

**Studies on genetic divergence, stability,
heterosis and combining ability in
sunflower (*Helianthus annuus* L.)**

BY
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DEPARTMENT OF GENETICS AND PLANT BREEDING
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CERTIFICATE – I

This is to certify that this thesis entitled, “**Studies on genetic divergence, stability, heterosis and combining ability in sunflower (*Helianthus annuus* L.)**” submitted for the degree of **Doctor of Philosophy** in the subject of **Genetics and Plant Breeding** to the CCS Haryana Agricultural University, Hisar is a bonafide research work carried out by **Sachin Kumari, Admn. No. 2012A42D** under my supervision and guidance and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been duly acknowledged.

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This is to certify that this thesis entitled, “**Studies on genetic divergence, stability, heterosis and combining ability in sunflower (*Helianthus annuus* L.)**” submitted by **Sachin Kumari, Admn. No. 2012A42D** to the CCS Haryana Agricultural University, Hisar in partial fulfillment of the requirements for the degree of **Doctor of Philosophy** in the subject of **Genetics and Plant Breeding** has been approved by the student’s advisory committee after an oral examination on the same in collaboration with an external examiner.

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With Thou blessings, a tiny seed developed into a tree.”***

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CONTENTS

CHAPTER	DESCRIPTION	PAGE NO.
I	INTRODUCTION	1-3
II	REVIEW OF LITERATURE	4-18
III	MATERIAL AND METHODS	19-34
IV	RESULTS	35-218
V	DISCUSSION	219-239
VI	SUMMARY AND CONCLUSION	240-243
	BIBLIOGRAPHY	i-xi
	APPENDIX –I	I-XL

LIST OF TABLE

TABLE NO.	DESCRIPTION	PAGE No.
3.1	List of genotypes selected for the study	20
3.2	Skeleton for analysis of variance	25
3.3	Analysis of variance for combining ability (individual environment.)	29
3.4	Analysis of variance for combining ability (pooled over environments)	31
3.5	Analysis of variance following Eberhart and Russell (1966) model	33
4.1	Estimation of variability and heritability in E_1	41
4.2	Estimation of variability and heritability in E_2	42
4.3	Estimation of variability and heritability in E_3	43
4.4	Estimation of variability and heritability in E_4	44
4.5	Estimation of variability and heritability over the environments	45
4.6	Clustering of 96 genotypes of sunflower on the basis of Euclidean minimum distance method	47
4.7	Average intra and inter-cluster D^2 values in 96 genotypes of sunflower	48
4.8	Cluster Mean values of seed yield and its component traits in sunflower	50
4.9	Analysis of variance for stability for seed yield and component traits in sunflower over all the environments	52
4.10	Stability analysis of 96 genotypes for plant height , head diameter, stem diameter , Days to 50% flowering of sunflower over all the environments	60
4.11	Stability analysis of 96 genotypes for days to maturity, 100 seed weight, seed yield, oil content over all the environments	64
4.12	Stability analysis of 96 genotypes for hull content (%), percent seed filling (%), germination (%) and electrical conductivity over the environments	68
4.13	Stability analysis of 96 genotypes for viability (%), vigour index I, Vigour index II and palmitic acid (%) over all the environments	73
4.14	Stability analysis of 96 genotypes for stearic acid (%), oleic acid and linoleic acid over all the environments	78
4.15	Analysis of variance for combining ability in E_1	84
4.16	Analysis of variance for combining ability in E_2	85
4.17	Analysis of variance for combining ability in E_3	86
4.18	Analysis of variance for combining ability in E_4	87
4.19	Analysis of variance for combining ability over the environments	88
4.20	Estimation of GCA and SCA variance for yield and its component traits in sunflower	89
4.21	General combining ability effects of parents for seed yield, oil content and its component traits of E_1 in sunflower.	91
4.22	General combining ability effects of parents for seed yield, oil content and its component traits of E_2 in sunflower	93

4.23	General combining ability effects of parents for seed yield, oil content and its component traits of E_3 in sunflower	101
4.24	General combining ability effects of parents for seed yield, oil content and its component traits of E_4 in sunflower	103
4.25	General combining ability effects of parents for seed yield, oil content and its component traits over the environments in sunflower	105
4.26	Estimation of sca effects for hybrids in E_1 .	118
4.27	Estimation of sca effect for hybrids in E_2	125
4.28	Estimation of sca effect for hybrids in E_3	131
4.29	Estimation of sca effect for hybrids in E_4	137
4.30	Estimation of sca effect for hybrids over the environments	144
4.31	Analysis of variance for plants and hybrids in E_1	153
4.32	Analysis of variance for plants and hybrids in E_2	154
4.33	Analysis of variance for plants and hybrids in E_3	155
4.34	Analysis of variance for plants and hybrids in E_4	156
4.35	Analysis of variance for plants and hybrids over the environments	157
4.36.1	Estimation of heterotic effects of hybrids for morphological traits and 100 seed weight in E_1	173
4.36.2	Estimation of heterotic effects for oil content, hull content and seed germination in E_1	176
4.36.3	Estimation of Heterotic effects of hybrids for linoleic acid, oleic acid and seedling vigour in E_1	179
4.37.1	Estimation of heterotic effects of hybrids for morphological traits and seed yield in E_2	182
4.37.2	Estimation of heterotic effects for oil content, hull content and viability in E_2	185
4.37.3	Estimation of heterotic effects of hybrids for seedling vigour and fatty acids in E_2	188
4.38.1	Estimation of heterotic effects of hybrids for morphological traits and seed yield in E_3 .	191
4.38.2	Estimation of heterotic effects of hybrids for oil content, hull content and viability in E_3	194
4.38.3	Estimation of heterotic effects for seedling vigour and linoleic acid in E_3	197
4.39.1	Estimation of heterotic effects of hybrids for morphological traits and seed yield in E_4	200
4.39.2	Estimation of heterotic effects of hybrids for oil content, hull content and viability in E_4	203
4.39.3	Estimation of heterotic effects for seedling vigour and linoleic acid in E_4	206
4.40.1	Estimation of heterotic effects of hybrids for morphological characters and seed yield over the environments.	209

4.40.2	Effects of heterotic for oil content and viability over the environments	212
4.40.3	Estimation of heterotic effects for seedling vigour and linoleic acid over the environments	215
5.1	Superior hybrids and parents and promising selected hybrids for high seed yield and oil content.	239

CHAPTER-I

INTRODUCTION

Sunflower is an important oilseed crop widely adopted and accepted for its high quality edible oil. It is grown over 23.28 million hectares in the world with 39.42 million ton production and 1690 kg per hectare productivity (Anonymous, 2016). Sunflower (*Helianthus annuus* L.) belongs to the genus *Helianthus* of the family *Asteraceae*, which includes 20 genera with 400 species. Its basic chromosome number is $n = 17$. The genus '*Helianthus*' includes diploid, tetraploid and hexaploid species. The name *Helianthus* derived from the Greek word "helios" meaning sun, and "anthos" meaning flower.

The cultivated sunflower is believed to have originated from wild *Helianthus annuus* in the south-western USA. Its cultivation is presumed to begin in Arizona and New Mexico about 3000 BC. The tall mono-head sunflower seems to have been developed during 6th century. In 16th century, Spaniards introduced domesticated sunflower from México to Europe as an ornamental plant. Later on in 18th century, it was introduced to Russia from Netherl and as an ornamental plant where its potential as a source of edible oil was recognized. The cultivation of sunflower in India started from 1972 after the introduction of Russian varieties such as Peredovick (EC 68414) and Armavirskii (EC 68415) and has acquired the status of an important commercial oilseed crop with greater spread across a number of agro - climatic and geographical regions.

In India, Sunflower is known as "*Surajmukhi*" and it covers an area of 5.9 million hectare with production of 3.23 million ton and productivity of 736 kg/ha (Anonymous, 2016). Karnataka, Andhra Pradesh, Maharashtra and Tamil Nadu are considered as traditional sunflower growing states whereas, Punjab, Haryana, West Bengal and Uttar Pradesh are promising spring sunflower growing states. In some agro climatic regions of India, sunflower is grown twice a year as spring and autumn crop, both under irrigated and rainfed conditions. In Haryana, sunflower is a major oilseed crop in spring season which is grown over an area of 11.6 thousand hectares with all time high production of 32.1 thousand ton and productivity of 2767 kg/ha (Anonymous, 2016). It contributes significantly to the edible oilseeds kitty due to the development and availability of large number of hybrids coupled with improved agro-production technologies. Sunflower is a rich source of good quality edible oil and it well fitted in our cropping pattern also. It is emerged as the most potential crop to narrow the gap between the total requirements and the domestic production of edible oil in the country.

Although, nearly every part of the sunflower has been used by humans for different purpose. Sunflower oil, however, is nutritionally considered as premium oil because of its light color, flavor, high smoke point and good nutritional quality. The oil content in whole

seed varies from 40 to 52% depending on the genotype and growing conditions. Sunflower oil has high and moderate level of linoleic acid (40-67%) and oleic acid (22-50%) respectively, and less than 15% saturated fatty acids viz; palmitic and stearic acid. High proportion of the essential fatty acid is considered to reduce blood cholesterol, therefore, reduce risk of coronary heart disease; hence sunflower has a special significance. High oleic sunflower oil has a higher degree of oxidative stability where as low oleic acid oil (Fuller *et al.* 1967), which is desirable for frying purposes, refining and storage.

In plant breeding, genetic diversity is important for hybrids between lines of diverse origin generally display a greater heterosis than those between closely related parents. D^2 analysis is a statistical method for genetic divergence that provides better choice of parents in any breeding program. The D^2 statistics equip to discriminate between different cultivars according to the diversity present (Mahalanobis, 1936). It furnishes a pleasant idea about the diverse nature of population. As per the Ward's method of the Euclidean method (Ward, 1963), the genotypes are clustered and distance between and within clusters is determined.

In recent years considerable importance is being given to genotype x environment interaction in the crop breeding programme. The purpose of stability studies is to evaluate the performance of genotypes including inbreds, hybrids and synthetic varieties of sunflower for yield and other characters to determine their stability over a set of environments by using the regression method of Eberhart and Russell (1966).

Sunflower, being a highly cross pollinated crop is ideally suited for exploitation of heterosis. The aim of breeding programme is to develop hybrids with high seed yield and oil yield potential having superior agronomic and economic advantages over varieties (high productivity, high oil content, uniformity, etc.). Hence, sunflower hybrid development is the main objective of breeding programme. Heterosis has been commercially exploited in sunflower and is expected to enhance productivity further. This is the only crop which has more than 80% sunflower growing area under the hybrids. In India, the hybrid breeding program has been quite successful and 29 productive hybrids were developed by both public (18) and private sectors (11). In spite of these successes, problems in the form of stagnating and unstable yields, genetic vulnerability and susceptibility to various diseases are threatening sunflower productivity in India. The favorable characters of sunflower hybrids like production stability, response to high input agriculture, self fertility, uniform growth and maturity shifted the focus towards heterosis breeding, lead to release of first ever sunflower hybrid BSH-1 in India (Seetharam, 1981), which provided required fillip to expand sunflower cultivation in the country. Since then, many hybrids have been released for commercial cultivation based on cytoplasmic genetic male sterility and fertility restoration system. Cytoplasmic male sterility (CMS) is the central component of sunflower hybrid development. Leclercq (1969)

discovered the first cms source for synthesis of hybrids with high heterotic effect and Kinman (1970) detect the fertility restoration genes that gave the required impetus to commercial hybrid seed production. The several hybrids have been released for commercial cultivation by both public and private sectors after utilizing deversified parental lines. Consequently, there have been relatively less efforts to diversify the inbreds to get better heterosis over check hybrids.

Several biometrical techniques have been developed to generate information on gene action and mode of inheritance of various characters, among which line $\times$ tester analysis (Kempthorne, 1957) has been widely used for genetic analysis in large number of crop plants. It is very efficient technique for evaluating large number of inbreds for its combining ability besides, this technique also provides information on general combining ability (GCA) and specific combining ability (SCA), which are useful to judge gene action controlling various characters to adopt appropriate breeding strategy.

Sunflower breeding aims at the evolution of high yielding, disease resistant, early maturing, short stature, and high oil content hybrids with stable performance under varying agro climatic conditions. Keeping above points into consideration, the present study was planned with the following objectives:

1. To study the genetic divergence among parents and hybrids.
2. To determine stability parameters in parents and their hybrids in contrasting environments over two years.
3. To estimate general and specific combining ability effects.
4. To measures the extent of relative heterosis.

CHAPTER-II

REVIEW OF LITERATURE

The relevant research work has been done so far by different research workers on different aspects of present research entitled, “Studies on genetic divergence, stability, heterosis and combining ability in sunflower (*Helianthus annuus* L.)” and it is reviewed under following headings.

1. Parameters of genetic variability
2. Genetic divergence
3. Stability
4. Heterosis
5. Combining ability

2.1 Genetic variability, heritability and genetic advance.

For the formulation of successful breeding programme, knowledge of the nature and magnitude of the genotypic and phenotypic variability present in any crop species plays a vital role. The phenotypic expression of a character is the result of the interaction between genotype and environment. Hence the total variation needs to be partitioned into variance due to genotype (heritable) and variance due to environment (non-heritable) for assessing the true breeding behavior of the phenotype. The efficiency of selection in plant breeding largely depends upon the amount of heritable variation present in the material.

Rao *et al.* (2003) estimated genetic variability for 11 characters with 82 genotypes in sunflower. Analysis of variance revealed significant genotypic differences for all the characters studied. The maximum phenotypic and genotypic variance exhibited for plant height and seed yield per plant.

PCV and GCV revealed high values for seed yield, oil yield and moderate values for plant height, head diameter, 100 seed weight, days to 50 *per cent* flowering, days to maturity, plant height, head diameter and oil yield. High heritability coupled with high expected genetic advance was observed for head diameter and oil yield. The elite genotypes with high seed yield, number of filled seeds and oil content were selected for intermating to generate next base population for cyclic selection. Superior genotypes may serve to develop inbreds for further use in heterosis breeding (Seneviratne *et al.*, 2004).

Killi and Altunbay (2005) claimed that the response of oilseed (P- 6480) and confectionary (Inegol) sunflower cultivars to days to maturity, plant height, head diameter, total number of seeds per head, seed setting efficiency, 1000 seeds weight, seed yield, hull ratio and seed oil content of oilseed and confectionery sunflower cultivars were significantly

affected by different planting dates. Oilseed sunflower cultivar had higher seed setting efficiency (93.3%), seed yield (3352 kg/ha) and oil content (34.2%) than confectionary sunflower 80.7%, 3226 kg/ha and 27% respectively. Vidhyavathi *et al.* (2005) indicated that simultaneous selection could be used for non-oilseed or confectionery types due to that no association with between yield and seed characters, seed length, 100 seed weight and oil content in both seeds and kernels.

The study was conducted using eight diverse genotypes of sunflower for genetic variances, genotypic and phenotypic coefficients of variability, heritability and correlations by Khan *et al.* (2007) for different traits. Differences among the average values for days to maturity, plant height, head diameter, seeds per head, 1000 seed weight, oil content, seed and oil yield were found statistically significant. The phenotypic coefficient of variation was found higher than the genotypic coefficient of variation for all the traits. High heritability estimates were observed for oil content, seed weight, days to maturity and plant height while seed yield, seeds per head and days to flowering depicted low heritability estimates. High expected genetic advance in *per cent* of mean was demonstrated by plant height, seeds per head, seed yield and oil yield per hectare making these characters valuable to breeders. Seed yield showed highly significant and positive correlation with plant height, seeds per head, oil content, seed weight and oil yield.

Muhammad *et al.* (2007) noticed high genotypic and phenotypic variances for plant height, oil content and achene yield with high heritability and expected genetic advance for the latter two traits indicating an additive effect. The dominant and epistatic nature of inheritance was reflected by high heritability and low genetic advance estimates for plant height and capitulum diameter.

Protein yield depends on seed yield and seed protein content. Seed protein content is one of the indicators of sunflower seed quality, (Hladni *et al.*, 2009a). Protein content varies depending on the genotype, agro ecological conditions and the interaction of the genotype and external environmental conditions, it ranges from 16-28 percent. With kernel increase, the amount of protein in the seed also increases so breeding for increased seed protein content should be followed by the selection of genotypes with larger kernels.

