \delta^2 ij.}{(n-2)} \right] \Bigg/ \text{pooled error mean square}$$

A joint consideration of three parameters, that is

i) The mean performance of the genotype over environments (locations), $\bar{X}_i$

ii) Regression co-efficient bi and

iii) The deviation from linear regression S^2di, are used to define stability of genotype (variety).

The estimate of deviation from regression suggests the degree of reliance that should be put to linear regression in interpretation of data. If these values are significantly deviating from zero, the expected phenotype cannot be predicted satisfactorily. When deviations are non significant, the conclusions may be drawn by joint consideration of mean yield and regression values (Finlay and Wilkinson, 1963 and Eberhart and Russell, 1966) as below:

Regression	Stability	Mean yield	Remarks
bi = 1	Average	High	Well adapted to all the environments
bi = 1	Average	Low	Poorly adapted to all environments
bi > 1	Below average	High	Specifically adapted to favourable environments
bi < 1	Above average	High	Specifically adapted to unfavorable environments

Regression value of unity is interpreted as average stability since the average slope over all varieties on the environment index will be unity.

3.3.3 Estimation of heterosis

The treatments mean values for various characters were used for the estimation of standard heterosis. The standard heterosis was worked out as the per cent increase or decrease of mean of F_1 over the mean of the respective standard checks. Four checks viz., KBSH-1, MSFH-17, Morden and Sungene-85 were used in this investigation.

$$\text{Percentage of heterosis over Standard checks (SH)} = \frac{\overline{F_1} - \overline{\text{Standard check}}}{\overline{\text{Standard check}}} \times 100$$

The "t" test was employed to test the significance of heterosis as shown below,

$$\textbf{'t' check} = \frac{\overline{F_1} - \overline{\text{Check}}}{SE}$$

$$\textbf{SE (check)} = \sqrt{\frac{2MSSe}{r}}$$

Where,

MSSe = Error mean sum of squares

r = number of replications

SE = Standard error

3.3.4 Correlation coefficients

The correlation coefficients were calculated to determine the degree of association of the characters with yield and also among the yield components. Phenotypic correlations was computed by using formula given by Weber and Moorthy (1952).

Where, r_p = Phenotypic correlation

$$r_p = \frac{Cov(x_p y_p)}{\sqrt{\sigma x_p \sigma y_p}}$$

Cov (x_p y_p) is phenotypic covariance between the characters 'x' and 'y'. σx_p and σy_p are the phenotypic variance of the characters 'x' and 'y'. Phenotypic correlation coefficient was tested ('t' test) against 'r' values given in Fisher and Yates table (1963) at (n-2) df at the probability levels of 0.05 and 0.01 to test their significance.

3.3.5 Path coefficient analysis

Path coefficient analysis was carried out using the phenotypic correlation coefficients to ascertain the direct and indirect effects of the yield components on yield as suggested by Wright (1921) and illustrated by Dewey and Lu (1957).

Standard path coefficients which are the standardize partial regression coefficients were obtained by solving the following set of 'P' simultaneous equations through the use of "Doo little technique" as described by Goulden (1959).

$P_{01} + P_{02}\, r_{12} + \ldots\ldots\ldots\ldots\ldots\ldots P_{0p}\, r_{1p} = r_{01},$

$P_{01}\, r_{12} + P_{02} + \ldots\ldots\ldots\ldots\ldots P_{0p}\, r_{2p} = r_{02},$

" " "

" " "

$P_{op}\, r_{1p} + P_{02}\, r_{2p} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots + P_{0p} = r_{op}$

Where,

$P_{o1}, P_{o2} \ldots\ldots P_{op}$ are the direct path coefficients of variables 1,2,3 .....P on the dependent variable 0, r_{12}, r_{13} .... r_{1p} .... r_{p} (P-1) are the possible correlation coefficients between various independent variables and r_{01}, r_{02} .... r_{op} are the correlation coefficients between dependent variable and independent variable.

The indirect effect of i^{th} variable via j^{th} variable was obtained as (P_{oj} x r_{ij}). The contribution of the remaining unknown factors was measured as the residual factors and calculated as below.

$P^2_{ox} = 1\text{-}(P^2_{01} + 2P_{02}\ r_{12} + 2P_{01}\ P_{03}\ r_{13} + P^2_{02} + 2P_{02} + P_{03}\, r_{13} + \ldots$
$\ldots\ldots P^2_{0p})$

Residual effect = $\sqrt{P^2\ ox}$

Path coefficient analysis for seed yield per plant was carried out considering days to 50 per cent flowering, number of leaves per plant, plant height, head diameter, stem diameter, hindered seed weight, percent seed filling, kernel weight, husk content, oil content.

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

The results of the present investigation are presented in this chapter under the following heads.

1. Mean performance of hybrids and checks under different environments
2. Heterosis
3. Genotype x environment interactions
4. Stability analysis
5. Correlation coefficient
6. Path coefficient analysis

4.1 Mean performance of hybrids and checks under different environments

The analysis of variance with respect to twelve different characters in three environments are presented in Table 6. The analysis of variance revealed that highly significant differences among genotypes for all the characters studied at all three environments.

The mean performance of hybrids and checks over environments for twelve characters are presented in Table 7.

4.1.1 Days to 50 per cent flowering

Days to 50 per cent flowering differed significantly from one environment to another as indicated by varying environmental indices (-1.21 to 1.56) indicates that First environment (Bangalore) had the highest environmental index and environment mean (1.56 and 58.86 days respectively). The mean range for this trait was from 53 (IB108 x PZ8R) to 65 days (IB102 x 6D-1), 50 (IB108 x PZ8R) to 62 days (IB107 x 6D-1) and 53 (IB108 x PZ8R, IB108 x RHA587 and IB111 x 3376R) to 63 days (IB103 x PZ8R) at first, second and third environment respectively among newly synthesized hybrids and while, among checks, 46

Table 6 : Analysis of variance for twelve characters in sunflower hybrids over three environments

Source of variation	d.f.	Mean sum of squares											
		Days to 50 % flowering			Days to maturity			Number of leaves per plant			Plant height (cm)		
		E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3
Replication	2	5.31	0.86	2.27	2.91	0.28	2.59	13.66	45.46	5.87	355.00	607.75	97.13
Genotypes	39	49.40**	30.03**	34.28**	42.13**	36.19**	33.71**	10.66**	29.56**	24.24**	1302.69**	708.58**	1084.53**
Error	78	1.86	0.76	2.95	2.37	0.40	2.00	4.25	8.59	2.05	78.87	93.64	65.69
S.Em.±	-	0.78	0.50	0.99	0.88	0.36	0.81	1.19	1.69	0.82	5.12	5.58	4.67
C.D at 5%	-	2.18	1.39	2.75	2.46	1.02	2.26	3.30	11.84	2.29	14.21	7.21	12.97
C.V. (%)	-	2.31	1.55	3.02	1.74	0.75	1.64	8.31	4.70	6.24	5.10	15.49	6.59

Table 6 : Contd…..

Source of variation	d.f.	Mean sum of squares											
		Head diameter (cm)			Stem diameter (cm)			Seed yield per plant (g)			Hundred seed weight (g)		
		E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3
Replication	2	5.61	0.70	3.86	0.01	0.43	0.12	93.89	62.68	6.67	0.06	0.01	0.01
Genotypes	39	3.53**	2.65**	2.53**	0.11**	0.05**	0.20**	149.58**	93.25**	40.74**	0.99**	0.53**	0.50**
Error	78	1.67	1.12	0.47	0.03	0.02	0.03	46.82	20.12	4.42	0.10	0.08	0.03
S.Em.±	-	0.74	0.61	0.39	0.10	0.08	0.10	3.95	2.58	1.21	0.18	0.16	0.10
C.D at 5%	-	2.07	1.70	1.09	0.30	0.23	0.27	10.95	7.18	3.37	0.51	0.45	0.28
C.V. (%)	-	9.14	9.45	7.14	8.51	10.54	11.77	24.53	17.05	10.61	9.61	7.32	5.03

* Significance at 5 per cent E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

** Significance at 1 per cent

Table 6 : Contd…..

Source of variation	d.f.	Mean sum of squares											
		Per cent seed filling (%)			Kernel weight (g)			Husk content (%)			Oil content (%)		
		E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3
Replication	2	71.13	11.88	7.19	0.01	0.02	0.01	0.91	9.39	8.84	0.84	0.69	3.91
Genotypes	39	106.76**	32.84**	65.61**	0.13**	0.08**	0.06**	24.89**	38.84**	30.91**	11.45**	20.10**	12.11**
Error	78	14.26	5.23	7.14	0.02	0.02	0.01	4.12	7.87	3.48	2.93	2.90	2.45
S.Em.±	-	2.18	1.32	1.54	0.08	0.08	0.05	1.17	1.61	1.07	0.98	0.98	0.90
C.D at 5%	-	6.04	3.66	4.28	0.21	0.22	0.14	3.25	4.49	2.98	2.74	2.73	2.51
C.V. (%)	-	4.25	2.52	3.20	11.37	10.14	7.25	7.51	11.26	7.13	5.13	4.51	4.42

* Significance at 5 per cent E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

** Significance at 1 per cent

Table 7 : Mean performance of newly developed hybrids and checks for twelve characters over three environments in sunflower

Sl. No.	Genotypes	Days to 50 per cent flowering				Days to maturity				Number of leaves per plant			
		E_1	E_2	E_3	Mean	E_1	E_2	E_3	Mean	E_1	E_2	E_3	Mean
1	IB101 x R-274	63.00	60.33	61.66	61.67	93.33	87.33	91.33	90.67	27.60	29.00	26.06	27.56
2	IB101 x 3376R	61.32	60.66	62.33	61.44	89.66	87.33	91.66	89.56	24.33	22.60	20.53	22.49
3	IB101 x PZ8R	62.33	59.66	60.00	60.67	91.33	88.33	91.00	90.22	25.60	26.00	22.86	24.82
4	IB102 x R-274	64.00	59.33	61.66	61.67	92.00	89.33	89.66	90.33	26.40	30.20	22.00	26.20
5	IB102 x RHA 587	55.33	53.00	54.00	54.17	89.66	82.00	83.66	85.11	23.33	21.26	21.20	21.93
6	IB102 x 3376R	55.33	58.66	55.66	56.56	85.66	86.00	84.66	85.44	23.00	19.66	20.46	21.04
7	IB102 x PZ8R	59.66	58.66	58.00	58.58	88.00	87.00	87.33	87.44	24.93	21.53	20.53	22.33
8	IB102 x 6D-1	64.66	58.66	61.33	61.56	93.66	88.66	89.33	90.56	22.33	22.00	20.53	21.62
9	IB102 x RHA 586	60.66	55.33	57.66	57.89	90.66	85.33	87.00	87.67	23.40	28.60	24.86	25.62
10	IB103 x RHA 587	57.00	55.66	54.66	55.78	86.66	84.00	84.33	85.00	24.40	28.06	27.20	26.56
11	IB103 x PZ8R	61.33	57.66	63.33	60.78	90.00	86.00	88.33	88.11	25.00	27.46	21.26	24.58
12	IB103 x 83R-6	65.33	59.66	62.00	62.33	93.33	89.00	90.00	90.78	26.00	25.93	23.60	25.18
13	IB103 x 6D-1	64.00	60.00	59.00	61.00	92.66	88.33	89.00	90.00	26.33	23.93	24.13	24.79
14	IB103 x RHA 586	61.66	57.00	57.33	58.67	91.00	85.33	86.66	87.67	28.33	31.40	23.66	27.80
15	IB105 x R-274	63.66	59.33	60.00	61.00	93.33	88.33	89.00	90.22	26.00	28.26	16.73	23.87
16	IB105 x RHA 587	56.00	53.66	54.33	54.67	86.00	81.66	83.66	83.78	26.30	22.66	22.60	23.87
17	IB105 x 3376R	58.33	55.00	58.33	57.22	88.00	82.66	87.33	86.00	26.00	22.66	23.40	24.02
18	IB105 x RHA 586	64.33	59.66	58.66	60.89	93.66	89.00	89.66	90.78	29.33	24.80	20.80	24.98
19	IB106 x RHA 587	57.00	53.66	54.00	54.89	87.33	82.00	84.00	84.44	24.66	25.46	24.46	24.87
20	IB106 x 3376R	57.33	52.33	54.33	54.67	87.66	80.33	83.33	83.78	22.53	22.20	22.00	22.24
21	IB106 x PZ8R	57.33	50.66	54.00	54.00	87.33	80.66	84.66	84.22	25.13	23.93	23.33	24.13
22	IB106 x RHA 586	61.00	57.00	57.33	58.44	92.33	84.33	87.33	88.00	27.20	26.13	26.80	26.71
23	IB107 x PZ8R	59.00	58.33	56.33	57.89	89.33	86.33	87.33	87.67	22.66	20.46	23.46	22.20
24	IB107 x 6D-1	63.00	61.66	62.33	62.33	92.66	89.66	91.00	96.11	24.60	22.66	22.33	23.20
25	IB108 x RHA 587	55.33	53.00	52.66	53.67	85.33	81.66	82.66	83.22	23.00	24.80	18.40	22.07
26	IB108 x PZ8R	52.66	50.00	52.66	51.78	82.00	79.66	83.00	81.56	23.73	22.40	19.73	21.96
27	IB109 x R-274	64.33	59.33	59.66	61.11	92.66	88.33	90.33	90.44	27.13	30.33	29.66	29.04
28	IB109 x RHA 587	58.00	58.33	53.33	56.56	87.66	86.33	83.00	85.67	25.53	25.13	26.26	25.64
29	IB109 x PZ8R	57.00	59.00	54.33	56.78	87.00	87.00	84.33	86.11	26.23	24.86	26.20	25.80
30	IB110 x RHA 587	57.00	52.66	57.33	55.67	87.00	81.33	87.66	85.33	23.33	23.20	24.33	23.62
31	IB110 x 3376R	56.00	51.00	56.33	54.54	85.66	80.33	86.00	84.00	24.46	24.26	21.26	23.33
32	IB110 x PZ8R	55.66	55.00	54.00	54.89	85.33	84.00	84.00	84.44	24.93	24.26	20.26	23.16
33	IB111 x RHA 587	55.33	54.00	56.66	55.33	85.00	82.33	86.33	84.56	25.06	25.86	22.86	24.60
34	IB111 x 3376R	55.66	53.00	52.66	54.11	86.66	81.66	83.00	83.78	21.93	22.53	24.40	22.96
35	IB111 x PZ8R	56.33	52.00	57.33	55.22	85.33	80.00	86.66	84.00	24.60	20.06	20.66	21.78
36	IB111 x RHA 586	61.00	58.66	61.00	60.22	91.00	86.33	90.00	89.33	24.73	29.93	23.66	26.11
37	KBSH-1	60.00	57.33	55.00	57.44	89.00	85.33	85.00	86.44	15.49	27.53	24.60	22.54
38	MSFH-17	58.00	56.00	53.33	55.78	88.33	84.33	83.33	85.33	24.20	25.60	29.60	26.47
39	Morden	46.00	46.46	51.33	48.00	75.66	75.00	76.00	75.56	19.46	18.66	18.06	18.73
40	Sungene-85	52.66	52.00	52.00	52.22	83.33	80.00	81.33	81.56	23.40	23.53	23.20	23.28
	Environmental mean	58.86	56.09	56.95	57.30	88.55	84.56	86.37	86.46	24.58	24.75	22.95	24.09
	Environmental index	1.56	-1.21	-0.35		2.06	-1.93	-0.13		0.49	0.65	-1.14	
	C.D. at 5 %	0.22	1.42	2.80		2.51	1.04	2.31		4.75	4.79	2.34	
	CV (%)	2.31	1.53	2.02		1.74	0.75	1.63		11.75	11.84	6.24	

E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

Table 7 : Mean performance of newly developed hybrids and checks for twelve characters over three environments in sunflower (Contd.......)

Sl. No.	Genotypes	Plant height (cm)				Head diameter (cm)				Stem diameter (cm)			
		E_1	E_2	E_3	Mean	E_1	E_2	E_3	Mean	E_1	E_2	E_3	Mean
1	IB101 x R-274	196.60	140.20	135.40	157.40	15.63	11.36	11.53	12.78	2.09	1.28	1.70	1.70
2	IB101 x 3376R	168.60	126.06	113.53	136.07	13.23	11.73	10.76	11.91	2.37	1.46	1.50	1.78
3	IB101 x PZ8R	190.66	139.20	122.40	150.76	15.16	11.00	8.20	11.46	2.66	1.51	1.16	1.78
4	IB102 x R-274	171.06	150.06	109.13	143.42	14.23	12.93	10.10	12.42	1.94	1.57	1.32	1.61
5	IB102 x RHA 587	156.33	130.33	109.46	132.04	13.73	11.13	8.46	11.11	1.92	1.26	1.08	1.42
6	IB102 x 3376R	142.46	98.20	99.13	113.27	14.16	11.20	10.16	11.84	1.98	1.34	1.28	1.53
7	IB102 x PZ8R	170.46	134.80	109.93	138.40	14.53	11.76	9.16	11.82	2.06	1.40	1.27	1.58
8	IB102 x 6D-1	170.80	135.86	128.26	144.98	15.10	11.80	10.50	12.47	2.18	1.48	1.69	1.79
9	IB102 x RHA 586	168.73	129.73	129.53	142.67	12.43	9.06	10.36	10.62	1.98	1.26	1.35	1.53
10	IB103 x RHA 587	171.80	148.13	147.33	155.76	13.43	11.80	10.46	11.90	2.09	1.30	1.66	1.69
11	IB103 x PZ8R	176.53	136.60	109.53	140.89	14.50	11.53	8.63	11.56	2.07	1.50	1.23	1.60
12	IB103 x 83R-6	184.93	131.13	122.60	146.22	16.36	11.46	9.16	12.33	2.22	1.26	1.69	1.73
13	IB103 x 6D-1	186.73	144.73	125.33	152.27	15.73	12.80	9.13	12.56	2.53	1.80	1.56	1.97
14	IB103 x RHA 586	208.93	150.66	129.73	163.11	16.36	12.40	8.96	12.58	2.39	1.42	1.34	1.72
15	IB105 x R-274	190.33	143.53	93.60	142.49	15.20	12.66	8.13	12.00	2.30	1.46	0.97	1.58
16	IB105 x RHA 587	184.26	137.06	135.46	152.27	14.56	10.36	10.10	11.68	2.23	1.26	1.78	1.76
17	IB105 x 3376R	167.26	128.80	121.80	139.29	14.73	12.53	9.70	12.32	2.29	1.48	1.34	1.70
18	IB105 x RHA 586	191.93	150.53	109.26	150.58	14.76	12.00	9.56	12.11	2.34	1.32	1.16	1.61
19	IB106 x RHA 587	180.93	150.20	129.00	153.28	13.63	10.80	9.53	11.32	2.19	1.36	1.45	1.67
20	IB106 x 3376R	171.33	117.53	122.33	137.07	13.50	11.73	10.76	12.00	2.20	1.46	1.44	1.70
21	IB106 x PZ8R	174.66	130.33	132.86	145.96	13.10	10.46	9.90	11.16	2.26	1.33	1.66	1.75
22	IB106 x RHA 586	195.86	147.00	139.20	160.29	15.20	11.73	10.53	12.49	2.17	1.35	1.88	1.80
23	IB107 x PZ8R	183.86	137.00	129.40	150.09	14.43	10.93	9.43	11.60	1.99	1.40	1.51	1.64
24	IB107 x 6D-1	197.53	148.33	130.66	158.84	13.66	11.33	8.80	11.27	2.32	1.52	1.75	1.87
25	IB108 x RHA 587	153.33	120.20	92.20	121.91	13.13	9.93	9.38	10.82	2.64	1.20	1.14	1.66
26	IB108 x PZ8R	146.80	123.40	103.13	124.44	13.63	9.06	9.70	10.82	1.18	1.35	1.33	1.56
27	IB109 x R-274	199.20	153.60	163.46	172.09	16.36	12.13	11.40	13.30	2.30	1.46	1.76	1.84
28	IB109 x RHA 587	188.00	145.53	156.60	163.38	15.03	11.86	10.40	12.43	2.16	1.47	1.82	1.82
29	IB109 x PZ8R	184.26	142.00	154.80	160.36	13.66	11.60	9.86	11.71	2.45	1.55	1.92	1.98
30	IB110 x RHA 587	172.93	139.06	146.60	152.87	13.53	10.80	10.20	11.51	1.92	1.23	1.63	1.60
31	IB110 x 3376R	167.53	124.40	101.20	131.04	13.59	11.86	8.53	11.43	2.26	1.48	1.40	1.72
32	IB110 x PZ8R	167.86	128.93	121.33	139.28	13.33	10.23	8.70	10.76	2.10	1.31	1.28	1.56
33	IB111 x RHA 587	170.53	136.40	132.60	146.51	12.93	11.26	8.46	10.89	2.03	1.25	1.52	1.60
34	IB111 x 3376R	160.73	114.60	122.13	132.49	13.33	10.66	8.76	10.92	1.98	1.32	1.62	1.64
35	IB111 x PZ8R	181.66	134.86	113.76	143.29	13.46	10.00	9.56	11.01	2.06	1.32	1.39	1.59
36	IB111 x RHA 586	197.53	148.33	130.66	158.84	13.33	11.46	8.73	11.18	2.24	1.28	1.26	1.60
37	KBSH-1	177.20	136.93	132.40	149.18	14.40	10.76	9.43	11.53	2.35	1.36	1.36	1.69
38	MSFH-17	169.80	139.80	146.40	152.00	13.53	10.93	11.33	11.93	2.29	1.32	1.95	1.86
39	Morden	82.86	70.33	68.20	73.80	13.30	9.73	8.13	10.39	2.09	1.16	0.97	1.41
40	Sungene-85	156.20	129.73	119.20	135.04	11.56	10.06	8.56	10.07	1.96	1.30	1.16	1.48
	Environmental mean	174.27	134.16	123.03	143.82	14.15	11.22	9.57	11.65	2.19	1.38	1.50	1.69
	Environmental index	30.45	-9.66	-20.79		0.51	-0.30	-0.22		2.50	-0.43	-2.07	
	C.D. at 5 %	14.50	15.80	13.23		2.11	1.73	1.12		0.30	0.24	0.28	
	CV (%)	5.10	7.21	6.58		9.15	9.45	7.14		8.51	10.54	11.77	

E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

Table 7 : Mean performance of newly developed hybrids and checks for twelve characters over three environments in sunflower (Contd.......)

Sl. No.	Genotypes	Seed yield per plant (g)				100 seed weight (g)				Per cent seed filling (%)			
		E_1	E_2	E_3	Mean	E_1	E_2	E_3	Mean	E_1	E_2	E_3	Mean
1	IB101 x R-274	31.44	20.35	24.01	25.27	2.71	3.03	2.85	2.87	84.98	91.93	91.43	89.45
2	IB101 x 3376R	18.90	23.93	17.43	20.09	2.38	3.51	2.94	2.95	75.90	91.86	87.73	85.17
3	IB101 x PZ8R	33.76	23.44	14.47	23.89	3.46	3.57	3.48	3.51	90.36	93.73	79.86	87.99
4	IB102 x R-274	18.18	26.65	14.33	19.72	2.31	3.43	3.20	2.98	86.83	93.40	82.80	87.68
5	IB102 x RHA 587	25.79	28.09	17.12	23.67	3.28	3.33	3.22	3.28	92.86	91.20	80.96	88.34
6	IB102 x 3376R	14.82	25.48	11.76	17.36	2.46	3.68	3.02	3.06	88.06	84.43	78.93	83.81
7	IB102 x PZ8R	25.52	28.50	21.06	25.03	3.28	3.67	3.42	3.46	92.03	92.73	83.93	89.57
8	IB102 x 6D-1	22.04	25.22	26.44	24.57	2.76	3.14	2.98	2.96	79.56	93.33	91.33	88.08
9	IB102 x RHA 586	17.10	17.48	13.45	16.01	2.23	2.76	2.55	2.52	83.30	92.43	83.56	86.43
10	IB103 x RHA 587	34.06	30.76	19.47	28.10	4.06	4.06	3.98	4.04	93.40	88.36	76.16	85.98
11	IB103 x PZ8R	23.80	35.96	20.18	26.65	3.50	4.49	3.86	3.95	85.80	93.56	88.33	89.23
12	IB103 x 83R-6	29.46	22.61	24.75	25.61	3.66	4.04	3.76	3.82	79.40	85.00	92.53	85.64
13	IB103 x 6D-1	18.65	44.05	25.36	29.36	2.83	4.55	3.76	3.71	79.13	91.96	87.46	86.19
14	IB103 x RHA 586	43.31	24.77	22.63	30.24	3.03	3.44	3.29	3.26	94.63	93.40	81.73	89.92
15	IB105 x R-274	25.89	29.61	18.37	24.63	2.68	4.04	3.36	3.36	85.86	94.00	86.33	88.73
16	IB105 x RHA 587	37.96	30.20	20.64	29.60	4.09	4.39	4.21	4.23	96.30	85.40	76.63	86.11
17	IB105 x 3376R	31.93	30.84	18.14	26.98	3.47	4.26	3.53	3.76	87.50	91.53	79.06	86.03
18	IB105 x RHA 586	27.79	29.21	20.14	25.56	2.93	3.58	3.24	3.25	90.33	93.00	91.40	91.58
19	IB106 x RHA 587	32.61	24.83	18.86	25.44	3.75	3.46	3.52	3.58	95.80	90.16	80.33	88.77
20	IB106 x 3376R	25.04	19.42	12.57	19.02	3.16	3.80	2.93	3.30	88.93	87.83	83.33	86.70
21	IB106 x PZ8R	29.27	21.45	19.53	23.42	4.08	4.04	3.91	4.01	91.83	94.06	78.90	88.27
22	IB106 x RHA 586	31.79	24.75	21.21	25.88	2.80	3.45	3.34	3.20	92.00	91.06	84.86	89.31
23	IB107 x PZ8R	29.07	22.24	20.26	23.86	3.63	3.71	3.50	3.62	87.80	89.16	84.96	87.31
24	IB107 x 6D-1	15.27	27.70	20.33	21.10	2.73	3.95	3.63	3.44	71.18	94.63	90.26	85.36
25	IB108 x RHA 587	31.67	25.06	15.79	24.17	3.92	3.47	3.54	3.65	93.10	93.66	79.00	88.59
26	IB108 x PZ8R	26.47	18.70	18.17	21.12	3.90	3.25	3.38	3.51	95.33	90.23	82.60	89.39
27	IB109 x R-274	34.16	31.11	20.30	28.53	2.88	3.76	3.32	3.32	87.23	94.13	80.03	87.13
28	IB109 x RHA 587	44.14	29.13	23.58	32.29	4.21	3.87	3.62	3.90	94.53	91.80	79.63	88.66
29	IB109 x PZ8R	39.50	26.94	22.83	29.76	3.97	4.25	4.09	4.11	96.10	88.96	79.70	87.59
30	IB110 x RHA 587	32.31	28.32	24.39	28.34	3.91	3.94	3.85	3.90	95.60	87.50	79.50	87.53
31	IB110 x 3376R	27.20	28.20	16.24	23.88	3.55	4.31	3.76	3.88	89.10	92.23	80.66	87.53
32	IB110 x PZ8R	31.92	25.84	18.86	25.54	4.00	4.38	4.17	4.18	95.03	90.36	74.86	86.76
33	IB111 x RHA 587	32.70	23.16	21.85	25.90	3.73	3.98	4.20	3.98	95.60	88.40	81.20	88.40
34	IB111 x 3376R	20.32	21.15	22.35	21.28	3.27	3.94	3.66	3.62	86.53	88.80	82.80	86.04
35	IB111 x PZ8R	30.47	25.11	23.67	26.42	3.56	3.73	3.59	3.63	90.60	94.86	80.86	88.78
36	IB111 x RHA 586	19.83	23.61	19.43	20.96	2.43	3.40	2.91	2.92	82.66	92.20	89.86	88.20
37	KBSH-1	27.18	26.77	21.69	25.31	3.46	3.75	3.62	3.61	87.26	93.60	88.63	89.83
38	MSFH-17	27.47	38.24	24.53	30.12	3.96	4.42	4.18	4.19	86.48	90.80	81.16	86.15
39	Morden	23.14	12.99	14.32	16.82	3.83	3.99	3.88	3.90	92.00	79.80	87.00	86.27
40	Sungene-85	24.09	30.27	22.16	25.51	3.40	4.04	3.58	3.68	93.00	87.20	87.40	89.20
	Environmental mean	27.89	26.31	19.82	24.67	3.33	3.80	3.52	3.55	88.85	90.77	83.44	87.68
	Environmental index	3.22	1.63	-4.85		-0.22	0.25	-0.03		1.16	3.08	-4.24	
	C.D. at 5 %	11.17	7.33	3.43		0.52	0.45	0.30		6.17	3.73	4.36	
	CV (%)	24.53	17.05	10.61		9.61	7.32	5.03		4.25	2.51	3.20	

E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

Table 7 : Mean performance of newly developed hybrids and checks for twelve characters over three environments in sunflower (Contd.......)

Sl. No.	Genotypes	Kernel weight (g)				Husk content (%)				Oil content (%)			
		E_1	E_2	E_3	Mean	E_1	E_2	E_3	Mean	E_1	E_2	E_3	Mean
1	IB101 x R-274	0.94	1.10	1.02	1.02	22.33	22.43	21.33	22.03	34.16	37.46	33.90	35.18
2	IB101 x 3376R	0.90	1.26	1.08	1.08	32.56	23.96	26.20	27.56	32.13	38.33	35.10	35.19
3	IB101 x PZ8R	1.28	1.29	1.27	1.28	24.70	25.13	24.26	24.70	35.03	41.46	39.56	38.69
4	IB102 x R-274	0.75	1.25	1.00	1.00	24.26	23.56	24.06	23.97	34.03	39.53	37.26	36.94
5	IB102 x RHA 587	1.14	1.09	1.09	1.11	28.40	25.43	26.70	26.84	34.53	37.70	35.76	36.00
6	IB102 x 3376R	0.96	1.22	1.09	1.09	26.56	24.90	25.83	25.77	33.60	35.03	36.23	34.96
7	IB102 x PZ8R	1.22	1.40	1.29	1.31	23.93	21.53	23.13	22.87	35.90	39.43	37.50	37.61
8	IB102 x 6D-1	0.94	1.02	0.96	0.98	24.33	21.06	23.06	22.82	31.93	41.03	36.50	36.49
9	IB102 x RHA 586	0.76	0.91	0.83	0.83	28.16	26.50	27.56	27.41	31.70	36.33	33.43	33.82
10	IB103 x RHA 587	1.46	1.34	1.36	1.39	28.80	27.43	29.10	28.44	33.43	35.70	34.03	34.39
11	IB103 x PZ8R	1.25	1.56	1.32	1.38	28.43	21.00	25.70	25.04	34.00	39.50	35.90	36.47
12	IB103 x 83R-6	1.25	1.44	1.33	1.34	26.50	25.76	26.30	26.19	35.23	36.43	35.96	35.88
13	IB103 x 6D-1	1.10	1.66	1.35	1.37	26.80	20.73	23.63	23.72	32.46	43.00	38.70	38.06
14	IB103 x RHA 586	1.11	1.28	1.20	1.20	23.45	26.30	25.16	24.97	32.53	34.66	33.76	33.66
15	IB105 x R-274	0.93	1.51	1.20	1.22	28.00	23.40	25.56	25.66	30.13	36.30	33.66	33.37
16	IB105 x RHA 587	1.40	1.47	1.39	1.42	29.50	31.76	31.20	30.82	33.96	36.43	34.86	35.09
17	IB105 x 3376R	1.18	1.49	1.30	1.32	26.53	22.70	24.80	24.68	34.50	38.70	36.16	36.46
18	IB105 x RHA 586	0.95	1.28	1.10	1.11	26.10	25.83	27.00	26.31	31.00	37.16	34.23	34.13
19	IB106 x RHA 587	1.23	1.22	1.21	1.23	28.23	29.50	28.73	28.82	33.96	35.83	34.86	34.89
20	IB106 x 3376R	1.06	1.33	1.16	1.18	26.93	23.76	25.96	25.56	33.70	37.13	34.66	35.17
21	IB106 x PZ8R	1.60	1.49	1.50	1.54	23.00	21.06	22.43	22.17	35.33	39.96	36.76	37.36
22	IB106 x RHA 586	1.03	1.09	1.07	1.07	25.10	24.90	25.66	25.22	32.30	38.80	35.76	35.62
23	IB107 x PZ8R	1.39	1.36	1.36	1.37	24.26	21.76	23.23	23.09	36.16	39.83	37.66	37.89
24	IB107 x 6D-1	0.98	1.48	1.23	1.23	24.03	18.60	20.60	21.08	33.40	44.03	39.13	38.86
25	IB108 x RHA 587	1.31	1.17	1.27	1.25	31.10	31.16	30.76	31.02	33.90	35.30	35.30	34.83
26	IB108 x PZ8R	1.47	1.14	1.34	1.32	27.13	23.10	25.06	25.10	35.70	39.03	35.86	36.87
27	IB109 x R-274	1.02	1.23	1.12	1.12	26.03	26.33	26.26	26.21	32.73	36.96	34.76	34.82
28	IB109 x RHA 587	1.33	1.30	1.27	1.31	27.16	28.56	28.26	28.00	34.66	37.53	34.66	35.62
29	IB109 x PZ8R	1.44	1.67	1.50	1.54	25.20	24.83	25.93	25.32	35.03	39.90	36.90	37.28
30	IB110 x RHA 587	1.34	1.23	1.25	1.28	29.30	27.13	28.96	28.47	35.96	36.83	35.16	35.99
31	IB110 x 3376R	1.24	1.53	1.33	1.37	25.20	20.46	23.33	23.00	34.53	38.43	36.16	36.28
32	IB110 x PZ8R	1.34	1.52	1.40	1.42	26.33	22.43	24.63	24.47	33.53	38.96	38.30	36.93
33	IB111 x RHA 587	1.24	1.32	1.24	1.27	30.00	27.16	29.30	28.82	34.00	35.93	34.23	34.72
34	IB111 x 3376R	1.16	1.44	1.31	1.31	27.56	22.66	24.73	24.99	28.23	36.83	33.83	33.10
35	IB111 x PZ8R	1.23	1.42	1.29	1.32	25.33	21.03	23.56	23.31	34.23	40.53	35.63	36.79
36	IB111 x RHA 586	0.81	1.23	1.05	1.03	25.63	21.66	23.13	23.48	29.56	38.50	34.70	34.26
37	KBSH-1	1.18	1.30	1.22	1.24	29.06	25.30	27.56	27.31	34.76	39.66	36.43	36.43
38	MSFH-17	1.19	1.38	1.20	1.26	38.03	35.20	38.13	37.12	28.23	30.76	29.10	29.37
39	Morden	1.38	1.44	1.37	1.40	28.56	29.66	28.56	28.87	30.36	32.43	31.16	31.32
40	Sungene-85	1.14	1.27	1.13	1.18	28.53	30.43	30.70	29.89	32.70	35.03	33.10	33.61
	Environmental mean	1.17	1.33	1.23	1.24	27.02	24.91	26.15	26.03	33.34	37.81	35.41	35.52
	Environmental index	-0.07	0.09	-0.01		1.16	3.08	-4.24		-0.07	0.09	-0.01	
	C.D. at 5 %	0.21	0.22	0.14		3.31	4.58	3.04		2.79	2.78	2.55	
	CV (%)	11.37	10.14	7.25		7.51	11.26	7.13		5.13	4.51	4.42	

E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

(Morden) to 60 days (KBSH-1), 46 (Morden) to 57 days (KBSH-1) and 51 (Morden) to 55 (KBSH-1) respectively. From the view point of overall means, IB108 x PZ8R (52 days) and Morden (48 days) were earliest and IB103 x 83R-6 (62 days) and KBSH-1 (61 days) were late flowered among hybrids and checks respectively.

4.1.2 Days to maturity

Mean of this trait ranged from 82 (IB108 x PZ8R) to 94 days (IB105 x RHA 586), 80 (IB108 x PZ8R) to 90 days (IB107 x 6D-1) and 83 (IB108 x PZ8R, IB108 x RHA587 and IB111 x 3376R) to 92 days (IB101 x 3376R) at first, second and third environment respectively among new hybrids. While among checks, range varied from 76 (Morden) to 89 days (KBSH-1), 75 (Morden) to 85 days (KBSH-1) and 76 (Morden) to 85 days (KBSH-1) respectively. Pooled means over environments indicates that IB108 x PZ8R (81 days) and Morden (76 days) were early to mature, where as IB107 x 6D-1 (91 days) and KBSH-1 (89 days) matured late from among new hybrids and checks respectively. Environmental indices (-1.93 to 2.06) indicates that days to maturity differed significantly from one environment to other. First environment had the highest environment index and environment mean (2.06 and 88.55 days respectively) where as second environment recorded lowest values for these parameters (-1.93 and 84.57 days).

4.1.3 Number of leaves per plant

Varying environmental indices (-1.14 to 0.65) and environmental means (22.95 to 24.75) indicated significant differences for number of leaves per plant across environments. The range of variation for this character was from 21.93 (IB111 x 3376R) to 29.33 (IB105 x RHA 586), 19.66 (IB102 x 3376R) to 31.40 (IB103 x RHA 586) and 16.73 (IB105 x R-274) to 29.66 (IB109 x R-274) at first, second and third environment respectively and 15.49 (KBSH-1) to 24.20 (MSFH-17), 18.66 (Morden) to 27.53 (KBSH-1) and 18.06 (Morden) to 29.60 (MSFH-17) respectively among checks. Over all means indicated that IB102 x 3376 R (21.04) and Morden (18.73) recorded lowest mean, where as IB109 x R-274 (29.04) and MSFH-17 (26.47) showed highest mean among new hybrids and checks respectively.

4.1.4 Plant height (cm)

Differences in plant height across the environments was evident from the varying environmental indices (-20.79 to 30.45) and environmental means (123.03 to 174.27 cm). The highest environmental mean was noticed at first environment (174.27), while it was lowest at third environment (123.03). Variation for this character ranged from 142.46 (IB102 x 3376R) to 208.93 cm (IB103 x RHA-586), 98.20 (IB102 x 3376R) to 153.60 cm (IB109 x R-274) and 92.20 (IB108 x RHA587) to 163.46 cm (IB109 x R-274) at first, second and third environment respectively. Among checks KBSH-1 (177.20 cm) recorded highest plant height in first environment, while MSFH-17 at both second and third environments, where as, Morden recorded lowest plant height in all environments. Pooled means indicated that IB102 x 3376R (113.27 cm) recorded lowest mean, while highest by IB109 x R-274 (172.09 cm).

4.1.5 Head diameter (cm)

As indicated by varying environmental indices (-0.30 to 0.51) and environmental means (9.57 to 14.15 cm), head diameter also varied across environments. Variation for this character ranged from 12.43 (IB102 x RHA 586) to 16.36 cm (IB109 x R-274 and IB 103 x 83 R-6), 9.06 (IB102 x RHA 586 and IB108 x PZ8R) to 12.93 cm (IB102 x R-274) and 8.13 (IB105 x R-274) to 11.53 cm (IB101 x R-274) respectively at first, second and third environment. Among checks, Morden recorded lowest mean at second and third, while Sungene-85 (11.56 cm) at first environment. However, highest head diameter was recorded by KBSH-1 (14.40 cm) at first, while MSFH-17 at both second and third environment. Pooled means indicated that IB101 x R-274 (12.78 cm) and IB102 x

RHA 586 (10.62 cm) recorded highest and lowest mean head diameter respectively.

4.1.6 Stem diameter (cm)

The environmental indices and means ranged from –2.07 to 2.50 and 1.38 to 2.19 cm respectively. Variation for this character ranged from 1.92 (IB102 x RHA 587 and IB110 x RHA 587) to 2.66 cm (IB101 x PZ8R), 1.20 (IB108 x RHA 587) to 1.57 cm (IB102 x R-274) and 0.97 (IB105 x R-274) to 1.92 cm (IB109 x PZ8R) at first, second and third environment respectively. Pooled means across environments indicated that IB109 x PZ8R (1.98 cm) and MSFH-17 (1.86 cm) recorded highest mean and while IB102 x RHA 587 (1.42 cm) and Morden (1.41 cm) recorded lowest mean respectively among new hybrids and checks.

4.1.7 Seed yield per plant (g)

Evidence from the varying environmental indices (-4.85 to 3.22) revealed the differences between environments for this character. The highest environmental mean at first environment (27.89 g) showed that it was the most favourable environment for the expression of highest seed yield per plant, which is followed by second environment (26.31 g). The range of variation for this character was from 14.82 (IB102 x 3376R) to 44.14 g (IB109 x RHA 587), 17.48 (IB102 x RHA 586) to 44.05 g (IB103 x 6D-1) and 11.76 (IB102 x 3376R) to 26.44 g (IB102 x 6D-1) at first, second and third environment respectively and among checks, it ranged from 23.14 (Morden) to 27.47 g (MSFH-17), 12.99 (Morden) to 38.24 g (MSFH-17) and 14.32 (Morden) to 24.53 g (MSFH-17) respectively. Pooled means over environments revealed that IB109 x RHA 587 (32.29 g) and MSFH-17 (30.12 g) recorded highest yield, while lowest by IB102 x RHA 586 (16.01 g) and Morden (16.82 g) among new hybrids and checks respectively.

4.1.8 Hundred seed weight (g)

Maximum environmental index (0.25) and environmental mean (3.80) was recorded at second environment (Hiriyur), while, both were lowest at first environment (–0.22 and 3.33 g respectively). Variation for this character ranged from 2.23 (IB102 x RHA 586) to 4.21 g (IB109 x RHA 587), 2.76 (IB102 x RHA 586) to 4.55 g (IB103 x 6D-1) and 2.55 (IB102 x RHA 586) to 4.21 g (IB105 x RHA 587) at first, second and third environment respectively. Among checks, MSFH-17 recorded highest test weight in all environments, whereas, Sungene-85 recorded lowest at first and third, while KBSH-1 at second environment. Pooled means indicated that IB102 x RHA 586 (2.52) and KBSH-1 (3.61 g) recorded lowest mean test weight, while highest by IB105 x RHA 587 (4.23 g) and MSFH-17 (4.19 g) among new hybrids and checks respectively.

4.1.9 Per cent seed filling (%)

Maximum environment index (3.08) and environmental mean (90.77%) was recorded at second environment, where as both were lowest at third environment (-4.24 and 83.44% respectively). The variation for this trait ranged from 71.18 (IB107 x 6D-1) to 96.30 per cent (IB105 x RHA 587), 84.43 (IB102 x 3376R) to 94.86 per cent (IB111 x PZ8R) and 74.86 (IB110 x PZ8R) to 92.53 per cent (IB103 x 83R-6) at first, second and third environment. Pooled means indicated that KBSH-1 (89.83 %) recorded highest per cent seed filling, while, MSFH-17 (86.15 %) was lowest among checks. Where as IB105 x RHA 586 (91.58 %) and IB102 x 3376R (83.81 %) recorded highest and lowest seed filling respectively among new hybrids.

4.1.10 Kernel content (g)

The mean range of variation for this trait was from 0.75 (IB102 x R-274) to 1.60 g (IB106 x PZ8R), 0.91 (IB102 x RHA 586) to 1.67 g (IB109 x PZ8R) and 0.83 (IB102 x RHA 586) to 1.50 g (IB106 x PZ8R) at first, second and third environment respectively. Among checks, highest mean was recorded by Morden at all environment while, lowest by Sungene-85. Maximum environmental index (0.09) and environmental mean (1.33 g) was recorded at second environment, where as both were lowest at first environment (-0.07 and 1.17 g respectively). The overall mean indicated that Morden (1.40 g) and IB106 x PZ8R (1.54 g) had highest mean among checks and new hybrids respectively, while lowest by Sungene-85 (1.18 g) and IB102 x RHA 586 (0.83 g).

4.1.11 Husk content (%)

This character exhibited variation across the environment as evident from the varying environmental indices (-4.24 to 3.08). Environment mean was lowest at second environment (24.91 %) followed by third environment (26.15 %). The range of variation for this trait was from 22.33 (IB101 x R-274) to 32.96 per cent (IB101 x 3376R), 18.60 (IB107 x 6D-1) to 31.76 per cent (IB105 x RHA-587) and 20.60 (IB107 x 6D-1) to 31.20 per cent (IB105 x RHA 587) at first, second and third environment respectively from among new hybrids. The overall mean revealed that MSFH-17 (37.12%) and IB105 x RHA 587 (30.82%) recorded highest husk content, where as, lowest by KBSH-1 (27.31%) and IB107 x 6D-1 (21.08%) among checks and new hybrids respectively.

4.1.12 Oil content (%)

Varying environmental indices (-0.07 to 0.09) and environmental means (33.34 to 37.81 %) indicated that oil content differed significantly from one environment to other. The highest environmental index and mean (0.09 and 37.81 %) was recorded at second environment, while it was lowest at first environment (-0.07 and 33.34 % respectively). The range of variation for this trait was from 28.33 (IB111 x 3376R) to 36.16 per cent (IB107 x PZ8R), 34.66 (IB103 x RHA 587) to 44.03 per cent (IB107 x 6D-1) and 33.43 (IB102 x RHA 586) to 39.56 per cent (IB101 x PZ8R) at first, second and third environment respectively. Among checks, KBSH-1 recorded highest oil content, while lowest by MSFH-17 in all the environments. The overall means revealed that KBSH-1 (36.43 %) and IB107 x

6D-1 (38.86%) recorded highest oil content, where as it was lowest by MSFH-17 (29.37%) and IB111 x 3376R (33.10%) among checks and new hybrids respectively.

4.2 Heterosis

The extent of heterosis manifested in new hybrids over standard checks (standard heterosis) viz., KBSH-1, MSFH-17, Morden and Sungene-85 was estimated for data pertaining to individual environments as well as pooled over environments for 11 characters. The results are summarized in Table 8 and presented character wise for pooled over environments in the following paragraphs.

4.2.1 Days to 50 per cent flowering

None of the hybrids included under studies showed significant negative heterosis over Morden and Sungene-85, while, fourteen and six hybrids exhibited significant heterosis over KBSH-1 and MSFH-17 respectively. The magnitude of significant negative heterosis over KBSH-1 and MSFH-17 ranged from –9.86 (IB108 x PZ8R) to –2.90 per cent (IB103 x RHA 587) and –7.17 (IB108 x PZ8R) to –2.39 per cent (IB110 x 3376R) respectively. In contrast, fourteen and nineteen hybrids exhibited significant positive heterosis for this trait over them respectively.

4.2.2 Days to maturity

Similar to days to 50 per cent flowering, for this character, none of the hybrids expressed significant negative heterosis over Morden and Sungene-85. However, as many as fourteen and eight hybrids showed significant negative heterosis over KBSH-1 and MSFH-17 respectively. The magnitude of negative heterosis ranged from –5.66 (IB108 x PZ8R) to –1.59 per cent (IB102 x RHA 587), -4.43 (IB108 x PZ8R) to –1.30 per cent (IB106 x PZ8R) over KBSH-1 and MSFH-17 respectively. As regards to positive heterosis, seventeen and eighteen

Table 8 : Per cent heterosis over standard checks for days to 50 per cent flowering in sunflower over three environments

Sl. No.	Hybrids	KBSH-1				MSFH-17				MORDEN				SUNGENE-85			
		E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled
1	IB101 x R-274	5.00**	5.23**	12.12**	7.35**	8.62**	7.74**	15.63**	10.56**	36.92**	29.29**	20.13**	28.47**	19.62**	16.03**	18.59**	18.09**
2	IB101 x 3376R	2.22	5.81**	13.33**	6.96**	5.75**	8.33**	16.88**	10.16**	33.33**	30.00**	21.43**	28.01**	16.46**	16.67**	19.87**	17.66**
3	IB101 x PZ8R	3.89*	4.07**	9.09**	5.61**	7.47**	6.55**	12.50**	8.76**	35.51**	27.86**	16.88**	26.39**	18.35**	14.74**	15.38**	16.17**
4	IB102 x R-274	6.67**	3.49**	12.12**	7.53**	10.34**	5.95**	15.63**	10.56**	39.13**	27.14**	20.13**	28.47**	21.52**	14.10**	18.59**	18.09**
5	IB102 x RHA 587	-7.78**	-7.56**	-1.82	-5.80**	-4.60*	-5.36**	1.25	2.99**	20.29**	13.57**	5.19	12.73**	5.06*	1.92	3.85	3.62**
6	IB102 x 3376R	-7.78**	2.33	1.21	-1.55	-4.60*	4.76**	4.38	1.39	20.29**	25.71**	8.44**	17.82**	5.06*	12.82**	7.05**	8.30**
7	IB102 x PZ8R	-0.56	2.33	5.45*	2.32*	2.87	4.76**	8.75**	5.38**	29.71**	25.71**	12.99**	22.45**	13.29**	12.82**	11.54**	12.55**
8	IB102 x 6D-1	-7.78**	2.33	11.52**	7.16**	11.49**	4.76**	15.00**	10.36**	40.58**	25.71**	19.48**	28.24**	22.78**	12.82**	17.95**	17.87**
9	IB102 x RHA 586	1.11	-3.49**	4.85	0.77	4.60*	-1.19	8.13**	3.78**	31.88**	18.57**	12.34**	20.60**	15.19**	6.41**	10.90**	10.85**
10	IB103 x RHA 587	-5.00**	-2.91*	-0.61	-2.90**	-1.72	-0.60	2.50	0.00	23.91**	19.29**	6.49*	16.20**	8.23**	7.05**	5.13	6.81**
11	IB103 x PZ8R	2.22	0.58	15.15**	5.80**	5.75**	2.98*	18.75**	8.96**	33.33**	23.57**	23.38**	26.62**	16.46**	10.90**	21.79**	16.38**
12	IB103 x 83R-6	8.89**	4.07*	12.73**	8.51**	12.64**	6.55**	16.25**	11.75**	42.03**	27.86**	20.78**	29.86**	24.05**	14.74**	19.23**	19.36**
13	IB103 x 6D-1	6.67**	4.65**	7.27**	6.19**	10.34**	7.14**	10.63**	9.36**	39.13**	28.57**	14.94**	27.08**	21.52**	15.38**	13.46**	16.81**
14	IB103 x RHA 586	2.78	-0.58	4.24	2.13	6.32**	1.79	7.50**	5.18**	34.06**	22.14**	11.69**	22.22**	17.09**	9.62**	10.26**	12.34**
15	IB105 x R-274	6.11**	3.49**	9.09**	6.19**	9.77**	5.95**	12.50**	9.36**	38.41**	27.14**	16.88**	27.08**	20.89**	14.10**	15.38**	16.81**
16	IB105 x RHA 587	-6.67**	-6.48**	-1.21	-4.84**	-3.45	-4.17**	1.88	-1.99	21.74**	15.00**	5.84*	13.89**	6.33**	3.21*	4.49	4.68**
17	IB105 x 3376R	-2.78	-7.56**	6.06*	-0.39	0.57	-5.36**	9.38**	2.59*	26.81**	13.57**	13.64**	19.21**	10.76**	1.92	12.18**	9.57**
18	IB105 x RHA 586	7.22**	4.07**	6.67*	6.00**	10.92**	6.55**	10.00**	9.16**	39.86**	27.86**	14.29**	26.85**	22.15**	14.74**	12.82**	16.80**
19	IB106 x RHA 587	-5.00**	-6.40**	-1.82	-4.45**	-1.72	-4.17**	1.25	-1.59	23.91**	15.00**	5.19	14.35**	8.23**	3.21*	3.85	5.11**
20	IB106 x 3376R	-4.44*	-8.72**	-1.21	-4.84**	-1.15	-6.55**	1.88	-1.99	24.64**	12.44**	5.84*	13.89**	8.86**	0.69	4.49	4.68**
21	IB106 x PZ8R	-4.44*	-11.63**	-1.82	-6.00**	-1.15	-9.52**	1.25	-3.19**	24.64**	8.57**	5.19	12.50**	8.86**	-2.56	3.85	3.40**
22	IB106 x RHA 586	1.67	-0.58	4.24	1.74	5.17**	1.79	7.50**	4.78**	32.61**	22.14**	11.69**	21.76**	15.82**	9.62**	10.26**	11.91**
23	IB107 x PZ8R	-1.67	1.74	2.42	0.77	1.72	4.17**	5.63*	3.78**	28.26**	25.00**	9.74**	20.60**	12.03**	12.18**	8.33**	10.85**
24	IB107 x 6D-1	5.00**	7.56**	13.33**	8.51**	8.62**	10.12**	16.88**	11.75**	36.96**	32.14**	21.43**	29.86**	19.62**	18.59**	19.87**	19.36**
25	IB108 x RHA 587	-7.78**	-7.56**	-4.24	-6.58**	-4.60*	-5.36**	-1.25	-3.78**	20.29**	13.57**	2.60	11.81**	5.06*	1.92	1.28	2.77*
26	IB108 x PZ8R	-12.32**	-12.79**	-4.24	-9.86**	-9.20**	-10.71**	-1.25	-7.17**	14.49**	7.14**	2.60	7.87**	0.00	-3.85**	1.28	-0.85
27	IB109 x R-274	7.22**	3.49**	8.48**	6.38**	10.92**	5.95**	11.88**	9.56**	39.86**	27.14**	16.23**	27.13**	22.15**	14.10**	14.74**	17.02**
28	IB109 x RHA 587	-3.33	1.74	-3.03	-1.55	0.00	4.17**	0.00	1.39	26.09**	25.00**	3.90	17.82**	10.13**	12.18**	2.56	8.30**
29	IB109 x PZ8R	-5.00**	2.91*	-1.21	-1.16	-1.72	5.36**	1.88	1.79	23.91**	26.43**	5.84*	18.29**	8.23**	13.46**	4.45	8.72**
30	IB110 x RHA 587	-5.00**	-8.14	4.24	-3.09**	-1.72	-5.95**	7.50**	-0.20	23.91**	12.86**	11.69**	15.97**	8.23**	1.28	10.26**	6.60**
31	IB110 x 3376R	-6.67**	-11.05**	2.42	-5.22**	-3.45	-8.93**	5.63*	-2.39*	21.74**	9.29**	9.74**	13.43**	6.33**	-1.92	8.33**	4.26**
32	IB110 x PZ8R	-7.22**	-4.07**	-1.82	-4.45**	-4.02*	-1.79	1.25	-1.59	21.01**	17.86**	5.19	14.35**	5.20**	5.77**	3.85	5.11**
33	IB111 x RHA 587	-7.78**	-5.81**	3.03	-3.68**	-4.60*	-3.57	6.25*	-0.80	20.29**	15.71**	10.19**	15.28**	5.06*	3.85**	8.97**	5.96**
34	IB111 x 3376R	-5.66**	-7.58**	-4.24	-5.80**	-2.30	-5.36**	-1.25	-2.99**	23.19**	13.57**	2.60	12.73**	7.59**	1.92	1.28	3.62**
35	IB111 x PZ8R	-6.11**	-9.30**	4.24	-3.87**	-2.87	-7.14**	7.50**	-1.00	22.46**	11.43**	11.69**	15.05**	6.96**	0.00	10.26**	5.74**
36	IB111 x RHA 586	1.67	2.33	10.91**	4.84**	5.17**	4.76**	14.38**	7.97**	32.61**	25.71**	18.83**	25.46**	15.82**	12.82**	17.71**	15.32**

* Significance at 5 % E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

** Significance at 1 %

Table 8 (Contd....) : Per cent heterosis over standard checks for days to maturity in sunflower over three environments

Sl. No.	Hybrids	KBSH-1				MSFH-17				Morden				SUNGENE-85			
		E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled
1	IB101 x R-274	4.87**	2.34**	7.45**	4.88**	5.66**	3.56**	9.60**	6.25**	23.35**	16.44**	20.18**	20.00**	12.00**	9.17**	12.30**	11.17**
2	IB101 x 3376R	0.75	2.34**	7.84**	3.60**	1.51	3.56**	10.00**	4.95**	18.50**	16.44**	20.61**	18.53**	7.60**	9.17**	12.70**	9.81**
3	IB101 x PZ8R	2.62	3.52**	7.06**	4.37**	3.40*	4.79**	9.20**	5.73**	20.70**	17.78**	19.74**	19.41**	9.60**	10.42**	11.89**	10.63**
4	IB102 x R-274	3.37*	4.69**	5.49**	4.50**	4.15**	5.93**	7.60**	5.86**	21.59**	19.11**	17.98**	19.56**	10.40**	11.67**	10.25**	10.76**
5	IB102 x RHA 587	0.75	-3.91**	-1.57	-1.54*	1.51	-2.77**	0.40	-0.26	18.50**	9.23**	10.09**	12.65**	7.60**	2.50**	2.87*	4.36**
6	IB102 x 3376R	-3.75*	0.78	-0.39	-1.16	-3.02*	1.98**	1.60	0.13	13.22**	14.67**	11.40**	13.09**	2.80	7.50**	4.10**	4.77**
7	IB102 x PZ8R	-1.12	1.95**	2.75*	1.16	-0.38	3.16**	4.80**	2.47**	16.30**	16.00**	14.91**	15.74**	5.60**	8.75**	7.38**	7.22**
8	IB102 x 6D-1	-5.24**	3.91**	5.10**	4.76**	6.04**	5.14**	7.20**	6.12**	23.79**	18.22**	17.54**	19.85**	12.40**	10.83**	9.84**	11.04**
9	IB102 x RHA 586	1.87	0.00	2.35	1.41*	2.64	1.19	4.40**	2.73**	19.82**	13.78**	14.47**	16.03**	8.80**	6.67**	6.97**	7.49**
10	IB103 x RHA 587	-2.62	-1.56*	-0.78	-1.67*	-1.89	-0.40	1.20	-0.39	14.54**	12.00**	10.96**	12.50**	4.00**	5.00**	3.69**	4.22**
11	IB103 x PZ8R	1.12	0.78	3.92**	1.93**	1.89	1.98**	6.00**	3.26**	18.94**	14.67**	16.23**	16.62**	8.00**	7.50**	8.67**	8.04**
12	IB103 x 83R-6	4.87**	4.30**	5.88**	5.01**	5.66**	5.53**	8.00**	6.38**	23.35**	18.67**	18.42**	20.15**	12.00**	11.25**	10.66**	11.31**
13	IB103 x 6D-1	4.12**	3.52**	4.71*	4.11**	4.91**	4.74**	6.80**	5.47**	22.47**	17.78**	17.11**	19.12**	11.20**	10.42**	9.43**	10.35**
14	IB103 x RHA 586	2.25	0.00	1.96	1.41*	3.02*	1.19	4.00**	2.73**	20.26**	13.78**	14.04**	16.03**	9.20**	6.67**	6.56**	7.49**
15	IB105 x R-274	4.87**	3.52**	4.71**	4.37**	5.66**	4.74**	6.80**	5.73**	23.35**	17.78**	17.11**	19.41**	12.00**	10.42**	9.43**	10.63**
16	IB105 x RHA 587	-3.37	-4.30**	-1.57	-3.08**	-2.64	-3.16**	0.40	-1.82**	13.66**	8.89**	10.09**	10.88**	3.20*	2.08**	2.87*	2.72**
17	IB105 x 3376R	-1.12	-3.13**	2.75*	-0.51	-0.38	-1.98**	4.80**	0.78	16.30**	10.22**	14.91**	13.82**	5.60**	3.33**	7.38**	5.45**
18	IB105 x RHA 586	5.24**	4.30**	5.49**	5.01**	6.04**	5.53**	7.60**	6.38**	23.79**	18.67**	17.98**	20.15**	12.40**	11.25**	10.25**	11.31**
19	IB106 x RHA 587	-1.87	-3.91**	-1.18	-2.31**	-1.13	-2.77**	0.80	-1.04	15.42**	9.33**	10.53**	11.76**	4.80**	2.50**	3.28*	3.57**
20	IB106 x 3376R	-1.50	-5.86**	-1.96	-3.08**	-0.75	-4.74**	0.00	-1.82**	15.86**	7.11**	9.65**	10.88**	5.20**	0.42	2.46	2.72**
21	IB106 x PZ8R	-1.87	-5.47**	-0.39	-2.57**	-1.13	-4.35**	1.60	-1.30*	15.42**	7.56**	11.40**	11.47**	4.80**	0.83	4.10**	3.27**
22	IB106 x RHA 586	3.75**	-1.17	2.75*	1.80**	4.53**	0.00	4.80**	3.12**	22.08**	12.44**	14.91**	16.47**	10.80**	5.42**	7.38**	7.90**
23	IB107 x PZ8R	0.37	1.17	2.75*	1.41*	1.13	2.37**	4.80**	2.73**	18.06**	15.11**	14.91**	16.03**	7.20**	7.92**	7.38**	7.49**
24	IB107 x 6D-1	4.12**	5.08**	7.06**	5.40**	4.91**	6.32**	9.20**	6.77**	22.47**	19.56**	19.74**	20.59**	11.20**	12.08**	11.89**	11.72**
25	IB108 x RHA 587	-4.12**	-4.30**	-2.75*	-3.73**	-3.40**	-3.16**	-0.80	-2.47**	12.78**	8.89**	8.77**	10.15**	2.40	2.08**	1.64	2.04**
26	IB108 x PZ8R	-7.87**	-6.64**	-2.35	-5.66**	-7.17**	-5.53**	-0.40	-4.43**	8.37**	6.22**	9.21**	7.94**	-1.60	-0.42	2.05	0.00
27	IB109 x R-274	4.12**	3.52**	6.27**	4.63**	4.91**	4.74**	8.40**	5.99**	22.47**	17.78**	18.86**	19.71**	11.20**	10.42**	11.07**	10.90**
28	IB109 x RHA 587	-1.50	1.17	-2.35	-0.90	-0.75	2.37**	-0.40	0.39	15.86**	15.11**	9.21**	13.38**	5.20**	7.92**	2.05	5.04**
29	IB109 x PZ8R	-2.25	1.95**	-0.78	-0.39	-1.51	3.16**	1.20	0.91	14.98**	16.00**	10.96**	13.97**	4.40**	8.75**	3.69**	5.59**
30	IB110 x RHA 587	-2.25	-4.69**	3.14*	-1.29*	-1.51	-3.56**	5.20**	0.00	14.98**	8.44**	15.35**	12.94**	4.40**	1.67*	7.79**	4.63**
31	IB110 x 3376R	-3.75**	-5.86**	1.18	-2.83**	-3.02	-4.74**	3.20*	-1.56*	13.22**	7.11**	13.16**	11.18**	2.80	0.42	5.74**	3.00**
32	IB110 x PZ8R	-4.12**	-1.56*	-1.18	-2.31**	-3.40*	-0.40	0.80	-1.04	12.78**	12.00**	10.53**	11.76**	2.40	5.00**	3.28*	3.54**
33	IB111 x RHA 587	-4.49**	-3.52**	1.57	-2.19**	-3.77**	-2.37**	3.60**	-0.91	12.33**	9.78**	13.60**	11.91**	2.00	2.92**	6.15**	3.68**
34	IB111 x 3376R	-2.62	-4.30**	-2.35	-3.08**	-1.89	-3.16**	-0.40	-1.82**	14.54**	8.89**	9.21**	10.88**	4.00**	2.08**	2.05	2.72**
35	IB111 x PZ8R	-4.12**	-6.25**	1.96	-2.83**	-3.40*	-5.14**	4.00**	-1.56**	12.78**	6.67**	14.04**	11.18**	2.40	0.00	6.56**	3.00**
36	IB111 x RHA 586	2.25	1.17	6.67**	3.34**	3.02*	2.37**	8.80**	4.69**	20.26**	15.11**	19.30**	18.24**	9.20**	7.92	11.48**	9.54**