Tan (2010) studied hybrids and open-pollinated confectionary sunflower and the lowest seed yield (343 kg ha⁻¹) were obtained from the varieties ETAE-Y-TM-2007-5 and Armada, respectively. In the confectionary variety experiments, the highest seed yield (563 kg ha⁻¹) and the lowest seed yield (202 kg ha⁻¹) was produced in 2009 by the varieties ETAE-D1-2-B2 and ETAE-Ç-P-1-2, respectively. The results indicated that statistically significant differences were found among the sunflower varieties for the characters in question.

Gontcharov *et al.* (2011) evaluated sunflower lines and hybrids for seed yield and 1000 seeds weight. The most prominent hybrid combination (VK-905 A $\times$ K-4) and parental lines (CMS-line VK-905 A and restorer lines K-4, K-3 and K-1) for the future sunflower breeding work. It was further observed that seed yield level was 3.23 t/ha higher than the check variety.

Hladni *et al.* (2011b) indicated that in order to meet the Serbian market demands special attention has been given to the increase the protein content and quality while decreasing the seed oil content, to the increase 1000 seed weight and decrease of the hull ratio. New NS confectionary hybrids NS-H-6316, NS-H-6318 and NS-H-6320 were adequately good for nutrition, dehulling and core production. They belong to the group of mid-early hybrids while their genetic potential for seed yield was above 4.5 ton ha⁻¹ and seed oil content was less than 40 per cent. Protein content in the core was 23-27 per cent, mass of 1000 seeds was above 95 g, and the hull ratio was low. Hladni *et al.* (2011a) showed that the new confectionary hybrids were expressing higher seed yields in comparison to standards (Vranac and Cepko) though with a lower seed oil content. This also indicated that seed yield, seed protein content and mass of 1000 seeds have a high influence on protein yield. The degree of interdependence between different traits is a sign of direction which is supposed to facilitate better planning of confectionary sunflower breeding program.

Nabloussi *et al.* (2011) evaluated the performance and seed quality of Moroccan and Spanish sunflower germplasm used for food. Six cultivars from Morocco and six landraces from Spain were evaluated for seed yield, hundred-achene weight, hundred-kernel weight, achene oil content, kernel oil content, and fatty acid profile. The results showed that confectionery-type and oilseed-type cultivars did not differ in seed yield, hundred-kernel weight and kernel oil content. Since confectionery type cultivars from Spain performed similarly to local oilseed-type cultivars, they could be introduced to diversify the offer of in-shell sunflower seed snack in Morocco.

Mahmoud (2012) studied the genetic parameters in sunflower genotypes. The values of PCV and GCV were relatively high for head diameter and seed yield. The results showed little differences in the genotypic and phenotypic coefficients of variability and gave high values of heritability for all traits studied.

Natkar *et al.* (2013) investigated 34 mutants of Morden and 32 mutants of DSF 15B in M3 generation progenies of sunflower along with control. Most of the characters exhibited moderate to high variability. All the characters exhibited moderate to high heritability in mutants.

Safavi *et al.* (2015) observed that the analysis of variance was significantly differed for two studied traits. Genotypic and phenotypic coefficients of variations were high for

Thousand Kernel Weight (TKW), Head Diameter (HD) and Leaf Number (LN). Heritability estimates were observed for leaf number (LN), Days to physiological Maturity (DM) and Seed yield (SY). High genetic gain was observed for TKW, HD and LN. High heritability estimates associated with high genetic advance as percent mean were obtained in characters i.e., TKW, SY, HD and LN.

Amin *et al.* (2016) observed that the broad sense heritability (h^2_b) estimates ranged from 27.27% to 90.09% in summer and from 31.0% to 85.7% in winter. The narrow sense heritability (h^2_n) estimates ranged from 0.91% to 39.66% in summer and from 0.61% to 74% in winter. The genetic advance ranged from 11% to 77% in summer and from 12.2% to 79.1% in winter.

Muthupriya *et al.* (2016) developed RIL population with high and low oil content in sunflower. The phenotypic coefficient of variation (PCV) and genotypic coefficient variation (GCV) values were higher for oil yield per plant, seed yield per plant, 100-seed weight. High genetic advance was observed for the traits viz., oil yield per plant, seed yield per plant, 100-seed weight, plant height and volume weight.

Supriya *et al.* (2017) evaluated twenty sunflower hybrids for various parameters under field conditions to estimate genetic parameters, correlation coefficient and path analysis. Analysis of variance and mean performance for yield and its components revealed significant differences among all the genotypes for all the characters. Indicating highly significant differences among all the hybrids. Higher PCV and GCV were obtained for seed yield per plant followed by head diameter and test weight. Moderate PCV and GCV were obtained for the characters viz., plant height, volume weight and oil content. High value of heritability coupled with the high genetic advance was estimated for plant height, test weight, seed yield per plant, volume weight and head diameter, whereas, high heritability coupled with moderate genetic advance was recorded for days to 50 per cent flowering and oil content indicated additive gene action controlling these traits.

Lira *et al.* (2017) conducted an experiment using complete randomized block design with four replicates. The nature for the effects of genotypes and blocks was fixed. Except for the character chapter length, genetic variance was the main component of the phenotypic variance among the genotypes, indicating high genetic variability and experimental efficiency with proper environmental control. They reported that, the genetic correlations were superior to phenotypic and environmental. The high values reported for heritability and selective accuracy indicated efficiency of phenotypic selection. Results showed high genetic variability among genotypes, which may contribute to the genetic improvement of sunflower.

2.2 Genetic divergence studies among parents and hybrids.

In plant breeding genetic diversity plays an important role because crosses between diverse parental lines display a greater heterosis than those between closely related parents. It is important to identify best parents with wide genetic divergence for achieving desired heterosis for characters. Mahalanobis (1936) outlined a statistical procedure 'D² statistic' to measure the genetic divergence in a given population. It is a powerful tool in quantifying the degree of genetic divergence among parents (Muppidathi *et al.* 1995; Sujatha *et al.* 2002 and Punitha *et al.* 2010). Multivariate analysis has been considered as an important tool in quantifying the degree of genetic divergence in different crops (Ward, 1963). Genotypes from different localities are generally included in the hybridization programmes assuming genetic diversity and greater feasibility of recovering promising segregants. However, Murthy and Anand (1966) noted that there is no parallelism between geographical and genetical diversity.

Sujatha *et al.* (2002) studied genetic divergence of 51 inbreds and 3 checks GAUSUF-15, TNASUF-7 and TNAU-1 of sunflower using the Mahalanobis D² statistics. The genotypes were grouped into eight clusters which were not related to their geographic origin. Stem girth and seed yield per plant contributed the most to the total genetic divergence. Maximum inter-cluster distance was observed between the inbreds grouped in clusters I and V containing five and twelve inbreds, respectively, while the intra-cluster distance ranged from 0 to 2306.05. Based on mean performance, genetic divergence and clustering pattern, few inbreds namely; CMS-234B, 7-1B, CMS-597B, CMS-852B, ARM-250B, ARM-245B, HAM-69, ARM-284B, ARM-247B and HAM-174 were considered as potentially important for further breeding programme

Subrahmanyam *et al.* (2003) studied the extent of genetic divergence with respect to eleven characters in 85 sunflower genotypes consisting of 80 inbreds and five checks and concluded that the inclusion of GP-347, GP-1341, 300-B, ARM-244, ARM-248, HAR-5, 853-B, GP-913, GP-507 and GP-831 in future breeding programmes could results in the development of superior sunflower cultivars

In 2005, Mohan and Seetharam assessed genetic divergence in 137 inter specifically derived sunflower lines and they concluded that divergence among lines were mainly due to five characters viz. head diameter, plant height, seed length, oil content and days to 50 % flowering.

Mahalakshmi *et al.* (2006) studied twenty nine genotypes of sunflower for their genetic divergence by D² analysis. The genotypes were grouped into 7 clusters. On the basis of cluster distance and cluster mean, potential parents were identified from clusters I, VII and VI for hybridization programme. The character days to first flowering contributed more towards genetic divergence.

Binodh *et al.* (2007) studied genetic divergence of 24 breeding lines for eight traits in sunflower. The genotypes were grouped into ten clusters where cluster I was the largest containing 13 genotypes, followed by cluster IV with 3 genotypes. The inter-cluster distance was the maximum between clusters VI and VIII, followed by clusters IV and VI, and clusters VI and IX. The study revealed that plant height contributed maximum towards divergence (45.29%), followed by seed yield per plant (25.72%) and oil content (15.94%). Based on the inter-cluster distance and *per se* performance, the genotypes viz., 17A, 47A, CSFI 5325, CSFI 5415, CSFI 5436 and CSFI 5013 were identified as suitable parents which could be intercrossed to obtain high heterosis.

Kumar *et al.* (2008) evaluated 32 inbred lines using D^2 analysis and noticed that inbred DSI-2 in cluster IX and 207 B in XI were solitary, which indicated prevalence of certain extents of diversity in the material maintained. Based on inter cluster-distance, authors concluded that oil content contributed maximum to total divergence followed by days to 50 per cent flowering and days to maturity.

Camarano *et al.* (2010) investigated genotypic divergence among 10 sunflower populations using Mahalanobis' D^2 statistics and canonic variables to identify more similar and more divergent groups. The results of the individual variance analysis pointed out significant differences for the initial flowering, final flowering, plant height, oil content, moisture content and yield in all the experiments. Very high genetic variability was noted among the populations for these traits. The traits, stem diameter, head diameter, 1000-seed weight and number of seeds per head showed differences, which were sometimes significant and sometimes not, indicating that these traits show genotype-environment interaction.

Punitha *et al.* (2010) investigated genetical diversity among 17 sunflower genotypes using nine agronomic characters and indicated that the inclusion of CSFI 5076, CSFI 5162, CMS 47A, CSFI 5005, CMS 17A, CMS 47A, CSFI 5069, CSFI 5422, CSFI 5109, CSFI 5155, CSFI 5002, COSF 1A, CSFI 5161 and CSFI 5015 in future breeding programs could result in the development of superior sunflower cultivars.

Mandel *et al.* (2011) studied the Genetic diversity and population structure in cultivated sunflower and compared to its wild progenitor (*Helianthus annuus* L.).

Dan *et al.* (2012) studied genetic divergence of 79 inbred lines of sunflower using Mahalanobis D^2 statistics indicated the presence of substantial genetic diversity. On the basis of inter cluster distance oil content contributed maximum towards genetic divergence, followed by plant height and 100-seed weight. Head diameter and seed yield per plant contributed the least.

Kumari and Sheoran (2012) studied the genetic divergence in sunflower on the basis of seed yield and oil content.

Reddy *et al.* (2012) studied genetic divergence in 64 genotypes of sunflower and grouped them in nine clusters. The pattern of distribution of genotypes into various clusters was random and indicated that the geographical and genetic diversity were not related. Plant height contributed maximum towards genetic divergence, followed by stem diameter and head diameter.

Tyagi *et al.* (2013) reported genetic diversity among 18 sunflower inbred lines involving alloplasmic *cms* lines, conventional *cms* and restorer lines (*petiolaris* source) using twenty traits. Mahalanobis D^2 statistic indicated presence of substantial genetic diversity and genotypes were grouped into five cluster. ARG-3A and *cms* -XA were designated as the most diverse *cms* sources.

Ayaz *et al.* (2014) studied genetic divergence among 17 sunflower hybrids and 15 inbred lines analyzed by Euclidean method of D^2 analysis that allocate into 4 clusters. The clusters I and IV comprised of four whereas cluster II and cluster III have three and five hybrids respectively. All the restores were clustered in III and IV and CMS lines in I and II groups respectively. According to principle component analysis the first two components contribute 64% and 89% in total variation in hybrids as well as in inbred lines respectively.

Shamshad *et al.* (2014) investigated that 31 germplasm line analyzed by D^2 analysis and assigned the genotypes into 6 clusters indicating presence of enough genetic diversity in the material. The intra cluster distances ranged from 0 (cluster II, IV, V and VI) to 417.294 (cluster I) indicating presence of only one line in cluster II, IV, V and VI whereas, genotypes in cluster I were more dissimilar in agronomic and yield traits than other clusters. The maximum inter-cluster distance was observed between the members of cluster II with cluster VI followed by cluster I with cluster VI, cluster V with cluster VI and cluster II with cluster IV. The genotypes NC-41B (Morden), HOAL-38, P61R and TX-16R were most diverse genotype as they grouped in different clusters and should be used in hybridization program to realize high heterosis.

Chandirakala and Manivannan (2014) evaluated 38 sunflower genotypes for the quantification of nature and extent of genetic diversity using Mahalanobis D^2 statistics. The genotypes were grouped into thirteen clusters. Cluster IX was the largest with 9 genotypes followed by cluster X with 5 genotypes. The genotypes GMU 322, COSF3B and COSF4B in the cluster II, the genotypes GMU 503, GMU 1074 and GMU 1108 in the cluster XII and the genotypes COSF1B in the cluster XIII were widely divergent. The characters viz., days to 50 percent flowering and seed yield were found to be important contributors for genetic divergence.

Pandya *et al.* (2014) studied 40 genotypes of sunflower and grouped them into five clusters. The cluster III having higher means for days to maturity, head diameter, number of

seeds per capitula, number of filled seeds per capitula, seed yield per plant and 100-seed weight was found to be more divergent from cluster IV which had higher means for number of unfilled seeds per capitula. The clustering pattern of genotypes was independent of their geographical distribution.

Neelima *et al.* (2016) studied genetic divergence among 174 genotypes of sunflower and partitioned into 13 clusters which indicate prevalence of good extent of diversity in the material. Cluster I had more no. of genotypes followed by clusters IV, VII and VIII. Cluster X had higher mean value for plant height and head diameter, cluster XII had higher test weight and cluster XI had high seed yield per plant. The maximum inter cluster distance was recorded between cluster XI and XII followed by cluster X and XII and clusters V and XII. They concluded that 100 seed weight, plant height and days to maturity were the major contributor to genetic divergence among the accessions.

2.3 Stability

Lin *et al.* (1986) amplified that “stability is defined in many ways depending on, how the scientist wishes to look at the problem.” Yield stability of a genotype is evaluated from estimates of stability parameters. A desirable, stable genotype is one having mean yield higher than the average yield of all genotypes under test, regression coefficient (b_i) close to unity, and least deviations (S_d^2) from regression possibly close to zero. The growth response index (regression coefficient) measures responses to increments in an improving environment. Genotypes with regression coefficients greater than one could be adapted to favorable growing conditions, whereas those, with regression coefficients less than one would be adapted to less favorable growing conditions.

Ghafoor *et al.* (2005) tested stability of fifteen sunflower genotypes across eight environments with respect to oil yield. On the basis of six different stability measures, genotypes such as SF-187, SM4-269, SC-110 and PSH-21 were found as stable genotypes. Use of Ward’s fusion strategy of hierarchical clustering technique demonstrates similar response of some genotype over all environments.

Binodh *et al.* (2009) investigated the test of adaptability of 9 high yielding heterotic hybrids with 3 check hybrids over three environment viz. rabi (E_1), kharif (E_2) and summer (E_3). Genotype x Environment interaction was significant for seed yield and oil content over the environments. The study revealed that the hybrids, CSFH 6008, CSFH 6037, CSFH 6039, CSFH 6045 and CSFH 6058 were stable over environments for seed yield and oil yield and hybrid CSFH 6045 was found superior.

Kaya *et al.* (2007) identified stable cultivars by growing in different environments. The research was conducted in Trakya with 3 commercial sunflower hybrids. These 3 hybrids used as control for comparing over 500 sunflower hybrids in 15 yield trials in 2002 and 8

yield trials in 2003. The result revealed that sunflower hybrid Sanbro was the most stable cultivar, Tarsan-1018 cultivar showed its high yield performance only in bad conditions, Coban demonstrated less variability based on some stability parameters and maintained its high performance only in good conditions.

Alba *et al.* (2010) evaluated eleven hybrids following a randomized complete block design with three replications at each location-year combination. Eight agronomic characters including seed oil content were recorded. Classification and ordination procedures were used to investigate hybrid performance in relation to three different sowing dates. Combined analysis of variance showed that hybrids, location-year combination, sowing date and their interactions were highly significant for all characters. Hybrid performances were classified by cluster analysis into groups that were differentiable in terms of means and stability. The first three components accounted for 74 per cent, 82 per cent, and 87 per cent of the total variation for the first, second and third sowing dates respectively.

Piasai *et al.* (2010) evaluated 10 synthetic variety of sunflower and 2 check hybrids over 7 environments. The pooled analysis of variance showed that varieties-environment interactions ($V \times E$) were significant for seed yield, plant height, disk size, and seed size. The regression analysis was used to partition $V \times E$ interaction into linear and non-linear components. The stability parameters (b_i and S^2_{di}) showed that 10 varieties were stable for yield, 7 varieties for plant height, none for disk size, and 10 varieties for seed size. They concluded that synthetic varieties LOC, CM1, LOO, and HOO with above average seed yield were stable and could be recommended for general production.

Bhoite *et al.* (2010) studied 14 sunflower (*Helianthus annuus* L.) hybrids with two checks and were assessed for stability during 2004 and 2005 for seed yield. The analysis of variance for hybrids, environments and $G \times E$ interaction was found significant. The hybrids KSFH 401, 402 and 446 were found to be below average stability, whereas the hybrid KSFH 434 showed stable performance for seed yield.

Sheoran *et al.* (2012) studied genotype $\times$ environment interaction and stability analysis in sunflower (*Helianthus annuus* L.) and suggested that the yield of the hybrids was inconsistent in different seasons.

Ahmed *et al.* (2013) studied 19 locally developed hybrids and one Hysun 33 in two irrigated conditions for two seasons (2003, 2004 and 2004, 2005) for stability parameter in seed yield per hectare. The variance of genotype $\times$ environment interaction ($G \times E$) was highly significant, suggesting that the yield of the hybrids was inconsistent in different environments. The two released hybrids (Salih and Shambat 6) were adapted to favorable environments, whereas Ka99 $\times$ 25-2 adapted to unfavorable conditions. However, the graph for scatter points for yield of the locally developed hybrids revealed that Salih and Shambat 6

were stable, whereas Hysun 33 was unstable under these environments and its yield was only increased with improving the conditions.

Ahmad *et al.* (2017) they crossed 10 cms lines with 13 restorer line to obtain the F₁ hybrids and evaluate the F₁ hybrids during spring 2002 at Pakistan. They concluded that all the hybrids were highly significant for all the traits studied. The hybrids CMS-341 × R-266, CMS-372 × R-374, CMS-372 × R-374 and CMS-341 × R-373 were the best for yield, therefore they were recommended to be included in breeding programs for further improvement.

Mijic *et al.* (2017) studied 7 sunflower hybrids in a period of 4 years at Osijek location and suggested that hybrid OS-H-4 was a promising hybrid as it had higher grain yield and high oil yield, hence may be used for further breeding programme.

2.4 Heterosis

Heterosis is the superiority of F₁ of a cross over the mean of its parents or mean of check variety or hybrid. The utilization of heterosis as a means of maximizing the yield of agricultural crops has become one of the most important methods in plant breeding. A brief review of work pertaining to heterosis is presented below:

Hladni *et al.* (2005) studied the heterosis in inbred lines and F₁ generation. They concluded that heterosis values for seed yield per plant were positive and highly significant relative to mid parents (98.4% to 274.1%) and over the better parent (54.8% to 223.2%) where as for plant height it was less significant. Development of new high-yielding and stable sunflower hybrids based on interspecific hybridization was recommended

Ahmad *et al.* (2005) investigated heterosis and inbreeding depression of parental inbred lines, their F₁ hybrids and F₂ populations using randomized complete block design with three replications. Genetic differences were observed among the parents, their F₁ hybrids and F₂ populations for all the characters under study. Yield and leaf area showed highly significant heterosis in F₁ ranging from 102 to 309% and 46.3 to 163.9% over mid parent and better parent, respectively, while inbreeding depression in the F₂ population ranged from 17% to 71% and -9.7% to 43%, respectively. Leaves per plant showed low level of heterosis (-0.9 to 39.7%), whereas the effect of inbreeding depression in F₂ population was comparatively high (1.1 to 22.2%) for this character. The parent RHA-822 proved itself to be a good general combiner by making higher contribution towards heterosis in F₁ hybrids.

Habib *et.al.* (2006) investigated the level of heterosis in 84 hybrids of sunflower and parents during spring at Pakistan. The results showed the highly significant difference existed among genotype for all the plant traits. The highest positive heterosis and heterobelteosis for oil content was exhibited in crosses ORI-6 x RL-27 and ORI-47 x RL-69. The cross ORI-3 x

RL-77 showed the highest positive heterosis over mid and better parent for number of seeds per head and oil yield.

Anwar *et al.* (2006) tested seventeen sunflower hybrids; the heterobelteosis was reported to range from 3.72 to 284.37 for seed yield, and from 1.33 to 21.48 for oil content. The hybrid ORI-43 x RL-10 produced maximum seed yield per plant (56.25 g).

Habib *et al.* (2007) evaluated 84 hybrids obtained from crossing 14 *cms* lines and 6 inbreds in line x tester design for heterosis and heterobelteosis of seed yield, plant height and days to flowering. The highest positive 17 heterosis over mid and better parent for seed yield was reported for the cross ORI-3 x RL-77 as 214 per cent and 118.1 per cent respectively.

Sawant *et al.* (2007) crosses four *cms* lines with ten restorer lines in L x T design to estimate heterosis for yield and its attributing traits. The standard heterosis for seed yield ranged from -71.83 to 28.73 per cent and with the highest standard heterosis and heterobelteosis recorded for cross 17 A x HAM-183.

Massod *et al.* (2009) evaluated 8 x 8 diallel cross analysis to determine magnitude of heterosis for six heritable traits of sunflower. Heterosis for seed yield ranging from as -4.82 to 27.44 per cent and for oil content from -19.66 to 28.07 per cent.

Sujatha and Reddy (2009) evaluated 40 crosses obtained from four *cms* lines and ten restorer lines in a L x T design and reported that the heterosis ranging from -49.23 to 27.65 per cent for seed yield and -58.18 to 35.22 per cent for oil content. The top most hybrid DCMS 36 x DRS-16 had seed yield per plant 48.35 and 45.5 per cent oil content

Aslam *et al.* (2010) studied the heterosis breeding for improvement in oil quality of parents and their 16 hybrids highly significant genetic differences ($p < 0.01$) were observed among parents and F_1 hybrids for oleic acid (C18: 1), linoleic acid (C18:2) and behenic acid (C20:0). TS-335 x 291RGI had highest negative mid and high parent heterotic effects, TS-18 x R-25 had maximum positive mid and high parent heterosis for C18:1, TS-18 x TR-6023 has maximum positive mid and high parent heterotic effects for C18:2 and highest negative mid parent heterosis was observed for C20:0 by TS-17 x TR-9, TS-18 x 291RGI. It was concluded that the mid and high parents of heterotic effects improved the oil quality of the parent of these eight hybrids and suggested for use in sunflower breeding program.

El-Seidy *et al.* (2010) investigated the level of heterosis, general and specific combining ability for yield and its components and oil percent in six CMS lines (A3, A10, A28, A29, A33 and A34) and four R lines (R1, R5, R8, R10) of sunflower and their 24 hybrids. They concluded that cross (A33 x R10) was the best hybrid for earliness and the crosses viz. (A10 x R10), (A10 x R1) and (A10 x R5) were the best hybrids for seed and oil yield, and suggested that these crosses could be used as a good hybrids for cultivation at North Delta Region of Egypt.

Karasu *et al.* (2010) studied the heterosis in 6 hybrids that were created by crossing 3 *cms* and 2 restorer line of sunflower (*Helianthus annuus* L.). They concluded that CMS 10 and RHA 10 proved to be good combiners having the highest positive GCA effect in yield and other yield traits. The crosses such as CMS 10 x RHA 03, CMS 01 x RHA 10, CMS 10 x RHA 10 and CMS 23 x RHA 10 are promising hybrid combinations in terms of seed yield. The values of heterosis and Heterobeltiosis values ranged from 109.8 to 218.3% for seed yield. All the tested hybrids showed positive and significant Heterobeltiosis for seed yield.

Athoni and Nandini (2012) investigated the level of heterosis in 60 F₁ hybrids along with their parents during summer for nine characters. The percent contribution of component characters viz. thousand seed weight, plant height, and head diameter towards expression of heterotic effect were the extent of 15.06, 30.82 and 53.86 %, respectively.

Amin *et al.* (2014) planted sunflower generation in two seasons i.e. during summer 2004 and winter 2005, and the material was evaluated during summer 2005. The analysis of variance and component of generation means indicated that dominant gene effect controlled the most traits tested. The estimation of heterosis was highly significant ($P>0.01$) for most traits of sunflower.

Deshmukh *et al.* (2016) studied heterosis in sunflower, 45 hybrids were sown along with parents and standard check (Phule Raviraj, SVSH -475). The results revealed that the magnitude of heterosis was high for all the characters. The hybrid SVSAL-1 x SVSR-7 (202.57%) showed highest standard heterosis for total number of seed per head and hybrid SVSAL-1 x SVSR-9 (33.57%) showed highest standard heterosis for the characters like seed yield per plant over superior check.

2.5 Combining ability studies

The ability of a genotype to produce superior progeny upon hybridization with other depends upon combining ability. Sprague and Tatum (1942) developed the concept of combining ability and coined two terms viz., general combining ability and specific combining ability. The average performance of a genotype in cross combination with a set of other genotypes is called as general combining ability of the genotype and is expressed as GCA effect (g_i) and GCA variance (σ^2_g). It denotes the additive component of genetic variance and is fixable on selfing. The relative performance of any cross combination is expressed as specific combining ability and is denoted as SCA effects (S_{ij}) and SCA variance (σ^2_{sj}). The *sca* variance denotes Non-additive or dominance portion of variance and its generally non fixable on selfing but can be exploited in hybrid combination.

Devi *et al.* (2005) studied line x tester for 10 sunflower inbreds. The results revealed that lines SA, 9A, 10 A and 21 R testers were good general combiners and shows the non additive gene action. They concluded that majority of the heterotic crosses involved parents

with low x low GCA or high x low GCA effects and suggested that a single high general combiner, in the cross combination was results in best specific combination.

Hladni *et al.* (2006) studied 7 CMS lines and 3 restorer lines were crossed in line x tester resulting in 21 F₁ hybrids. Non-additive component of genetic variance played the main role in the inheritance of oil content. The ratio GCA/SCA for oil content in the F₁ generation which was smaller than unit (0.33). The highest average contribution to the expression of oil content (77.3%) was exhibited by the A lines.

Loganathan *et al.* (2006) studied combining ability of nine genotypes in a half diallel design and reported the predominance of additive gene action for days to 50 per cent flowering, plant height, head diameter, hull content, test weight, seed yield and oil content while non-additive gene action for per cent seed filling.

Hladni *et al.* (2008) studied the combining effect for A lines, Rf testers and their F₁ hybrids for seed yield and 100 seed weight. Analysis of variance of the combining abilities revealed highly significant differences for GCA and SCA. The inheritance of the total seed number per head and the mass of 100 seeds was played by non additive component of the genetic variance which was confirmed by the GCA/SCA relation in F₁ generation that was less than one. Seed yield and 100 seed weight were positive and significant. Therefore they were useful for the creation of new high-yielding sunflower hybrids on the basis of *intraspecific* hybridization.

Khan *et al.* (2009) evaluated crosses of four lines and four testers from L x T design for combining ability, reported high *gca* variance for days to first flowering, days to hundred per cent flowering and plant height, whereas predominance of non-additive genetic effect was recorded for days to maturity. The tester R-25 proved to be the best general combiner for earliness, whereas the tester 291RGI proved to be the best general combiner for plant height.

Sujatha and Reedy (2009) evaluated 40 crosses in L x T design reported the role of additive gene actions in the control of head diameter and non-additive gene actions for seed yield/plant, oil content, plant height, days to 50 per cent flowering and days to maturity and also recorded the highest standard heterosis of 35.22 per cent for oil content and 27.13 per cent for seed yield/plant.

In a study comprising 45 crosses obtained from crossing restorer lines in a diallel fashion by Tavade *et al.* (2009) elucidated the significance of both *sca* and *gca* variances in the control of seed yield, yield components, and oil content in sunflower.

Karasu *et al.* (2010) studied that 3 CMS and 2 restorer lines were crossed in all possible combination to produce 6 hybrids. GCA: SCA variance ratio was lower than 1, indicating importance of the non additive gene action. CMS 10 and RHA 10 were the good combiners while the crosses CMS 10 x RHA 03, CMS 01 x RHA 10, CMS 10 x RHA 10 and CMS 23 x

RHA 10 were considered as promising hybrid combinations in terms of seed yield. The values of heterosis and heterobelteosis ranged from 109.8 to 218.3% for seed yield. They concluded that the tested hybrids showed positive and significant heterobelteosis for seed yield.

Ghaffari *et al.* (2011) crossed 6 restorer lines with 4 CMS lines in line x tester design, 24 F₁ hybrids were evaluated and suggested that restorer line “R 21” and CMS line “CMS 356” had stronger effect on their corresponding hybrids. Cross “R 23 x CMS 78” was identified as superior early maturity hybrid with high oil content and yield.

Chandra *et al.* (2011) evaluated 42 hybrids obtained from crossing seven CMS lines and six inbreds in line x tester design for combining ability and gene action of plant height, number of filled seeds per head, seed yield per plant and oil yield per plant. The pooled analysis of variance for combining ability revealed that *sca* variance was higher in magnitude as compared to *gca* variance for all the characters except oil content, indicating the preponderance of non-additive gene action for all the characters while additive gene action for oil content. The *gca* effects of the parents in pooled analysis revealed that among the lines ARM 243B and CMS 17B and among the testers RHA-6D-1R, RES-834-1 and 3376R were observed to be promising general combiners for seed yield and yield component characters.

Athoni and Nandini (2012) investigated crosses from L x T mating design to estimate the combining ability of 5 CMS lines and 12 testers that were crossed in all possible combination. The estimates of SCA variance were higher than general combining ability (GCA) variance for all the characters, which indicated predominance of non-additive gene action.

Ciric *et al.* (2012) evaluated 10 CMS lines and 3 fertility restorer lines and their 30 hybrids by line x tester method to analyze the combining ability for traits and suggested that crosses MG-MI-2 x PL-DI-15 and MG-MI-1 x PL-DI-15 were the best hybrids for combining ability.

Jondhale *et al.* (2014) studied that 10 CMS lines were crossed with 9 inbred lines to elucidate the information on the combining ability. A total of 90 crosses were evaluated for 12 different quantitative traits. They concluded that CMS E002-92 and CMS-AGR-6, inbreds R-27 Br and R-77-2III were the best combiners for different traits. The estimates of variance components revealed predominance of non-additive gene action for all characters studied.

Nasreen *et al.* (2016) crossed 6 CMS lines and 6 testers in a line x tester design resulting 36 F₁ hybrids. The SCA variances were higher than GCA for seed yield and related traits revealing the involvement of non-additive type of gene action controlling the characters, which can be utilized in a hybrid improvement programme through heterosis breeding in sunflower.

Shinde *et al.* (2016) made the cross in L X T mating design, including 5 lines and 10 testers. Non additive inheritance of genetic variance played a predominant role for all the characters under study. Among 50 hybrids CMS -107 x SVR -472, CMS -378 x SVR -444 and CMS -351 x SVR-495 were the superior hybrids as per their high per se performance and significant specific combining ability for seed yield.

CHAPTER-III

MATERIALS AND METHODS

The present investigation entitled “Studies on genetic divergence, stability, heterosis and combining ability in sunflower (*Helianthus annuus* L.)” was carried out at experimental area and laboratories of Oilseed Section, Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The research station represents the alluvial plain of Indo Gangetic basin and is situated at 29 degree North latitude and 75 degree East longitude and a mean height of 216 meter above sea level.