* Significance at 5 %　　E_1 = Bangalore　　E_2 = Hiriyur　　E_3 = Katthalgere

** Significance at 1 %

Table 8 (Contd....) : Per cent heterosis over standard checks for number of leaves per plant in sunflower over three environments

Sl. No.	Hybrids	KBSH-1				MSFH-17				MORDEN				SUNGENE-85			
		E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled
1	IB101 x R-274	13.11	5.33	5.96	22.35**	14.05*	13.28	-11.94**	4.11	41.78**	55.36**	44.28**	47.09**	17.95*	23.23*	12.36*	17.87**
2	IB101 x 3376R	-0.27	-11.92*	-16.53**	-0.23	0.55	-11.72	-30.63**	-15.03**	25.00**	21.07	13.65*	20.05**	3.99	-3.97	-11.49*	-3.80
3	IB101 x PZ8R	4.92	-5.57	-7.05	10.12*	5.79	1.56	-22.75**	-6.21	31.51**	39.29**	26.57**	32.50**	9.40	10.48	-1.44	6.18
4	IB102 x R-274	8.20	9.69	-10.57*	16.23**	9.09	17.97	-25.68**	-1.01	35.62**	61.79**	21.77**	39.86**	12.82	28.33**	-5.17	12.07*
5	IB102 x RHA 587	-4.37	-22.76**	-13.82**	-2.70	-3.58	-16.93	-28.38**	-17.13**	19.86*	13.93	17.34**	17.08**	-0.28	-9.63	-8.62	-6.18
6	IB102 x 3376R	-5.74	-28.57**	-16.80**	-6.64	-4.96	-23.18*	-30.86**	-20.49**	18.15*	5.36	13.28*	12.34*	-1.71	-16.43	-11.78*	-9.98*
7	IB102 x PZ8R	2.19	-21.79*	-16.53**	-0.92	3.03	-15.89	-30.63**	-15.62**	28.08**	15.36	13.65*	19.22**	6.55	-8.50	-11.49*	-4.47
8	IB102 x 6D-1	-8.47	-20.10*	-16.53**	-4.08	-7.71	-14.06	-30.63**	-18.30**	14.73	17.86	13.65*	15.42**	-4.56	-6.52	-11.49*	-7.51
9	IB102 x RHA 586	-4.10	3.87	1.08	13.67**	-3.31	11.72	-15.99**	-3.19	20.21*	53.21**	37.64**	36.77**	0.00	21.53*	7.18	9.60*
10	IB103 x RHA 587	0.00	1.94	10.57*	17.81**	0.83	9.64	-8.11	0.34	25.34**	50.36**	50.55**	41.76**	4.27	19.26	17.24**	13.59**
11	IB103 x PZ8R	2.46	-0.24	-13.55**	9.04	3.31	7.29	-28.15**	-7.14	28.42**	47.14**	17.71**	31.20**	6.84	16.71	-8.33	5.13
12	IB103 x 83R-6	6.56	-5.81	-4.07	11.70*	7.44	1.30	-20.89**	-4.87	33.56**	39.93**	30.63**	34.40**	11.11	10.21	1.72	7.70
13	IB103 x 6D-1	7.79	-13.08	-1.09	9.97*	8.68	-6.51	-18.47**	-6.34	35.10**	28.21**	33.58**	32.33**	12.39	1.70	4.02	6.04
14	IB103 x RHA 586	16.12*	14.04	-3.79	23.33**	17.08*	22.66	-20.05**	5.04	45.55**	68.21**	31.00**	48.40**	21.18**	33.43**	2.01	18.92**
15	IB105 x R-274	9.02	2.66	-31.98**	5.88	9.92	10.42	-43.47**	-9.82*	36.64**	51.43**	-7.38	27.40**	13.68	20.11*	-27.87**	2.09
16	IB105 x RHA 587	7.92	-17.68*	-8.13	5.88	8.82	-11.46	-23.65**	-9.82*	35.27**	21.43	25.09**	27.40**	12.54	-3.68	-2.59	2.09
17	IB105 x 3376R	6.56	-17.68*	-4.88	6.57	7.44	-11.46	-20.95**	-9.24*	33.56**	21.43	29.52**	28.23**	11.11	-3.68	0.86	2.76
18	IB105 x RHA 586	20.22**	-9.93	-15.45**	10.81*	21.21**	-3.13	-29.73**	-5.63	50.68**	32.86*	15.13*	33.33**	25.36**	5.38	-10.34*	6.84
19	IB106 x RHA 587	1.09	-7.51	-0.54	10.32*	1.93	-0.52	-17.34**	-6.03	26.71**	36.43**	35.42**	32.74**	5.41	8.22	5.46	6.37
20	IB106 x 3376R	-7.65	-19.37*	-10.57*	-1.32	-6.89	-13.28	-25.68**	-15.95**	15.75	18.93	21.77**	18.74**	-3.70	-5.67	-5.17	-4.85
21	IB106 x PZ8R	3.01	-13.08	-5.15	7.06	3.86	-6.51	-27.17**	-8.82*	29.11**	28.21*	29.15**	28.83**	7.41	1.70	0.57	3.23
22	IB106 x RHA 586	11.48	-5.08	8.94	18.50**	12.40	2.08	-9.46*	0.92	39.73**	40.00**	48.34**	42.39**	16.24*	11.05	15.52**	14.20**
23	IB107 x PZ8R	-7.10	-25.67**	-4.61	-1.51	-6.34	-20.05*	-20.72**	-16.12**	16.44	9.64	29.89**	18.51**	-3.13	-13.03	1.15	-5.04
24	IB107 x 6D-1	0.82	-17.68**	-6.21	2.92	1.65	-11.46	-24.55**	-12.34**	26.37**	21.43	23.62**	23.84**	5.13	-3.68	-3.74	-0.76
25	IB108 x RHA 587	-5.74	-9.93	-25.20**	-2.10	-4.96	-3.13	-37.84**	-16.62**	18.15*	32.86*	1.85	17.79**	-1.17	5.38	-20.69**	-5.61
26	IB108 x PZ8R	-2.73	-18.64*	-19.78**	-2.60	-1.93	-12.50	-33.33**	-17.04**	21.92*	20.00	9.23	17.20**	1.42	-4.42	-14.94**	-6.08
27	IB109 x R-274	11.20	10.17	20.60**	28.85**	12.12	18.49*	0.23	9.74**	39.38**	62.50**	64.21**	55.04**	15.95*	28.90**	27.87**	24.24**
28	IB109 x RHA 587	4.64	-8.72	6.78	13.77**	5.51	-1.82	-11.23**	-3.11	31.16**	34.64**	45.39**	36.89**	9.12	6.80	13.22**	9.70*
29	IB109 x PZ8R	7.92	-9.69	6.50	14.46**	8.82	-2.36	-11.49**	-2.52	35.27**	33.21**	45.02**	37.72**	12.54	5.67	12.93*	10.36*
30	IB110 x RHA 587	-4.37	-15.64	-1.08	4.80	-3.58	-9.38	-17.79**	-10.75*	19.86*	24.29	34.69**	26.10**	-0.28	-1.42	4.89	1.05
31	IB110 x 3376R	0.27	-11.86	-13.55**	3.51	1.10	-5.21	-28.15**	-11.84**	25.68**	30.00**	17.71**	24.56**	4.56	3.12	-8.33	-0.19
32	IB110 x PZ8R	2.19	-11.86	-17.62**	2.73	3.03	-5.21	-31.53**	-12.51**	28.08**	30.00**	12.18	23.61**	6.55	3.12	-12.64*	-0.95
33	IB111 x RHA 587	2.73	-6.05	-7.05	9.13	3.58	1.04	-22.75**	-7.05	28.97**	38.57**	26.97**	31.32**	7.12	9.92	-1.44	5.23
34	IB111 x 3376R	-10.11	-18.16*	-0.81	1.84	-9.37	-11.98	-17.57**	-13.27**	12.67	20.71	35.06**	22.54**	-6.27	-4.25	5.77	-1.81
35	IB111 x PZ8R	0.82	-27.12**	-15.99**	-3.39	1.65	-21.61*	-30.63**	-17.72**	26.37**	7.50	14.39*	16.25**	5.13	-14.73	-10.92*	-6.84
36	IB111 x RHA 586	1.37	8.72	-3.79	15.84**	2.20	16.93	-20.05**	-1.34	27.03**	60.36**	31.00**	39.38**	5.70	27.20**	2.01	11.69**

* Significance at 5 % E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

** Significance at 1 %

Table 8 (Contd….) : Per cent heterosis over standard checks for plant height in sunflower over three environments

Sl. No.	Hybrids	KBSH-1				MSFH-17				MORDEN				SUNGENE-85			
		E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled
1	IB101 x R-274	10.95**	2.39	1.50	5.51	15.78**	0.29	-7.51	3.55	137.25**	99.34**	98.53**	113.28**	25.86**	8.07	13.59*	16.55**
2	IB101 x 3376R	-4.85	-7.94	-14.89**	-8.79**	-0.71	-9.82	-22.45**	-10.48**	103.46**	79.24**	66.47**	84.37**	7.94	-2.83	-4.75	0.76
3	IB101 x PZ8R	7.60	1.66	-8.25	1.06	12.29**	-0.43	-16.39**	0.82	130.09**	97.91**	79.47**	104.28**	22.07**	7.30	2.68	11.63*
4	IB102 x R-274	-3.46	9.59	-18.19**	3.86	0.75	7.34	-25.46**	-5.64*	106.44**	113.36**	60.02**	94.34**	9.52*	15.67**	-8.45	6.20*
5	IB102 x RHA 587	-11.78**	-4.82	-17.94**	-11.49**	-7.93	-6.77	-25.33**	-13.13**	88.66**	85.31**	60.51**	78.92**	0.09	0.46	-8.17	-2.22
6	IB102 x 3376R	-19.60**	-28.29**	-25.69**	-24.07**	-16.10**	-29.76**	-32.29**	-25.48**	71.92**	39.62**	45.36**	53.48**	-8.79	-24.31**	-16.83**	-16.33**
7	IB102 x PZ8R	-3.80	-1.56	-17.59**	-7.22*	0.39	-3.58	-24.91**	-8.95**	105.71**	91.66**	61.16**	87.53**	9.13*	3.91	-7.77	2.48
8	IB102 x 6D-1	-3.61	-0.78	-3.85	-2.82	0.59	-2.81	-12.39**	-4.62	106.11**	93.18**	88.07**	96.45**	9.35*	4.73	7.61	7.36*
9	IB102 x RHA 586	-4.78	-5.26	-2.90	-4.36	-0.63	-7.20	-11.52*	-6.14*	103.62	84.45**	89.93**	93.32**	8.02	0.00	8.67	5.64
10	IB103 x RHA 587	-3.05	8.18	10.44*	4.41	1.18	5.96	0.64	2.47	107.32**	110.62**	116.03**	111.05**	9.99*	14.18*	23.60**	15.34**
11	IB103 x PZ8R	-0.38	-0.24	-17.89**	-5.56	3.97	-2.29	-25.18**	-7.31**	113.03**	94.22**	60.61**	90.91**	13.02**	5.29	-8.11	4.33
12	IB103 x 83R-6	4.36	-4.24	-8.10	-1.98	8.91*	-6.20	-16.26**	-3.80	123.17**	86.45**	79.77**	98.13**	18.40**	1.08	2.85	8.28**
13	IB103 x 6D-1	5.38	5.70	-6.05	2.07	9.97*	3.53	-14.39**	0.18	125.34**	105.78**	83.77**	106.32**	19.55**	11.56	5.15	12.75**
14	IB103 x RHA 586	17.91**	10.03	-2.75	9.34**	23.05**	-7.77	-11.38*	7.31**	152.13**	114.22**	90.22**	121.02**	33.76**	16.14**	8.84	20.78**
15	IB105 x R-274	7.41	4.82	-29.84**	-4.48	12.09**	2.67	-36.07**	-6.26*	129.69**	104.08**	37.24**	93.07**	21.85**	10.64	-21.48**	5.51
16	IB105 x RHA 587	3.99	0.10	1.55	2.07	8.52*	-1.96	-7.47	0.18	122.37**	94.88**	98.63**	106.32**	17.97**	5.65	13.65*	12.75**
17	IB105 x 3376R	-5.61	-5.94	-8.70	-6.63*	-1.49	-7.87	-16.80**	-8.36**	101.85**	83.13**	78.59**	88.74**	7.08	-0.72	2.18	3.14
18	IB105 x RHA 586	8.31*	9.93	-18.09**	0.94	13.03**	7.68	-25.36**	-0.94	131.62**	114.03**	60.22**	104.03**	22.38**	16.03**	-8.13	11.50**
19	IB106 x RHA 587	2.11	9.69	-3.30	2.82	6.56	7.44	-11.89**	0.91	118.34**	113.55**	89.15**	107.83**	15.83**	15.78**	8.22	13.58**
20	IB106 x 3376R	-3.31	-14.17	-8.30	-8.12**	0.90	-15.93**	-16.44	-9.82**	106.76**	67.11**	79.37**	85.73**	9.69*	-9.40	2.63	1.50
21	IB106 x PZ8R	-1.43	-4.82	-0.40	-2.16	2.87	-6.77	-9.24*	-3.98	110.78**	85.31**	94.82**	97.77**	11.82*	0.46	11.47*	8.08*
22	IB106 x RHA 586	10.53*	7.35	4.35	7.72**	15.35**	5.15	-4.92	5.72*	136.36**	109.00**	104.11**	117.74**	25.39*	13.31*	16.78**	18.99**
23	IB107 x PZ8R	3.76	0.05	-3.00	0.61	8.28	-2.00	-11.61*	-1.26	121.88**	94.79**	89.74**	103.37**	17.71**	5.60	8.56	11.14**
24	IB107 x 6D-1	11.47**	8.33	-2.05	6.48*	16.33**	6.10	-10.75*	4.50	138.37**	110.90**	91.59**	115.24**	26.46**	14.34*	9.62	17.62**
25	IB108 x RHA 587	-13.47**	-12.22*	-30.88**	-18.28**	-9.70*	-14.02*	-37.02**	-19.80**	85.04**	70.90**	35.19**	65.19**	-1.84	-7.35	-22.65**	-9.73**
26	IB108 x PZ8R	-17.16**	-9.88	-22.69**	-16.58**	-13.55**	-11.73*	-29.55**	-18.13**	77.15**	75.45**	51.22**	68.62**	-6.02	-4.88	-13.48*	-7.85*
27	IB109 x R-274	12.42**	12.17	22.54**	15.36**	17.31**	9.87	11.66**	13.22**	140.39**	118.39**	139.69**	133.18**	27.53**	18.40**	37.14**	27.43**
28	IB109 x RHA 587	6.09	6.28	17.39**	9.52**	10.72*	4.10	6.97	7.49**	126.87**	106.92**	129.62**	121.38**	20.36**	12.18*	31.38**	20.98**
29	IB109 x PZ8R	3.99	3.70	16.04**	7.49**	8.52*	1.57	5.74	5.50	122.37**	101.90**	126.98**	117.28**	17.97**	9.46	29.87**	18.74**
30	IB110 x RHA 587	-2.41	1.56	9.90*	2.47	1.85	-0.52	0.14	0.57	108.69**	97.73**	114.96**	107.14**	10.71*	7.19	22.99**	13.20**
31	IB110 x 3376R	-5.46	-9.15	-24.14**	-12.16**	-1.33	-11.02	-30.87**	-13.79**	102.17**	76.87**	48.39**	77.57**	7.26	-4.11	-15.10**	-2.96
32	IB110 x PZ8R	-5.27	-5.84	-9.05	-6.57*	-1.14	-7.77	-17.12**	-8.30**	102.57**	83.32**	77.91**	88.86**	7.47	-0.62	1.79	3.21
33	IB111 x RHA 587	-3.76	-0.39	-0.60	-1.79	0.43	-2.43	-9.43*	-3.61	105.79**	93.43**	94.43**	98.52**	9.18*	5.14	11.24*	8.49**
34	IB111 x 3376R	-9.29*	-16.31**	-8.45	-11.19**	-5.34	-18.03**	-16.58**	-12.84**	93.97**	62.94**	79.08**	79.52**	2.90	-11.66	2.46	-1.89
35	IB111 x PZ8R	2.52	-1.61	-14.94**	-3.95	6.99	-3.62	-22.50**	-5.73*	119.23**	91.56**	66.37**	94.16**	16.30**	3.85	-4.81	6.10
36	IB111 x RHA 586	6.88	2.78	-16.19**	-1.25	11.54**	0.67	-23.63**	-3.08	128.56**	110.09**	63.93**	99.61**	21.55**	8.48	-6.21	9.08**

* Significance at 5 % E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

** Significance at 1 %

Table 8 (Contd....) : Per cent heterosis over standard checks for head diameter in sunflower over three environments

Sl. No.	Hybrids	KBSH-1				MSFH-17				MORDEN				SUNGENE-85			
		E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled
1	IB101 x R-274	8.56	5.57	20.14**	10.79*	15.52*	3.96	0.00	7.08	17.54*	16.78	39.34**	22.99**	35.16**	12.91	32.30**	26.93**
2	IB101 x 3376R	-8.10	8.98	14.31*	3.28	-2.22	7.32	-5.00	-0.19	-0.50	20.55*	32.38**	14.65**	14.41	16.56	25.68**	18.32**
3	IB101 x PZ8R	5.32	2.17	-13.07*	-0.67	12.07	0.61	-27.65**	-4.00	14.04	13.01	0.82	10.27*	31.12**	9.27	-4.28	13.80**
4	IB102 x R-274	-1.16	20.12*	7.07	7.71	5.17	18.29*	-10.88*	4.10	7.02	32.88**	24.18**	19.57**	23.05*	28.48**	17.90**	23.40**
5	IB102 x RHA 587	-4.63	3.41	-10.25	-3.66	1.48	1.83	-25.29**	-6.89	3.26	14.38	4.10	6.95	18.73*	10.60	-1.17	10.37**
6	IB102 x 3376R	-1.62	4.02	7.77	2.70	4.68	2.44	-10.29*	-0.74	6.52	15.07	25.00**	14.01**	22.48*	11.26	18.68**	17.66**
7	IB102 x PZ8R	0.93	9.29	-2.83	2.51	7.39	7.62	-19.12**	-0.93	9.27	20.89*	12.70	13.80**	25.65**	16.89*	7.00	17.44**
8	IB102 x 6D-1	4.86	9.60	11.31	8.09	11.58	7.93	-7.35	4.47	13.53	21.23*	29.10**	20.00**	30.55**	17.22*	22.57**	23.84**
9	IB102 x RHA 586	-13.66	-15.79*	9.89	-7.90	-8.13	-17.07*	-8.53	-10.99**	-6.52	-6.85	27.46**	2.25	7.49	-9.93	21.01**	5.52
10	IB103 x RHA 587	-6.71	9.60	10.95	3.18	-0.74	7.93	-7.65	-0.28	1.00	21.23*	28.96**	14.55**	16.14	17.22*	22.18**	18.21**
11	IB103 x PZ8R	0.69	7.12	-8.48	0.19	7.14	5.49	-23.82**	-3.17	9.02	18.49*	6.15	11.23*	25.86**	14.57	0.78	14.79**
12	IB103 x 83R-6	13.66	6.50	-2.83	6.94	20.94**	4.88	-19.12**	3.35	23.06**	17.81*	12.70	18.72**	41.50**	13.91	7.00	22.52**
13	IB103 x 6D-1	9.26	18.89*	-3.18	8.86*	16.26*	17.07*	-19.41**	5.21	18.30*	31.51**	12.30	20.86**	36.02**	27.85**	6.61	24.72**
14	IB103 x RHA 586	13.66	15.17	-4.95	9.06*	20.94**	13.41	-20.88**	5.40	23.06**	27.40**	10.25	21.07**	41.50**	23.18**	4.67	24.94**
15	IB105 x R-274	5.56	17.65*	-13.78*	4.05	12.32	15.85*	-28.24**	0.56	14.29	30.14**	0.00	15.51**	31.41**	25.83**	-5.06	19.21**
16	IB105 x RHA 587	1.16	-3.72	7.07	1.25	7.94	-5.18	-10.88*	-2.14	9.52	6.51	24.18**	12.41*	25.94**	2.98	17.90**	16.00**
17	IB105 x 3376R	2.31	16.41*	2.83	6.84	8.87	14.63	-14.41**	3.26	10.78	28.77**	19.26**	18.61**	27.38**	24.50**	13.23*	22.41**
18	IB105 x RHA 586	2.55	11.46	1.41	5.01	9.11	9.76	-15.59**	1.49	11.03	23.29**	17.62*	16.58**	27.67**	19.21*	11.67	20.31**
19	IB106 x RHA 587	-5.32	0.31	1.06	-1.83	0.74	-1.22	-15.88**	-5.12	2.51	10.96	17.21*	8.98	17.87	7.28	11.28	12.47**
20	IB106 x 3376R	-6.25	8.98	14.13*	4.05	-0.25	7.32	-5.00	0.56	1.50	20.55**	32.38**	15.51**	16.71	16.56	25.68**	19.20**
21	IB106 x PZ8R	-9.03	-2.79	4.95	-3.28	-3.20	-4.27	-12.65*	-6.52	-1.50	7.53	21.72**	7.38	13.26	3.97	15.56*	10.82*
22	IB106 x RHA 586	5.56	8.98	11.66*	8.29	12.32	7.32	-7.06	4.66	14.29	20.55*	29.51**	20.21**	31.41**	16.56	22.96**	24.06**
23	IB107 x PZ8R	0.23	1.55	0.00	0.58	6.65	0.00	-16.76**	-2.79	8.52	12.33	15.98*	11.66*	24.78**	8.61	10.12	15.23**
24	IB107 x 6D-1	-5.09	5.26	-6.71	-2.31	0.99	3.66	-22.35**	-5.59	2.76	16.44	8.20	8.45	18.16*	12.58	2.72	11.92*
25	IB108 x RHA 587	-8.80	-7.74	-0.49	-6.20	-2.96	-9.15	-17.18**	-9.35*	-1.25	2.05	15.41*	4.13	13.54	-1.32	9.57	7.46
26	IB108 x PZ8R	-5.32	-15.79*	2.83	-6.36	0.74	-17.07*	-14.41**	-9.50*	2.51	-6.85	19.26**	3.96	17.87	-9.93	13.23*	7.28
27	IB109 x R-274	13.66	12.69	20.85**	15.32**	20.94**	10.98	0.59	11.45**	23.06**	24.66**	40.16**	28.02**	41.50**	20.53*	33.07**	32.12**
28	IB109 x RHA 587	4.40	10.22	10.25	7.80	11.08	8.54	-8.24	4.19	13.03	21.92*	27.87**	19.68**	29.97**	17.88*	21.40**	23.15**
29	IB109 x PZ8R	-5.09	7.74	4.59	1.54	0.99	6.10	-12.94**	-1.86	2.76	19.18*	21.31**	12.73**	18.16**	15.23	15.18*	16.34**
30	IB110 x RHA 587	-6.02	0.31	8.13	-0.19	0.00	-1.22	-10.00	-3.54	1.75	10.96	25.41**	10.80*	17.00	7.28	19.07**	14.35**
31	IB110 x 3376R	-3.47	10.22	-9.54	-0.87	2.71	8.54	-24.71**	-4.19	4.51	21.92*	4.92	10.05*	20.17*	17.88*	-0.39	13.58**
32	IB110 x PZ8R	-7.41	-4.95	-7.77	-6.74	-1.48	-6.40	-23.29**	-9.89*	0.25	5.14	6.97	3.53	15.27	1.66	1.56	6.84
33	IB111 x RHA 587	-10.19	4.64	-10.25	-5.59	-4.43	3.05	-25.65**	-8.75*	-2.76	15.75	4.10	4.81	11.82	11.92	-1.17	8.17
34	IB111 x 3376R	-7.41	-0.93	-7.07	-5.30	-1.48	-2.44	-22.65**	-8.47*	0.25	9.59	7.79	5.13	15.27	5.96	2.33	8.50
35	IB111 x PZ8R	-6.48	-7.12	1.41	-4.53	-0.49	-8.54	-15.59**	-7.73	1.25	2.74	17.62*	5.99	16.43	-0.66	11.67	9.38
36	IB111 x RHA 586	-7.41	6.50	-7.42	-3.08	-1.48	4.88	-22.94**	-6.33	0.25	17.81*	7.38	7.59	15.27	13.91	1.95	11.04*

* Significance at 5 % E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

** Significance at 1 %

Table 8 (Contd....) : Per cent heterosis over standard checks for stem diameter in sunflower over three environments