3.1 Experimental material

The experimental material consisted of 15 CMS (cytoplasmic male sterile) lines used as seed parents viz. CMS 11A, CMS 17A, CMS 44A, CMSH 91A, CMS 103A, CMS 148A, CMS 207A, CMS 234A, CMS 302A, CMS 607A, CMS 852A, CMS ARG-2, CMS ARG-3, CMS ARG-6 and CMS DV-10 and five restorers (R line) used as a pollen parents namely 6D-1, HRHA 5-3, HRHA 4-2, RHA 297 and RHA 271 which were grown in paired rows and crossed in Line X Tester design to obtain 75 F₁ hybrids, and there was a commercial check hybrid HSFH 848. Each CMS and restorer lines were grown in 2 rows of 4 meter length with a spacing of 45 cm x 30 cm.

Crossing Procedure

During the *spring* season of 2014, all the F₁'s were obtained by crossing the cytoplasmic male sterile lines with restorer lines. The cytoplasmic male sterile lines and restorer lines were sown in the field to affect crossing. At the time of flowering, all the heads in lines and testers were covered with muslin cloth bags to prevent open pollination. The pollen of the five restorer lines were collected separately in petridishes with the help of camel hairbrush during morning hours (7:00 to 11:00 AM) and pollinated to each of the cytoplasmic male sterile lines separately and the cloth bag was covered again after pollination. Pollination was done till all the florets in the capitulum showed sign of drying. The heads of all the resultant 75 hybrids were collected, dried and threshed. The well filled seeds from each cross were separated out for hybrid evaluation.

The hybrid evaluation was conducted over 4 environments during 2014 -2015 *i.e.* Summer 2014 Last week of August (E₁) and First week of September (E₂) and during spring 2015, *i.e.* first week of February (E₃) and last week of February (E₄).

Table 3.1 The list of selected genotypes

S. No.	CMS LINE	S. No.	RESTORER LINE
1	CMS 11 A	1	6D-1
2	CMS 234 A	2	RHA 271
3	CMS 44 A	3	HRHA 4-2
4	CMSH 91 A	4	HRHA 5-3
5	CMS 17 A	5	RHA 297
6	CMS 103 A		
7	CMS 148 A		
8	CMS 207 A		
9	CMS 302 A		
10	CMS 607 A		
11	CMS 852 A		
12	ARG 2-A		
13	ARG 3-A		
14	ARG 6-A		
15	DV -10		

The list of hybrids and commercial check included in study are enlisted below:

S. No.	CROSSES	S. No.	CROSSES
1	CMS 11A x 6D-1	40	CMS 302A x RHA 297
2	CMS 11A x RHA 271	41	CMS 607A x 6D-1
3	CMS 11A x HRHA 4-2	42	CMS 607A x RHA 271
4	CMS 11A x HRHA 5-3	43	CMS 607A x HRHA 4-2
5	CMS 11A x RHA 297	44	CMS 607A x HRHA 5-3
6	CMS 17 A x 6D-1	45	CMS 607A x RHA 297
7	CMS 17 A x RHA 271	46	CMS 852A x 6D -1
8	CMS 17 A x HRHA 4-2	47	CMS 852A x RHA 271
9	CMS 17A x HRHA 5-3	48	CMS 852A x HRHA 4-2
10	CMS 17 A x RHA 297	49	CMS 852A x HRHA 5-3
11	CMS 44 A x 6D -1	50	CMS 852 A x RHA 297
12	CMS 44A x RHA 271	51	ARG 2A x 6D-1
13	CMS 44A x HRHA 4-2	52	ARG 2A x RHA 271
14	CMS 44A x HRHA 5-3	53	ARG 2A x HRHA 4-2
15	CMS 44A x RHA 297	54	ARG 2A x HRHA 5-3
16	CMS 148A x 6D -1	55	ARG 2A x RHA 297
17	CMS 148A x RHA 271	56	ARG 3A x 6D -1
18	CMS 148A x HRHA 4-2	57	ARG 3A x RHA 271
19	CMS 148A x HRHA 5-3	58	ARG 3A x HRHA 4-2

20	CMS 148A x RHA 297	59	ARG 3A x HRHA 5-3
21	CMSH 91A x 6D -1	60	ARG 3A x RHA 297
22	CMSH 91A x RHA 271	61	ARG 6A x 6D-1
23	CMSH 91A x HRHA 4-2	62	ARG 6A x RHA 271
24	CMSH 91A x HRHA 5-3	63	ARG 6A x HRHA 4-2
25	CMSH 91A x RHA 297	64	ARG 6A x HRHA 5-3
26	CMS 103A x 6D-1	65	ARG 6A x RHA 297
27	CMS 103A x RHA 271	66	DV 10 x 6D -1
28	CMS 103A x HRHA 4-2	67	DV 10 x RHA 271
29	CMS 103A x HRHA 5-3	68	DV 10 x HRHA 4-2
30	CMS 103A x RHA 297	69	DV 10 x HRHA 5-3
31	CMS 234A x 6D-1	70	DV 10 x RHA 297
32	CMS 234A x RHA 271	71	CMS 207A x 6D -1
33	CMS234A x HRHA 4-2	72	CMS 207A x RHA 271
34	CMS234A x HRHA 5-3	73	CMS 207A x HRHA 4-2
35	CMS 234A x RHA 297	74	CMS 207A x HRHA 5-3
36	CMS302A x 6D-1	75	CMS 207A x RHA 297
37	CMS 302A x RHA 271		
38	CMS 302A x HRHA 4-2		COMMERCIAL CHECK HYBRID
39	CMS 302A x HRHA 5-3	76	HSFH 848

3.2 WEATHER DURING CROP SEASON

The meteorological data was taken from Department of Agricultural Meteorology Haryana Agricultural University, Hisar. During the crop season of 2014 (February) the maximum and minimum temperature ranges from 20.6°C and 7.9°C respectively, relative humidity varies from 75 -65 % with 4.1 mm rainfall. Maximum and minimum air temperature for last week of August (2014) was 33 - 25.5°C and for first week of September (2014) was 34.4 - 24.7°C respectively. The air temperature 21.9°C - 6.2°C, 22.4°C-9.4°C maximum and minimum was recorded for the first week of February and last week of February respectively.

3.3 COLLECTION OF DATA

In all the entries, five random competitive plants were tagged in each replication for recording the observations. Mean of five plant observations was used for the statistical analysis. The procedure adopted for recording the observations for different characters is given below:

OBSERVATION RECORDED

3.3.1. Days to 50% flowering

The number of days taken to 50 per cent flowering was recorded by counting number of days from the date of sowing to the date when 50 per cent of the plants in a genotype had flowered.

3.3.2. Days to maturity

The number of days taken to maturity was recorded as total number of days from date of sowing to the date of physiological maturity i.e. when back side of the capitulum turned yellowish - brown and brackets started drying

3.3.3. Plant height (cm)

Five plants were marked from each genotype to measure plant height. The height was measured from base to the tip of main stem with the help of measuring tape at the time of maturity when plant attained maximum growth. The mean data of five plants was used for statistical analysis.

3.3.4. Head diameter (cm)

Head diameter was measured in centimeters from one end of head to other after seed setting from five randomly tagged plants at maturity.

3.3.5. Stem girth (cm)

The stem girth was measured at about one foot above from the ground level with the help of thread method

3.3.6. Hundred seed weight (g)

One hundred seeds were counted from each genotype / hybrid and weighed on electronic balance.

3.3.7. Seed yield per plant (g)

At maturity, all the heads of selected plants were harvested and threshed separately. Seed weight of the threshed seed from each plant was recorded on electronic balance.

3.3.8. Seed filling percent (%)

Seed filling percentage was calculated by dividing the number of filled seeds per head by the total number of seeds per head and multiplied by 100 to express in per cent.

$$\text{Seed filling percent \%} = \frac{\text{Number of filled seeds per head}}{\text{Total number of seeds per head}} \times 100$$

3.3.9. Hull Content (%)

Ten grams of seed was weighed and soaked overnight. The hull was removed, thereafter; hull and dehulled seeds were dried in oven and weighed separately to compute the hull percentage.

$$\text{Hull Content \%} = \frac{\text{Weight of hull (g)}}{\text{Weight of the whole seed (g)}} \times 100$$

3.3.10. Oil content (%)

Oil content in seed samples was determined by the method of A.O.A.C. (1995). The seeds were oven dried at 80°C for 16-18 hrs, crushed and weighed. The oil of crushed seeds was extracted by using the petroleum ether in Soxhlet apparatus. The loss in weight was estimated as the oil content (%).

3.3.11. Seed germination (%)

Between the rolled paper, 100 seeds per replication from each entry were kept at 25°C temperature with 90-95 per cent RH in seed germinator. Normal seedling, abnormal seedling, hard seed and dead seed were counted and recorded as standard germination in per cent on the 10th day from the commencement of the test (As per the ISTA Rules, 1985).

3.3.12. Seed viability (T_v) test

In a 100 ml beaker 50 seeds were soaked containing 80 ml distilled water for 16 hr, then husk of seeds was removed and dipped in 0.5 % tetrazolium solution for 4 hrs the seeds bearing red color on their tips and embryo were counted and expressed in percentage as viable seeds (Moore, 1985).

3.3.13. Seedling vigour

Seedling vigour was calculated by the two methods seedling vigour index I and seedling vigour index II.

VI- I

On the 10th day of germination test, the ten normal seedling per replication from each genotype were randomly taken and their root and shoot length were measured and summed up. So the vigour index I was calculated as:

$$\text{Total seedling length (cm)} \times \text{standard germination (\%)} \quad \text{VI - I}$$

VI - II

Ten normal seedling which were selected for measuring root and shoot length, dried in a hot air oven for 72 hours at 65°C temperature and their dry weight was recorded for the seedling vigour index II was calculated as:

$$\text{Seedling dry weight (milligram)} \times \text{germination (\%)} \quad \text{VI - II}$$

3.3.14. Electrical conductivity ($\mu\text{S}^{-1}\text{cm}^{-1}$)

For estimation of electrical conductivity of the seeds leachate, 50 seeds of known weight were soaked in 100 ml beaker containing 80 ml distilled water for overnight at 25°C. Electrical conductivity of the seeds leachate was measured with conductivity meter and expressed as in $\mu\text{S}^{-1}\text{cm}^{-1}$ seed.

3.3.15. Fatty acid profile (%)

Gas Liquid Chromatography (GLC) was used for fatty acid estimation. Methyl esters were prepared according to the method of Luddy *et al.* (1968).

Reagent

- a) **12 % KOH:** weight by volume dissolved 12 gm of potassium hydroxide in 100 ml of distilled water to prepare 12 % KOH solution.
- b) Hexane
- c) Carbon tetrachloride (CCl_4)

Procedure

About 20 – 25 seeds were crushed in a pestle and mortar and 20 mg (approximately) of crushed seeds were transferred to a test tube. In a test tube 10-15 ml hexane was added and filter the samples by using whatman's filter paper no.1. After filtration add 2ml of 12 % potassium hydroxide (KOH), 0.5 ml carbon tetrachloride (CCl₄) and 5ml Hexane. It was covered with aluminum foil and heated in water bath at 60°C for 10-20 minutes then test tube was removed carefully from the bath and cooled to room temperature without disturbing the sample. Take out the supernatant in eppendorf tube and centrifuge at 5000 rpm for 30 seconds. Keep the sample at room temperature for 30 minutes. Inject the 0.2 µl in GLC unit.

Identification and estimation of fatty acids

2µl sample was injected into GLC by means of 10µl Hamilton syringe. The various peaks were identified by comparison of their retention times with those of standard fatty acids. The printer ORACLE-3, computing integrator directly gave the per-cent composition of fatty acids. Palmitic acid, Stearic acid, Oleic acid and Linoleic fatty acids were estimated.

3.4 STATISTICAL METHODS

The following statistical methods were employed for analysis of data. The mean value of five randomly selected plants for each character in each replication were used for statistical analysis.

3.4.1. Analysis of variance

Analysis of variance of the observations recorded on different traits was carried out as per the standard procedure suggested by Panse and Sukhatme (1995). The following model was adopted for the analysis of variance of various characters:

$$Y_{ij} = \mu + \alpha_i + \beta_j + e_{ij}$$

Where,

Y_{ij} = observation of i^{th} treatment and j^{th} block

μ = General mean

α_i = i^{th} treatment effect

β_j = j^{th} block effect

e_{ij} = random error associated with the i^{th} treatment in j^{th} block

The assumptions of the model adopted were:

- i. All the observations should be independent.
- ii. The different effects in the model should be additive.
- iii. Error involved in the population should be distributed normally and independently with mean zero and common variance.

TABLE 3.2. Skeleton for analysis of variance

Sources of Variation	Degrees of freedom (d.f)	Sum of squares (SS)	Mean sum of squares (MS)	Expected mean squares	F calculated Value
Replication	r-1	SSr	MSr		
Genotypes	g-1	SSg	MSg	$r\sigma^2 g + \sigma^2 e$	MSg/MSe
Error	(r-1) (g-1)	Sse	MSe	$\sigma^2 e$	
Total	rg-1				

Where,

r = Number of replications

g = Number of genotypes

MSr, MSg and MSe denotes means squares due to replications, genotypes and error, respectively.

$\sigma^2 g$ = Genotypic variance of the character

$\sigma^2 e$ = Error variance of character

The genotypic and phenotypic variances were calculated by adopting the following formulae:

$\sigma^2 e$ = Mean sum of square for error (MSe)

Genotypic variance of a character $\sigma^2 g = MSg - MSe/r$

Phenotypic variance of a character = $\sigma^2 g + \sigma^2 e$

3.4.2. Parameters of variability

i) Mean (X)

The mean value of each character was computed by dividing the total sum of values with corresponding number of observations.

$$X = \frac{\sum_{i=1}^n X_i}{n}$$

Where,

X = Mean; Xi = Individual value, and n = Number of observations, $\sum$ = sum of values

ii) Range

The minimum and maximum values of each character were recorded.

iii) Standard error of mean [S.E. (m)]

Standard error of mean was calculated with the help of error mean squares from the analysis of variance table given as under:

$$S. E. (m) = \frac{\sqrt{MSe}}{r}$$

S.E = Standard error

MSe = Error mean sum of squares

r = Number of replications

iv) Critical difference (CD)

For every character, the critical difference as the difference of any two mean values in order to compare the treatment means was calculated using the following formula:

$$\text{S. E. (d)} = \frac{\sqrt{2MSe}}{r}$$
$$\text{CD at 5 or 1\%} = \frac{\sqrt{2MSe}}{r} \times t$$

Where,

‘t’ is the tabulated value at error degree of freedom at 5 or 1% level of significance as the case may be.

v) Coefficient of variation (%)

The coefficient of variation being a standardized form of variance is useful for comparing the extent of variance between different characters with different scales (Singh and Chaudhary, 1977). According to Burton and Devane (1953), genotypic and phenotypic coefficients of variation were estimated based on the estimates of genotypic and phenotypic variances.

$$\text{Genotypic coefficient of variation (GCV \%)} = \frac{\sqrt{\sigma^2_g}}{\bar{x}} \times 100$$

$$\text{Phenotypic coefficient of variation (PCV \%)} = \frac{\sqrt{\sigma^2_p}}{\bar{x}} \times 100$$

Where,

$\bar{x}$ = Grand mean of character

σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance

The genotypic and phenotypic coefficients of variation were categorized as per the method suggested by Sivasubramanian and Menon (1973):

0-10% = Low;

10-20% = Moderate,

>20% = High

vi) Heritability (broad sense)

Heritability in broad sense h^2 (BS) was calculated as the ratio of genotypic variance to the phenotypic variance and expressed as percentage (Falconer, 1981).

$$h^2 \text{ (BS)} = \sigma^2_g / \sigma^2_p \times 100$$

The calculated heritability was classified into three groups as suggested by Johnson *et al.* (1955):

0-30% = Low

30-60% = Moderate

> 60% = High

vii) Expected genetic advance (GA)

Genetic advance was worked out by adopting the following formula given by Johnson *et al.* (1955):

$$GA = k \times h^2 \times \sqrt{\sigma^2 p}$$

Where,

h^2 = Heritability in broad sense (σ^2_g/σ^2_p)

k = Selection differential, which is equal to 2.06 at 5% intensity of selection (Lush, 1949)

$\sqrt{\sigma^2 p}$ = Phenotypic standard deviation

3.5 Cluster analysis

3.5.1. Euclidean Distance

A convenient measure of dissimilarity between the objects r and s can be obtained from the Euclidean distance between the two points. This distance is denoted by d_{rs} where:

$$d_{rs}^2 = \sum_{j=1}^p (X_{rj} - X_{sj})^2$$

The quantity d_{rs}^2 will be referred to as the squared Euclidean distance. For two ($p=2$) dimension the distance between objects r and s can be represented as:

$$d_{rs}^2 = (X_{r1} - X_{s1})^2 + (X_{r2} - X_{s2})^2$$

3.5.2. Euclidean Distance in Matrix Form

Given ($n \times p$) data matrix X with ($1 \times p$) row vector $x_1, x_2, \dots, x_n$, the square of the Euclidean distance, d_{rs}^2 , values is often called a squared Euclidean distance matrix.

Standardized Euclidean Distance

A disadvantage of the Euclidean distance as a measure of proximity of its sensitivity to the scales of measurements. It is possible for one or a few variables to dominate the distance measure because of large differences in scale. In general, if the scales of measurement are not common for all p variables, it is preferable to use a weighted distance given by $\sum w_j (x_{rj} - x_{sj})^2$ where the weights w_j reflects the importance of the variable $j = 1, 2, \dots, p$.

A special case of the weighted Euclidean distance is the standardized Euclidean distance is given by :

$$d_{rs}^2 = \sum_{j=1}^p \frac{1}{s_{2j}} (X_{rj} - X_{sj})^2 = (X_r - X_s)' B^{-1} (X_r - X_s)$$

Where $s_{2j}^2 = 1, 2, \dots, p$ denotes the variance of the variable X_j over the n objects and B is the diagonal matrix with diagonal elements given by $s_{2j}^2, j = 1, 2, \dots, p$. The ($p \times 1$) vectors x_r and x_s denote the observations on the two profiles.

3.5.3. Ward's Minimum Variance Method

The method of clustering was originally developed by Ward (1963). It was also proposed independently by several authors under the names of Minimum Variance Clustering, Sum of Squares method (Orloci, 1967) and Incremental Sum of Squares method (Burr, 1968).

The years (*i.e.* the objects) have been clustered on the basis of a criterion, which is assumed to be measuring the similarity between the years. Once the clusters have been formed, the objects and their respective distances are represented in the form of a tree diagram, referred as dendrogram. Here, on X-axis, the objects are represented in the same order as they are included in the clusters the 'stem' or links between the clusters (and the objects) are drawn on Y-axis whose height depends on the average distance between the clusters.

Ward's method involves fusion of clusters from the matrix of inter-year distances as follows:

To start with, the squared distances of objects $1/2d_{ij}^2$ ($ij = 1, \dots, n$) are computed corresponding to all possible pairs of objects. These distances from the matrix D_0 . From D_0 , the pair of objects having the least $1/2 d_{ij}^2$ is grouped to form the initial cluster, say $C(1)$. D_1 represents the "Increase in the total" within cluster sum of square of the distances from the centroids of the $C(1)$ with the other objects, in addition to the $1/2 d_{ij}^2$ values of the objects which are not clustered. The search for new clusters is again carried out on the least values of D_1 .

The procedure of revising the matrix $D [i = 1, \dots]$ on the basis of $D(1)$ and the search for the fusion clusters is continued till at the fusion of clusters are combined into a single cluster. The values of D_i during each step of fusion provide 'links' or distances between the clusters and the objects through which the dendrogram can be constructed. During every step of fusion, the matrix D is revised in terms of an Index I which can be computed as follows:

$$1 [C(i), C(j)] = \frac{n_i n_j}{n_i + n(j)} [x(i) - x(j)]^2$$

Where, $x(i)$ and $x(j)$, are respectively the centroids of the clusters $C(i)$ and $C(j)$ which consist of $n(i)$ and $n(j)$ objects. This method of clustering has been used in present study.

3.5.4. Cluster mean value

The cluster mean of a particular character is the summation of mean of mean values of genotypes included in a cluster, divided by number genotypes in the same cluster.

3.6 ESTIMATION OF HETEROSIS

Heterosis is the relative performance of F_1 hybrid over either of its parents in negative or positive direction.

$$H (BP) \% = \frac{F_1 - BP}{BP} \times 100$$

Heterosis over standard check was also calculated for all the characters as:

$$H (SC) \% = \frac{F_1 - SC}{SC} \times 100$$

Where ,

H (BP) % = Heterosis is per cent over better parent

H (SC) % = Heterosis is per cent over standard check

F_1 = Mean of F_1

BP = Mean of better parent

SC = Mean of standard check

The critical difference (CD) was calculated for comparing the heterosis and standard heterosis over standard check as :

$$CD = S.E. (d) \times t \text{ value}$$

Where,

$$SE (d) = \text{Standard Error of difference of mean} = \frac{\sqrt{2EMS}}{r}$$

t = tabulated value of 't' at error degree of freedom at 5 % and 1% level of significance.

The level of significance was given to the corresponding values of heterosis by comparing CD values with difference ($\bar{F}_1 - \bar{BP}$) and ($\bar{F}_1 - \bar{SC}$).

3.7. COMBINING ABILITY ANALYSIS

3.7.1. Analysis of variance for combining ability for individual environment

The combining ability analysis was carried out according to the model suggested by Kempthorne (1957), which is related to design ii according to which

$$Y_{ijk} = \mu + I + \beta_j + (\beta)_{ij} + e_{ijk}$$

$$\sum I = \sum \beta_j = (\beta)_{ij} = 0$$

Where,

Y_{ijk} = value of the ij^{th} observation involving i^{th} line and j^{th} tester in k^{th} replication

μ = General mean

I = effect due to i^{th} male parent

β_j = effect due to j^{th} female parent

$(\beta)_{ij}$ = interaction due to ij^{th} cross combination and

e_{ijk} = random error associated with ijk^{th} observation

Table 3.3: The analysis of variance based on the above model had following form for single environment

Source	d.f.	MS	Expected mean square
Replications	(r-1)		
Hybrids	(mf-1)		
Males	(m-1)	M1	$\sigma^2 + q[\text{Cov. (F.S.)} - 2 \text{ Cov. (H.S.)}] + [fr \text{ Cov. (H.S.)}]$
Females	(f-1)	M2	$\sigma^2 + r [\text{Cov. (F.S.)} - 2 \text{ Cov.}]$
Males x Females	(m-1) (f-1)	M3	$\sigma^2 + r [\text{Cov. (F.S.)} - 2 \text{ Co}]$
Error	(r-1) (mf-1)	M4	σ^2

Where,

m = number of males

f = number of females

$Y_{...}$ = sum of all hybrids

$Y_{i..}$ = total of i^{th} male parent over all females and replications

$Y_{.j.}$ = total of j^{th} female parent over all male parents and replications.

From the expectations of mean squares the Cov. (H.S.) and Cov. (F.S.) were estimated as below:

$$\text{Cov. (H.S.)} = (M1-M3) + (M2-M3)/r (m+f)$$

$$\text{Cov. (F.S.)} = (M1-M4) + (M2-M4) + (M3-M4)/3r + 6r \text{ Cov. (H.S.)} - r (f+m) \text{ Cov. (H.S.)}/3r$$

The estimates of Cov.(H.S.) and Cov.(F.S.) were used to estimate the variance due to general combining ability (σ^2 g.c.a) and variance due to specific combining ability (σ^2 s.c.a) as below:

$$\sigma^2 \text{ g.c.a} = \text{Cov. (H.S.)}$$

$$\sigma^2 \text{ s.c.a} = \text{Cov. (F.S.)} - 2 \text{ Cov. (H.S.)}$$

The combining ability effects were estimated as below:

$$\hat{U} = \frac{Y_{...}}{m.f.r}$$

where ,

$Y_{...}$ = the total of all hybrids.

$$\hat{g}_i = \frac{Y_{i....}}{f.r.} - \frac{Y_{...}}{m.f.r}$$

where,

$Y_{i..}$ = the total of i^{th} male parent over all females and replications

$$\hat{g}_j = \frac{Y_{.j.}}{m.f} - \frac{Y_{...}}{m.f.r}$$

where,

$Y_{.j.}$ = total of the j^{th} female parent over all male parents and replications

$$\hat{s}_{ij} = \frac{Y_{ij}}{r} - \frac{Y_{i.}}{f.r} - \frac{Y_{.j.}}{m.r} + \frac{Y_{...}}{m.f.r}$$

where ,

$Y_{(ij)}$ = ij^{th} combination totals over all replications

Standard error for general and specific combining ability effects were estimated as below:

$$\text{S.E of g.c.a effect for females} = \frac{\overline{M'e}}{m}$$

$$\text{S.E of g.c.a effect for males} = \frac{\overline{M'e}}{f}$$

$$\text{S.E of s.c.a for a cross} = \frac{\overline{M'e}}{mf}$$

3.7.2. Combining ability analysis pooled over environments

For pooled analysis of combining ability, the following linear model was assumed:

$$Y_{ijk} = \mu + g_i + g_j + s_{ij} + P_1 + (Gp)_{ij1} + (SP)_{IJ1} + e_{ijk1}$$

Where,

i = 1, 2, ..., m; = no. of males

j = 1, 2, ..., f; = no. of females

k = 1, 2, ..., r; = no. of replications

1 = 1, 2, ..., P; = no. of environments

Y_{ijk1} = Value of k^{th} replication of the progeny of i^{th} tester and the j^{th} line in the i^{th} environments.

The form of analysis of variance and the expectations of the mean square is given the table.

Table 3.4. Analysis of variance for combining ability (pooled over environments)

Source	d.f.	M.S.	Expected M.S.
Environments	$P - 1$		
Replication in envt	$(r - 1)$		
Males	$m - 1$	M1	$\sigma^2 + r\sigma^2_{fmp} + rf\sigma^2_{mp} + rP\sigma^2_{mf} + rfP\sigma^2_m$
Females	$f - 1$	M2	$\sigma^2 + r\sigma^2_{fmp} + rm\sigma^2_{fp} + rP\sigma^2_{fm} + rmfP\sigma^2_m$
Males x Females	$(m - 1)(f - 1)$	M3	$\sigma^2 + r\sigma^2_{fmp} + +rP\sigma^2_{fm}$
Males x envt.	$(m - 1)(P - 1)$	M4	$\sigma^2 + r\sigma^2_{fmp} + +rP\sigma^2_{mp}$
Females x envt	$(f - 1)(P - 1)$	M5	$\sigma^2 + r\sigma^2_{fmp} + r m \sigma^2_{fp}$
M x F x envt	$(m - 1)(f - 1)(P - 1)$	M6	$\sigma^2 + r\sigma^2_{fmp}$
Pooled Error	$P(r - 1)(fm - 1)$	M7	σ^2

Where,

P = number of environments

σ^2_m = Variance due to males (testers)

σ^2_f = Variance due to females (lines)

σ^2_{mp} = Variance due to males x envt. interaction

σ^2_{fp} = Variance due to female x envt. interaction

σ^2_{mpf} = Variance due to male x female x envt. interaction

3.7.3. Estimation of combining ability effects over the environments (fixed effects model)

$$M = \frac{X}{Mfrp}$$

$$g_i = \frac{Xi....}{frp} - M$$

$$g_j = \frac{X.i..}{mrp} - M$$

$$S_{ij} = \frac{X_{ij}}{r} - \frac{X_{i.}}{frp} - \frac{X_{.j.}}{mrp} + M$$

Where,

X = total of all crosses over envts. and replications

X_{i.} = total of ith tester over all the lines, envts. and replications

X_{.j.} = total of jth line over all the testers, envts. and replications

X_{ij.} = total of ijth cross over the envts. and replications

Standard error of GCA and SCA effects

$$\text{S.E g.c.a (males)} = \frac{\overline{\sigma^2 e}}{frp}$$

$$\text{S.E g.c.a (females)} = \frac{\overline{\sigma^2 e}}{mrp}$$

$$\text{S.E s.c.a} = \frac{\overline{\sigma^2} m+f}{mfrep}$$

$$\text{C.D.} = \text{S.E.} \times \sqrt{2} \times \text{at error d.f.}$$

Estimation of variance components

$$\text{i. } \sigma^2_m = \frac{M1-M3-M4+M6}{rfp}$$

$$\text{ii. } \sigma^2_f = \frac{M2-M3-M5+M6}{rmp}$$

$$\text{iii. } \sigma^2_{mf} = \frac{M4-M6}{rp}$$

$$\text{iv. } \sigma^2_{mp} = \frac{M4-M6}{rf}$$

$$\text{v. } \sigma^2_{fp} = \frac{M5-M6}{rm}$$

$$\text{vi. } \sigma^2_{fmp} = \frac{M6-M7}{r}$$

Significance of these variances were tested by taking ratio of two mean squares used in calculating the particular variance component and comparing it with the value of F in the table at 5 per cent and 1 per cent with the corresponding degrees of freedom. In those cases where more than two mean squares were involved, sum of square and degree of freedom associated with respective source of variation were pooled estimates of mean squares were obtained for further comparison:

$$\sigma^2_{\text{g.c.a}} = \text{Cov. H.S.} = \frac{f\sigma^2_m + m\sigma^2_f}{f+m} = 1/2\sigma^2_A$$

$$\sigma^2_{\text{s.c.a}} = \text{Cov. F.S.} - 2 \text{ Cov. H.S.} = \sigma^2_{fm} = \sigma^2_D$$

$$\text{Cov. F.S.} = \sigma^2_{fm} + 2 \text{ Cov. H.}$$

3.8. Stability analysis

The genotypes were assessed for their stability of performance over environments as suggested by Eberhart and Russell (1966).

The following model was used to describe the performance of a variety over a series of environments.

$$Y_{ij} = \mu_i + B_i I_j + \delta_{ij}$$

Where,

Y_{ij} = Mean of the i^{th} genotype in the j^{th} environment

(Where, $i = 1, 2, \dots, g$, $j = 1, 2, \dots, n$)

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

B_i = Regression coefficient of i^{th} genotype to the varying environments

δ_{ij} = Deviation from regression of the i^{th} genotype in the j^{th} environment

I_j = Environmental index obtained as the mean of all the genotypes in the j^{th} environment minus the grand mean i.e.

$$I_j = \frac{Y_{.j}}{g} - \frac{Y_{..}}{gn}$$

Where,

$$\sum_j I_j = 0$$

g = number of genotypes

n = number of environments

In this approach, the model partitions the genotype x environment interaction of each genotype into two parts:

- (i) Variation due to linear response of the genotypes to varying environmental indices (sum of squares due to regression), and
- (ii) The unexpected deviation from the regression (δ^2_{di}) on the environmental index. With this model, the sum of squares due to environment and genotype x environment interaction were partitioned into environment (linear) and deviations from regression

Table 3.5. Analysis of variance following Eberhart and Russell (1966) model

Source of variation	d.f.	MS	F (cal.)
Genotypes	(g-1)	MS 1	MS1/MS3
Environments	(n-1)		
Genotypes x Environments	(g-1)(n-1)		
Environments + Genotypes x Environments	(n-1) + (g-1) (n-1) = g(n-1)		
Environment (linear)		S	

Genotypes x Environments (linear)	(g-1)	MS2	MS2/MS3
Pooled deviation	g(n-2)	MS3	MS3/MSe
Genotype 1	(n-2)		
Genotype g	(n-2)		
Pooled error	n(g-1)(r-1)	S ² e	

Where,

r, n and g indicate the number of replications, environments and genotypes, respectively. S²e was the mean square due to pooled error which was calculated as:

$$S^2e = \sum [S^2j / (r-1)(g-1)n] / r$$

Where,

S²j = error sum of the squares at the jth location

Tests of significance

I. The significance of differences among the genotypic means

H₀ : $\mu_1 = \mu_2 \dots \dots \dots = \mu_g$, can be tested by the F test

$$F = MS1/MS3$$

II. The hypothesis that there are no differences among genotypes for their regression on the environmental index.

H₀: $b_1 = b_2 \dots \dots \dots = b_g$, can be tested by the F test

$$F = MS2/MS3$$

The MS3 was tested against S²e. In case MS3 was non-significant, S²e and MS3 were pooled to test the remaining sources of variation.