Sl. No.	Hybrids	KBSH-1				MSFH-17				MORDEN				SUNGENE-85			
		E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled
1	IB101 x R-274	-11.05	-5.39	25.49*	0.26	-8.72	-3.02	-12.63	-8.73*	0.00	10.29	75.34**	20.16**	6.80	-1.53	46.29**	14.73**
2	IB101 x 3376R	0.85	7.35	10.29	5.12	3.49	10.05	-23.21**	-4.31	13.38	25.14*	54.11**	25.98**	21.09**	11.73	28.57*	20.30**
3	IB101 x PZ8R	13.31*	11.27	-14.22	5.39	16.28*	14.07	-40.27**	-4.07	27.39**	29.71**	19.86	26.30**	36.05**	15.82	0.00	20.60**
4	IB102 x R-274	-17.56**	15.69	-2.94	-4.73	-15.41*	18.59*	-32.42**	-13.28**	-7.32	34.86**	35.62*	14.71*	-1.02	20.41*	13.14	9.02
5	IB102 x RHA 587	-18.41**	-7.35	-20.59*	-16.03**	-16.28*	-5.03	-44.71**	-23.56**	-8.28	8.00	10.96	0.63	-2.04	-3.57	-7.43	-3.91
6	IB102 x 3376R	-15.86*	-1.47	-5.88	-9.33*	-13.66*	1.01	-34.47**	-17.46**	-5.41	14.86	31.51*	8.66	1.02	2.55	9.71	3.76
7	IB102 x PZ8R	-12.18	3.43	-6.37	-6.44	-9.88	6.03	-34.81**	-14.83**	-1.27	20.57*	30.82*	12.13*	5.44	7.65	9.14	7.07
8	IB102 x 6D-1	-7.37	9.31	24.51*	5.65	-4.94	12.06	-13.31	-3.83	4.14	27.43**	73.97**	26.62**	11.22	13.78	45.14**	20.90**
9	IB102 x RHA 586	-15.58*	-7.35	-0.49	-9.33*	-13.37*	-5.03	-30.72**	-17.47**	-5.10	8.00	39.04**	8.66	1.36	-3.57	16.00	3.76
10	IB103 x RHA 587	-11.05	-3.92	22.56*	-0.13	-8.72	-1.51	-14.68*	-9.09*	0.00	12.00	71.23**	19.62**	6.80	0.00	42.86**	14.28**
11	IB103 x PZ8R	-11.90	10.29	-9.31	-5.25	-9.59	13.07	-36.86**	-13.75**	-0.96	28.57**	26.71	13.54*	5.78	14.80	5.71	8.42
12	IB103 x 83R-6	-5.67	-6.86	24.51*	2.10	-3.20	-4.52	-13.31	-7.06	6.05	8.57	73.97**	22.36**	13.27	-3.06	45.14**	16.84**
13	IB103 x 6D-1	7.65	32.84**	14.71	16.30**	10.47	36.18**	-20.14**	5.86	21.02**	54.86**	60.27**	39.37**	29.25**	38.27**	33.71**	33.08**
14	IB103 x RHA 586	1.70	4.41	-1.47	1.58	4.36	7.04	-31.40**	-7.54	14.33*	21.71*	37.67**	21.73**	22.11**	8.67	14.86	16.24**
15	IB105 x R-274	-2.27	7.84	-28.43**	-6.57	0.29	10.55	-50.17**	-14.95**	9.87	25.71*	0.00	11.97*	17.35*	12.24	-16.57	6.92
16	IB105 x RHA 587	-5.10	-7.35	30.88**	3.94	-2.62	-5.03	-8.87	-5.38	6.69	8.00	82.88**	24.57**	13.95	-3.57	52.57**	18.94**
17	IB105 x 3376R	-2.55	8.82	-1.47	0.79	0.00	11.56	-31.40**	-8.25	9.55	26.86**	37.67**	20.79**	17.01*	13.27	14.86	15.34**
18	IB105 x RHA 586	-0.28	-2.94	-14.22	-4.73	2.33	-0.50	-40.27**	-13.28**	12.10	13.14	19.86	14.17**	19.73*	1.02	0.00	9.02
19	IB106 x RHA 587	-6.80	0.49	6.86	-1.18	-4.36	3.02	-25.60**	-10.05*	4.78	17.14	49.32**	18.43**	11.90	4.59	24.57**	13.08*
20	IB106 x 3376R	-6.23	-7.84	5.88	0.79	-3.78	10.55	-26.28**	-8.25	5.41	25.71*	47.95**	20.79**	12.59	12.24	23.43	15.34**
21	IB106 x PZ8R	-3.97	-1.96	22.55*	3.68	-1.45	0.50	-14.68*	-5.62	7.96	14.29	71.23**	24.26**	15.31*	2.04	42.86**	18.65**
22	IB106 x RHA 586	-7.65	-0.49	38.24**	6.57	-5.23	2.01	-3.75	-2.99	3.82	16.00	93.15**	27.72**	10.88	3.57	61.14**	21.95**
23	IB107 x PZ8R	-15.30*	3.43	11.27	-3.15	-13.08*	6.03	-22.53	-11.84**	-4.78	20.57*	55.48**	16.06**	1.70	-7.65	29.71*	10.82*
24	IB107 x 6D-1	-1.13	11.76	28.92**	10.38*	1.45	14.57	-10.24	0.48	11.15	30.29**	80.14**	32.28**	18.17*	16.33	50.29**	26.31**
25	IB108 x RHA 587	12.18	-11.27	-15.69	-1.57	15.12*	-9.05	-41.30**	-10.40*	26.11**	3.43	17.81	17.96**	34.69**	-7.65	-1.71	12.63*
26	IB108 x PZ8R	-15.58*	-0.49	-1.96	-7.88	-13.37*	2.01	-31.74**	-16.15**	-5.10	16.00	36.99*	10.39	1.36	3.57	14.29	5.41
27	IB109 x R-274	-1.98	7.84	29.41**	9.07	0.58	10.55	-9.90	-0.72	10.19	25.71*	80.82**	30.71**	17.69*	12.24	50.86**	24.81**
28	IB109 x RHA 587	-7.93	8.33	34.31**	7.75	-5.52	11.06	-6.48	-1.91	3.50	26.29**	87.67**	29.14**	10.54	12.76	56.57**	23.31**
29	IB109 x PZ8R	4.25	14.22	41.67**	16.95*	6.98	17.09	-1.37	6.46	17.20*	33.14**	97.95**	40.16**	25.17**	18.88*	65.14**	33.83**
30	IB110 x RHA 587	-18.41**	-9.31	20.10	-5.65	-16.28*	-7.04	-16.38**	-14.12**	-8.28	5.71	67.81**	13.07*	-2.04	-5.61	40.00**	7.97
31	IB110 x 3376R	-3.97	8.82	3.43	1.45	-1.45	11.56	-27.99**	-7.65	7.96	26.86**	44.52**	21.58**	15.31*	13.27	20.57	16.09**
32	IB110 x PZ8R	-10.76	-3.43	-5.88	-7.49	-8.43	-1.01	-34.47**	-15.79**	0.32	12.57	31.51*	10.87	7.14	0.51	9.71	5.86
33	IB111 x RHA 587	-13.60*	-7.84	11.76	-5.25	-11.34	-5.53	-22.18**	-13.75**	-2.87	7.43	56.16**	13.54*	3.74	-4.08	30.29*	8.42
34	IB111 x 3376R	-15.58*	-2.94	19.12	-2.89	-13.37*	-0.50	-17.06**	-11.60**	-5.10	13.14	66.44**	16.38**	1.36	1.02	38.86**	11.13*
35	IB111 x PZ8R	-12.18	-2.94	2.45	-5.78	-9.88	-0.50	-28.67**	-14.23**	-1.27	13.14	43.15**	12.91*	5.44	1.02	19.63	7.82
36	IB111 x RHA 586	-4.82	-5.39	-7.35	-5.65	-2.33	-3.02	-35.49**	-14.11**	7.01	10.29	29.45*	13.07*	14.29	1.53	8.00	7.97

* Significance at 5 % E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

** Significance at 1 %

Table 8 (Contd....) : Per cent heterosis over standard checks for seed yield per plant in sunflower over three environments

Sl. No.	Hybrids	KBSH-1				MSFH-17				MORDEN				SUNGENE-85			
		E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled
1	IB101 x R-274	15.67	-23.98	9.32	-0.15	14.46	-46.93**	-2.12	-16.10*	35.86	56.58*	67.69**	50.23**	30.52	-32.78**	8.33	-0.95
2	IB101 x 3376R	-30.48	-10.60	-20.64**	-20.62*	-31.21	-37.59**	-28.94**	-33.30**	-18.35	84.15**	21.74	19.43**	-21.56	-20.94	-21.35**	-21.25*
3	IB101 x PZ8R	24.19	-12.44	-34.13**	-5.60	22.89	-38.87**	-41.02**	-20.67**	45.87	80.35**	1.05	42.03**	40.14	-22.57	-34.72**	-6.35
4	IB102 x R-274	-33.12	-0.45	-34,75**	-22.07*	-33.81	-30.50**	-41.58**	-34.52**	-21.44	105.05**	0.09	17.25	-24.53	-11.97	-35.34**	-22.69*
5	IB102 x RHA 587	-5.11	4.96	20.36**	-6.47	-6.10	-26.73**	-30.22**	-21.40**	11.45	116.18**	19.55	40.72**	7.07	-7.19	-22.77**	-7.21
6	IB102 x 3376R	-45.46	-4.81	-46.43**	-31.41**	-46.03*	-33.54**	-52.04**	-42.36**	-35.94	96.08**	-17.83	3.20	-38.46	-15.82	-46.92**	-31.96**
7	IB102 x PZ8R	-6.12	6.47	-4.13	-1.10	-7.10	-25.67**	-14.16*	16.90*	10.27	119.31**	47.07**	48.79**	5.94	-5.85	-4.99	-1.89
8	IB102 x 6D-1	-18.91	-5.78	-20.16**	-2.92	-19.75	-34.22**	7.77	18.42*	-4.75	94.08**	84.64**	46.07**	-8.49	-16.68	19.28*	-3.96
9	IB102 x RHA 586	-37.10	-34.69*	-38.74**	-36.73**	-37.76	-54.41**	-45.15**	-46.83**	-26.12	34.52	-6.03	4.80	-29.03	-42.25**	-39.29**	-37.23**
10	IB103 x RHA 587	25.31	14.92	-11.35	11.04	24.00	-19.78*	-20.63**	-6.70	47.18	136.70**	35.99**	67.06**	41.39	1.62	-12.15	10.15
11	IB103 x PZ8R	-12.43	34.33*	-8.10	5.31	-13.35	-6.22	-17.72*	-11.51	2.85	176.69**	40.97**	58.44**	-1.19	18.78	-8.93	4.47
12	IB103 x 83R-6	8.36	-15.51	12.70	1.20	7.23	-41.02**	0.91	-14.96	27.28	74.02**	72.88**	52.26**	22.27	-25.29*	11.68	0.39
13	IB103 x 6D-1	-31.39	64.56**	15.45*	15.99	-32.10	14.88	3.37	-2.53	-19.41	238.96**	77.09**	74.52**	-22.58	45.52**	14.41	15.07
14	IB103 x RHA 586	59.32**	-7.47	3.02	19.48*	57.66**	-35.41**	-7.76	0.40	87.13**	90.59**	58.03**	79.76**	78.77**	-18.18	2.09	18.53*
15	IB105 x R-274	-4.77	10.62	-16.34*	-2.69	-5.76	-22.77*	-25.10**	-18.23*	11.85	127.85**	28.33*	46.40**	7.46	-2.18	-17.10*	-3.47
16	IB105 x RHA 587	39.63	12.84	-6.02	16.97	38.17	-21.23*	-15.86*	-1.71	64.00**	132.42**	44.16**	75.99**	57.55*	-0.22	-6.87	16.04
17	IB105 x 3376R	17.47	15.23	-17.41*	6.59	16.25	-19.56*	-26.05**	-10.43	37.98	137.54**	26.70*	60.37**	32.55	1.89	-18.15*	5.74
18	IB105 x RHA 586	0.55	9.13	-8.30	1.01	-0.50	-23.82*	-17.89*	-15.12*	18.10	124.78**	40.67**	51.98**	13.46	-3.50	-9.13	0.21
19	IB106 x RHA 587	19.95	-7.22	-14.11	0.51	18.70	-35.23**	-23.10**	-15.54*	40.88	91.10**	31.75**	51.23**	35.35	-17.96	-14.89	-0.29
20	IB106 x 3376R	-7.87	-27.44*	-42.75**	-24.86**	-8.83	-49.35**	-48.74**	-36.86**	8.21	49.35	-12.17	13.05	3.96	-35.84**	-43.26**	-15.46**
21	IB106 x PZ8R	7.68	-19.85	-11.08	-7.45	6.55	-44.05**	-20.38**	-22.24**	26.47	65.09*	36.41**	39.24**	21.50	-29.12*	-11.88	-8.19
22	IB106 x RHA 586	16.93	-7.53	-3.90	2.28	15.71	-35.45**	-13.95*	-14.06	37.34	90.46**	47.42**	53.88**	31.95	-18.23	-4.77	1.46
23	IB107 x PZ8R	6.95	-16.92	-7.74	-5.72	5.84	-42.00**	-17.39*	-20.77**	25.62	71.12*	41.53**	41.85**	20.68	-26.54*	-8.57	-6.47
24	IB107 x 6D-1	-43.82*	3.47	-7.42	-16.61	-44.41*	-27.76**	-17.11*	-29.93**	-34.01	113.13**	42.02**	25.46	-36.61	-8.50	-8.26	-17.28
25	IB108 x RHA 587	16.50	-6.39	-28.12**	-4.48	15.29	-34.65**	-35.64**	-19.73**	36.84	92.82**	10.27	43.71**	31.46	-17.22	-28.77**	-5.24
26	IB108 x PZ8R	-2.61	-30.12*	-17.25*	-16.55	-3.63	-51.22**	-25.91**	-29.88**	14.39	43.93	36.93*	25.56	9.89	-38.21**	-18.00*	-17.21
27	IB109 x R-274	25.67	16.24	-7.57	12.73	24.36	-18.85**	-17.24*	-5.28	47.61*	139.42**	41.78**	69.60**	41.81	2.79	-8.41	11.83
28	IB109 x RHA 587	62.36**	8.83	7.37	27.58**	60.66**	-24.03*	-3.86	7.20	90.70**	124.16**	64.71**	91.94**	83.20**	-3.77	6.41	26.56**
29	IB109 x PZ8R	45.32*	0.66	3.96	17.61	43.80*	-29.73**	-6.92	-1.18	70.68**	107.90**	59.47**	76.94**	63.97**	-10.99	3.02	16.67
30	IB110 x RHA 587	18.85	5.79	11.05	11.99	17.60	-26.15**	-0.57	-5.90	39.59	117.90**	70.34**	68.49**	34.10	-6.45	10.05	11.09
31	IB110 x 3376R	0.05	5.34	-26.04**	-5.63	-0.99	-26.46**	-33.78**	-20.70**	17.51	116.98**	13.45	41.98**	12.89	-6.85	-26.71**	-6.39
32	IB110 x PZ8R	17.42	-3.47	-14.14	0.92	16.20	-32.61**	-23.13**	-15.20*	37.92	98.82**	31.70**	51.84**	32.50	-14.64	-14.92	0.12
33	IB111 x RHA 587	20.29	-13.49	-0.53	2.36	19.04	-39.60**	-10.94	-13.99	41.29	78.20**	52.98**	54.00**	35.74	-23.50	-1.43	1.54
34	IB111 x 3376R	-25.25	-20.98	1.76	-15.93	-26.03	-44.84**	-8.89	-29.36**	-12.20	62.76*	56.10**	26.49	-15.65	-30.13*	0.84	-16.60
35	IB111 x PZ8R	12.09	-6.18	7.78	4.40	10.92	-34.50**	-3.49	-12.27	31.65	93.25**	65.34**	57.08**	26.48	-17.03	6.81	3.57
36	IB111 x RHA 586	-27.04	-11.80	-11.53	-17.18	-27.80	-38.43**	-20.77**	-30.41**	-14.30	81.66**	35.91**	24.61	-17.67	-22.01	-12.33	-17.84*

* Significance at 5 % E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

** Significance at 1 %

Table 8 (Contd….) : Per cent heterosis over standard checks for hundred seed weight in sunflower over three environments

Sl. No.	Hybrids	KBSH-1				MSFH-17				MORDEN				SUNGENE-85			
		E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled
1	IB101 x R-274	-21.73**	-19.25**	-21.18**	-20.69**	-31.60**	-31.37**	-31.79**	-31.58**	-29.22**	-24.04**	-26.59**	-26.58**	-20.20**	-25.04*	-20.30**	-22.01**
2	IB101 x 3376R	-31.25**	-6.57	-18.69**	-18.51**	-39.92**	-20.59**	29.64**	-29.70**	-37.83**	-12.10*	-24.27**	-24.56**	-29.90**	-13.26*	-17.78**	-19.86**
3	IB101 x PZ8R	-0.10	-4.88	-3.68	-2.95	-12.69	-19.16**	-16.65**	-16.28**	-9.65	-10.52	-10.29**	-10.16*	1.86	-11.20*	-2.61	-4.57
4	IB102 x R-274	-33.37**	-8.52	-11.60**	-17.49**	-41.76**	-22.25**	-23.51**	-28.82**	-39.74**	-13.94*	-17.67**	-23.62**	-32.06**	-15.07**	-10.61**	-18.86**
5	IB102 x RHA 587	-5.19	-11.18	-10.87**	-9.16*	-17.14**	-24.51**	-22.87**	-21.64**	-14.26*	-16.44**	-16.98**	-15.91**	-3.33	-17.55**	-9.87*	-10.67*
6	IB102 x 3376R	-28.85**	-1.95	-16.57**	-15.43**	-37.82**	-16.67**	-27.81**	-27.05**	-35.65**	-7.76	-22.30**	-21.71**	-27.45**	-8.98	-15.64**	-16.84**
7	IB102 x PZ8R	-5.19	-2.31	-5.43	-4.27	-17.14**	-16.97**	-18.17**	-17.42**	-14.26*	-8.10	-11.92**	-11.38**	-3.33	-9.31	-4.38	-5.87
8	IB102 x 6D-1	-20.19**	-16.42**	-17.50**	-17.98**	-30.25**	-28.96**	-28.61**	-29.25**	-27.83**	-21.37**	-23.16**	-24.08**	-18.63*	-22.41**	-16.57**	-19.35**
9	IB102 x RHA 586	-35.58**	-26.44**	29.37**	-30.34**	-43.70**	-37.48**	-38.88**	-39.91**	-41.74**	-30.80**	-34.22**	-35.52**	-34.31**	-31.71**	-28.58**	-31.50**
10	IB103 x RHA 587	17.21*	8.07	10.13**	11.68**	2.44	-8.14	-4.70	-3.66	6.00	1.67	2.57	3.39	19.51*	0.33	11.36**	9.82*
11	IB103 x PZ8R	0.96	19.52**	6.63	9.28*	-11.76	1.58	-7.73*	-5.73	-8.70	12.44*	-0.69	1.17	2.94	10.96	7.82	7.47
12	IB103 x 83R-6	5.77	7.54	3.87	5.75	-7.56	-8.60	-10.12**	-8.78*	-4.35	1.17	-3.26	-2.11	7.84	-0.16	5.03	3.99
13	IB103 x 6D-1	-18.27*	21.21**	3.04	2.52	-28.57**	3.02	-10.84**	-11.56**	-26.09**	14.02*	-4.03	-5.09	-16.67*	12.52*	4.19	0.82
14	IB103 x RHA 586	-12.50	-8.34	-8.93*	-9.87*	-23.53**	-22.10**	-21.20**	-22.25**	-20.87**	-13.77*	-15.18**	-16.56**	-10.78	14.91**	-7.91	-11.37**
15	IB105 x R-274	-22.50**	7.63	-7.09	-6.92	-32.27**	-8.52	-19.60**	-19.70**	-29.91**	1.25	-13.46**	-13.83**	-20.98**	-0.08	-6.05	-8.46
16	IB105 x RHA 587	18.17*	16.86**	16.48**	17.15**	3.28	-0.68	0.80	1.06	6.87	9.93	8.49*	8.45*	20.49**	8.48	17.78**	15.20**
17	IB105 x 3376R	0.29	13.40*	-2.30	3.97	-12.35	-3.62	-15.46**	-10.32**	-9.30	6.68	-9.01*	-3.76	2.25	5.27	-1.21	2.24
18	IB105 x RHA 586	-15.38	-4.53	-10.41**	-9.96*	-26.05**	-18.85**	-22.47**	-22.33**	-23.48**	-10.18	-1655**	-16.65**	-13.73	-11.27*	-9.40*	-11.46**
19	IB106 x RHA 587	8.17	-7.81	-2.67	-0.98	-5.46	-21.64**	-15.68**	-14.58**	-2.17	-13.27*	-9.35*	-8.34*	10.29	-14.42	-1.58	-2.63
20	IB106 x 3376R	-8.85	1.15	-19.06**	-8.79*	-20.34**	-14.03**	-29.96**	-21.32**	-17.57	-4.84	-24.61**	-15.57**	-7.06	-6.10	-18.16**	-10.31*
21	IB106 x PZ8R	17.79*	7.54	8.10*	11.01*	2.94	-8.60	-6.45	-4.24	6.52	1.17	0.69	2.76	20.10**	-0.16	9.31*	9.16*
22	IB106 x RHA 586	-19.23*	-8.07	-7.73	-11.53**	-29.41**	-21.87**	-20.16**	-23.68**	-26.96**	-13.52*	-14.07**	-18.10**	-17.65*	-14.66**	-6.70	-13.00**
23	IB107 x PZ8R	4.71	-1.06	-3.31	0.03	-8.49	-15.91**	-16.33**	-13.71**	-5.30	-6.93	-9.95**	-7.40	6.76	-8.15	-2.23	-1.63
24	IB107 x 6D-1	-21.15**	5.15	0.37	-4.86	-31.09**	-10.63*	-13.15**	-17.93**	-28.70**	-1.09	-6.52	-11.92**	-19.16*	-2.39	1.49	-6.44
25	IB108 x RHA 587	13.27	-7.54	-2.12	0.92	-1.01	-21.42**	-15.30**	-12.94**	2.43	-13.02*	-8.83*	-6.57	15.49*	-14.17*	-1.02	-0.76
26	IB108 x PZ8R	12.50	-13.49*	-6.54	-2.86	-1.68	-26.47**	-19.20**	-16.20**	1.74	-18.61**	-12.95**	-10.07*	14.71	-19.69**	-5.49	-4.47
27	IB109 x R-274	-16.83*	0.18	-8.29*	-8.08	-27.31**	-14.86**	-20.64**	-20.71**	24.78**	-5.76	-14.58**	-14.91**	-15.20*	-7.00	7.26	-9.61*
28	IB109 x RHA 587	21.44**	3.11	0.09	7.96	6.13	-12.37*	-13.39**	-6.87	9.83	-3.00	-6.78	-0.06	23.82**	4.28	1.21	6.17
29	IB109 x PZ8R	14.52	13.22*	13.08**	13.59**	0.08	-3.77	-2.15	-2.02	3.57	6.51	5.32	5.15	16.76*	5.11	14.34**	11.70**
30	IB110 x RHA 587	12.79	5.06	6.45	7.99	-1.43	-10.71*	-7.89*	-6.84	2.00	-1.17	-0.86	-0.03	15.00	-2.47	7.64	6.20
31	IB110 x 3376R	2.50	14.82*	3.96	7.26	-10.42	-2.41	-10.04**	-7.48	-7.30	8.01	-3.17	-0.71	4.51	6.59	5.12	5.47
32	IB110 x PZ8R	15.38*	16.59**	15.29**	15.77**	0.84	-0.90	-0.24	-0.13	4.35	9.68	7.38*	7.17	17.65*	8.24	16.57**	13.84**
33	IB111 x RHA 587	7.69	6.12	16.21**	9.99*	-5.88	-9.80	0.56	-5.12	-2.61	-0.17	8.23*	1.82	9.80	-1.48	17.50**	8.16
34	IB111 x 3376R	-5.67	4.88	1.20	0.28	-17.56**	-10.86*	-12.43**	-13.50**	-14.70*	-1.34	-5.75	-7.17	-3.82	-2.64	2.33	-1.39
35	IB111 x PZ8R	2.69	-0.71	-0.83	0.34	-10.25	-15.61**	-14.18**	-13.44**	-7.13	-6.59	-7.63*	-7.11	4.71	-7.83	0.28	-1.33
36	IB111 x RHA 586	-29.81**	9.32	-19.61**	-19.31**	-38.66**	-22.93**	-30.44**	-30.39**	-36.52**	-14.69**	-25.13**	-25.30**	-28.43**	-15.82**	-18.72**	-20.65**

* Significance at 5 % E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

** Significance at 1 %

Table 8 (Contd....) : Per cent heterosis over standard checks for per cent seed filling in sunflower over three environments

Sl. No.	Hybrids	KBSH-1				MSFH-17				MORDEN				SUNGENE-85			
		E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled
1	IB101 x R-274	-2.62	-1.78	3.16	-0.43	-1.74	1.25	12.65**	3.83*	-7.63*	15.20**	5.10*	3.69*	-8.62**	5.43*	4.61	0.28
2	IB101 x 3376R	-13.03**	-1.85	-1.02	-5.19**	-12.24**	1.17	8.09**	-1.14	-17.50**	15.12**	0.84	-1.28	-18.39**	5.35*	0.38	-4.52**
3	IB101 x PZ8R	3.55	0.14	-9.89**	-2.05	4.49	3.23	-1.60	2.13	-1.78	17.46**	-8.20**	2.00	-2.83	7.49**	-8.62**	-1.36
4	IB102 x R-274	-0.50	-0.21	-6.58**	-2.40	0.40	2.86	2.01	1.77	-5.62	17.04**	-4.83	1.64	-6.63*	7.11**	-5.26**	-1.71
5	IB102 x RHA 587	6.42	-2.56	-8.65**	-1.66	7.38*	0.44	-0.25	2.55	0.94	14.29**	-6.93**	2.41	-0.14	4.59*	-7.36**	-0.96
6	IB102 x 3376R	0.92	-9.79**	-10.94**	-6.70**	1.83	-7.01**	-2.75	-2.71	-4.28	5.81*	-9.27**	-2.85	-5.30	-3.17	-9.69**	-6.04**
7	IB102 x PZ8R	5.46	-0.93	-5.30*	-0.30	6.42	2.13	3.41	3.97*	0.04	16.21**	-3.52	3.83*	-1.04	6.35**	-3.97	0.41
8	IB102 x 6D-1	-8.82*	-0.28	3.05	-1.95	-8.00*	2.79	12.53**	2.24	-13.51**	16.96**	4.98*	2.10	-14.44**	7.03**	4.50	-1.26
9	IB102 x RHA 586	-4.55	-1.25	-5.72*	3.78*	-3.68	1.80	2.96	0.33	-9.46**	15.83**	-3.95	0.19	-10.43**	6.00**	-4.39	-3.10*
10	IB103 x RHA 587	7.03*	-5.59**	-14.07**	-4.29**	8.00*	-2.68	-6.16*	-0.20	1.52	10.74**	-12.45**	-0.33	0.43	1.34	-12.85**	-3.61*
11	IB103 x PZ8R	-1.68	-0.04	-0.34	-0.67	-0.79	3.03	8.83**	3.58*	-6.74*	17.25**	1.53	3.44*	-7.74*	7.30**	1.07	0.04
12	IB103 x 83R-6	-9.01*	-9.19**	4.40	-4.66**	-8.19*	-6.39**	14.00**	-0.59	-13.70**	6.52**	6.36*	-0.72	-14.62**	-2.52	5.87*	-3.99**
13	IB103 x 6D-1	-9.32**	-1.75	-1.32	-4.06**	-8.50*	1.28	7.76**	0.05	-13.99**	15.25**	0.54	-0.09	-14.91**	5.47**	0.08	-3.38*
14	IB103 x RHA 586	8.44*	-0.21	-7.78**	0.10	9.42**	2.86	0.70	4.38*	2.86	17.04**	-6.05*	4.24**	1.76	7.11**	-6.48**	0.81
15	IB105 x R-274	-1.60	-0.43	-2.59	-1.22	-0.71	3.52	6.37*	3.00	-6.67*	17.79**	-0.77	2.86	-7.67**	7.80**	1.22	-0.52
16	IB105 x RHA 587	10.35**	-8.76**	-13.54**	-4.14**	11.35**	-5.95**	-5.59*	-0.05	4.67	7.02**	-11.92**	-0.18	3.55	-2.06	-12.32**	-3.46*
17	IB105 x 3376R	0.27	-2.21	-10.79**	-4.23**	1.18	0.81	-2.59	-0.14	-4.89	14.70**	-9.12**	-0.27	-5.91	4.97	-9.53**	-3.55*
18	IB105 x RHA 586	3.51	-0.64	3.12	1.94	4.45	2.42	12.61**	6.30**	-1.81	16.54**	5.06*	6.16**	-2.87	6.65**	4.58	2.67
19	IB106 x RHA 587	9.78**	-3.67	-9.36**	-1.19	10.77**	-0.70	-1.03	3.04	4.13	14.70**	-7.66**	2.90	3.01	4.97*	-8.09**	-0.49
20	IB106 x 3376R	1.91	-6.16**	-5.98*	-3.49*	2.83	-3.27	2.67	0.64	-3.33	10.07**	-4.21	0.50	-4.37	0.73	-4.65	-2.80
21	IB106 x PZ8R	5.23	0.50	-10.98**	-1.74	6.19	3.60	-2.79	2.46	-0.18	17.88**	-9.31**	2.32	-1.25	7.87**	-9.73**	-1.05
22	IB106 x RHA 586	5.42	-2.71	-4.25	-0.58	6.38	0.29	4.56	3.67*	0.00	14.12**	-2.45	3.52*	-1.08	4.43*	-2.90	0.12
23	IB107 x PZ8R	0.61	-4.74*	-4.14	-2.81	1.52	-1.80	4.68	1.35	-4.57	11.74**	-2.34	1.21	-5.59	2.26	-2.78	-2.12
24	IB107 x 6D-1	-18.43**	1.10	1.84	-4.98**	-17.70**	4.22*	11.21**	-0.92	-22.63**	18.59**	3.75	-1.05	-23.46**	8.52**	3.28	-4.30**
25	IB108 x RHA 587	6.68	0.07	-10.87**	-1.39	7.65*	3.16	-2.67	2.83	1.20	17.38**	-9.20**	2.69	0.11	7.42**	-9.61**	-0.69
26	IB108 x PZ8R	9.24**	-3.60	-6.81**	-0.49	10.23**	-0.62	1.77	3.76*	3.62	13.07**	-5.06*	3.62*	2.51	3.48	5.49	0.21
27	IB109 x R-274	-0.04	0.57	-9.70**	-3.01*	0.87	3.67	-1.40	1.14	-5.18	17.96**	-8.01**	1.00	-6.20	7.59**	-8.43**	-2.32
28	IB109 x RHA 587	8.33*	-1.92	-10.15**	-1.37	9.31**	1.10	-1.89	2.91	2.75	15.04**	-8.47**	2.77	1.65	5.28*	-8.89**	-0.61
29	IB109 x PZ8R	10.12**	-7.09**	-10.08**	-2.50	11.12**	-4.22*	-1.81	1.67	4.46	8.98**	-8.39**	1.53	3.33	-0.27	-8.81**	-1.81
30	IB110 x RHA 587	9.55**	-6.52**	-10.30**	-2.56	10.54**	-3.63	-2.05	1.61	3.91	9.65**	-8.62**	1.47	2.80	0.34	-9.40**	-1.87
31	IB110 x 3376R	2.10	-1.46	-8.99**	-2.78	3.03	1.58	-0.62	1.37	-3.15	15.58**	-7.28**	1.24	-4.19	5.77**	-7.70**	-2.09
32	IB110 x PZ8R	8.90*	-3.45	-15.53**	-3.43*	9.89**	-0.48	-7.76**	0.70	3.30	13.24**	-13.95**	0.57	2.19	3.63	-14.34**	-2.74
33	IB111 x RHA 587	9.55**	-5.56**	-8.39**	-1.60	10.54**	-22.64	0.04	2.61	3.91	10.78**	-6.67**	2.47	2.80	1.38	-7.09**	-0.90
34	IB111 x 3376R	-0.84	-5.13*	-6.58**	-4.22**	0.06	-2.20	2.01	-0.12	-5.94	11.28**	-4.83	-0.26	-6.95*	1.83	-5.26*	-3.54*
35	IB111 x PZ8R	3.82	1.35	-8.76**	-1.18	4.76	4.48*	-0.37	3.05	-1.52	18.88**	-7.05**	2.91	-20.58	8.79**	-7.48**	-0.47
36	IB111 x RHA 586	-5.27	-1.50	1.39	-1.77	-4.41	1.54	10.72**	2.43	-10.14**	15.54**	3.30	2.29	-11.11**	5.73**	2.82	-1.07

* Significance at 5 % E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

** Significance at 1 %

Table 8 (Contd....) : Per cent heterosis over standard checks for husk content in sunflower over three environments

Sl. No.	Hybrids	KBSH-1				MSFH-17				MORDEN				SUNGENE-85			
		E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled
1	IB101 x R-274	-23.17**	-11.33	-22.61**	-19.32**	-41.28**	-26.37**	-44.06**	-40.65**	-21.27**	-24.38**	-25.32**	-23.67**	-21.73**	-26.29**	-30.51**	-26.28**
2	IB101 x 3376R	12.04*	-5.27	-4.96	0.98	-14.37**	-31.91**	-31.29**	-25.71**	14.81*	-19.21*	-8.28	-4.47	14.14*	-21.25**	-14.66**	-7.73
3	IB101 x PZ8R	-15.02**	-0.66	-11.97*	-9.56	-35.06**	-28.60**	-36.36**	-33.46**	-12.93*	-15.28*	-15.05**	-14.43**	-13.43*	-17.42*	-20.96**	-17.36**
4	IB102 x R-274	-16.51**	-6.85	-12.70*	-12.25*	-36.20**	-30.05**	-36.89**	-35.44**	-14.45*	-20.56**	-15.75**	-16.97**	-14.95*	-22.56**	-21.61**	-19.81**
5	IB102 x RHA 587	-2.29	0.53	-3.14	-1.71	-25.33**	-27.75**	-29.98**	-27.69**	0.12	-14.27	-6.53	-7.01	-0.47	-16.43*	-13.03**	-10.19*
6	IB102 x 3376R	-8.60	-1.58	-6.29	-5.66	-30.07**	-29.36**	-32.26**	-30.59**	-6.35	-16.07*	-9.57	-10.74*	-6.89	-18.18*	-15.85**	-13.79**
7	IB102 x PZ8R	-17.66**	-14.89	-16.08**	-16.27**	-37.07**	-38.83**	-39.34**	-38.40**	-15.63**	-27.42**	-19.02**	-20.79**	-16.12**	-29.24**	-24.65**	-23.49**
8	IB102 x 6D-1	-16.28**	-16.73	-16.32**	-16.44**	-36.02**	-40.25**	-39.51**	-38.52**	-14.22*	-28.99**	-19.25**	-20.94**	-14.72*	-30.78**	-24.86**	-23.64**
9	IB102 x RHA 586	-3.10	4.74	0.00	0.37	-25.94**	-24.72**	-27.71**	-26.16**	-0.71	-10.67	-3.50	-5.04	-1.29	-12.92	-10.21*	-8.29
10	IB103 x RHA 587	-0.92	8.43	5.56	4.15	-24.28**	-22.06**	-23.69**	-23.38**	1.53	-7.53	1.87	-1.46	0.93	-9.86	-5.21	-4.83
11	IB103 x PZ8R	-2.18	-17.00	-6.77	-8.30	-25.24**	-40.34**	-32.60**	-32.54**	0.24	-29.21**	-10.04	-13.24**	-0.35	-31.00**	-16.29**	-16.21**
12	IB103 x 83R-6	-8.83	1.84	-4.59	-4.11	-30.32*	-26.80**	-31.03**	-29.45**	-6.58	-13.15	-7.93	-9.28	-7.13	-15.33*	-14.33**	-12.38**
13	IB103 x 6D-1	-7.79	-18.05*	-14.27**	-13.14*	-29.53**	-41.10**	-38.02**	-36.09**	-5.51	-30.11**	-17.27**	-17.82**	-6.06	-31.81**	-23.02**	-20.63**
14	IB103 x RHA 586	-19.32**	3.95	-8.71	-8.56	-38.34**	-25.28**	-34.00**	-32.73**	-17.33**	-11.35	-11.90*	-13.49**	-17.82**	-13.58	-18.02**	-16.45**
15	IB105 x R-274	-3.67	-7.51	-7.26	-6.06	-26.38**	-33.52**	-32.95**	-30.89**	-1.29	-21.12**	-10.50*	-11.12*	-1.87	-23.11**	-16.72**	-14.16**
16	IB105 x RHA 587	1.49	25.56**	13.81*	12.86*	-22.44**	-9.75	-18.18**	-16.97**	4.00	7.08	9.22	6.77	3.39	4.38	1.63	3.12
17	IB105 x 3376R	-8.72	-10.28	-10.04	9.64	-30.24**	-33.51**	-34.97**	-33.52**	-6.46	-23.48**	-13.19*	-14.51**	-7.01	-25.41**	-19.22**	-17.43**
18	IB105 x RHA 586	-10.21	2.11	-2.06	-3.66	-31.38**	-26.61**	-29.20**	-29.12**	-7.99	-12.92	-5.48	-8.85	-8.53	-15.11**	-12.05*	-11.97*
19	IB106 x RHA 587	-2.87	16.60	4.23	5.53	-25.77**	-16.19*	-24.65**	-22.36**	-0.47	-0.56	0.58	-0.15	-1.05	-3.07	-6.41	-3.57
20	IB106 x 3376R	-7.34	-6.06	-5.80	-6.43	-29.18**	-32.48**	-31.91**	-31.16**	-5.05	-19.89**	-9.10	-11.47*	-5.61	-21.91**	-15.42**	-14.50**
21	IB106 x PZ8R	-20.87**	-16.73	-18.62**	-18.84**	-39.53**	-40.15**	-41.67**	-40.29**	-18.92**	-28.99**	-21.47**	-23.21**	-19.39**	-30.78**	-26.93**	-25.84**
22	IB106 x RHA 586	-13.65*	-1.58	-6.89	-7.65	-34.01**	-29.26**	-32.69**	-32.06**	-11.52*	-16.07*	-10.15	-12.63**	-12.03*	-18.18*	-16.40**	-15.61**
23	IB107 x PZ8R	-16.51**	-13.97	-15.72**	-15.46**	-36.20**	-38.16**	-39.07**	-37.80**	-14.45*	-26.63**	-18.67**	-20.02**	-14.95*	-28.48**	-24.32**	-22.75**
24	IB107 x 6D-1	-17.32**	-26.48**	-29.27**	-22.82**	-36.81**	-47.16**	-45.98**	-43.22**	-15.28**	-37.30**	-27.89**	-26.98**	-15.77**	-38.88**	-32.90**	-29.48**
25	IB108 x RHA 587	7.00	23.19*	11.61*	13.55**	-18.23**	-11.46	-19.32**	-16.46**	9.64	5.06	7.70	7.43	9.00	2.41	0.22	3.75
26	IB108 x PZ8R	-6.65	-8.70	-9.07	-8.10	-28.66**	34.38**	-34.27**	-32.39**	-4.35	-22.13**	-12.25*	-13.05**	-4.91	-24.10**	-18.35**	-16.02**
27	IB109 x R-274	-10.44	4.08	-4.72	-4.03	-31.55**	-25.19**	-31.12**	-29.39**	-8.23	-11.24	-8.05	-9.20	-8.76	-13.47	-14.44**	-12.30**
28	IB109 x RHA 587	-6.54	12.91	2.54	2.52	-28.57**	-18.84**	-25.87**	-24.57**	-4.23	-3.71	-1.05	-3.00	4.79	-6.13	-7.93	-6.32
29	IB109 x PZ8R	-13.30*	-1.84	-5.93	-7.28	-33.74**	-29.45**	-31.99**	-31.79**	-11.16	-16.29*	-9.22	-12.28*	-11.68*	-18.40	-15.53**	-15.28**
30	IB110 x RHA 587	0.80	7.25	5.08	4.23	-22.96**	-22.92**	-24.04**	-23.32**	3.29	-8.54	1.40	-1.39	2.69	-10.84	-5.65	-4.76
31	IB110 x 3376R	-13.30*	-19.10*	-15.36**	-15.79**	-33.74**	-41.86**	-38.81**	-38.04**	-11.16	-31.01**	-18.32**	-20.32**	-11.68*	-32.75**	-24.00**	-2305**
32	IB110 x PZ8R	-9.40	-11.33	-10.64	-10.41*	-30.76**	-36.27**	-35.40**	-34.09**	-7.17	-24.38**	-13.77**	-15.24**	7.71	-26.29**	-19.76**	-18.14**
33	IB111 x RHA 587	3.21	7.38	6.29	5.53	-21.12**	-22.82**	-23.16**	-22.36**	5.76	-8.43	2.57	-0.15	5.14	-10.73	-4.56	-3.57
34	IB111 x 3376R	-5.16	-10.41	-10.28	-8.50	-27.52**	-35.61**	-35.14**	-32.68**	-2.82	-23.60**	-13.42*	-13.43**	-3.39	-25.52**	-19.44**	-16.39**
35	IB111 x PZ8R	-12.84**	-16.86	-14.51**	-14.65**	-33.39**	-40.25**	-38.20**	-37.20**	-10.69	-29.10**	-17.50**	-19.25**	-11.21	-30.89**	-23.24**	-22.01**
36	IB111 x RHA 586	-17.32**	-14.36	-16.08**	-14.04**	-36.81**	-38.45**	-39.34**	36.76**	-15.28**	-26.97**	-27.89**	-18.67**	-15.77**	-28.81**	-32.90**	-21.45**

* Significance at 5 % E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

** Significance at 1 %

Table 8 (Contd....) : Per cent heterosis over standard checks for oil content in sunflower over three environments

Sl. No.	Hybrids	KBSH-1				MSFH-17				MORDEN				SUNGENE-85			
		E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled	E_1	E_2	E_3	Pooled
1	IB101 x R-274	-1.73	-5.55	-6.95*	-4.81	21.02**	21.78**	16.49**	19.79**	12.51**	15.52**	8.77*	12.31**	4.49	6.95	2.42	4.66
2	IB101 x 3376R	-7.57	-3.36	-3.66	-4.78	13.81**	24.59**	20.62**	19.85**	5.82	18.19**	12.62**	12.34**	-1.73	9.42*	6.04	4.69
3	IB101 x PZ8R	0.77	4.54	8.60*	4.69	24.08**	34.78**	35.97**	31.74**	15.37**	27.85**	26.95**	23.52**	7.14	18.36**	19.54**	15.11**
4	IB102 x R-274	-2.11	-0.34	2.29	-0.03	20.54**	28.49**	28.06**	25.80**	12.07**	21.89**	19.57**	17.95**	4.08	12.84**	12.59**	9.92**
5	IB102 x RHA 587	-0.67	-4.96	-1.83	-2.59	22.31**	22.54**	22.91**	22.59**	13.72**	16.24**	14.76**	14.93**	5.61	7.61	8.06*	7.11*
6	IB102 x 3376R	-3.36	-11.68**	-0.55	-5.41*	19.01**	13.87**	24.51**	19.03**	10.65*	8.02	16.26**	11.60**	2.75	0.00	9.47*	4.00
7	IB102 x PZ8R	3.26	-0.59	2.93	1.77	27.15**	28.17**	28.87**	28.07**	18.22**	21.58**	20.32**	20.08**	9.79*	12.56**	13.29**	11.90**
8	IB102 x 6D-1	-8.15*	3.45	0.18	-1.26	13.11**	33.37**	25.43**	24.25**	5.16	26.52**	17.11**	16.50**	-2.34	17.13**	10.29**	8.56**
9	IB102 x RHA 586	-8.82*	-8.40*	-8.23*	-8.48**	12.28**	18.09**	14.89**	15.17**	4.39	12.02**	7.27	7.98**	-3.06	3.71	1.01	0.63
10	IB103 x RHA 587	-3.84	-10.00**	-6.59	-6.95**	18.42**	16.03**	16.95**	17.10**	10.10*	10.07*	9.20*	9.79**	2.24	1.90	2.82	2.31
11	IB103 x PZ8R	-2.21	-0.42	-1.46	-1.32	20.43**	28.39**	23.37**	24.18**	11.96**	21.79**	15.19**	16.42**	3.98	12.75**	8.46*	8.50**
12	IB103 x 83R-6	1.34	-8.15*	-1.28	-2.92	24.79**	18.42**	23.60**	22.17**	16.03**	12.33**	15.40**	14.54**	7.75	4.00	8.66**	6.74*
13	IB103 x 6D-1	-6.62	8.40*	6.22	2.98	14.99**	39.76**	32.99**	29.59**	6.92	32.58**	24.17**	21.50**	-0.71	22.74**	16.92**	13.22**
14	IB103 x RHA 586	-6.42	-12.61**	-7.32*	-8.93**	15.23**	12.68**	16.04**	14.60**	7.14	6.89	8.34**	7.45*	-0.51	-1.05	2.01	0.13
15	IB105 x R-274	-13.33**	-8.49*	-7.59*	-9.71**	6.73	17.98**	15.69**	13.62**	-0.77	11.92**	8.02	6.53*	-7.85	3.62	1.71	-0.73
16	IB105 x RHA 587	-2.30	-8.15*	-4.30	-5.05*	20.13**	18.42**	19.82**	19.49**	11.86**	12.33**	11.87**	12.03**	3.87	4.00	5.34	4.40
17	IB105 x 3376R	-0.77	-2.44	-0.73	-1.35	22.20**	25.79**	24.28**	24.14**	13.61**	19.32**	16.04**	16.39**	5.50	10.47**	9.26*	8.46**
18	IB105 x RHA 586	-10.33**	-6.30	-6.04	-7.64**	9.80*	20.80**	17.64**	16.23**	2.09	14.59**	9.84*	8.97**	-5.20	6.09	3.42	1.55
19	IB106 x RHA 587	-2.30	-9.66**	-4.30	-5.59*	20.31**	16.47**	19.82**	18.80**	11.86**	10.48*	11.87**	11.39**	3.87	2.28	5.34	3.80
20	IB106 x 3376R	-3.07	-6.39	-4.85	-4.84	19.36**	20.69**	19.13**	19.75**	10.98**	14.49**	11.23**	12.27**	3.06	5.99	4.73	4.63
21	IB106 x PZ8R	1.63	0.76	0.91	1.08	25.15**	29.90**	26.35**	27.20**	16.36**	23.23**	17.97**	19.26**	8.05	14.08**	11.08**	11.14**
22	IB106 x RHA 586	-7.09	-2.18	-1.83	-3.61	14.40**	26.11**	22.91**	21.30**	6.37	19.63**	14.76**	13.73**	-1.22	10.15**	8.06*	5.98*
23	IB107 x PZ8R	4.03	0.42	3.39	2.53	28.10**	29.47**	29.44**	29.02**	19.10**	22.82**	20.86**	20.96**	10.60*	13.70**	13.80**	12.73**
24	IB107 x 6D-1	-3.93	11.01**	7.41*	5.14*	18.30**	43.12**	34.48**	32.31**	9.99*	35.77**	25.56**	24.05**	2.14	25.69**	18.23**	15.66**
25	IB108 x RHA 587	-2.49	-11.01**	-3.11	-5.74*	20.07**	14.73**	21.31**	18.62**	11.64*	8.84*	13.26**	11.21**	3.67	0.76	6.65	3.64
26	IB108 x PZ8R	2.68	-1.60	-1.56	-0.24	26.45**	26.87**	23.25**	25.24**	17.56**	20.35**	15.08**	17.70**	9.17*	11.42**	8.36*	9.69**
27	IB109 x R-274	-5.85	-6.81	-4.57	-5.77*	15.94**	20.15**	19.47**	18.58**	7.79	13.98**	11.55**	11.17**	0.10	5.52	5.04	3.60
28	IB109 x RHA 587	-0.29	-5.38	-4.85	-3.61	22.79**	21.99**	19.13**	21.30**	14.16**	15.72**	11.23**	13.73**	6.01	7.14	4.73	5.98*
29	IB109 x PZ8R	0.77	0.59	1.28	0.87	24.08**	29.69**	26.80**	26.94**	15.37**	23.02**	18.40**	19.01**	7.14	13.89**	11.48**	10.91**
30	IB110 x RHA 587	3.45	-7.14*	-3.48	-2.62	27.39**	19.72**	20.85**	22.55**	18.44**	13.57**	12.83**	14.90**	9.99*	5.14	6.24	7.07*
31	IB110 x 3376R	-0.67	-3.11	-0.73	-1.56	22.31**	24.92**	24.28**	23.87**	13.72**	18.50**	16.04**	16.14**	5.61	9.71*	9.26*	8.23**
32	IB110 x PZ8R	-3.55	-1.76	5.12	-0.06	18.77**	26.65**	31.62**	25.77**	10.43*	20.14**	22.89**	17.91**	2.55	11.23**	15.71**	9.88**
33	IB111 x RHA 587	-2.21	-9.41**	-6.04	-6.04*	20.43**	16.79**	17.64**	18.24**	11.96**	10.79*	9.84*	10.85**	3.98	2.57	3.42	3.31
34	IB111 x 3376R	-17.64**	-7.14*	-7.14*	-10.43**	1.42	19.72**	16.27**	12.71**	-5.71	13.57**	8.56*	5.68	-12.44**	5.14	2.22	-1.52
35	IB111 x PZ8R	-1.53	2.10	-2.20	-0.45	21.25**	31.64**	22.45**	25.27**	12.73**	24.87**	14.33**	17.45**	4.61	15.60**	7.65*	9.45**
36	IB111 x RHA 586	-14.96**	-2.94	-4.76	-7.31**	4.72	25.14**	19.24**	16.65**	-2.63	18.71**	11.34**	9.37**	-9.58*	9.90*	4.83	1.92

* Significance at 5 % E_1 = Bangalore E_2 = Hiriyur E_3 = Katthalgere

** Significance at 1 %

hybrids showed positive heterosis significantly over KBSH-1 and MSFH-17 respectively.

4.2.3 Number of leaves per plant

From among thirty six hybrids studied, none of them expressed significant negative heterosis over KBSH-1 and Morden while, one hybrid and nineteen hybrids showed significant negative heterosis over Sungene-85 and MSFH-17 respectively. The magnitude of negative heterosis ranged from –20.49 (IB102 x 3376R) to –8.82 per cent (IB106 x PZ8R) over MSFH-17. Only one hybrid IB102 x 3376R showed negative significant heterosis (-9.98 %) over Sungene-85.

The extent of significant positive heterosis ranged from 9.97 (IB103 x 6D-1) to 28.85 per cent (IB109 x R-274), 12.34 (IB102 x 3376R) to 55.04 per cent (IB109 x R-274) and 9.60 (IB102 x RHA 586) to 24.24 per cent (IB109 x R-274) over KBSH-1, Morden and Sungene-85 respectively.

4.2.4 Plant height

As regards to plant height, none of the hybrids showed significant negative heterosis over Morden. However, ten, sixteen and three hybrids registered significant heterosis over KBSH-1, MSFH-17 and Sungene-85 respectively and the variation for negative heterosis ranged from –24.07 (IB102 x 3376R) to –6.57 per cent (IB110 x PZ8R), -25.48 (IB102 x 3376R) to –5.64 per cent (IB102 x R-274) and –16.13 (IB102 x 3376R) to –7.85 per cent (IB108 x PZ8R) over them respectively.

As for positive heterosis, all the hybrids expressed significant positive heterosis over Morden, while ten, four and twenty two hybrids showed significance for positive heterosis over KBSH-1, MSFH-17 and Sungene-85 respectively and variation ranges from 6.48 (IB107 x 6D-1) to 15.36 per cent (IB109 x R-274), 5.72 (IB106 x RHA 586) to 13.22 per cent (IB109 x R-274), 35.19 (IB108 x RHA 587) to 139.69 per cent (IB109 x R-274) and 6.20 (IB102 x R-274) to 27.43 per cent (IB109 x R-274) over them respectively.

4.2.5 Head diameter

From among hybrids studied, six hybrids showed significance for negative heterosis over MSFH-17, while none of the hybrids showed significant negative heterosis over KBSH-1, Morden and Sungene-85. However, four, one, twenty four and twenty nine hybrids exhibited significant positive heterosis over KBSH-1, MSFH-17, Morden and Sungene-85 respectively. IB109 x R-274 (11.55 %) was only the hybrid expressed significant positive heterosis over MSFH-17.

The range of negative heterosis was observed from -10.99 (IB102 x RHA 586) to -8.47 per cent (IB111 x 3376R) over MSFH-17. However the variation for positive heterosis ranged from 8.86 (IB103 x 6D-1) to 15.32 per cent (IB109 x R-274), 10.05 (IB110 x 3376R) to 28.02 per cent (IB109 x R-274) and 10.37 (IB102 x RHA 587) to 26.93 per cent (IB101 x R-274) over KBSH-1, Morden and Sungene-85 respectively.

4.2.6 Stem diameter

None of the 36 hybrids studied showed significant positive heterosis for stem diameter over MSFH-17, while three, thirty one and twenty two hybrids exhibited significant positive heterosis over KBSH-1, Morden and Sungene-85 respectively. The extent of positive heterosis ranged from 10.38 (IB107 x 6D-1) to 16.95 per cent (IB109 x PZ8R), 11.97 (IB105 x R-274) to 40.16 per cent (IB109 x PZ8R) and 10.82 (IB107 x PZ8R) to 32.83 per cent (IB109 x PZ8R) over them respectively.

None of the hybrids among studied registered significant negative heterosis over Morden and Sungene-85, while three and twenty hybrids recorded over KBSH-1 and MSFH-17 respectively. Heterotic effect in negative direction for stem diameter ranged from -16.03 (IB102 x RHA 587) to -9.33 per cent (IB102 x

RHA 586), -23.56 (IB102 x RHA 587) to -8.73 per cent (IB101 x R-274) over KBSH-1 and MSFH-17 respectively.

4.2.7 Seed yield per plant

From among thirty six new hybrids all of them failed to show significant positive heterosis for seed yield per plant over MSFH-17, while two, twenty seven and two hybrids expressed significance for positive heterosis over KBSH-1, Morden and Sungene-85 respectively. The magnitude of positive heterosis ranged from 39.24 (IB106 x PZ8R) to 91.24 per cent (IB109 x RHA 587) and 18.53 (IB103 x RHA 586) to 26.56 per cent (IB109 x RHA 587) over Morden and Sungene-85 respectively. IB103 x RHA 586 (19.48 %) and IB109 x RHA 587 (27.58 %) recorded significant positive heterosis over KBSH-1

4.2.8 Hundred seed weight

All the thirty six hybrids included under investigation failed to express significant positive heterosis for hundred seed weight over MSFH-17, while seven and five hybrids had positive heterosis over KBSH-1 and Sungene-85 respectively. IB105 x RHA 587 was the only hybrid showed significant positive heterosis over Morden.

The variation of positive heterosis ranged from 9.28 (IB103 x PZ8R) to 17.15 per cent (IB105 x RHA 587), 9.16 (IB106 x PZ8R) to 15.20 per cent (IB105 x RHA 587) over MSFH-17 and Sungene-85 respectively.

4.2.9 Per cent seed filling

None of the new hybrids exhibited significant positive heterosis for per cent seed filling over KBSH-1 and Sungene-85. While seven hybrids showed significant positive heterosis over MSFH-17 and Morden. The magnitude of positive heterosis for this character ranged from 3.58 (IB103 x PZ8R) to 6.30 per cent (IB105 x RHA 586) and 3.44 (IB103 x PZ8R) to 6.16 per cent (IB105 x RHA 586) over MSFH-17 and Morden respectively.

As for negative heterosis, none of the hybrids showed significance over MSFH-17 and Morden, while thirteen and ten hybrids showed significance over KBSH-1 and Sungene-85 respectively.

4.2.10 Husk content

Among hybrids studied, none of the hybrids showed significant positive heterosis over MSFH-17, Morden and Sungene-85 but two hybrids showed significant over KBSH-1 (IB105 x RHA 587 (12.86 %) and IB108 x RHA 57 (13.55 %)). As for negative heterosis is concerned, all 36 hybrids showed significance over MSFH-17, while twelve, twenty three and twenty seven hybrids showed significance over KBSH-1, Morden and Sungene-85 respectively.

Negative heterotic effect for husk content ranged from -22.82 (IB107 x 6D-1) to -10.4 per cent (IB110 x PZ8R), -43.22 (IB107 x 6D-1) to -16.46 per cent (IB108 x RHA 587), -26.98 (IB107 x 6D-1) to -10.74 per cent (IB102 x 3376R) and -29.48 (IB107 x 6D-1) to -10.19 per cent (IB102 x RHA 587) over KBSH-1, MSFH-17, Morden and Sungene-85 respectively.

4.2.11 Oil content

All the thirty six hybrids included under studies exerted significant positive heterosis over MSFH-17, while one, thirty five and twenty hybrids showed significance over KBSH-1, Morden and Sungene-85 respectively. Whereas, none of the hybrids studied showed negative heterosis over MSFH-17, Morden and Sungene-85, while, fourteen hybrids showed significance heterosis over KBSH-1 for this character.

The magnitude of positive heterosis for oil content ranged from 13.62 (IB105 x R-274) to 32.31 per cent (IB107 x 6D-1), 6.53 (IB105 x R-274) to 24.05 per cent (IB107 x 6D-1) and 5.98 (IB106 x RHA 586) to 15.66 per cent (IB107 x 6D-1) over MSFH-17, Morden and Sungene-85 respectively.

4.3 Genotype x environment interaction

The basic step in stability analysis would be identification and confirmation of existence of genotype x environment interaction. Therefore, pooled analysis of variance was carried out for forty genotypes (including checks) across three environments for twelve characters that showed highly significant genotypic differences at all the environments. Analysis of variance for individual environment are presented in Table 6.

The results of pooled analysis of variance for different characters are presented in Table 9. The results of pooled ANOVA revealed significant genotype x environment interaction for all the characters. The genotypic differences were significant at one per cent for days to 50 per cent flowering, days to maturity, plant height, head diameter, seed yield per plant, hundred seed weight, kernel weight, husk content and oil content and showed significance at five per cent for stem diameter. However genotypic differences were non significant for number of leaves per plant and per cent seed filling. Environmental differences showed significance for all the characters at one per cent except number of leaves per plant that showed significance at five per cent level.

Since, genotype x environment interaction found significant for all the characters, it was further partitioned following Eberhart and Russel's (1966) model in order to know the magnitude of predictable and unpredictable source of variation towards genotype x environment interaction, The results have been presented in Table 10.

Firstly, pooled deviation (unpredictable portion of G x E interaction) was tested for significance against pooled error mean square. Pooled deviation found highly significant for all the characters except hundred seed weight, kernel weight, husk content and oil content. Further, pooled deviation mean square was used as denominator to test the variance components of stability for all the characters except for hundred seed weight, kernel weight, husk content and oil

Table 9 : Pooled analysis of variance in respect of yield and yield attributes in sunflower over three environments (Kharif, 1997)

Source of variation	d.f.	Mean sum of squares					
		Days to 50 % flowering	Days to maturity	Number of leaves per plant	Plant height	Head diameter	Stem diameter
Genotypes (G)	39	34.97**	33.06**	13.18	817.46**	1.53**	0.05*
Environment (E-1)	2	80.74**	159.85**	39.48*	29054.75**	214.31**	8.00**
Genotype x Environment (G x E)	78	2.79**	2.13**	10.47**	107.23**	0.684**	0.03**
Pooled error	234	0.62	0.53	2.11	26.46	0.36	0.01

Table 9 : Contd.......

Source of variation	d.f.	Mean sum of squares					
		Seed yield per plant	100 seed weight	Per cent seed filling	Kernel weight	Husk content	Oil content
Genotypes (G)	39	44.13**	0.52**	7.78	0.07**	27.73**	10.87**
Environment (E-1)	2	731.00**	2.19**	576.91**	0.27**	45.34**	199.99**
Genotype x Environment (G x E)	78	25.19**	0.07**	30.31**	0.01**	1.91**	1.84**
Pooled error	234	7.93	0.233	2.96	0.005	1.72	0.92

* Significance at 5 per cent

** Significance at 1 per cent

Table 10 : Analysis of variance for stability (Eberhart and Ruseel, 1996) in respect of yield and yield attributes in sunflower (Kharif, 1997)

Source of variation	d.f.	Mean sum of squares					
		Days to 50 % flowering	Days to maturity	Number of leaves per plant	Plant height	Head diameter	Stem diameter
Genotypes (G)	39	34.97**	33.06**	13.18**	817.46**	1.53**	0.05
Environment (E-1)	2	80.74**	159.85**	39.48*	29054.75**	214.31**	8.00**
Genotype x Environment (G x E)	78	2.79**	2.13**	10.47**	107.23**	0.684**	0.03**
Environment + (G x E)	80	4.74	6.08**	6.09	830.93**	6.02**	0.23**
Environment (Linear)	1	161.48**	319.69**	78.96**	58109.49**	428.62**	16.00**
G x E (Linear)	39	2.30	1.95	5.53	125.89	0.78	0.03
Pooled deviation	40	3.30**	2.33**	4.95**	88.58**	0.58**	0.04**
Pooled error	234	0.62	0.53	2.11	26.46	0.36	0.01

Table 10 : Contd.......

Source of variation	d.f.	Mean sum of squares					
		Seed yield per plant	100 seed weight	Per cent seed filling	Kernel weight	Husk content	Oil content
Genotypes (G)	39	44.13	0.52**	7.78	0.07**	27.73**	10.87**
Environment (E-1)	2	731.00**	2.19**	576.91**	0.27**	45.34**	199.99**
Genotype x Environment (G x E)	78	25.19**	0.07**	30.31**	0.01**	1.91**	1.84**
Environment + (G x E)	80	42.84	0.130**	43.97	0.01**	2.99**	6.79**
Environment (Linear)	1	1462.00**	4.37**	1153.82**	0.54**	90.68**	399.79**
G x E (Linear)	39	14.90	0.13**	22.35	0.54**	3.45**	3.13**
Pooled deviation	40	35.49**	0.023	38.28**	0.001	0.38	0.56
Pooled error	234	7.93	0.233	2.96	0.005	1.91	0.92

* Significance at 5 per cent

** Significance at 1 per cent

content, for them pooled error mean square was used.

Variance due to genotypes found highly significant for all the characters except for stem diameter, seed yield per plant and per cent seed filling. Environment (linear) was found highly significant for all the characters. The variance due to genotype x environment (linear) was found significant only for hundred seed weight, kernel weight, husk content and oil content. Since G x E interactions were found significant for all the characters, the data was further subjected to stability analysis.