CHAPTER-IV

RESULTS

The experiment involved 75 hybrids developed by crossing fifteen CMS lines with five testers (restorers) in a line x tester mating design along with one standard check (HSFH 848) in Randomized Block Design with three replications in both spring (February) and summer (August- September) seasons during 2014-2015. Analysis of variance and results pertaining to various genetic parameters for nineteen traits including morphological, oil and quality traits are presented under the following headings.

- 4.1 Mean performance, range, variability, heritability and genetic advance as *per cent* over for different environments
- 4.2 Genetic divergence
- 4.3 Stability analysis in parents and their hybrids under contrasting environments over two years.
- 4.4 Combining ability analysis for seed yield and quality traits in E₁, E₂, E₃, E₄ and pooled over environments during different years
- 4.5 Heterosis for seed yield, oil content and quality traits in E₁, E₂, E₃, E₄ and over the environment

4.1 Mean performance, range, variability, heritability and genetic advance as *per cent* mean of over the environments (E₁, E₂, E₃, E₄)

To understand the extent by which the observed variation is due to genetic factors, the genetic variability parameters viz., mean, range, phenotypic co-efficient of variation (PCV), genotypic co-efficient of variation (GCV), heritability (broad sense) and expected genetic advance as *per cent* mean of for all the 19 characters are furnished in the Table 4.1, 4.2, 4.3, 4.4, 4.5 and briefly described in the following paragraphs.

The mean performance of parents and hybrids in the four environments viz., E₁, E₂, E₃, E₄ and pooled over the years for different characters is appended in Appendix- I.

It is evident that considerable amount of variation was present among genotypes for each character. The magnitude of the PCV (%) estimates was slightly higher than their corresponding GCV (%) estimates for all the traits.

GCV in E₁, ranged from 2.94 % (days to maturity) to 37.91% (oleic acid) while PCV ranged from 3.32% (days to maturity) to 38.68% (oleic acid). Heritability (broad sense) ranged from 65.38% (electrical conductivity) to 96.09% (oleic acid) while expected genetic advance varied from 5.35% (days to maturity) to 76.57% (oleic acid) (table 4.1)

In E₂ (table 4.2), GCV ranged from 3.04% (days to maturity) to 35.87% (seedling vigour index II) while PCV was in the range of 3.25% (days to maturity) to 36.36% (seedling vigour index II) and heritability had variation from 70.97% (head diameter) to 98.44% (percent seed filling). Similarly in E₃ (table 4.3), GCV ranged from 2.67% (days to maturity) to 57.31% (electrical conductivity), whereas PCV had range from 3.00% (days to maturity) to 57.79% (electrical conductivity) and heritability varied from 62.62% (days to 50 % flowering) to 99.99% (seedling vigour index – I), whereas expected genetic advance was in the range of 4.89% (days to maturity) to 117.08% (electrical conductivity).

In E₄ (table 4.4), GCV ranged from 4.23% (days to maturity) to 73.68% (electrical conductivity) while PCV ranged from 5.96% (days to maturity) to 74.75% (electrical conductivity). Heritability was observed in the range of 66.95% (100 seed weight) to 99.18% (plant height), whereas expected genetic advance had variation from 6.18% (days to maturity) to 149.62% (electrical conductivity).

On pooled basis (table 4.5), GCV ranged from 1.88% (days to maturity) to 32.47% (electrical conductivity) while PCV ranged from 2.01% (days to maturity) to 33.01% (electrical conductivity) and heritability varied from 68.70 % (hull content) to 98.51 % (percent seed filling), whereas expected genetic advance was observed in the range of 3.50 % (days to maturity) to 65.55 % (electrical conductivity).

4.1.1 Plant height (cm)

The plant height ranged from 70.26 to 115.33 cm in E₁, 67.70 to 116.60 cm in E₂, 90.29 to 197.27 cm in E₃, 88.75 to 206.27 cm in E₄ and 82.27 to 152.70 cm over all the environments. The variation for plant height was found to be high in all environments (E₁, E₂, E₃ and E₄) as well as over the environments. The genotypic (9.40 %, 11.06 %, 12.78%, 17.341 % and 10.50 %) and phenotypic coefficients of variability (9.62 % 11.23%, 13.73 %, 17.41% and 10.64 %) were moderate for this trait. It had showed high heritability estimate (95.57%, 96.70 %, 86.65 %, 99.18 % and 97.41%) with moderate expected genetic advance as *per cent* of mean (18.94%, 22.37%, 24.52%, 35.577% and 21.36%).

4.1.2 Head diameter (cm)

The head diameter varied from 5.88 to 20.67 cm in E₁, 6.45 to 17.67 cm in E₂, 8.10 to 24.13 cm in E₃, 8.42 to 20.27 cm in E₄ and 7.51 to 17.70 cm over all the environments. This character exhibited higher estimates of GCV (20.18 %, 16.32 %, 18.51 %, 18.34 % and 15.29 %) and PCV (22.36 %, 19.37%, 20.83%, 21.034 % and 16.10 %). Moderate heritability (81.47 %, 70.93 %, 78.53 %, 76.03% and 90.20%) with high expected genetic advance as *per cent* of mean (37.53 %, 28.32 %, 33.88 %, 32.94 % and 29.92%) were observed in all environment viz., E₁, E₂, E₃, E₄ and over the environments respectively.

4.1.3 Stem diameter (cm)

Stem diameter ranged from 2.89 to 9.10 cm in E₁, 3.16 to 8.93 cm in E₂, 3.79 to 11.43 cm in E₃, 3.46 to 9.67 cm in E₄ and 3.56 to 8.23 cm over the environments. High estimates of GCV (21.49 %, 19.08%, 21.50%, 21.49% and 18.44%) and PCV (23.21 %, 21.13 %, 23.18 %, 25.46% and 19.25 %) were observed for this trait in all environments E₁, E₂, E₃, E₄ and over the environments respectively. It had showed high heritability estimates (85.68%, 81.53%, 85.99%, 71.25% and 91.75%) with high expected genetic advanced as *per cent* of mean (40.97%, 35.50%, 41.07%, 37.37% and 36.39%).

4.1.4 Days to 50 % flowering

It varied from 52.13 to 64.15 days in E₁, 53.18 to 66.68 days in E₂, 56.62 to 69.00 days in E₃, 56.52 to 69.41 days to E₄ and 56.13 to 62.82 days in pooled analysis. Low estimates of GCV (4.47%, 5.37%, 4.38%, 4.23% and 2.42%) and PCV (4.98%, 5.70%, 5.54%, 5.96% and 2.88%), were recorded for all the environments. Moderate estimates of heritability (80.72%, 88.57%, 62.62%, 50.34% and 70.67%) and with low expected genetic advance as *per cent* of mean (8.28%, 10.41%, 7.15%, 6.18% and 4.19%) were recorded for this trait.

4.1.5 Days to maturity

It ranged from 86.66 to 100.04 days in E₁, 88.00 to 109 .26 days in E₂, 86.67 to 99.67 days in E₃, 89.00 to 103.33 days in E₄ and 89.66 to 99.48 days over all the environments. This character exhibited low estimates of GCV (2.94%, 3.04%, 2.67%, 3.04% and 1.88%) and PCV (3.32%, 3.25%, 3.01%, 3.33% and 2.03%) under all the environments individually and pooled basis. It showed high estimate of heritability (78.11%, 87.77%, 78.95%, 83.26% and 85.82%) coupled with low estimates of expected genetic advance as *per cent* of mean (5.35%, 5.87%, 4.89%, 5.72% and 3.60%).

4.1.6 Hundred seed weight (g)

Hundred seed weight varied from 3.50 to 9.23 g in E₁, 2.96 to 8.93 g in E₂, 4.00 to 9.40 g in E₃, 3.27 to 9.10 in E₄ and 4.23 to 8.47. The character exhibited the high estimate of GCV (20.67%, 21.34%, 18.02%, 17.29% and 16.67%) and PCV (24.59%, 25.09%, 21.28%, 21.13% and 17.75%) under all the environments as well pooled basis. It showed high estimates of heritability (70.66%, 72.32%, 71.69%, 66.95% and 88.19%) with high expected genetic advance as *per cent* of mean (35.79%, 37.39%, 31.43%, 29.15% and 32.25%).

4.1.7 Seed yield per plant (g)

Seed yield per plant showed range of 13.82 to 33.76 g in E₁, 11.24 to 28.62 g in E₂, 12.10 to 54 .64 g in E₃, 12.35 to 57.21g in E₄ and 15.74 to 40.13 g over the environments. High estimates of GCV (17.66 %, 17.57%, 22.01%, 23.72% and 19.42%) and PCV (20.98%, 18.82%, 22.97%, 23.17% and 19.75%) were observed in all environments (E₁, E₂, E₃, E₄) and

when pooled over the environments. It showed high estimate of heritability (70.84%, 87.18%, 91.79%, 95.39% and 96.62%) with high expected genetic advance values as *per cent* of mean (30.61%, 33.81%, 43.44%, 46.61% and 39.31%).

4.1.8 Oil content (%)

Oil content varied from 26.36 to 40.90% in E₁, 26.14 to 41.53% in E₂, 36.73 to 52.69% in E₃, 36.67 to 52.84% in E₄ and 35.62 to 43.16% over pooled analysis. Lower estimates of GCV (9.25%, 10.67%, 9.71%, 9.15% and 2.91%) and PCV (10.39%, 11.57%, 10.46%, 9.81% and 3.51%) were recorded for this trait in different environments i.e. E₁, E₂, E₃, E₄ and over the environments, respectively. It showed moderate heritability (79.30%, 85.03%, 86.23%, 86.98% and 68.70%) with low estimates of expected genetic advance as *per cent* of mean (16.97%, 20.27%, 18.58%, 17.59% and 4.97%).

4.1.9 Hull content (%)

Hull content ranged from 26.72 to 61.82% in E₁, 18.7 to 60.99% in E₂, 19.73 to 64.52% in E₃, 18.13 to 64.58% in E₄ and 23.54 to 58.93% under all the environments. Moderate estimates of GCV (16.47%, 21.26%, 15.90%, 19.65% and 15.21%) and PCV (20.16%, 22.98%, 17.23%, 21.05% and 15.86%) were observed for this trait in different environments. The estimates of heritability were observed higher (66.77%, 85.58%, 85.25%, 87.13% and 91.99%) along with high expected genetic advance as *per cent* of mean values (27.73%, 40.53%, 30.26%, 37.79% and 30.05%).

4.1.10 Percent seed filling

It was varied from 33.45 to 97.11% in E₁, 27.76 to 98.29% in E₂, 27.40 to 97.00 % in E₃, 29.08 to 94.79% in E₄ and 29.45 to 93.77% in pooled basis. This character exhibited high estimates of GCV (21.24%, 22.65%, 23.50%, 24.67% and 19.14%), PCV (21.97%, 22.82%, 23.87%, 25.03% and 19.28%), heritability (93.49%, 98.44%, 96.92%, 97.12% and 98.51%) and expected genetic advance as *per cent* of mean (42.32%, 46.29%, 47.66%, 50.08% and 39.13%) in E₁, E₂, E₃, E₄ and over the environments, respectively.

4.1.11 Germination (%)

Germination ranged from 47.50 to 98.69 % in E₁, 46.03 to 97.47 in E₂, 35.81 to 96.75 in E₃, 34.45 to 96.00 % in E₄ and 48.93 to 94.98% over pooled basis. Under all environments, moderate estimates of GCV (9.17%, 11.11%, 18.29%, 18.67% and 10.46%) and PCV (9.95%, 11.77%, 18.86%, 19.29% and 10.69%) were recorded for this trait. It showed high estimates of heritability (84.55%, 89.14%, 94.03%, 93.76% and 95.76%) coupled with high expected genetic advance as *per cent* of mean (17.37%, 21.61%, 36.54%, 37.26% and 21.09%).

4.1.12 Electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$)

It was varied from 0.21 to 1.24 $\mu\text{Scm}^{-1}\text{g}^{-1}$ in E_1 , 0.27 to 1.24 $\mu\text{Scm}^{-1}\text{g}^{-1}$ in E_2 , 0.16 to 1.65 $\mu\text{Scm}^{-1}\text{g}^{-1}$ in E_3 , 0.07 to 1.59, 0.23 $\mu\text{Scm}^{-1}\text{g}^{-1}$ in E_4 to 1.28 $\mu\text{Scm}^{-1}\text{g}^{-1}$ over pooled basis. This character showed high estimates of GCV (23.17%, 27.83%, 57.31% and 32.47%), PCV (28.65%, 27.35%, 57.79% and 33.01%), heritability (65.38%, 96.58%, 98.34%, 97.16% and 96.70%) and expected genetic advance as *per cent* of mean (38.59%, 55.37%, 117.08%, 149.62% and 65.77%) in E_1, E_2, E_3, E_4 and over the environments, respectively.

4.1.13 Viability (%)

Viability showed range of 41.64 to 95.02 % in E_1 , 40.43 to 95.21% in E_2 , 34.72 to 94.74% in E_3 , 34.41 to 94.17 % in E_4 and 43.58 to 92.07% over the environments. Moderate estimates of GCV (11.37%, 12.62%, 19.04%, 18.66% and 11.49%) and PCV (11.96%, 12.83%, 19.41%, 19.06% and 11.63%) were observed for this trait in different environments whereas, estimates of heritability were higher (70.34%, 96.79%, 96.27%, 95.85% and 97.73%) along with high estimates of genetic advance as *per cent* of mean (22.25%, 25.58%, 38.50%, 37.64%, 23.41%).

4.1.14 Vigour index – I

It varied from 180079.00 to 35612.00 in E_1 , 16900.67 to 36626.67 in E_2 , 11836 .00 to 34783.33 in E_3 , 20232.00 to 102435.33 in E_4 and 19724.33 to 32249.33 over all the environments .Moderate estimates of GCV (13.37%, 16.82%, 14.74%, 12.94% and 10.50%) and PCV (15.94%, 16.99%, 14.75%, 13.78% and 10.72%) were observed under all the environments for this trait. Estimates of heritability (70.34%, 97.97%, 99.99%, 67.55% and 95.92%) and expected genetic advance as *per cent* of mean (23.10%, 34.30%, 30.37%, 6.92% and 21.18%) were higher for this trait.

4.1.15 Vigour index – II

It ranged from 12.42 to 59.30 in E_1 , 11.4 to 55.63 in E_2 , 13.20 to 63.10 in E_3 , 12.25 to 50.34 in E_4 and over pooled analysis 13.84 to 48.19. The character seedling vigour index – II, exhibited high estimates of GCV (25.30%, 35.87%, 29.41%, 30.67% and 22.91%), PCV (33.14%, 36.36%, 30.33%, 31.71% and 23.63%), heritability (58.27%, 97.33%, 94.03%, 93.55% and 94.01%) and genetic advance as *per cent* of mean (39.79%, 72.90%, 58.75%, 61.12% and 45.76%) in different environments.

4.1.16 Palmitic acid (%)

Palmitic acid showed range of 3.76 to 9.81% in E_1 , 4.00 to 13.25% in E_2 , 5.01 to 17.56% in E_3 , 4.89 to 17.31% in E_4 and 5.41 to 11.89% over the environments. This trait also showed, high estimates of GCV (16.39%, 22.05%, 29.41%, 22.41% and 13.98%), PCV (18.03%, 23.72%, 30.33%, 23.55% and 14.44%), heritability (82.63%, 86.40% ,80.62%,

90.53% and 93.73%) and expected genetic advance as *per cent* of mean (30.70%,42.22%, 39.39%,43.92% and 27.88%) under all the environments.

4.1.17 Stearic acid (%)

It ranged from 3.40 to 13.31% in E₁, 2.18 to 14.40% in E₂, 2.36 to 8.33% in E₃, 2.14 to 8.24% in E₄ and 3.37 to 8.03% in pooled basis. High estimates of GCV (31.48%, 34.85%, 28.59%, 25.81% and 18.79%), PCV (32.28%, 35.40%, 30.01%,29.09% and 19.29%), heritability (95.09%, 96.91%, 90.77%, 78.73% and 94.82%) and expected genetic advance as *per cent* of mean (63.24, 70.68%,56.12%, 47.18% and 37.69%) were observed for this trait in E₁,E₂, E₃,E₄ and over the environments, respectively.