4.4 Stability analysis

Stability parameters were estimated as per the linear regression model given by Eberhart and Russel (1966) for all the 12 characters in respect of 40 genotypes. Results obtained on three stability parameters viz., mean ($\bar{x}$), regression coefficient (bi) and deviation from regression (S^2di) are presented character wise and summarized in Table-11. Where, the "significant bi" indicates that regression coefficient is deviating significantly from unity, while the "significant S^2di" refers significant deviation of S^2di from zero.

4.4.1 Days to 50 per cent flowering

For earliness, the genotypes with low mean values are preferred. Four out of 40 genotypes viz., IB108 x PZ8R, Sungene-85, IB108 x RHA 587 and IB106 x PZ8R flowered early with non significant regression coefficient and mean square deviations. On contrary, genotypes, IB103 x 83R-6, IB107 x 6D-1, IB101 x R-274 and IB102 x R-274 recorded highest mean value with non significant regression coefficient and mean square deviation. Although, Morden recorded lowest mean value out of genotypes included in investigation with non significant regression coefficient, it showed significance for mean square deviation. From among forty genotypes, twenty one recorded below grand mean and thirteen genotypes exhibited significance for deviation from regression coefficient. While none of the genotypes showed significance for regression coefficient.

Table 11 : Stability parameters over three enviornments for 40 genotypes in sunflower

Sl. No.	Genotypes	Days to 50 per cent flowering			Days to maturity			Number of leaves per plant		
		Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
1	IB101 x R-274	61.67	0.92	-0.45	90.67	1.48	0.58	27.55	1.35	-0.41
2	IB101 x 3376R	61.44	0.11	0.74	89.56	0.53	6.62**	22.49	1.63	-0.10
3	IB101 x PZ8R	60.67	1.00	-0.46	90.22	0.73	0.62	24.82	1.72	-2.10
4	IB102 x R-274	61.67	1.60	-0.11	90.33	0.68	-0.03	26.20	3.81	2.97
5	IB102 x RHA 587	54.17	0.82	-0.57	85.11	1.95	1.60*	21.93	0.55	0.23
6	IB102 x 3376R	56.56	-1.03	1.84*	85.44	-0.06	0.40	21.04	0.36	3.68
7	IB102 x PZ8R	58.78	0.45	-0.01	87.44	0.25*	-0.52	22.33	1.42	4.53
8	IB102 x 6D-1	61.56	2.09	-0.19	90.56	1.28	1.15	21.62	0.93	-1.99
9	IB102 x RHA 586	57.89	1.86	-0.31	87.67	1.35	-0.17	25.62	0.87	10.77*
10	IB103 x RHA 587	55.78	0.60	0.65	85.00	0.68	-0.03	26.56	-0.41	4.91
11	IB103 x PZ8R	60.78	0.92	12.45**	88.11	0.99	-0.34	24.58	2.98	-0.14
12	IB103 x 83R-6	62.33	1.99	-0.39	90.78	1.10	0.07	25.18	1.37	-2.07
13	IB103 x 6D-1	61.00	1.64	2.57*	90.00	1.11	0.57	24.79	0.47	0.90
14	IB103 x RHA 586	58.67	1.78	0.17	87.67	1.44	0.46	27.80	3.72	0.93
15	IB105 x R-274	61.00	1.62	-0.32	90.22	1.28	1.14	23.87	6.27	-1.90
16	IB105 x RHA 587	54.67	0.85	-0.61	83.78	1.08	-0.53	23.87	0.95	5.24
17	IB105 x 3376R	57.22	1.00	2.76*	86.00	1.30	2.87*	24.02	0.40	3.71
18	IB105 x RHA 586	60.89	1.89	3.19*	90.78	1.19	0.84	24.98	3.44	10.96*
19	IB106 x RHA 587	54.89	1.26	-0.30	84.44	1.34	-0.42	24.87	0.38	-1.84
20	IB106 x 3376R	54.67	1.76	-0.48	83.78	1.84	-0.47	22.24	0.20	-2.04
21	IB106 x PZ8R	54.00	2.29	0.42	84.22	1.65	0.12	24.13	0.65	-1.25
22	IB106 x RHA 586	58.44	1.52	-0.09	88.00	2.01	-0.28	26.71	-0.12	-1.56
23	IB107 x PZ8R	57.89	0.43	2.49*	87.67	0.76	-0.45	22.20	-1.19	-0.09
24	IB107 x 6D-1	62.33	0.46	-0.57	91.11	0.75	-0.53	23.20	0.67	-0.01
25	IB108 x RHA 587	53.67	0.93	0.09	83.22	0.93	-0.25	22.07	3.26	-1.30
26	IB108 x PZ8R	51.78	0.80	1.54	81.56	0.55	2.93*	21.96	1.88	-0.76
27	IB109 x R-274	61.11	1.91	0.33	90.44	1.08	-0.53	29.04	-0.41	3.26
28	IB109 x RHA 587	56.56	0.31	14.63**	85.67	0.40	9.76**	25.64	-0.56	-2.06
29	IB109 x PZ8R	56.78	-0.37	9.80**	86.11	0.04	4.19**	25.80	-0.41	-1.12
30	IB110 x RHA 587	55.67	1.27	6.42**	85.33	1.36	8.95**	23.62	-0.62**	-2.11
31	IB110 x 3376R	54.54	1.47	8.51**	84.00	1.28	6.54**	23.33	1.79	-1.99
32	IB110 x PZ8R	54.89	0.35	0.31	84.44	0.34	-0.29	23.16	2.48	-1.58
33	IB111 x RHA 587	55.33	0.28	2.62*	84.56	0.62	4.67**	24.60	1.54	-1.96
34	IB111 x 3376R	54.11	1.45	0.76	83.78	1.27	0.03	22.96	-1.23	-1.79
35	IB111 x PZ8R	55.22	1.21	9.53**	84.00	1.27	11.54**	21.78	0.78	8.82*
36	IB111 x RHA 586	60.22	0.70	1.04	89.33	1.13	2.77**	26.11	2.34	9.57**
37	KBSH-1	57.44	1.24	5.73**	86.44	0.95	2.09*	22.54	-1.29	73.49**
38	MSFH-17	55.78	1.01	6.25**	85.33	1.05	4.69**	26.47	-2.66	-0.41
39	Morden	48.00	-0.67	14.48**	75.56	1.16	-0.21	18.73	0.55	-2.71
40	Sungene-85	52.22	0.26	0.59	81.56	0.84	-0.51	23.78	-0.16*	-2.10
	Grand mean	57.30			86.49			24.09		

Trt. Mean = Treatment mean bi = Regression coefficient

S^2di = Deviation from regression coefficient (Contd.....)

* Signaificance 5 %

** significance at 1 %

Table 11 : Stability parameters over three enviornments for 40 genotypes in sunflower (Contd.....)

Sl. No.	Genotypes	Plant height (cm)			Head diameter (cm)			Stem diameter (cm)		
		Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
1	IB101 x R-274	157.40	1.25	16.95	12.78	1.00	1.13*	1.70	0.81	0.05*
2	IB101 x 3376R	136.07	1.07	-26.25	11.91	0.54*	-0.36	1.78	1.15	-0.01
3	IB101 x PZ8R	150.76	1.32	-24.09	11.46	1.51	-0.31	1.78	1.67	0.11**
4	IB102 x R-274	143.42	1.03	428.65**	12.42	0.85	0.81	1.61	0.61	0.04*
5	IB102 x RHA 587	132.04	0.84	42.39	11.11	1.12	0.02	1.42	0.95	0.02
6	IB102 x 3376R	113.27	0.91	37.97	11.84	0.89	-0.25	1.53	0.86	0.00
7	IB102 x PZ8R	138.40	1.10	56.34	11.82	1.15	-0.07	1.58	0.92	0.01
8	IB102 x 6D-1	144.98	0.84	-24.86	12.47	1.02	-0.28	1.79	0.78	0.00
9	IB102 x RHA 586	142.67	0.82	15.44	10.62	0.53	2.35**	1.53	0.88	-0.01
10	IB103 x RHA 587	155.76	0.51	-14.20	11.90	0.64	-0.32	1.69	0.82	0.03*
11	IB103 x PZ8R	140.89	1.22	67.96	11.56	1.25	0.04	1.60	0.88	0.05*
12	IB103 x 83R-6	146.22	1.25	-11.39	12.33	1.59	-0.31	1.73	0.99	0.05*
13	IB103 x 6D-1	152.27	1.16	-4.27	12.56	1.39	0.72	1.97	1.07	0.05*
14	IB103 x RHA 586	163.11	1.52	-18.04	12.58	1.59	0.02	1.72	1.30	0.01
15	IB105 x R-274	142.49	1.70	477.74**	12.00	1.47	2.20**	1.58	1.34	0.17*
16	IB105 x RHA 587	152.27	1.01	22.29	11.68	1.03	0.81	1.76	0.97	0.09**
17	IB105 x 3376R	139.29	0.91	-21.49	12.32	1.06	0.31	1.70	1.12	0.02
18	IB105 x RHA 586	150.58	1.46	301.09**	12.11	1.12	-0.16	1.61	1.40	0.03
19	IB106 x RHA 587	153.38	0.95	32.87	11.32	0.91	-0.33	1.67	1.02	-0.01
20	IB106 x 3376R	137.07	1.06	117.13*	12.00	0.60**	-0.36	1.70	0.97	0.00
21	IB106 x PZ8R	145.96	0.89	54.72	11.16	0.72	-0.14	1.75	1.01	0.02
22	IB106 x RHA 586	160.69	1.14	-14.25	12.49	1.04	-0.21	1.80	0.77	0.10*
23	IB107 x PZ8R	150.09	1.09	-15.70	11.60	1.11	-0.30	1.64	0.70	-0.01
24	IB107 x 6D-1	158.84	1.28	-20.48	11.27	1.03	0.03	1.87	0.91	0.00
25	IB108 x RHA 587	121.91	1.10	104.19*	10.82	0.85	0.06	1.66	1.88	0.01
26	IB108 x PZ8R	124.44	0.78	43.62	10.82	0.94	2.37**	1.56	0.83	-0.01
27	IB109 x R-274	172.09	0.81	160.68**	13.30	1.13	0.36	1.84	0.92	0.02
28	IB109 x RHA 587	163.38	0.73	166.20**	12.43	1.02	-0.34	1.82	0.70	0.04*
29	IB109 x PZ8R	160.36	0.70	195.55**	11.71	0.82	-0.28	1.98	0.95	0.04*
30	IB110 x RHA 587	152.87	0.60	79.31*	11.51	0.75	-0.13	1.60	0.66	0.04*
31	IB110 x 3376R	131.04	1.24	20.16	11.43	1.12	0.91	1.72	1.04	0.00
32	IB110 x PZ8R	139.28	0.92	-22.69	10.76	1.02	-0.35	1.56	1.03	0.00
33	IB111 x RHA 587	146.51	0.77	-14.60	10.89	0.93	0.56	1.60	0.86	0.01
34	IB111 x 3376R	132.49	0.86	126.11*	10.92	0.99	-0.32	1.64	0.69	0.02
35	IB111 x PZ8R	143.29	1.29	-1.32	11.01	0.89	0.25	1.59	0.92**	-0.01
36	IB111 x RHA 586	147.31	1.43	61.52	11.18	0.96	0.39	1.60	1.24	0.00
37	KBSH-1	149.18	0.89	-4.94	11.53	1.10	-0.23	1.69	1.28	0.00
38	MSFH-17	152.00	0.53	55.73	11.93	0.53	0.56	1.86	0.90	0.15**
39	Morden	73.80	0.29*	-25.80	10.39	1.14	-0.32	1.41	1.30	0.03*
40	Sungene-85	135.04	0.71	-22.70	10.07	0.64	-0.25	1.48	0.92	0.01
	Grand mean	143.82			11.65			1.69		

Trt. Mean= Treatment mean bi = Regression coefficient

S^2di = Deviation from regression coefficient

* Signaificance 5 %

** significance at 1 %

Table 11 : Stability parameters over three enviornments for 40 genotypes in sunflower (Contd.....)

Sl. No.	Genotypes	Seed yield per plant (g)			100 seed weight (g)			Per cent seed filling (%)		
		Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
1	IB101 x R-274	25.27	0.49	47.21**	2.87	1.89*	-0.02	89.95	0.21	25.89**
2	IB101 x 3376R	20.09	0.42	8.88	2.95	1.40	-0.02	85.17	-0.03	134.35**
3	IB101 x PZ8R	23.89	1.10	17.43	3.51	2.24*	-0.02	87.99	1.90*	-2.92
4	IB102 x R-274	19.72	0.89	42.56*	2.98	2.31	0.10*	87.68	1.29	5.93
5	IB102 x RHA 587	23.67	1.25	1.58	3.28	0.13	-0.02	88.34	1.57	8.76*
6	IB102 x 3376R	17.36	0.88	67.30**	3.06	2.60*	-0.02	83.81	0.96	13.00*
7	IB102 x PZ8R	25.03	0.73	0.90	3.46	0.83	-0.02	89.57	1.27	-1.36
8	IB102 x 6D-1	24.57	-0.14	-4.75	2.96	0.78	-0.02	88.08	-0.26	105.75**
9	IB102 x RHA 586	16.01	0.50	-7.21	2.52	1.11	-0.02	86.43	0.94	25.78**
10	IB103 x RHA 587	28.10	1.79*	-7.81	4.04	0.01	-0.02	85.98	2.00	39.03**
11	IB103 x PZ8R	26.65	1.02	90.31**	3.95	1.14	-0.02	89.23	0.46	22.39**
12	IB103 x 83R-6	25.61	0.32	12.88	3.82	0.82	-0.02	85.64	-1.33	32.61**
13	IB103 x 6D-1	29.36	0.25	336.40**	3.71	1.65	0.00	86.19	0.15	81.23**
14	IB103 x RHA 586	30.24	1.62	116.60**	3.26	0.86	-0.02	89.92	1.77	8.46*
15	IB105 x R-274	24.63	1.16	8.11	3.36	1.88	-0.01	88.73	0.80	20.29**
16	IB105 x RHA 587	29.60	1.45	3.33	4.23	1.63*	-0.02	86.11	1.73	105.01**
17	IB105 x 3376R	26.98	1.60	-6.38	3.76	1.45	-0.02	86.03	1.67	-2.60
18	IB105 x RHA 586	25.56	1.04	-1.15	3.25	1.39	-0.02	91.58	0.13	0.17
19	IB106 x RHA 587	25.44	1.48	7.37	3.58	-0.59	-0.02	88.77	1.67	38.83**
20	IB106 x 3376R	19.02	1.40	-1.94	3.30	1.51	0.13**	86.70	0.71	0.26
21	IB106 x PZ8R	23.42	0.94	12.77	4.01	-0.05	-0.01	88.27	2.14	-1.08
22	IB106 x RHA 586	25.88	1.10	6.56	3.20	1.33	0.03	89.31	0.95	1.09
23	IB107 x PZ8R	23.86	0.86	7.56	3.62	0.23	-0.01	87.31	0.56	-2.92
24	IB107 x 6D-1	21.10	-0.12	69.67**	3.44	2.51	0.09*	85.36	-0.30	305.55**
25	IB108 x RHA 587	24.17	1.61	-0.67	3.65	-0.92	0.00	88.59	2.13	3.69
26	IB108 x PZ8R	21.12	0.75	14.46	3.51	-1.33	0.02	89.39	1.33	28.29**
27	IB109 x R-274	28.53	1.70*	-7.86	3.32	1.47	-0.02	87.13	1.80	3.40
28	IB109 x RHA 587	32.29	1.86	63.54**	3.90	-0.60	0.11*	88.66	1.90	18.78**
29	IB109 x PZ8R	29.26	1.65	43.28*	4.11	1.61*	-0.02	87.59	1.44	72.56**
30	IB110 x RHA 587	28.34	0.87	-4.41	3.90	0.10	-0.02	87.53	1.50	61.49**
31	IB110 x 3376R	23.88	1.50	-2.04	3.88	1.66	-0.02	87.53	1.58*	-2.96
32	IB110 x PZ8R	25.54	1.46	-0.58	4.18	0.81	-0.02	86.76	2.47	47.23**
33	IB111 x RHA 587	25.90	1.01	24.69*	3.98	0.45	0.07*	88.40	1.35	48.23**
34	IB111 x 3376R	21.28	-0.23*	-7.82	3.62	1.41	-0.01	86.04	0.79	-2.66
35	IB111 x PZ8R	26.42	0.66	1.68	3.63	0.38	-0.02	88.78	1.89	-2.74
36	IB111 x RHA 586	20.96	0.22	0.88	2.92	1.33	0.03	88.24	-0.04	46.38**
37	KBSH-1	25.31	0.67	-7.71	3.61	0.61	-0.02	89.83	0.48	12.73*
38	MSFH-17	30.12	0.88	69.91**	4.19	0.97	-0.02	86.15	1.24	-0.97
39	Morden	16.82	0.72	34.13*	3.90	2.35*	-0.02	86.27	-0.57	62.97**
40	Sungene-85	25.51	0.53	17.60	3.68	1.41	-0.02	89.20	0.20	17.52**
	Grand mean	24.67			3.55			87.68		

Trt. Mean= Treatment mean bi = Regression coefficient

S^2di = Deviation from regression coefficient

* Signaificance 5 %

** significance at 1 %

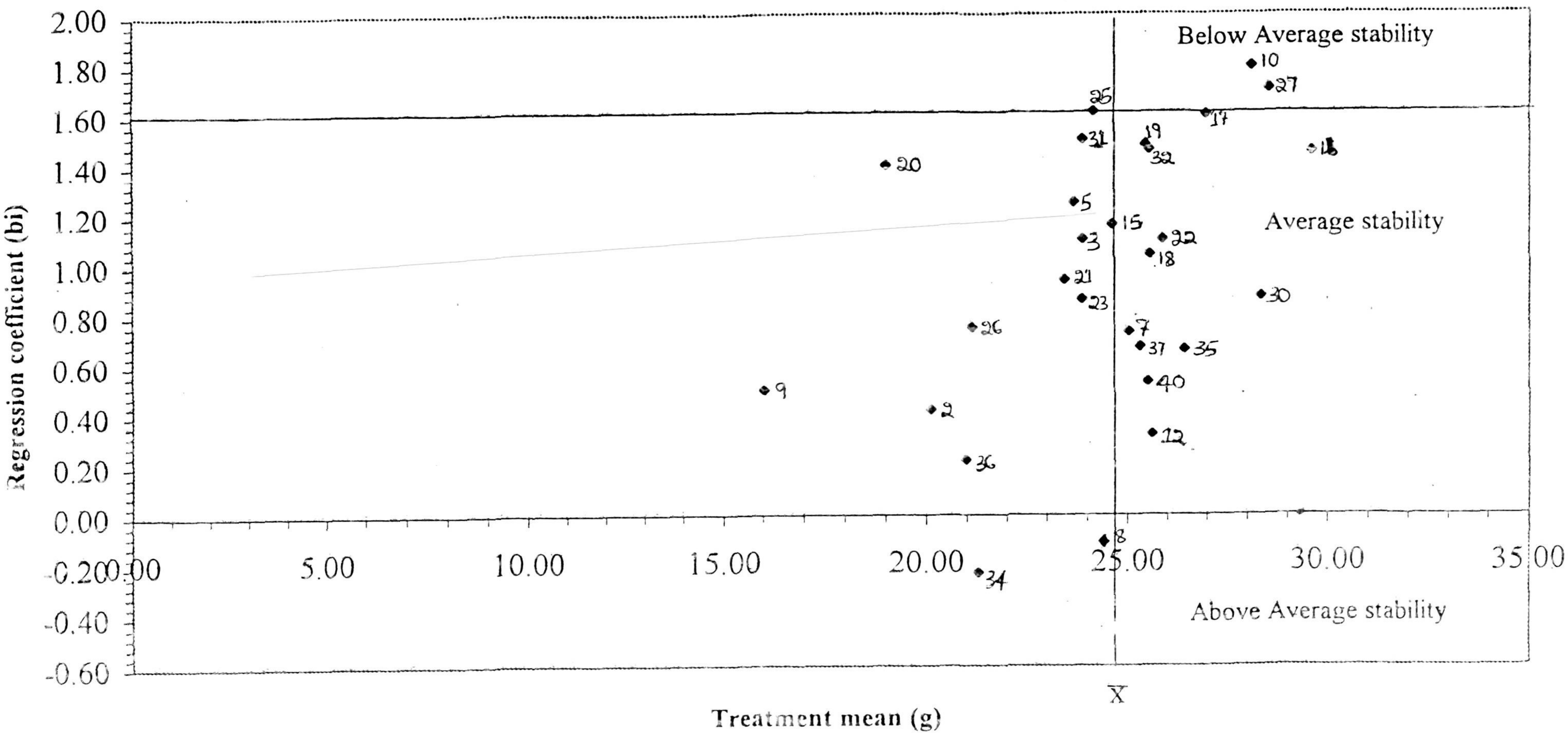

Fig. 1: Mean seed yield per plant in relation to stability

Table 11 : Stability parameters over three enviornments for 40 genotypes in sunflower (Contd.....)

Sl. No.	Genotypes	Kernel weight (g)			Husk content (%)			Oil content (%)		
		Trt. Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
1	IB101 x R-274	1.02	0.92	0.00	22.03	-0.11	-1.00	35.18	0.76	1.24
2	IB101 x 3376R	1.08	1.20	0.00	27.58	1.90	3.59	35.19	1.59*	-0.92
3	IB101 x PZ8R	1.28	0.10	0.00	24.70	-0.24	-1.47	38.69	1.42	0.67
4	IB102 x R-274	1.00	1.01	0.00	23.97	-0.34*	-1.71	36.94	1.22	-0.61
5	IB102 x RHA 587	1.11	-0.26	0.00	26.84	1.37	-1.51	36.00	0.71	-0.88
6	IB102 x 3376R	1.09	1.61	0.00	25.77	0.78	-1.72	34.96	0.30	1.66
7	IB102 x PZ8R	1.31	1.07	0.00	22.87	1.14	-1.70	37.61	1.79*	-0.92
8	IB102 x 6D-1	0.98	0.52	0.00	22.82	1.55*	-1.72	36.49	2.03	-0.84
9	IB102 x RHA 586	0.83	0.93	0.00	27.41	0.79	-1.71	33.82	1.04	-0.80
10	IB103 x RHA 587	1.39	-0.71	0.00	28.44	0.69	-1.23	34.39	0.51	-0.78
11	IB103 x PZ8R	1.38	1.94	0.00	25.04	3.53*	-1.66	36.47	1.24	-0.63
12	IB103 x 83R-6	1.34	1.14	0.00	26.19	-0.35*	-1.71	35.88	1.57*	-0.90
13	IB103 x 6D-1	1.17	1.36	0.00	23.72	1.83	-1.42	38.06	0.34	0.28
14	IB103 x RHA 586	1.20	1.04	0.00	24.97	-1.31	-1.52	33.66	0.47	-0.88
15	IB105 x R-274	1.22	1.51	0.00	25.66	1.14	-1.52	33.37	1.37	-0.62
16	IB105 x RHA 587	1.42	0.48	0.00	30.82	-1.03	-1.33	35.09	0.55	-0.88
17	IB105 x 3376R	1.32	1.92*	0.00	24.68	1.80	-1.70	36.46	0.94	-0.87
18	IB105 x RHA 586	1.11	1.08	0.00	26.31	0.18	-1.05	34.13	1.38	-0.83
19	IB106 x RHA 587	1.23	-0.03	0.00	28.82	-0.60**	-1.72	34.89	1.92**	-0.92
20	IB106 x 3376R	1.18	1.68*	0.00	25.56	1.51	-1.65	35.17	0.77	-0.66
21	IB106 x PZ8R	1.54	-0.63	0.00	22.17	0.93	-1.69	37.36	1.04	-0.58
22	IB106 x RHA 586	1.07	0.35	0.00	25.22	0.13	-1.44	35.62	1.45	-0.79
23	IB107 x PZ8R	1.37	-0.19	0.00	23.09	1.18	-1.72	37.89	0.82	-0.89
24	IB107 x 6D-1	1.23	0.97	0.00	21.08	1.50	-0.76	38.86	0.57	-0.50
25	IB108 x RHA 587	1.25	-0.87*	0.00	31.01	-0.05	-1.63	34.83	0.31	-0.55
26	IB108 x PZ8R	1.32	-2.00*	0.00	25.10	1.48	-1.61	36.87	0.76	0.35
27	IB109 x R-274	1.12	1.29	0.00	26.21	-0.14*	-1.71	34.82	0.95	-0.92
28	IB109 x RHA 587	1.31	-0.11	0.00	28.00	-0.63	-1.54	35.62	0.66	0.26
29	IB109 x PZ8R	1.54	1.43	0.00	25.32	0.22	-1.20	37.28	1.09	-0.82
30	IB110 x RHA 587	1.28	-0.64	0.00	28.47	1.05	-1.52	35.99	0.21	0.04
31	IB110 x 3376R	1.37	0.79	0.00	23.00	2.24*	-1.72	36.38	0.87	-0.90
32	IB110 x PZ8R	1.42	1.12	0.00	24.47	1.84*	-1.71	36.93	1.19	2.43
33	IB111 x RHA 587	1.27	0.57	0.00	28.42	1.36	-1.58	34.72	0.44	-0.63
34	IB111 x 3376R	1.31	1.63	0.00	24.99	1.27	-1.27	33.10	0.82	0.37
35	IB111 x PZ8R	1.32	1.16	0.00	23.31	2.03*	-1.72	36.79	1.42	0.60
36	IB111 x RHA 586	1.03	1.49	0.00	23.48	1.82	-1.22	34.26	0.99	-0.28
37	KBSH-1	1.24	0.71	0.00	27.31	1.78*	-1.72	36.96	1.10	-0.67
38	MSFH-17	1.26	1.21	0.00	37.12	1.41	-0.67	29.37	0.57	-0.86
39	Morden	1.40	0.44	0.00	28.87	-0.63	-1.65	31.32	1.46*	-0.90
40	Sungene-85	1.18	0.88	0.00	29.89	-0.82	-0.45	33.61	0.53	-0.61
	Grand mean	1.24			26.03			35.52		

Trt. Mean= Treatment mean bi = Regression coefficient

S^2di = Deviation from regression coefficient

* Signaificance 5 %

** significance at 1 %

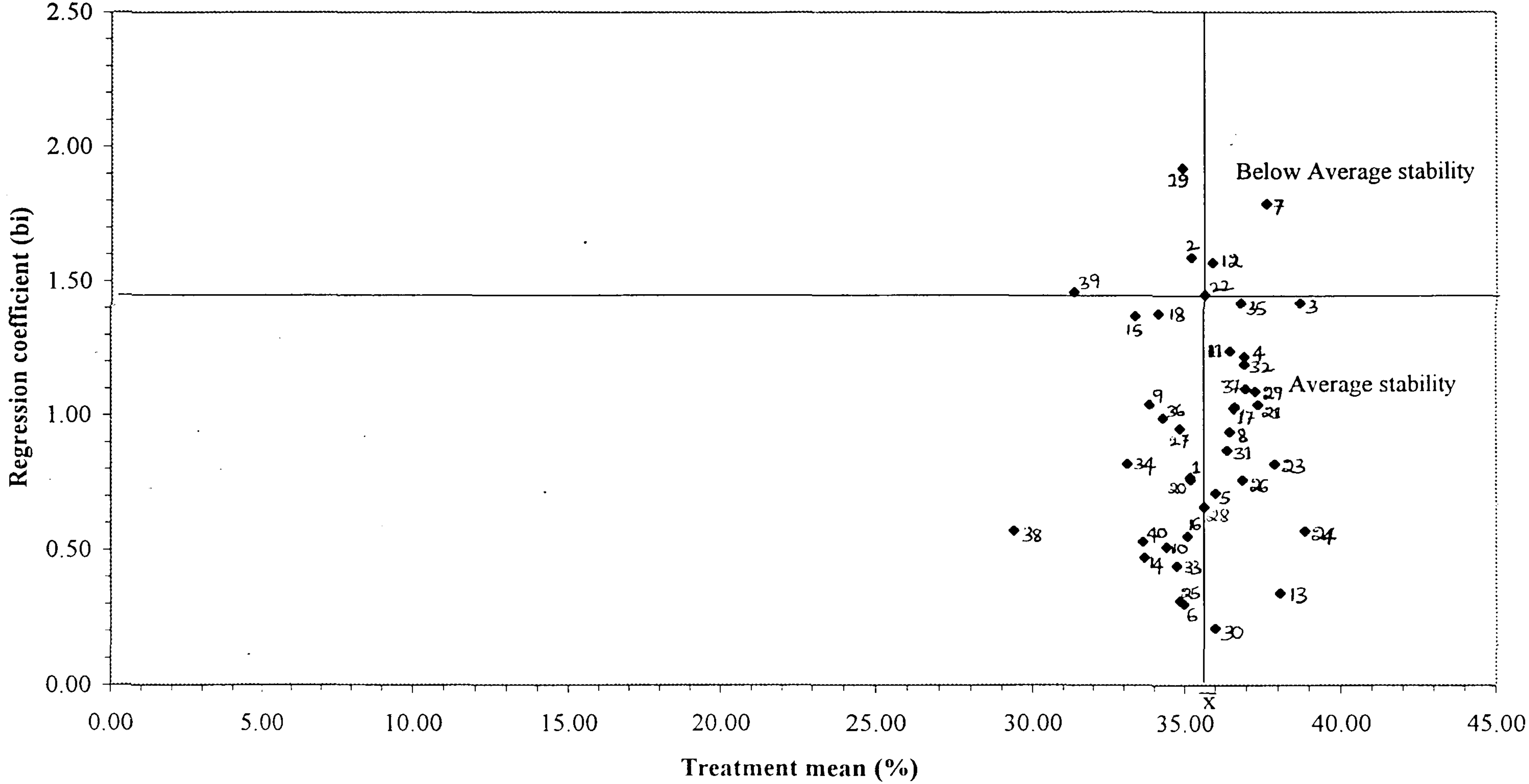

Fig. 2 : Mean oil content (%) in relation to stability

4.4.2 Days to maturity

Stability parameters for days to maturity are summarized in the Table 11. As for days to maturity is concerned, early maturing genotypes are desirable. Twenty two genotypes matured earlier to average mean but, all the genotypes studied showed non significant difference for regression coefficient except for IB102 x PZ8R. However, significance for mean square deviation was observed by eleven genotypes. Eleven out of twenty two genotypes that recorded lowest mean were also showed non-signifiance for regression coefficient and mean square deviation.