4.1.18 Oleic acid (%)

Oleic acid varied from 10.39 to 42.59% in E₁, 9.28 to 38. 52% in E₂, 4.97 to 79.20 % in E₃, 42.11 to 79.49% in E₄ and 9.05 to 29.00% over all the environments. The estimates of GCV (37.91%, 29.24%, 12.77%, 11.60% and 8.53%), PCV (38.68%, 30.57%, 13.33%, 12.02% and 8.79%), heritability (96.09%, 91.49%, 91.85%, 93.14% and 94.27%) and expected genetic advance as *per cent* of mean (76.57%, 57.62%, 25.22%, 23.07% and 17.07%) were observed high for this trait.

4.1.19 Linoleic acid (%)

Linoleic acid ranged from 32.53 to 78.40 % in E₁, 37.22 to 77. 26% in E₂, 10.34 to 44.61% in E₃, 10.45 to 44.58% in E₄ and 34.68 to 57.93% in pooled basis. This character exhibited moderate estimates of GCV (18.12%, 16.20%,17.57%, 19.98% and 11.96%) and PCV (18.62, 16.85, 17.66%, 20.13% and 12.18%) while high estimate of heritability (94.70%,92.44%, 98.93%, 98.50% and 96.41%) with expected genetic advance as *per cent* of mean (36.32%,32.09%,36.00%,40.85% and 24.19%) were observed high for this trait in E₁,E₂, E₃,E₄ and over the environments, respectively.

Table 4.1. Estimation of variability and heritability in E₁

CHARCTERS	MEAN ± SE	RANGE		GCV %	PCV %	HERITABILITY %	GENETIC ADV. AS PER CENT OF MEAN 5%
		Min.	Max.				
Plant height(cm)	94.17 ± 1.56	70.26	115.33	9.409	9.624	95.572	18.948
Head diameter(cm)	11.77 ± 0.93	5.88	20.67	20.189	22.369	81.457	37.535
Stem diameter (cm)	5.52 ± 0.40	2.89	9.10	21.49	23.217	85.68	40.978
Days to50 % flowering	55.96 ± 1.00	52.13	64.15	4.478	4.983	80.728	8.287
Days to maturity	95.33 ± 1.21	86.66	100.04	2.942	3.328	78.117	5.356
100 Seed weight (g)	6.39 ± 0.74	3.50	9.23	20.673	24.593	70.661	35.798
Seed Yield (g)	25.44 ± 2.35	13.82	33.76	17.66	20.982	70.841	30.619
Oil Content (%)	36.69 ± 1.42	26.36	40.90	9.255	10.392	79.303	16.977
Hull content(%)	49.58 ± 4.71	26.72	61.82	16.479	20.167	66.77	27.739
% Seed filling	79.42 ± 3.63	33.45	97.11	21.248	21.974	93.498	42.323
Germination (%)	89.60 ± 2.87	47.50	98.69	9.173	9.975	84.557	17.376
EC (µScm ⁻¹ g ⁻¹)	0.67 ± 0.09	0.21	1.24	23.171	28.654	65.389	38.598
Viability (%)	84.72 ± 2.58	41.64	95.02	11.371	11.968	90.272	22.256
Vigour Index I	25235.31 ±1788.75	18079.00	35612.00	13.37	15.942	70.344	23.101
Vigour Index II	32.26 ± 5.64	12.42	59.30	25.305	33.149	58.272	39.792
Palmitic acid (%)	6.71 ± 0.41	3.76	9.81	16.395	18.035	82.639	30.703
Stearic acid (%)	6.17 ± 0.36	3.40	13.31	31.485	32.288	95.092	63.248
Oleic acid (%)	21.93 ± 1.37	10.39	42.59	37.919	38.682	96.095	76.574
Linoleic acid (%)	62.18 ± 2.18	32.53	78.40	18.122	18.622	94.701	36.329

Table 4.2. Estimation of variability and heritability in E₂

CHARCTERS	MEAN ± SE	RANGE		GCV %	PCV %	HERITABILITY %	GENETIC ADV. AS PER CENT OF MEAN 5%
		Min.	Max.				
Plant height (cm)	95.00 ± 1.58	67.70	116.60	11.046	11.232	96.709	22.376
Head diameter (cm)	10.87 ± 0.93	6.45	17.67	16.32	19.372	70.973	28.323
Stem diameter (cm)	5.71 ± 0.42	3.16	8.93	19.086	21.137	81.534	35.502
Days to 50% flowering	58.28 ± 0.92	53.18	66.68	5.371	5.706	88.579	10.413
Days to maturity	96.74 ± 0.90	88.00	109.26	3.044	3.25	87.774	5.876
100 Seed weight (g)	6.24 ± 0.69	2.96	8.93	21.342	25.095	72.326	37.39
Seed Yield (g)	23.72 ± 1.31	11.24	28.62	17.578	18.826	87.181	33.81
Oil Content (%)	36.83 ± 1.35	26.14	41.53	10.673	11.574	85.037	20.276
Hull Content (%)	43.54 ± 3.10	18.07	60.99	21.267	22.989	85.585	40.53
% Seed filling	84.76 ± 1.97	27.76	98.29	22.65	22.829	98.441	46.295
Germination (%)	89.06 ± 2.82	46.03	97.47	11.114	11.771	89.141	21.616
EC (µScm ⁻¹ g ⁻¹)	0.65 ± 0.03	0.27	1.24	27.351	27.83	96.587	55.372
Viability (%)	83.03 ± 1.56	40.43	95.21	12.623	12.83	96.794	25.583
Vigour Index I	27099.05 ± 535.59	16900.67	36626.67	16.825	16.998	97.972	34.306
Vigour Index II	34.34 ± 1.66	11.04	55.63	35.872	36.36	97.335	72.906
Palmitic acid (%)	6.65 ± 0.48	4.00	13.25	22.052	23.724	86.405	42.227
Stearic acid (%)	5.78 ± 0.29	2.18	14.40	34.856	35.406	96.915	70.687
Oleic acid (%)	23.86 ± 1.74	9.28	38.52	29.243	30.572	91.498	57.623
Linoleic acid (%)	59.40 ± 2.25	37.22	77.26	16.203	16.852	92.444	32.092

Table 4.3 Estimation of variability and heritability in E₃

CHARCTERS	MEAN ± SE	RANGE		GCV %	PCV %	HERITABILITY %	GENETIC ADV. AS PER CENT OF MEAN 5%
		Min.	Max.				
Plant height (cm)	155.1±6.36	90.29	197.27	12.788	13.738	86.65	24.522
Head diameter (cm)	16.6± 1.29	8.10	24.13	18.514	20.836	78.953	33.889
Stem diameter (cm)	8.1 ± 0.57	3.79	11.43	21.503	23.188	85.998	41.078
Days to 50% flowering	61.1 ± 1.69	56.62	69.00	4.389	5.546	62.624	7.155
Days to maturity	93.8 ± 1.06	86.67	99.67	2.673	3.008	78.956	4.893
100 Seed weight (g)	6.36 ± 0.68	4.00	9.40	18.021	21.283	71.696	31.433
Seed Yield (g)	39.1 ± 2.10	12.10	54.64	22.01	22.973	91.792	43.441
Oil Content (%)	40.7± 1.29	36.73	52.69	9.715	10.461	86.238	18.584
Hull Content (%)	50.1 ± 2.71	19.73	64.52	15.909	17.23	85.256	30.261
% Seed filling	74.5 ± 2.55	27.40	97.00	23.505	23.875	96.92	47.669
Germination (%)	83.1 ± 3.13	35.81	96.75	18.293	18.865	94.03	36.542
EC (µScm ⁻¹ g ⁻¹)	0.6 ± 0.04	0.16	1.65	57.313	57.794	98.343	117.083
Viability (%)	79.3 ± 2.43	34.72	94.74	19.049	19.414	96.273	38.502
Vigour Index I	25379.1 ±13.29	11836.00	34783.33	14.747	14.747	99.998	30.379
Vigour Index II	34.0 ± 2.06	13.20	63.10	29.411	30.331	94.03	58.751
Palmitic acid (%)	7.2 ± 0.61	5.01	17.56	21.299	23.721	80.62	39.396
Stearic acid (%)	4.1 ± 0.31	2.36	8.33	28.598	30.016	90.773	56.128
Oleic acid (%)	59.7 ± 1.86	45.97	79.20	12.776	13.33	91.855	25.223
Linoleic acid (%)	34.8 ± 0.52	10.34	44.61	17.573	17.668	98.93	36.006

Table 4.4. Estimation of variability and heritability in E₄

CHARCTERS	MEAN ± SE	RANGE		GCV %	PCV %	HERITABILITY %	GENETIC ADV. AS PER CENT OF MEAN 5%
		Min.	Max.				
Plant height (cm)	172.20 ± 2.217	88.75	206.27	17.341	17.413	99.18	35.577
Head diameter (cm)	15.96 ± 1.342	8.42	20.27	18.341	21.034	76.034	32.945
Stem diameter (cm)	7.36 ± 0.82	3.46	9.67	21.492	25.461	71.254	37.373
Days to 50% flowering	62.18 ± 2.135	56.52	69.41	4.234	5.967	50.343	6.188
Days to maturity	96.90 ± 1.08	89.00	103.33	3.046	3.338	83.268	5.726
100 Seed weight (g)	6.30 ± 0.7	3.27	9.10	17.295	21.136	66.957	29.153
Seed Yield (g)	37.45 ± 1.557	12.35	57.21	23.17	23.723	95.392	46.617
Oil Content (%)	40.32 ± 1.166	36.67	52.84	9.157	9.817	86.988	17.593
Hull Content (%)	49.26 ± 3.038	18.13	64.58	19.654	21.055	87.131	37.791
% Seed filling	71.34 ± 2.475	29.08	94.79	24.671	25.034	97.12	50.085
Germination (%)	79.67 ± 3.133	34.45	96.00	18.679	19.29	93.767	37.26
EC (µScm ⁻¹ g ⁻¹)	0.54 ± 0.056	0.07	1.59	73.686	74.755	97.16	149.622
Viability (%)	76.02 ± 2.409	34.41	94.17	18.665	19.065	95.856	37.645
Vigour Index I	28565.98 ± 11213.11	20232.00	102435.33	12.94	49.786	6.755	6.928
Vigour Index II	25.54 ± 1.68	12.25	50.34	30.677	31.716	93.553	61.123
Palmitic acid (%)	7.41 ± 0.438	4.89	17.31	22.41	23.553	90.534	43.926
Stearic acid (%)	4.42 ± 0.485	2.14	8.24	25.816	29.094	78.736	47.189
Oleic acid (%)	53.99 ± 1.388	42.11	79.49	11.604	12.023	93.148	23.071
Linoleic acid (%)	34.12 ± 0.687	10.45	44.58	19.984	20.135	98.502	40.858

Table 4.5. Estimation of variability and heritability pooled over the environments

CHARCTERS	MEAN $\pm$ SE	RANGE		GCV %	PCV %	HERITAIBILTY %	GENETIC ADV. AS PER CENT OF MEAN 5%
		Min.	Max.				
Plant height (cm)	129.11 $\pm$ 1.80	82.27	152.70	10.506	10.645	97.415	21.362
Head diameter (cm)	13.79 $\pm$ 0.57	7.51	17.70	15.29	16.10	90.20	29.92
Stem diameter (cm)	6.66 $\pm$ 0.30	3.56	8.23	18.44	19.25	91.75	36.39
Days to 50% flowering	59.39 $\pm$ 0.76	56.13	62.82	2.42	2.88	70.67	4.19
Days to maturity	95.69 $\pm$ 0.60	89.66	99.48	1.88	2.03	85.82	3.60
100 Seed weight (g)	6.55 $\pm$ 0.34	4.23	8.47	16.67	17.75	88.19	32.25
Seed Yield (g)	31.43 $\pm$ 0.93	15.74	40.13	19.42	19.75	96.62	39.31
Oil Content (%)	38.62 $\pm$ 0.62	35.62	43.16	2.91	3.51	68.70	4.97
Hull Content (%)	48.13 $\pm$ 1.76	23.54	58.93	15.21	15.86	91.99	30.05
% Seed filling	77.49 $\pm$ 1.49	29.45	93.77	19.14	19.28	98.51	39.13
Germination (%)	85.36 $\pm$ 1.53	48.93	94.98	10.46	10.69	95.76	21.09
EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	0.62 $\pm$ 0.03	0.23	1.28	32.47	33.01	96.70	65.77
Viability (%)	80.76 $\pm$ 1.16	43.58	92.07	11.49	11.63	97.73	23.41
Vigour Index I	26369.83 $\pm$ 466.20	19724.33	32249.33	10.50	10.72	95.92	21.18
Vigour Index II	31.52 $\pm$ 1.49	13.84	48.19	22.91	23.63	94.01	45.76
Palmitic acid (%)	6.98 $\pm$ 0.21	5.41	11.89	13.98	14.44	93.73	27.88
Stearic acid (%)	5.12 $\pm$ 0.18	3.37	8.03	18.79	19.29	94.82	37.69
Oleic acid (%)	39.88 $\pm$ 0.69	29.00	49.05	8.53	8.79	94.27	17.07
Linoleic acid (%)	47.63 $\pm$ 0.90	34.68	57.93	11.96	12.18	96.41	24.19

4.2 Genetic divergence

The analysis of variance revealed significant variability among the genotypes for all the traits, but the extent of genetic diversity could not be explained, therefore, cluster analysis was performed to quantify the genetic divergence among all the genotypes using Mahalanobis' D^2 statistics (1936) as described by Ward (1963). The genotypes were grouped into different clusters on the basis of minimum genetic distance using Euclidean method (Ward, 1963).

Cluster analysis classified all the 96 genotypes into 6 clusters based on the relative magnitude of their D^2 values, in such a way that genotypes within each cluster had smaller D^2 value than between the clusters. Cluster pattern (Table 4.6) revealed that cluster IV and V had the maximum with 35 and 32 genotypes, respectively followed by cluster I (15 genotypes), cluster VI (8 genotypes), cluster II (5 genotypes) and clusters III (1 genotype).

The genotypes included in the same cluster are considered genetically similar with respect to the aggregate effect of the characters examined; the hybridization attempted between these could not expect to yield desirable recombinants. Therefore, putative parents for crossing programme should belong to different clusters characterized by large inter-cluster distance. Earlier, Mohan and Seetharam (2005) also observed similar clustering pattern of genotypes among clusters, as some clusters were unique having only single genotype.

Intra and Inter cluster distance

The intra and inter cluster distances among various clusters involving ninety six genotypes are presented in table 4.7. The inter cluster distances were greater than intra cluster distance which indicates the presence of narrow genetic variation within a cluster and divergence among the different clusters. The maximum intra cluster D^2 value was observed for cluster I (5.451) followed by cluster II (5.099), V (3.800), and VI (3.711) which reveals the existence of maximum differences among the genotypes that fall in these clusters.

When diversity was studied among the clusters based on the inter-cluster D^2 values, intercluster distance ranged from 4.126 to 17.040 (Table 4.7 and Figure 4.1). Clusters IV and V showed minimum inter-cluster distance of 4.126 indicating close relationship among the genotypes included in these clusters. Clusters III and V showed maximum inter-cluster distance of 17.040, followed by clusters III and IV (16.785), clusters I and III (16.190), clusters III and VI (15.898) and clusters II and III (14.929) which indicates that genotypes in these clusters are genetically diverse and can be used as promising parents for hybridization in a breeding programme.