Lowest days to maturity was recorded by Morden followed by Sungene-85, IB108 x RHA 587, IB111 x 3376R, IB105 x RHA 587 and showed non significance for regression coefficient and deviation from regression. On contrary, IB105 x RHA 586 recorded highest mean for this trait followed by IB103 x 83R-6 and IB101 x R-274, in addition to non significant bi and S^2di values.

4.4.3 Number of leaves per plant

Among the genotypes included under investigation, nineteen recorded below grand mean, two showed significance for regression coefficient, while, five exhibited significance for deviation from regression coefficient. Morden recorded lowest number of leaves per plant followed by IB102 x 3376R and IB102 x 6D-1 in addition to non significance for regression coefficient and deviation from regression. Highest mean was exhibited by IB109 x R-274 with non significance for bi and S^2di values. Hybrids viz., Sungene-85 and IB110 x RHA 587 showed significance for regression value in addition to lower grand mean and non significant S^2di value, where as, KBSH-1 and IB111 x RHA 586 recorded significance for S^2di but, showed non significance for bi values with below grand mean.

4.4.4 Plant height

The mean and stability parameters are summarized in Table-11. The highest plant height was recorded by IB109 x R-274 (172.09 cm) and lowest in the Morden (73.80 cm). The stability parameter S^2di was found significance for ten genotypes while one genotype (Morden) showed significance for regression coefficient. Crosses viz., IB102 x 3376R, IB108 x PZ8R, IB110 x 3376R and IB102 x RHA 587 recorded below grand mean and non significance for bi and S^2di values. Whereas crosses, IB109 x R-274 and IB109 x PZ8R also shared non significance for bi and S^2di values but they were not desirable as they recorded above grand mean.

4.4.5 Head diameter

From among forty genotypes included in the studies, eighteen genotypes recorded above grand mean, two genotypes showed significance for regression coefficient and four recorded significance for deviation from regression coefficient.

The highest head diameter was exhibited by IB109 x PZ8R, followed by IB103 x RHA-586, IB103 x 6D-1 and IB102 x 6D-1, while lowest head diameter by Sungene-85 followed by Morden, IB102 x RHA 586 and IB110 x PZ8R. Hybrids viz., IB101 x 3376R and IB106 x 3376R recorded highest mean combined with significant regression values and non significance for deviation from regression. While IB109 x R-274, IB103 x RHA 586 and IB103 x 6D-1 found to be stable as indicated by recording non significant bi and S^2di values, in addition to above average mean.

4.4.6 Stem diameter

Among 40 genotypes studied, twenty recorded higher mean value. IB107 x 6D-1 had highest mean combined with non significant regression coefficient and mean square deviation. Although genotypes, IB109 x PZ8R (1.98 cm) and IB103 x 6D-1 (1.97 cm) had highest mean and non significant regression coefficient, they showed significance for mean square deviation.

All the genotypes showed non significance for regression coefficient except IB111 x PZ8R which showed significance for bi combined with low mean and least mean square deviation. As many as 15 genotypes showed significance for deviation from regression, of which 10 had above mean along with non significant regression coefficient. Among 25 genotypes that had non significant mean square deviation, 10 exhibited higher mean combined with non significant regression coefficient.

4.4.7 Seed yield per plant

The mean values and stability parameters are presented in Table 11 and depicted in Figure 1.

Twenty two genotypes from among genotypes included in the investigation recorded above grand mean for seed yield, three genotypes showed significance for regression coefficient, while twelve genotypes exhibited significance for deviation from regression. Among genotypes recorded higher means, twelve genotypes showed non significance for both bi and S^2di values. IB109 x RHA 587 (32.29 g) recorded highest seed yield per plant, followed by IB103 x RHA 586 (30.24 g), MSFH-17 (3012 g) and IB109 x PZ8R (29.26 g) with non significant regression coefficient and highly significant mean square deviation. Crosses, IB105 x RHA 587 (29.60 g), IB110 x RHA 587 (28.34 g) and IB105 x 3376R (26.98 g) recorded above average mean with non significance for regression coefficient and deviation from regression. Two crosses, IB103 x RHA 587 (28.10 g) and IB109 x R-274 (28.53 g) recorded above average mean in addition to significant regression value and non significant S^2di value. Although, Morden and IB102 x 3376 R recorded non significant regression value but showed lower seed yield with significant mean square deviation.

4.4.8 Hundred seed weight

Mean values for this trait ranged from 2.52 to 4.23 gm. Twenty two genotypes out of genotypes studied recorded higher mean, six genotypes showed significance for regression coefficient, while five genotypes for deviation from regression (Table 11).

From among twenty two genotypes that recorded high mean for this trait, sixteen genotypes showed non significance for both regression coefficient and deviation from regression, three genotypes expressed significant bi values with non significance for S^2di (IB105 x RHA 587, IB109 x PZ8R and Morden), while two genotypes exhibited non significance for bi but significance for S^2di values (IB109 x RHA 587 and IB111 x RHA 587). Crosses viz., IB105 x RHA 587 (4.23 g) recorded highest mean followed by MSFH-17 (4.19 g) and IB110 x PZ8R (4.18 g), of these former genotype showed significance for regression coefficient with non significant deviation from regression, while later two genotypes had non significance for both regression coefficient and deviation from regression.

4.4.9 Per cent seed filling

From among genotypes included in the investigation, twenty one genotypes recorded above average mean, two genotypes showed significance for regression coefficient, while twenty five genotypes exhibited significance for deviation from regression. The highest mean for this trait was exhibited by IB105 x RHA 586 (91.58 %) followed by IB101 x R-274 (89.95 %), IB103 x RHA 586 (89.92 %), KBSH-1 (89.93 %) and IB102 x PZ8R (89.57 %). The lowest mean was recorded by IB102 x 3376R (83.81 %) and IB101 x 3376R (85.77 %).

Among twenty one genotypes that recorded above average mean, one genotype showed significance for regression coefficient (IB101 x PZ8R), thirteen genotypes expressed significance for deviation from regression where as seven genotypes showed significance for both regression coefficient and deviation from regression.

4.4.10 Kernel weight

Perusal of Table 11 indicates that, twenty three genotypes recorded above grand mean, four genotypes exhibited significant regression coefficient, while, none of the forty genotypes showed significance for mean square deviation.

Mean value of this trait ranged from 0.83 to 1.54 g. Highest mean was exhibited by IB106 x PZ8R and IB109 x PZ8R (1.54g) followed by IB105 x RHA 587 (1.42g), while lowest mean was recorded by IB102 x RHA 586 (0.83) and all these genotypes showed non significance for regression coefficient and deviation from regression. Among 23 genotypes recorded above grand mean, three genotypes showed significance for regression coefficient with non significant mean square deviation, while rest of 20 genotypes exhibited non significance for both regression value and mean square deviation.

4.4.11 Husk content

For husk content, genotypes with low mean means are desirable. Lowest grand mean was recorded by IB107 x 6D-1 (21.08 %) followed by IB101 x R-274 (22.03 %), IB106 x PZ8R (22.17 %), while highest mean was exhibited by MSFH-17 (37.12 %) and IB105 x RHA 587 (30.82 %). Both the above genotypes which recorded lowest and highest mean for husk content also showed non significant regression coefficient and mean square deviation indicating average and below average stability respectively.

From among forty genotypes studied twenty three recorded below grand mean. Ten genotypes exhibited significant regression coefficient. However, none of the genotypes showed significance for mean square deviation, most of them showing negative value. Among twenty three genotypes that recorded below grand mean, five showed significance for regression coefficient with non significant deviation from regression and remaining eighteen genotypes exhibited non significance for both regression coefficient and mean square deviation, best among them are IB107 x 6D-1, IB101 x R-274 and IB106 x PZ8R.

4.4.12 Oil content

The mean values and stability parameters are presented in the Table 11 and depicted in Figure 2. Three crosses, viz., IB107 x 6D-1 (38.86 %), IB101 x PZ8R (38.69 %) and IB103 x 6D-1 (38.06 %) recorded above grand mean for oil content with non significant regression coefficient and mean square deviation. The lowest mean was recorded by MSFH-17 (29.37 %) with non significant regression value and mean square deviation.

Out of forty genotypes, twenty one genotypes recorded above grand mean, five showed significance for regression coefficient, however, none of the genotypes showed significant mean square deviation.

Among 21 genotypes that recorded above mean, two genotypes (IB103 x 83R-6 and IB102 x PZ8R) exhibited significant regression coefficient indicating adoptability to favourable environments, rest of the genotypes found non significance for both regression coefficient and mean square deviation, showing wider adaptability across environments.

4.5 Correlation coefficients

The phenotypic correlation coefficients for pooled data was worked out for eleven characters viz., days to 50 per cent flowering, number of leaves per plant, plant height (cm), head diameter (cm), stem diameter (cm), seed yield per plant (g), hundred seed weight (g), per cent seed filling (%), kernel weight (g), husk content (%) and oil content (%)(Table 12).

Table 12 : Phenotypic correlations coefficients for eleven characters in sunflower (for pooled means)

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
X_1	1.000	0.150	0.238	0.309	0.140	0.012	-0.312	-0.042	-0.282	-0.249	0.018
X_2		1.000	0.558**	0.330*	0.365*	0.105	-0.047	0.039	-0.057	0.037	-0.169
X_3			1.000	0.467*	0.530**	0.314	0.022	-0.081	-0.006	-0.055	-0.080
X_4				1.000	0.417*	0.344*	0.015	-0.041	0.043	-0.136	-0.055
X_5					1.000	0.303	0.164	0.021	0.160	-0.134	0.055
X_6						1.000	0.570**	0.495**	0.474**	-0.128	0.241
X_7							1.000	0.189	0.877**	0.040	0.327
X_8								1.000	0.179	-0.179	0.215
X_9									1.000	-0.114	0.396*
X_{10}										1.000	-0.438**
X_{11}											1.000

* Significance at 5 per cent
** Signfiicance at 1 per cent

X_1 = Days to 50 per cent flowering
X_2 = Number of leaves per plant
X_3 = Plant height (cm)
X_4 = Head diameter (cm)
X_5 = Stem diameter (cm)
X_6 = Seed yield per plant (g)
X_7 = 100 seed weight (g)
X_8 =Per cent seed filling
X_9 =Kernel weight (g)
X_{10} =Husk content (%)
X_{11} =Oil content (%)

Seed yield per plant exhibited highly significant and positive correlation with hundred seed weight (0.570), per cent seed filling (0.495) and kernel weight (0.474). But it was positively significant with head diameter (0.344) at five per cent level of significance.

Hundred seed weight highly significant and positive correlation with kernel weight (0.877) and seed yield per plant (0.570). Per cent seed filling exhibited highly significant and positive correlation with seed yield per plant (0.495).

Kernel weight showed highly significant positive correlation with hundred seed weight (0.877) and seed yield per plant (0.474) and with oil content (0.396) at five per cent level of significance.

Husk content exhibited highly significant negative correlation with oil content (-0.438). Whereas oil content found to have highly significant negative correlation with husk content (-0.438) and positive significance with kernel weight (0.396) at five per cent level of significance.

Head diameter recorded highly significant positive correlation with plant height (0.467), while it showed positive significant association at five per cent level with stem diameter (0.417), seed yield per plant (0.344) and number of leaves per plant (0.330).

Stem diameter exhibited significant positive correlation with head diameter (0.417) and number of leaves per plant (0.365) at five per cent level of significance. While, it showed highly significant positive correlation with plant height (0.530).

Plant height showed highly significant positive correlation with number of leaves per plant (0.558), stem diameter (0.530) and with head diameter (0.467) it showed significance at five per cent level.

The number of leaves per plant exhibited significant positive association at one per cent level with plant height and at five per cent level with stem diameter

(0.365) and head diameter (0.330).

Days to 50 per cent flowering showed non significant correlation with all the traits included under investigation.

4.6 Path coefficient analysis

Path coefficient analysis at phenotypic level was estimated to find out the direct and indirect contribution of important characters to seed yield(Table 13).

Path coefficient for seed yield per plant was worked out with respect to days to 50 per cent flowering, number of leaves per plant, plant height (cm), head diameter (cm), stem diameter (cm), hundred seed weight (g), per cent seed filling, kernel weight (g), husk content and per cent oil content on correlation values.

4.6.1 Direct effects

Hundred seed weight (0.6285) showed highest direct effect towards seed yield followed by per cent seed filling (0.4406), plant height (0.2786), head diameter (0.2556), days to 50 per cent flowering (0.0491), per cent oil content (0.0091) and stem diameter (0.00280. However, the highest negative direct effects were exhibited by kernel weight (-0.1660) followed by number of leaves per plant (-0.1383) and husk content (-0.0212) towards seed yield.

4.6.2 Indirect effects

A high indirect contribution of days to 50 per cent flowering was observed through head diameter (0.0793). It was followed by plant height (0.0663), kernel weight (0.0468) and husk content (0.0053). However, this character showed a negligible indirect effect through stem diameter (0.0004) and per cent oil content (0.0002). Highest negative indirect effects was observed through hundred seed weight (-0.1961) followed by number of leaves (-0.0207) and per cent seed filling 9-0.0185).

The indirect effect of number of leaves was maximum through plant height

Table 13 : Phenotypic path coefficient analysis showing direct and indirect effects of different characters on seed yield per plant

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	Correlation with yield
X_1	**0.0491**	-0.0207	0.0663	0.0793	0.0004	-0.1961	-0.0185	0.0468	0.0053	0.0002	0.0121
X_2	0.0074	**-0.1383**	0.1555	0.0847	0.0010	-0.0295	0.0172	0.0095	-0.0008	-0.0015	0.1052
X_3	0.0117	-0.0772	**0.2786**	0.1198	0.0015	0.0138	-0.0357	0.0010	0.0012	-0.0007	0.3140
X_4	0.0152	-0.0456	0.1301	**0.2566**	0.0012	0.0094	0.0181	-0.0071	0.0029	-0.0005	0.3441*
X_5	0.0069	-0.0505	0.1477	0.1070	**0.0028**	0.1031	0.0093	-0.0266	0.0028	0.0005	0.3030
X_6	-0.0153	0.0065	0.0061	0.0038	0.0005	**0.6285**	0.0833	-0.1456	-0.0008	0.0030	0.5700**
X_7	-0.0021	-0.0054	-0.0226	-0.0105	0.0001	0.1188	**0.4406**	-0.0297	0.0038	0.0020	0.4950**
X_8	-0.0138	0.0079	-0.0017	0.0110	0.0005	0.5512	0.0789	**-0.1660**	0.0024	0.0036	0.4740**
X_9	-0.0122	-0.0051	-0.0153	-0.0349	-0.0004	0.0251	-0.0789	0.0189	**-0.0212**	-0.0040	-0.1280
X_{10}	0.0009	0.0234	-0.0223	-0.0141	0.0002	0.2056	0.0947	-0.0657	0.0093	**0.0091**	0.2411

Residual effect = 0.3347

Note : Bold figures denote direct effects

X_1 = Days to 50 per cent flowering
X_2 = Number of leaves per plant
X_3 = Plant height (cm)
X_4 = Head diameter (cm)
X_5 = Stem diameter (cm)
X_6 = 100 seed weight (g)
X_7 =Per cent seed filling
X_8 =Kernel weight (g)
X_9 =Husk content (%)
X_{10} =Oil content (%)

(0.1555) followed by head diameter (0.0847) and per cent seed filling (0.0172), however, negative indirect effects were through hundred seed weight (-0.0295) and per cent oil content (-0.0015).

The indirect effect of plant height was fairly high through head diameter (0.1198) followed by hundred seed weight (0.0138) and days to 50 per cent flowering (0.0117). However, negative indirect effects was observed through number of leaves (-0.0772) and per cent seed filling (-0.0357).

Head diameter exhibited highest indirect effects through plant height (0.1301) followed by days to 50 per cent flowering (0.0152) but negative indirect effect was exhibited through number of leaves (-0.0456) followed by per cent seed filling (-0.0181).

The stem diameter showed highest indirect effects through plant height (0.1477), head diameter (0.1070) and hundred seed weight (0.1031) and per cent seed filling (0.0093). However, negative indirect effects were observed through number of leaves (-0.0505) and kernel weight (-0.0266).

The indirect effects of hundred seed weight was observed through per cent seed filling (0.0833) followed by number of leaves (0.0065), plant height (0.061) and head diameter (0.0038), where as highest negative indirect effects was observed through kernel weight (-0.1456) followed by days to 50 per cent flowering (-0.0153).

The highest indirect effects of per cent seed filling was observed through hundred seed weight (0.1188) followed by husk content (0.0038), while negative indirect effects through kernel weight (-0.0297), plant height (-0.0226) and head diameter (-0.0105).

Kernel weight exhibited highest indirect effects through hundred seed weight (0.5512) followed by per cent seed filling (0.0789) but showed highest negative indirect effects through days to 50 per cent flowering

(-0.0138) followed by plant height (-0.0017).

Husk content showed maximum indirect effects through hundred seed weight (0.0251) followed by kernel weight (0.0189), however negative effects through per cent seed filling (-0.0789), head diameter (-0.0349), plant height (-0.0153).

Oil content exhibited maximum indirect effects on seed yield through hundred seed weight (0.2056) followed by per cent seed filling (0.0947) number of leaves (0.0234), where as negative indirect effects were observed through kernel weight (-0.0657), plant height (-0.0223) and head diameter (-0.0141).

DISCUSSION

V DISCUSSION

Plant breeding aims at improving the plant characters making them agronomically and economically superior. The major goal in sunflower breeding is the development of high yield with oil content and disease resistant varieties / hybrids for commercial cultivation. Like in other crops, exploitation heterosis for hybrid vigour is one of the important technique being used in sunflower to improve crop production and productivity.

Heterosis breeding programmes in sunflower become very popular with the identification of cytoplasmic male sterility by Leclercq (1969) and fertility restoration system by Kinman (1970). Once the high yielding genotypes were developed, next step would be identification of stable genotypes.

In the present investigation, 36 newly developed hybrids along with 4 checks were evaluated in three different environments to study stability parameters, heterosis and as well as correlation and path coefficient analysis. The results of the present findings are discussed under the following heads.

1. Mean performance of newly developed hybrids over checks under different environments.

2. Heterosis

3. Genotype x environment interactions

4. Stability parameters for individual characters

5. Correlation coefficients

6. Path coefficient analysis

5.1 Mean performance of newly developed hybrids over checks under different environments

None of hybrids studied, showed early flowering and as well as maturity over Modern at all environments. However, IB108 x PZ8R recorded lowest mean for both traits in at environments, except IB108 x RHA 587 that recorded lowest mean for days to maturity at third environment.

The hybrid IB102 x 3376R showed consistent performance among the top five hybrids that showed lower number of leaves per plant in all three environments among hybrids studied. Further hybrids, IB111 x 3376R, IB102 x 3376R and IB105 x R-274 recorded lowest per se performance at first, second and third environment respectively. Similarly, hybrid, IB102 x 3376R recorded lowest plant height at first and second environments, while, IB108 x RHA 587 at third environment. Hybrid, IB109 x R 274 showed consistent performance for head diameter at all environments from among top five hybrids that showed lower mean for head diameter. .

As for stem diameter is concerned, hybrids viz., IB 103 x 6D-1 and IB 109 x PZ8R surpassed superior checks both at first and second environments, while none of the hybrids surpassed superior check at third environment. As many as 19 hybrids recorded highest seed yield per plant over superior check (MSFH-17) at first environment, while one (IB103 x 6D-1) and three hybrids (IB 102 x 6D-1, IB103 x 6D-1 and IB 103 x 83R-6) at second and third environment respectively. Hybrids, IB109 x RHA 587, IB103 x 6D-1 and IB102 x 6D-1 recorded highest mean seed yield for plant at first, second and third environment respectively. None of the hybrids showed consistency in all three environments, however, IB103 x 6D-1 surpassed superior check for seed yield at second and third environments.

From among 36 hybrids studied, IB105 x RHA 587 expressed consistency in performance at all environments with respect to 100 seed weight.

Further hybrids viz., IB109 x RHA'587, IB103 x 6D-1 and IB105 x RHA-587 recorded highest 100 seed weight at first, second and third environment respectively. With respect to per cent seed filling none of the hybrids exhibited consistency in performance. However, IB107 x 6D-1 surpassed checks at second and third environment.

Hybrids viz., IB106 x PZ8R, IB109 x PZ8R and IB105 x RHA 587 surpassed superior check at all three environment indicating their consistency in performance. Of these hybrids, IB106 x PZ8R showed highest per se performance at first and third environment, while IB109 x PZ8R at second environment.

From among hybrids studied, IB107 x 6D-1 and IB101 x R-274 recorded lower husk content over checks and showed consistent performance at all three environments. Of these hybrids, IB101 x R-274 recorded lowest mean for this character at first environment, while IB107 x 6D-1 at both second and third environment. With respect to oil content, seven, eight and nine hybrids surpassed checks at first, second and third environment respectively. Among them, IB101 x PZ8R and IB109 x PZ8R performed consistently at all the three environments. However, IB107 x 6D-1 showed highest per se performance at first and second environments, while IB107 x PZ8R at third environment.

From the above discussion, we could identify the fact that, none of the hybrids showed superior performance with respect to all the characters over checks either at one environment or in all three environments. However, at first environment, IB109 x PZ8R showed superior performance over checks with respect to all characters except days to 50 per cent flowering, days to maturity, number of leavers per plant, plant height and stem diameter. This is followed by IB101 x PZ8R, IB103 x RHA 586, IB105 x RHA 587 and IB108 x RHA 587 showed better performance with respect to five out of twelve characters studied including seed yield per plant.

At second environment, hybrid, IB107 x 6D-1 showed better performance with respect to seven out of twelve characters studied followed by IB103 x 6D-1 and IB105 x R-274 which showed superior performance for six and five characters respectively. Although, IB105 x R-274 exhibited superior performance for five characters, it is not desirable as it did not include neither seed yield per plant nor oil content.

At third environment, IB102 x 6D-1 found to be superior among all hybrids studied, as it surpassed checks with respect to five characters including seed yield per plant. Over all means across environments indicated that only IB103 x RHA 586 performed better by surpassing better checks for four among twelve characters including seed yield per plant, while IB109 x PZ8R surpassed superior checks for three characters including oil content.

In general, based on environmental index and means, it is concluded that the second environment was congenial for most of the characters studied viz., days to 50 per cent flowering, days to maturity, number of leaves per plant hundred seed weight, per cent seed filling, kernel weight, husk content and oil content, where as, first environment found to be favorable for plant height, head diameter, stem diameter and seed yield per plant. However, none of the character was favorable at third environment.

5.2 Heterosis

Increased vigour of F_1 hybrid over the check variety or hybrid is referred to as standard heterosis or economic heterosis. The results pertaining to heterosis are discussed character wise in the following paragraphs.

5.2.1 Days to 50 per cent flowering

None of the new hybrids included in studies exhibited significant negative heterosis over standard checks Morden and Sungene-85, while fourteen and six hybrids showed significant negative heterosis over checks KBSH-1 and MSFH-

17 respectively. However, significant positive heterosis over KBSH-1 and MSFH-17 was visible in fourteen and nineteen hybrids respectively. It clearly indicates that majority of the hybrids flowered lately compared to all checks. The hybrid, IB108 x PZ8R exhibited the highest magnitude of significant negative heterosis over KBSH-1 and MSFH-17, which indicates its earliness to flowering compared to checks. Whereas, IB103 x 83R-6 and IB107 x 6D-1 were late maturing compared to all checks. These results are in accordance with Neagu and Catrina (1963), Shankara (1981), Shivaraju (1984), Chidananda (1985), Ibrahim (1985), Naik (1985), Govindaraju (1986), Jahagirdhar (1986), Manjunath (1986), Wali (1987), Uma (1987), Harini (1992), Naresh (1993) and Shekar (1996).

5.2.2 Days to maturity

It could be observed from Table 8 that none of the hybrids studied exhibited significant negative heterosis over Morden and Sungene-85, While fourteen and eight hybrids manifested negative significant heterosis over KBSH-1 and MSFH-17 respectively. This indicates that majority of the hybrids were late maturing types. The hybrid IB108 x PZ8R matured earlier as indicated by highest magnitude of negative heterosis, while IB107 x 6D-1 as late maturing compared to checks. Similar results were reported by several workers. Shivaraju (1984), Bindu Madhav (1990) and Chidambaram and Sundaram (1990) reported heterotic effect for earliness. In contrast Seetharam *et al.* (1977), Shivakumara (1989) and Harini (1992) reported for lateness.

5.2.3 Number of leaves per plant

All the thirty six, fourteen and ten hybrids exhibited significant positive heterosis over Morden, KBSH-1 and Sungene-85 respectively, while, only one hybrid IB109 x R-274 over MSFH-17. However, none of the hybrids registered significant negative heterosis over Morden and KBSH-1, while nineteen and one hybrid (IB102 x 3376 R) over MSFH-17 and Sungene-85 respectively. It indicates that majority of the hybrids possessed more number of leaves per plant over checks. IB109 x R-274 exhibited more number of leaves per plant over all the checks as indicated by highest significant positive heterosis, while IB102 x 3376R possessed lower number of leaves per plant.

5.2.4 Plant height

The data on heterosis for plant height from Table 8 revealed that none of the new hybrids showed negative heterosis over Morden, while all of them showed significant positive heterosis over Morden, which indicates that all the hybrids were taller than Morden. However, hybrid, IB102 x 3376R had lowest plant height by recording lowest value for significant negative heterosis over other checks.

From among new hybrids, IB109 x R-274 exhibited highest significant positive heterosis over all checks followed by IB109 x RHA 587 and IB103 x RHA 586 indicating that these hybrids were taller than the checks. Similar results were reported by many workers. Naik (1985) and Naresh (1993) reported heterotic effect for dwarfness, while Shankara (1981), Shivaraju (1984), Chidananda (1985), Ibrahim (1985), Govindaraju (1986), Jahagirdhar (1986), Uma (1987), Harini (1992) and Shekar (1996) reported heterotic effects for tallness in the hybrids from their investigation.

5.2.5 Head diameter

The estimates of heterosis for head diameter (Table 8) indicated that none of the hybrids exhibited significant negative heterosis over KBSH-1, Morden and Sungene-85, while six hybrids showed significant negative heterosis over MSFH-17. However, four, one, twenty four and twenty nine hybrids manifested significant positive heterosis over KBSH-1, MSFH-17, Morden and Sungene-85 respectively. This indicates that majority of the hybrids were having larger head size than checks. The hybrid, IB109 x R-274 had highest significant positive heterosis over all the checks, which indicates that it had higher head size among new hybrids. Similar results were reported by Shankara (1981), Shivaraju (1984), Chidananda (1985), Ibrahim (1985), Naik (1985), Jahagirdhar (1986), Manjunath (1986), Wali (1987), Shivakumara (1989), Harini (1992), Naresh (1993) and Shekhar (1996).

5.2.6 Stem diameter

The data on heterosis for stem diameter (Table 8) revealed that thirty one, twenty two and three hybrids showed significant positive heterosis over Morden, Sungene-85 and KBSH-1 respectively. While none of the hybrids expressed significant positive heterosis over MSFH-17. In contrast twenty and three hybrids recorded significant heterosis over MSFH-17 and KBSH-1 respectively, while none of the hybrids over Morden and Sungene-85. It clearly indicates that most of the hybrids were on par with KBSH-1 and almost all hybrids expressed negative heterosis with MSFH-17. Whereas, all the hybrids showed positive heterosis over both Morden and Sungene-85. IB109 x PZ8R recorded highest significant positive heterosis over all the checks except MSFH-17 which indicates that it had higher stem diameter among the new hybrids. These results are in similar line with Shankara (1981), Shivaraju (1984), Chidananda (1985), Govindaraju (1986), Jahagirdhar (1986), Manjunath (1986), Wali (1987), Uma (1987), Shivakumara (1989), Harini (1992), Naresh (1993) and Shekar (1996).

5.2.7 Seed yield per plant

It could be observed from the Table 8 that two hybrids each exhibited positive significant heterosis over KBSH-1 and Sungene-85, while twenty seven hybrids over Morden and none of the hybrids over MSFH-17. However, five, six and twenty two hybrids from among thirty six expressed significant negative heterosis over KBSH-1, Sungene-85 and Morden respectively and none of the hybrids over MSFH-17. These results revealed that majority of the hybrids expressed significant positive heterosis over Morden, which indicates that

Morden was a low yielder among checks. Majority of the hybrids exhibited negative heterosis over MSFH-17 either significantly or non significantly, which infers that MSFH-17 was a high yielder among checks, whereas most of the hybrids were on par with KBSH-1 and Sungene-85. The highest significant positive heterosis was recorded by IB109 x RHA 587 over all the checks, excluding MSFH-17. While, IB102 x RHA 586 recorded lowest yield among thirty six hybrids.

Several workers reported existence of both positive and negative heterosis in their hybrids. Grebenjuk (1967), Vranceanu (1967), Vulpe (1967), Gundeav (1968), Vranceanu and Stonenescu (1969), Neagu (1970), Leclercq (1971), Vicentini (1971), Seetharam (1984) and Wali (1987) reported positive heterosis for seed yield. On contrary, Shankara (1981), Shivaraju (1984), Chidananda (1985), Ibrahim (1985), Naik (1985), Govindaraju (1986), Jahagirdhar (1986), Manjunath (1986), Uma (1987), Shivakumara (1989), Harini (1992), Naresh (1993) and Shekar (1996) reported negative heterosis.

5.2.8 Hundred seed weight

From among hybrids studied, none of them manifested significant positive heterosis over MSFH-1, while one (IB105 x RHA 587), Seven and five hybrids over Morden, KBSH-1 and Sungene-85 showed significant positive heterosis respectively. Majority of the new hybrids exhibited significant negative heterosis for this character over all the checks. The hybrid, IB105 x RHA 587 exhibited highest significant positive heterosis over all the checks, excluding MSFH-17. These results are in agreement with Shankara (1983), Shivaraju (1984), Chidananda (1985), Ibrahim (1985), Naik (1985), Govindaraju (1986), Jahagirdhar (1986), Manjunath (1986), Wali (1987), Shivakumara (1987), Harini (1992), Naresh (1993) and Shekar (1996).

5.2.9 Per cent seed filling

It could be revealed from the Table 8 that none of the hybrids exhibited significant positive heterosis for per cent seed filling over KBSH-1 and Sungene-85, while, seven hybrids each over MSFH-17 and Morden showed significant positive heterosis. Whereas, none of the hybrids exhibited negative heterosis over MSFH-17 and Morden, while thirteen and ten hybrids over KBSH-1 and Sungene-85 respectively. This indicates that majority of the hybrids exhibited were heterosis over KBSH-1 and Sungene-85, while majority of the hybrids were on par with MSFH-17 and Morden. Hybrid, IB105 x RHA 586 recorded highest seed filling percentage among hybrids included in studies as indicated by highest positive significant heterosis over checks. These results were in similar line with Shivaraju (1984), Ibrahim (1985), Wali (1987), Shivakumara (1989), Harini (1992) and Naresh (1993).

5.2.10 Husk content

All the new hybrids exhibited significant negative heterosis over MSFH-17, while twelve, twenty three and twenty seven over KBSH-1, Morden and Sungene-85 respectively. However, none of the hybrids manifested significant positive heterosis over MSFH-17, Morden and Sungene-85. while two hybrids showed significant positive heterosis over KBSH-1. It indicates that MSFH-17 recorded highest husk content among checks and all hybrids were desirable compared to MSFH-17, while majority of hybrids were on par with Morden and Sungene-85 and twelve hybrids showed heterosis in desirable direction over KBSH-1. The hybrid IB107 x 6D-1 exhibited highest negative heterosis among new hybrids.

5.2.11 Oil content

It could be observed from Table 8 that all the thirty six hybrids exhibited significant positive heterosis over MSFH-17, while thirty five, twenty and one hybrid over Morden, Sungene-85 and KBSH-1 respectively. However, none of the hybrids manifested negative significant heterosis over MSFH-17, Morden and Sungene-85, while 14 hybrids expressed negative significant heterosis over KBSH-1. It clearly indicates that KBSH-1 recorded high, while MSFH-17 had low oil content among checks. Majority of the synthesized hybrids showed high oil content compared to MSFH-17, Sungene-85 and Morden, while only one hybrid (IB107 x 6D-1) exceeded KBSH-1 for oil content, which also proved best among all hybrids with respect to this character. These results were in similar line with Vranceanu *et al.* (1973), Voskoboinik and Soldatov (1975), Shankara(1981), Vranceanu (1981), Buchuchanu *et al.* (1984), Shivaraju (1984), Naik (1985), Jahagirdhar (1986), Manjunath (1986), Wali (1987), Uma (1987), Shivakumara (1989), Harini (1992), Naresh (1998) and Shekar (1996).

The results pertaining to heterosis indicated that the hybrid IB109 x PZ8R found to be superior for seed yield per plant, 100 seed weight and stem diameter as these hybrids showed heterosis in favorable direction. IB103 x RHA 586 also showed heterosis in favorable direction for seed yield per plant and per cent seed filling. Whereas, IB107 x 6D-1 showed heterosis for oil content, husk content and stem diameter in favorable direction. Hence these hybrids need further attention.

5.3 Genotype x environment interaction

The analysis of variance for twelve characters in each of the three environments revealed significant differences among genotypes. The error mean sum of squares over environments for each of twelve characters found homogenous when tested for homogeneity. After confirming the above two conditions, data was subjected for pooled analysis.

The results of pooled analysis of variance indicated significant differences for genotype x environment interaction for all twelve characters when tested against pooled error mean square, justifying the differential reactions of genotypes to different environments. The genotypic differences found significance for all characters except number of leaves per plant and per cent seed filling when tested against mean sum of squares due to genotype x environment. Variance due to environment also found significant for all the characters, justifying the selection of genotypes and environments for the present investigation. George (1983), Javirsingh and Yadava (1983), Pathak and Dixit (1984), Sen *et al.* (1985), Swamy Gowda and Giriraj (1991), Shinde *et al.* (1992), Moro *et al.* (1994), Uma *et al.* (1995) and Laishram and Singh (1997) reported existence of considerable G x E interaction in sunflower. Sen *et al.* (1985), Swamy Gowda and Giriraj (1989), Velazquet-cagal *et al.* (1990), Gross and Hanzel (1991), Shinde *et al.* (1992) and Madrap *et al.* (1994) reported significance for environment component, where as, Sen *et al.* (1985) and Gross and Hanzel (1991) reported significant differences between genotypes from their studies.

Since G x E interactions found significant for all twelve characters, stability analysis was then carried out for all of them. The analysis of variance for stability (Eberhart and Russel, 1966) also revealed significant differences among 40 genotypes for all the characters, except stem diameter, seed yield per plant and per cent seed filling. Variance due to environment (linear) was significant for all characters indicating the significance of additive environmental variance. The mean sum of square due to pooled deviation was found significant, but not the mean sum of squares due to genotype x environment (linear) for days to 50 per cent flowering, days to maturity, number of leaves per plant, plant height, head diameter, stem diameter, seed yield per plant and per cent seed filling, which infers that variation in the performance of genotypes is entirely unpredictable. Only genotype x environment (linear) was significant for hundred seed weight, kernel weight, husk content and oil content, which indicates that variation in the performance of genotypes is completely predictable for these characters. The more pronounced linearity of these characters could largely be explained by differences in regression slopes. This obviously meant that accurate prediction of the phenotypic performance of genotypes is possible.

5.4 Stability performance for individual characters

Once genotype x environment interaction found significant the next step would be identifying the stable genotypes which interact less with the environments giving a near consistent performance across varied environments.

Finlay and Wilkinson (1963) in their model considered the mean value of genotype and regression coefficient. But, Eberhart and Russel (1966) improved this model further and suggested that both linear and nonlinear components for G x E interaction should be considered in judging the phenotypic stability of particular genotype. So in their model they considered three stability parameters viz., (i) mean performance (μ), (ii) regression coefficient (bi), i.e., regression of means on environmental index (iii) deviation from regression (S^2di), a measure of G x E interaction of unpredictable type.

To consider a genotype to be ideal stable, it should possess high or low mean (desirable mean depending on the character), unit regression coefficient and non significant deviation from regression.

Finlay and Wilkinson (1963) recommended in their model that a genotype to be stable, if it had higher mean yield and unit regression coefficient. However, linear regression could simply be regarded as a measure of response of a particular genotype, where as, S^2di as the most suitable measure of stability. The genotypes with least deviation around the regression line being the most stable and vice-verse as emphasized by Breese (1969) and Samuel et al. (1970). This interpretation in fact is not much different from that of Eberhart and Russel (1966) except that when they called a genotype stable, it meant stability for high mean value (maximum mean value in the desirable direction), combining the suggestion of these authors (Finlay and Wilkinson, 1963 ; Breese, 1969 and Sumuel *et al.* (1970).

S^2di is considered as the measure of stability in interpretation of the results of the present investigation. Once the genotype is found suitable based on non significant S^2di, then the type of stability is based on regression coefficient and mean values. If bi is equal to unity, a genotype is considered to have average stability (Same performance in all environments), if bi is more than unity, it is considered to have below average stability (good performance in favorable environments) and if bi is less than unity, it is considered to have above average stability (good performance in poor environments). The character wise discussion of results pertaining to stability parameters are presented below.

5.4.1 Days to 50 per cent flowering

Most often lower means are preferred for this character. Based on overall mean, genotypes IB108 x PZ8R, Sungene-85, IB108 x RHA 587 and IB106 x PZ8R recorded lower mean and they proved ideal and stable across varied environments as they showed non significance for both bi and S^2di (Table.11) Morden found unstable in spite of recording lowest grand mean among 40 genotypes and non significant bi value as it showed significance for S^2di. While genotypes, IB103 x 83R-6, IB107 x 6D-1, IB101 x R-274 and IB102 x R-274 found stable with unit regression and non significant S^2di but, they are not desirable as they recorded higher mean values for this trait. Similar results were reported by Pillai *et al.* (1995).

5.4.2 Days to maturity

Usually early maturing genotypes are desirable. The genotypes viz., Morden, Sungene-85, IB108 x RHA 587, IB111 x 3376R and IB105 x RHA 587 recorded below average mean and indicated average stability as they recorded non significance for regression and deviation from regression.

Regression coefficient was non significant for all the genotypes except IB102 x PZ8R, however stability was unpredictable for eleven of them as they showed significance for S^2di. A total of eleven genotypes exhibited average stability out of forty genotypes.

5.4.3 Number of leaves per plant

Genotypes, Morden, IB102 x 3376R, IB102 x 6D-1 and IB111 x PZ8R expressed average stability by recording above average mean with non significant bi and S^2di value. Similarly, IB109 x R-274, IB103 x RHA 586 and IB101 x R-274 also showed average stability but they were not desirable as they recorded above average mean. Significance for regression coefficient was observed by two genotypes namely, Sungene-85 and IB110 x RHA 586 and hence found to be specifically adapted to favorable environments.

5.4.4 Plant height

Genotypes with lower plant height are preferred. Among 40 genotypes studied, Morden, IB102 x 3376R and IB108 x RHA 587 recorded below average mean, of which, Morden showed significance for bi but non significance for S^2di there by found specifically adapted to favorable environments. Genotypes viz., IB102 x 3376 R and IB108 x RHA 587 showed stable performance across environments as they had non significance for bi and S^2di values. Whereas, Genotypes viz., IB109 x R-274, IB109 x PZ8R and IB106 x RHA 586 found stable but their stability was unpredictable as they showed significance for S^2di values. These results were in similar line with Pillai et al. (1995). It is interesting to note that taller plants (above average mean) found unstable in performance as they showed significance for S^2di.

5.4.5 Head diameter

Plants with larger heads are desirable. Crosses viz., IB109 x R-274, IB103 x RHA 586, IB103 x 6D-1 and IB102 x 6D-1 had high grand mean combined with non significant regression coefficient and deviation from regression and hence showed average stability across environments. Although

IB101 x R-274 recorded higher grand mean and non significant regression found unstable by showing significance for deviation from regression. As many as sixteen genotypes showed average stability, sixteen genotypes, above average stability out of forty genotypes. Similar results were reported by Pillai *et al.* (1995).

5.4.6 Stem diameter

From among 40 genotypes studied. Twenty genotypes recorded higher mean values. All the genotypes recorded non significant regression coefficient except IB101 x PZ8R, indicating average stability for them. However, fifteen genotypes showed significance for deviation from regression coefficient. Genotypes IB107 x 6D-1 and MSFH-17 showed average stability by recording high mean combined with unit regression and non significant S^2di values. Whereas, IB109 x PZ8R and IB102 x 6D-1, with high mean showed specific adaptability to favorable environments as indicated by significant bi and non significant S^2di values.

5.4.7 Seed yield per plant

Being economic produce, genotypes with higher mean seed yield per plant are preferred. High mean seed yields were recorded by IB109 x RHA 587, IB103 x RHA 586, MSFH-17 and IB109 x PZ8R. Their regression coefficient value equals unity and hence were regarded as average stable genotypes. But these hybrids show significant deviations from regression which indicated that the prediction of stability may not be done satisfactorily. Two hybrids, IB103 x RHA 587 and IB109 x R-274, with high mean and non significant S^2di showed specific adaptation to the favorable environments by exhibiting significant regression coefficient (Table.11 and Fig. 1).

Genotypes, IB105 x RHA 587, IB110 x RHA587 and IB105 x 3376R with high mean and non significance for bi and S^2di values displayed average stability across environments. Eleven genotypes exhibited average stability, while, two and fifteen genotypes showed below average and above average stability respectively. It is interesting to note that genotypes with high mean performance showed significance for S^2di that indicates seed yield was inversely related to stability. These results are in agreement with the findings of Sharma and Chopde (1979), Seetharam (1980), Javirsingh and Yadava (1982), Sen et al. (1983), Pathak and Dixit (1984) and Vranceanu and Craiciu (1994).

5.4.8 Hundred seed weight

Genotypes with higher seed weight are desirable. Sixteen genotypes found to be stable across varied environments as indicated by recording above average mean with non significant bi and S^2di value. Three genotypes viz., IB105 x RHA 587, IB109 x PZ8R and Morden showed specific adaptation to favorable environments, while IB109 x RHA 587 found to be unstable by showing significance for S^2di although it recorded higher mean and non significant bi value.

The highest mean was recorded by IB109 x RHA 587, MSFH-17 and IB110 x PZ8R. Among them MSFH-17 and IB110 x PZ8R found to be stable (average stability) across environments, while IB105 x RHA 587 showed below average stability i.e., specific adaptation to favorable environments.

5.4.9 Per cent seed filling

Genotypes with higher mean values are preferred for this trait. Highest grand mean was recorded by IB105 x RHA 586, IB101 x R-274, IB103 x RHA 586, KBSH-1 and IB102 x PZ8R. Among them, IB105 x RHA 586 and IB102 x PZ8R found stable across environments by exhibiting non significant bi and S^2di, while KBSH-1 and IB101 x R-274 and IB103 x RHA 586 were unstable by showing non significance for bi, but significance for S^2di values. Genotypes viz., IB101 x PZ8R and IB110 x 3376R found to be specifically adapted to Favorable environments. S^2di was significant for 25 out of 40 genotypes. That indicates that performance could be unpredictable for most of the genotypes.

5.4.10 Kernel weight

Genotypes that possess higher means are preferred for this character. A total of 23 genotypes recorded above grand mean and ten genotypes showed significance for regression coefficient. None of the genotypes recorded significance for deviation from regression that indicates that performance could be predictable for all genotypes. Genotypes IB106 x PZ8R, IB109 x PZ8R, IB105 x RHA 587, IB110 x PZ8R expressed average stability as they recorded higher means with their regression value equals unity and non significant S^2di value.

5.4.11 Husk content

Genotypes with lower husk content are desirable. Genotypes, IB107 x 6D-1, IB101 x R-274 and IB106 x PZ8R recorded lowest mean with non significance for bi and S^2di, which implies that these genotypes were stable across varied environments. Among 40 genotypes studied, twenty three recorded below average mean, while ten had significant bi values. However none of the genotypes showed significance for S^2di, which indicates that performance of all genotypes can be predicted completely. Out of 23 genotypes that recorded below average mean, five showed significant bi with non significant S^2di values which infers that these genotypes showed specific adaptation to favorable environments (below average mean), while remaining eighteen genotypes showed stable performance across varied environments.

5.4.12 Oil content

As an economic produce genotypes with higher oil content are usually preferred. Three genotypes viz., IB107 x 6D-1, IB101 x PZ8R and IB103 x 6D-1 showed stable performance across varied environments by recording higher mean with non significant bi and S^2di values.

From among 40 genotypes studied twenty one genotypes recorded above average mean, five showed significance for bi, while none of the genotypes expressed significance for S^2di values, which indicates that performance of all genotypes could be completely predictable. Two genotypes viz., IB103 x 83R-6 and IB102 x 83R-6 exhibited higher mean with significant bi values indicating that these genotypes were specifically adaptable to favorable environments. Similar results were reported by Filipescu and Poparlan (1982), Javirsingh and Yadava (1983) and Velazquez-Cagal *et al.* (1990).

The character wise discussion presented for stability parameters revealed that maximum number of genotypes (twenty one out of forty) showed stability across for Kernel weight followed by nineteen for oil content, seventeen for hundred seed weight, husk percentage and number of leaves per plant.

Twelve genotypes showed stability for seed yield per plant. Among new hybrids, IB105 x 3376R and IB110 x PZ8R showed stability for eight characters (out of twelve) including seed yield per plant and oil content. The hybrid, IB106 x 3376R also showed stability for eight characters including oil content but excluding seed yield per plant. IB102 x PZ8R and IB111 x PZ8R showed stability for seven and six characters respectively.

The hybrid IB105 x RHA 587 could be rated as best for stability for high seed yield per plant which also showed stability for days to 50 per cent flowering, days to maturity, head diameter, and Kernel weight. Whereas the hybrid IB107 x 6D-1 was best for stability for high oil content and also showed stability for number of leaves per plant, stem diameter, kernel weight and husk content.

However none of the genotypes showed stability for all the characters, there by indicating that stability for a character is not always associated with stability for other characters.

5.5 Correlation coefficients

Yield is a quantitative character controlled by polygenes and it is the result of combined effect of several components and environment. The effect of each character on yield can be assessed through correlation studies.

Increased seed yield and higher oil content are two important selection criteria followed in the genetic improvement of sunflower. Hence, information on the correlation of seed yield and oil content with other related traits are very useful to determine the possible correlation or association that would aid in selection. The results on the correlation of different characters obtained during the investigation are discussed in the following paragraphs.

In present investigation seed yield per plant had highly and significant positive correlation with hundred seed weight (0.570) followed by per cent seed filling (0.495) and Kernel weight (0.474) and showed positively significant association with head diameter (0.344) at five per cent level of significance. Many researchers have reported the association of yield with above traits. Lakshmaniah (1978), Anand and Chandra (1980), Lakshman Rao (1983), Rao (1983), Mishra *et al.* (1985), Singh *et al.* (1985). Niranjanamurthy and Shambulingappa (1989) and Mogali and Virupakshappa (1994) reported that hundred seed weight, percent seed filling and head diameter were highly correlated with seed yield. Pathak (1975), Varshney and Singh (1977), Omran *et al.* (1979), Caylak and Emiroglu (1984), Abdel-Gawad *et al.* (1987), Wali (1987), Vanishree *et al.* (1988), Khan *et al.* (1991), Harini (1992), Chandra and Anand(1993), Pallikondaperumal and Rajashekaran (1993) and Jayarame.gowda (1994) reported significant positive correlation of seed yield with hundred seed weight and head diameter. Suma (1993) and Suma *et al.* (1994) reported significant positive correlation of seed yield with per cent seed filling and head diameter. Thus, it could be concluded that selection based on hundred seed weight will be more effective in improving seed yield.

Hundred seed weight showed positive and significant correlation with Kernel weight (0.877) and seed yield per plant (0.570). There are no reports about correlation between hundred seed weight and Kernel weight. However, there were many reports regarding significant positive correlation between hundred seed weight and seed yield. D'Jakov (1971), Pathak (1977), Chandra and Anand (1977), Varshney and Singh (1977), Omran *et al.* (1979), Lakshman Rao (1983), Singh *et al.* (1985), Vanishree *et al.* (1988), Harini (1992), Jayarame Gowda (1994) and Mogali and Virupakshappa (1994) were some of the reports indicated significant positive correlation of hundred seed weight with seed yield. On contrary, negative significant association between hundred seed weight and seed yield was reported by Srinivasa (1980), Tariq *et al.* (1992) and Kalaiselvan *et al.* (1994).

Percent seed filling was positively and significantly correlated with seed yield per plant (0.495). Similar results were observed by Badzhi (1976), Lakshmaniah (1978), Anand and Chandra (1980), Lakshman Rao (1983), Mishra *et al.* (1985), Singh *et al.* (1985), Niranjanamurthy and Shambulingappa (1989), Suma (1993), Suma *et al.* (1994) and Mogali and Virupakshappa (1994). Thus it indicates the role of seed filling in increase of seed yield.

Kernel weight exhibited significant positive correlation with hundred seed weight (0.877), seed yield per plant (0.474) and oil content (0.396). There were no reports for supporting the positive association of Kernel weight with hundred seed weight and seed yield per plant. However, Putt (1943). Russel (1953) and D'Jakov (1966, 1969) reported significant positive association of Kernel weight with oil content.

Oil content showed significant negative correlation with husk content (-0.438) and positive correlation with Kernel weight (0.396). Dedio (1982) reported significant negative correlation of oil content with husk content, while positive association of oil content with Kernel weight was reported by Putt (1943), Russel (1952), and D'Jakov (1966, 1969).

Head diameter was significantly and positively correlated with plant height (0.467), stem diameter (0.417), seed yield per plant (0.344) and number of leaves per plant (0.330). This was similar to the results obtained by Vanishree *et al.* (1988). Positive association of seed yield with head diameter, plant height and stem diameter was reported by Putt (1943) and Russel (1952). Pathak (1975), Lakshmaniah (1978), Anand and Chandra (1980), Srinivasa (1980), Caylak and Eimirogolu (1984), Chervet and Vear (1990) and Harini (1992). Abdel-Gawad *et al.* (1987) and Chandra and Anand (1993) reported positive association of seed yield with head diameter, number of leaves per plant and plant height.

Plant height showed significant positive association with number of leaves per plant (0.558), stem diameter (0.530) and head diameter (0.467). Similar results were reported by Abdel-Gawad *et al.* (1987) and Chandra and Anand (1993).

Days to 50 per cent flowering recorded non significant correlation with all the charcters under study. This was similar to the results obtained by Patil *et al.* (1996). However, Shabana (1975) and Wali (1987) reported positive and significant association between seed yield and days to 50 per cent flowering, where as, Patil (1993) and Gangappa and Virupakshappa (1994) reported non significant association between seed yield and days to 50 per cent flowering.

From the above discussion on correlation studies among yield and yield components, it may be inferred that seed yield had highest correlation with hundred seed weight (0.570) followed by per cent seed filing (0.495), Kernel weight (0.474) and head diameter (0.344), hence these characters could be considered for selection.

5.6 Path coefficient analysis

The correlation studies indicate only the nature and extent of association existing between the pairs of characters. Seed yield is a dependent character that may controlled by several component characters which are mutually associated. This mutual association will impair the true association existing between the components and seed yield. In order to obtain a clear picture of the contribution of each of such component characters in the total genetic architecture of yield, path coefficient analysis could be employed. Path coefficient analysis is simply a standardized partial regression analysis which separates the correlation coefficient into direct and indirect components.

Wright (1921) was first to adopt path analysis for animal breeding experiments. Subsequently this procedure was employed by Dewey and Lu (1957) in the determination of seed yield components in created wheat grass as a method in plant selection for better yield. Since then the technique has been employed effectively and extensively in several crops to get a correct picture of component characters affecting seed yield. Li (1956) emphasized the importance of path diagram which greatly facilitates the understanding of the nature of cause of effect system.

In the present study, ten characters were considered for seed yield for path coefficient analysis.

Hundred seed weight exerted maximum positive direct effect on seed yield. Its indirect effects through per cent seed filling was maximum and through other characters were low. Since this trait had highest direct effect and high indirect effects on seed yield through per cent seed filling, selection based on this trait would result in increased seed yield. These results are in similar line with Varshney and Singh (1977), Velkov (1980), Mishra *et al.* (1985), Niranjanmurthy and Shambulingappa (1989), Pathak and Dixit (1990), Pallikonda perumal and Rajshekaran (1993), Jayarame Gowda (1994), Punia and Gill (1994), Suma *et al.* (1994), Haile-kefene *et al.* (1996) and Patil *et al.* (1996). On contrary, Sivaram (1986) reported that hundred seed weight had negative and low direct effects on seed yield per plant.

Per cent seed filling had a moderate positive direct effect on seed yield. Its positive indirect effects through hundred seed weight was maximum, while indirect effects of other characters were low and positive indicating the possibility of increasing the yield by indirect selection of hundred seed weight. However, its negative indirect effects through Kernel weight and plant height were low. Varshney and Singh (1977), Mishra *et al.* (1985) and Niranjan murthy and Shambulingappa (1989) reported the similar results.

Plant height showed a moderate positive direct effect on seed yield and its indirect effects were maximum through head diameter and low and positive effects through hundred seed weight and days to 50 per cent flowering. However, its indirect effects were negative through number of leaves per plant and per cent seed filling. Since this trait had moderate direct effect with high positive indirect effect though head diameter, selection based on this trait would result in increased seed yield effectively as selection for plant height is easy. These results are in conformity with Varshney and Singh (1977), Giriraj *et al.* (1979), Alba and Greco (1980) Chaudhary and Anand (1985). Contrary to this, Chandra and Anand (1977) reported negative direct effect of plant height on seed yield.

Head diameter also had a moderate positive direct effect on seed yield. Similar results were observed by Varshney and Singh (1977), Lakshmaniah (1978), Giriraj *et al.* (1979), Anand and Chandra (1980), Alba and Greco (1980), Velkov (1980), Mishra *et al.* (1985), Niranjanmurthy and Shambulingappa (1989), Pathak and Dixit (1990) and Suma *et al.* (1994). It had a high positive indirect effects through plant height and negative indirect effect was exerted through number of leaves per plant and per cent seed filling. So indirect selection for this trait is effective for the improvement of yield.

Days to 50 per cent flowering had a low and positive direct effect on seed yield. Similar results were observed by Chaudhary and Anand (1985) and Pathak and Dixit (1990). It showed considerable indirect effects positively through head diameter, plant height, Kernel weight indicating its importance in increasing seed yield and negatively through hundred seed weight, number of leaves and per cent seed filling indicated its unusefulness in improving seed yield.

Oil content showed a positive but low direct effects on seed yield. Lakshmanaiah (1978) reported the similar results. It exerted high and positive indirect effects through hundred seed weight followed by per cent seed filling and number of leaves per plant indicating its importance in improving seed yield. While, it showed negative indirect effect through Kernel weight, plant height and head diameter. So indirect selection for these character is not effective for the improvement of yield.

Stem diameter exerted a positive but negligible amount of direct effect on seed yield. Similar result was observed by Niranjanmurthy and Shambulingappa (1989). On contrary, Chandra and Anand (1977) reported negative direct effect of stem diameter on seed yield. However it showed useful indirect effects through plant height, head diameter and hundred seed weight which indicates usefulness of indirect selection in improving seed yield. Whereas, its negative indirect effects through number of leaves per plant and Kernel weight were not having importance in improving seed yield.

Kernel weight exhibited the highest negative direct effect among other characters on seed yield. Although it expressed negative direct effects, its indirect effects through hundred seed weight was positive and moderate. Hence Kernel weight can be useful trait through its indirect effects.

The direct effect of number of leaves per plant was moderate but negative. This is in similar line with the result of Lakshman Rao (1983). It exerted positive, moderate indirect effect through plant height and head diameter. So number of leaves per plant influence the yield through plant height and head diameter.

Husk content exerted negative but low direct effects on yield. Its indirect effects were also minimum through hundred seed weight and kernel weight which indicates its un usefulness in improving seed yield.

From the above discussion on path coefficient analysis of yield components with seed yield, revealed that hundred seed weight exerted highest indirect effects on seed yield, followed by per cent seed filling, plant height and head diameter. Highest indirect effects on seed yield was observed by kernel weight through hundred seed weight, followed by oil content via hundred seed weight and number of leaves per plant via plant height. Hence hundred seed weight could be useful for its highest direct effects and per cent seed filling indirect effects on seed yield via. hundred seed weight in selection programmes.

SUMMARY

VI SUMMARY

The present investigation was carried out with a view to study stability and heterosis for 36 newly developed hybrids selected out of hybrids synthesized using 10 inbred lines and 7 restorer lines.

Thirty six hybrids along with four checks viz., KBSH-1, MSFH-17, Morden and Sungene-85 were evaluated at three different environments (Ban galore, Hiriyur and Katthalgere) in a Randomized Complete Block Design (RCBD) with three replications for stability of twelve characters, heterosis for eleven characters and as well as correlation and path coefficient analysis for eleven character.

1. Study on mean performance of hybrids revealed that hybrids viz., IB109 x RHA587, IB 103 x 6D-1 and IB102 x 6D-1 recorded highest seed yield at first, second and third environment respectively and also surpassed MSFH-17 in each of the environment. The overall mean indicated that IB109 x RHA 587 and IB103 x RHA 586 surpassed MSFH-17 for seed yield. Whereas, hybrids viz., IB107 x PZ8R, IB107 x 6D-1 and IB101 x PZ8R recorded highest oil content and also surpassed KBSH-1 for this trait. Over all mean indicated that IB107 x 6D-1 recorded highest oil content followed by IB101 x PZ8R, IB103 x 6D-1, IB107 x PZ8R and IB102 x PZ8R were also surpassed KBSH-1.

2. The magnitude of heterosis for seed yield was highest in the hybrid IB109 x RHA 587 over Morden (91.94 %), KBSH-1 (27.58 %), Sungene-85 (26.56 %) and MSFH-17 (7.20 %). Similarly the magnitude of heterosis for oil content was highest in the hybrid IB107 x 6D-1 over MSFH-17 (32.31 %), Morden (24.05 %), Sungene-85 (15.60 %) and KBSH-1 (5.14 %).

3 The overall performance of genotypes in three different environments revealed that second environment was congenial for the expression of majority of the characters followed by first and third environment. The analysis of variance for stability revealed significance of environment (linear) for all the characters. The G x E (linear) was significant for hundred seed weight, Kernel weight, husk content and oil content implying that part of the variability is completely predictable in nature. However for rest of the characters, pooled deviation was significant indicating that performance of the genotypes could be completely unpredictable.

Maximum number of hybrids showed average stability for Kernel weight followed oil content, 100 seed weight, husk percentage and number of leaves per plant. The hybrids IB105 x 3376R, IB110 x PZ8R, IB106 x 3376R, IB102 x PZ8R and IB111 x PZ8R showed average stability for maximum number of characters.

As regards to stability for seed yield per plant, IB105 x RHA 587 proved best among new hybrids studied, which also exhibited average stability for days to 50 per cent flowering, days to maturity, head diameter and Kernel weight. Where as IB107 x 6D-1 rated as best for stability of oil content which also showed stability for number of leaves per plant, stem diameter, Kernel content and husk content.

4. Correlation coefficient analysis indicated that seed yield per plant had shown highest and significant correlation with hundred seed weight (0.570), per cent seed filling (0.495), Kernel weight (0.474), and head diameter(0.344).

5. Path coefficient analysis revealed that the hundred seed weight exerted highest direct effect on seed yield per plant followed by per cent seed filling, other characters exerted their indirect influence through these

two traits, indicating that hundred seed weight and per cent seed filling are the most important yield contributing characters to be concentrated in selection programmes to improve seed yield.

Future line of work

Based on the results of heterosis and stability analysis over environments, three hybrids, IB109 x RHA 587, IB103 x RHA 586 and IB105 x RHA 587 were found to be promising in respect of seed yield, while, IB107 x 6D-1, IB101 x PZ8R, IB103 x 6D-1, IB107 x PZ8R and IB102 x PZ8R in respect of oil content. In addition to these hybrids, other newly synthesized hybrids are to be evaluated over seasons and over locations by including more than three locations to assess their superiority and for commercial cultivation.

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* Originals not seen