Table 4.6 Clustering of 96 genotypes of sunflower on the basis of Euclidean minimum distance method

Clusters	No. of genotypes	Name of genotypes
Cluster I	15	CMS 11A,CMS 17A,CMS 234A,CMSH 91A,CMS 103A,CMS ARG6A,CMS 207A,CMS ARG2-A,CMS ARG 3-A,CMS DV-10,6D-1,HRHA 4-2,RHA 271,HRHA 5-3,CMS 44A.
Cluster II	5	CMS 148A, RHA 297, CMS 302A, CMS 607A, CMS 852A.
Cluster III	1	HSFH 848
Cluster IV	35	CMS11A x 6D-1,CMS 11A x RHA 271,CMS 148A x RHA 271,CMS 11A x RHA 297, CMS ARG 6A x RHA 297,CMS 44A x HRHA 5-3,CMS 11A x HRHA 4-2,CMS 44A x RHA 271,CMS 17A x HRHA 5-3,CMS 17A x RHA 297,CMS 148A x HRHA 4-2,CMS 607A x RHA 271,CMS 44A x HRHA 5-3,CMS 44A x RHA 297,CMS 148A x HRHA 5-3,CMSH 91A x 6D-1, CMSH 91A x RHA 271, CMS DV-10 x 6D-1, CMS 302A x HRHA 5-3,CMS 234A x HRHA 5-3,CMS 852A x HRHA 4-2,CMS 607A x HRHA 4-2, CMS DV-10 x HRHA 4-2,CMS DV-10 x HRHA 5-3,CMS ARG 3-A x HRHA 5-3,CMSH91 A x HRHA 5-3,CMS 207A x HRHA 5-3,CMS 103A x HRHA 5-3,CMS 103A x HRHA 4-2,CMS 103A x 6D-1, CMSH91 A x RHA 297, CMS ARG 6A x 6D-1, CMS 852A x RHA 297.
Cluster V	32	CMS 17A x 6D-1,CMSH91A x HRHA 4-2,CMS 44A x 6D-1.CMS 148A x RHA 271,CMS 17A x HRHA 4-2,CMS 103A x RHA 297,CMS ARG 3A x HRHA 4-2, CMS ARG 3A x RHA 271, CMS 852A x 6D-1, CMS 234A x RHA 297, CMS 302A x 6D-1, CMS ARG 2A x RHA 297,CMS ARG 3A x RHA 297, CMS 607A x HRHA 4-2, CMS ARG 2A x 6D-1,CMS 302A x RHA 271,CMS 234A x HRHA 5-3, CMS ARG 6A x HRHA 4-2,CMS ARG 2A x HRHA 4-2, CMS 852A x HRHA 5-3,CMS 302A x RHA 297, CMS 234A x HRHA 4-2, CMS 852A x RHA 271, CMS207A x RHA 297, CMS ARG 3A x 6D-1,CMS ARG6A x HRHA 5-3, CMS ARG 6A x RHA 271,CMS DV-10 x RHA 271, CMS DV-10 x RHA 297, CMS 207A x RHA 271,CMS 207A x 6D-1,CMS 207A x HRHA 4-2.
Cluster VI	8	CMS 17A x RHA 271, CMS 103A x HRHA 5-3, CMS 148A x RHA 297, CMS 302A x HRHA 4-2, CMS 234A x 6D-1, CMS 607A x RHA 297, CMS 607A x 6D-1, CMS ARG 2A x RHA 271.

Table 4.7 Average intra- (diagonal) and inter- (above diagonal) cluster D² values for 96 genotypes of sunflower

Clusters	I	II	III	IV	V	VI
I	5.451	6.781	16.190	7.694	7.443	8.204
II		5.099	14.929	8.591	8.288	7.096
III			0.000	16.785	17.040	15.898
IV				3.444	4.126	5.299
V					3.800	5.240
VI						3.711

Clusters mean value of different clusters

The cluster means for seed yield per plant and its component characters are presented in Table 4.8. The data revealed considerable differences among all the clusters for most of the characters studied.

From the table 4.8, it was evident that genotypes present in cluster VI had higher plant height (cm) with a highest cluster mean value (136.97), while the lowest mean value (89.96) was observed for genotypes present in cluster III. Cluster VI also had highest value for head diameter (14.95 cm) and stem diameter (7.37 cm), while cluster III had lowest mean value (10.19) for head diameter and cluster I had lowest value (5.03) for stem diameter. Days to flowering was recorded lowest in cluster III (43.33), whereas higher mean value was observed in cluster I (62.05). Cluster III consist of lower mean value for days to maturity (69.42), while the highest value of days to maturity was recorded in cluster V (96.49).

Cluster VI showed the higher value (7.72) for 100 seed weight (g), while the minimum value was showed in cluster III (4.79). Cluster VI comprised of genotypes which have high cluster mean value for seed yield per plant (35.15), while lowest value was evident in cluster I (23.5). Cluster II showed higher value for oil content (48.33 %) and lowest value in cluster III (29.67). The minimum value for hull content (%) was recorded in cluster III (33.87) and maximum in cluster V (51.69). Seed percent filling had highest value in cluster V (85.83), while lowest value in cluster III (42.72).

Maximum germination per cent was recorded in cluster I (91.20 %) and minimum mean value in cluster III (51.02). Cluster IV had lowest mean value (0.51) for electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$), while the maximum mean value was observed in cluster II (1.16). The maximum mean value for viability was observed in cluster I (86.05) and minimum mean value (43.64) in cluster III. Vigour index I showed highest mean value in cluster IV (2685.20) and lowest mean in cluster III (1300.48).

Cluster IV had the highest mean value (35.93) for vigour index II, while the cluster II had the lowest mean value (18.84). Palmitic acid displayed highest mean in cluster V (7.77)

Figure 4.1 Ward's minimum variance dendrogram for 96 genotypes of sunflower based on standardized Euclidean's distance.

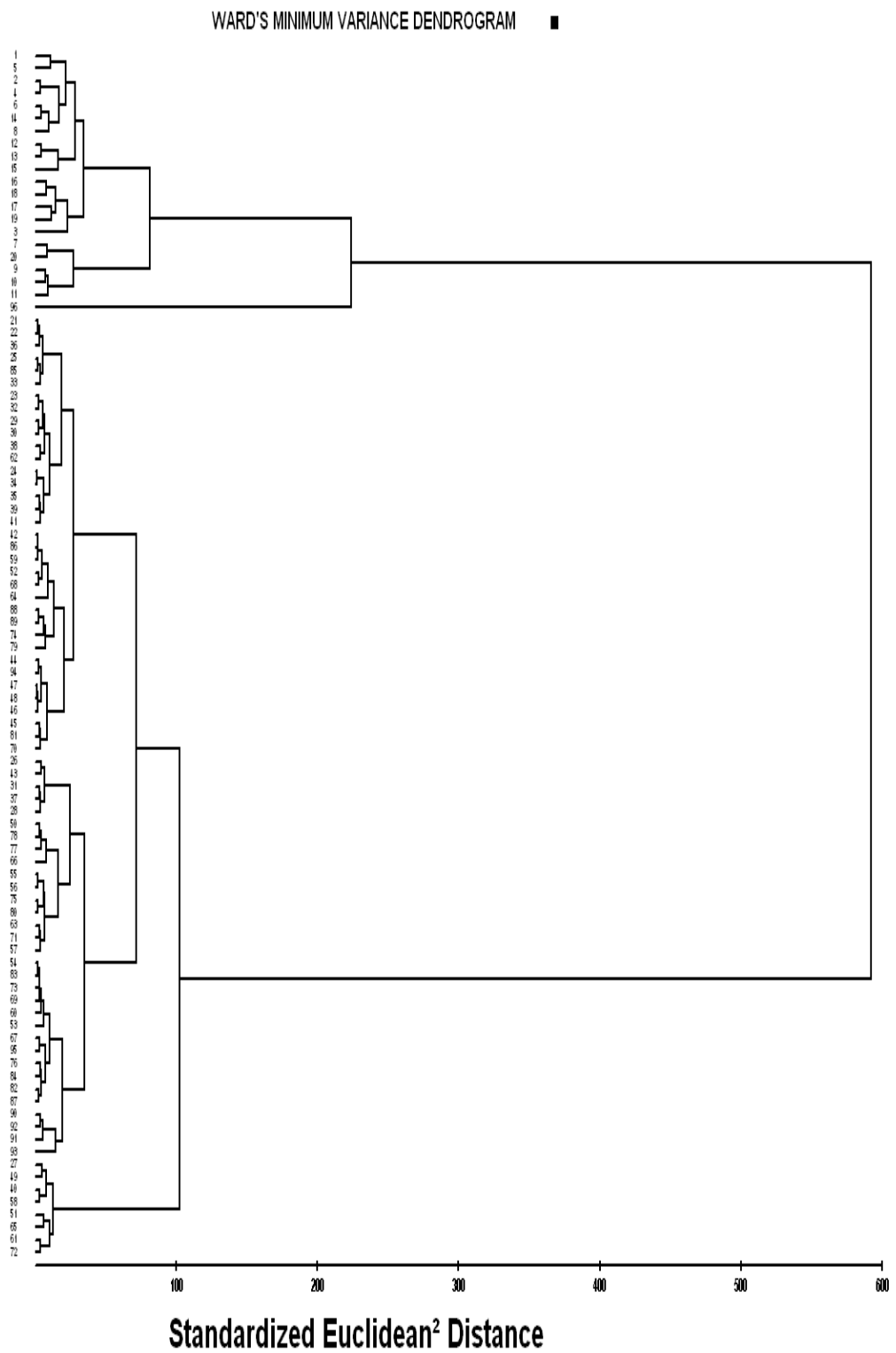


Table 4.8 Cluster Mean values of seed yield and its component traits in sunflower

Clusters	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI I	VI II	PALM (%)	STER. (%)	OLEIC (%)	LINO. (%)
I	120.50	11.55	5.03	62.05	95.53	5.24	23.5	47.17	39.42	55.82	91.20	0.69	86.05	2575.52	26.45	6.83	4.46	41.40	40.77
II	123.79	10.66	5.07	59.93	94.53	6.23	27.52	48.33	42.15	57.22	67.85	1.16	61.50	2591.73	18.84	6.69	3.84	41.95	40.14
III	89.96	10.19	5.07	43.33	69.42	4.79	23.68	29.67	33.87	42.72	51.02	0.68	43.64	1300.48	27.44	4.87	2.67	25.49	25.24
IV	136.14	14.93	7.35	59.40	95.54	7.40	34.65	38.58	50.82	84.88	88.97	0.51	84.94	2685.20	35.93	6.63	4.93	38.02	52.07
V	134.36	14.55	7.15	59.52	96.49	7.42	34.04	38.73	51.69	85.83	88.98	0.56	84.83	2532.72	33.48	7.77	5.37	42.37	46.93
VI	136.97	14.95	7.37	59.85	95.26	7.72	35.15	38.48	50.95	76.96	67.74	0.94	65.08	2496.71	29.08	6.96	5.72	40.08	47.12

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

and lowest mean (4.87) for cluster III. Stearic acid had lowest mean value in cluster III (2.67), while the highest mean value in cluster VI (5.72). The maximum value for oleic and linoleic acid was recorded in cluster V (42.37) and cluster VI (47.12) respectively, where the minimum mean value for oleic (25.49) and linolenic (25.24) was recorded in cluster III.

The overall comparison indicated that cluster IV, V and VI, had better cluster means for characters viz., 100 seed weight (g), head diameter (cm), stem diameter(cm), palmitic acid (%), stearic acid (%), vigour index II, oleic and linoleic acid (%). Therefore, cluster IV, V and VI could be considered while selecting genotypes for sunflower improvement for above traits.

4.3 Stability analysis

According to Eberhart and Russell (1996) model, the genotype x environment interaction was further partitioned into linear and non-linear components. The pooled analyses of variance revealed that mean squares due to pooled deviations were found significant for all the traits (Table 4.9). This indicates significant role of non-linear components of genotype x environment interaction in determining the stable performance of all the characters. The variances due to genotypes were significant for all the characters against pooled deviation suggesting that sufficient genetic variability was present among the genotypes under investigation. The mean squares due to environments (linear) as well as genotype x environment (linear) interactions were significant against pooled deviations for all the characters. These results indicated that variation in the performance of genotypes when grown over these environments is predictable for plant height (cm), head diameter (cm), stem diameter(cm), days to flowering, days to maturity, 100 seed weight (g), seed yield per plant (g), oil content (%), hull content (%), seed percent filling, germination (%), electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$), viability (%), vigour index I, vigour index II, palmitic acid (%), stearic acid (%), oleic acid (%) and linoleic acid (%). The variances due to pooled deviation were significant for almost all the characters, which indicated that genotypes differed with respect to their stability.

Based on three parameters of stability *i.e.* mean performance across four environments, regression coefficients and deviations from regression, a genotype is considered to be stable if it shows high mean value, unit regression coefficient (b_i) with least deviation from regression line (δ_{di}^{-2}). These stability parameters are presented in tables 4.10, 4.11, 4.12, 4.13, 4.14, 4.15 and character wise results are explained below:

Table 4.9 Analysis of variance for stability of seed yield and component traits in sunflower over all the environments

		MSS									
SOURCE	D.F.	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
VARIETIES	95	742.53**	18.45**	6.22**	9.42**	13.69**	5.50**	150.69**	5.82**	220.54**	884.14**
ENVIRONMENTS	3	157263.24**	802.49**	149.43**	762.05**	203.40**	14.84**	6098.83**	446.84**	911.03**	3313.87**
VAR. X ENV.	285	252.03**	3.64**	0.85	8.47**	6.71**	0.84	14.44**	17.94**	37.83**	133.37**
ENV+ (VAR. X ENV.)	288	1887.56**	11.96**	2.40**	16.32**	8.75**	0.99	77.82**	22.40**	46.92**	166.50**
ENV. (LINEAR)	1	471786.61**	2407.41**	448.29**	2284.31**	612.45**	44.53**	18296.62**	1340.76**	2733.51**	9940.29**
VAR. X ENV.(LINEAR)	95	616.51**	6.67**	1.26	9.37**	7.54**	0.90	27.00**	49.85**	50.01**	165.75**
POOLED DEVIATION	192	69.08**	2.10**	0.64	7.95**	6.21**	0.80	8.08**	1.96**	31.40**	115.96**
POOLED ERROR	760	18.83	1.95**	0.50	3.47	1.71	0.74	5.28	2.57	18.13	11.14

		MSS								
SOURCE	D.F.	GERM.(%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB.(%)	VI-I	VI-II	PALM.(%)	STER.(%)	OLEIC (%)	LINO.(%)
VARIETIES	95	323.61**	0.17	347.33**	43237.4**	213.06**	3.89**	3.78**	47.25**	131.35**
ENVIRONMENTS	3	2210.52**	0.30	1458.60**	238900.0**	1604.08**	12.73**	96.49**	37483.54**	22312.63**
VAR. X ENV.	285	104.16**	0.06	98.36**	27074.4**	62.42**	1.68**	2.34**	57.74**	59.14**
ENV+ (VAR.X ENV.)	288	126.10**	0.06	112.53**	29287.9**	78.47**	1.79**	3.32**	447.59**	290.95**
ENV.(LINEAR)	1	6629.56**	0.89	4375.07**	71640.0**	4812.80**	38.18**	289.46**	112449.89**	66938.38**
VAR X ENV. (LINEAR)	95	224.85**	0.10	196.15**	40572.1**	88.89**	3.22**	3.67**	81.36**	87.83**
POOLED DEVIATION	192	43.37**	0.04	48.95**	2017.8**	48.66**	0.90	1.66**	45.45**	44.33**
POOLED ERROR	760	13.41	0.01	7.79	484571.1	15.61	0.36	0.20	3.85	3.95

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, %SF – Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid. * at 5% level of significance, ** at 1% level of significance .

4.3.1 Plant height (cm)

The mean performance of genotypes presented in table 4.10 showed that female parents CMS 852 A (119.19 cm), CMS 607 A (115.36 cm) and pollen parent 6D-1 (115.23 cm) had the higher mean value for plant height while among hybrids CMS 607 A x HRHA 5-3 (152.70 cm), CMS 17 A x 6D-1 (146.33) and CMS 607 A x RHA 271 (145.48 cm) recorded the maximum height. All the parents exhibited regression coefficient less than unity, but for the hybrids it was equal to or more than unity with significant deviations from regression line.

The hybrids CMS 148 A x RHA 271 and ARG 6A x RHA 297 had low mean for plant height, above average stability to environments ($b < 1$) with non-significant deviation from regression line, hence these genotypes were appropriate for favorable environment with predictable performance. Hybrids CMS 207 A x RHA 297 and CMS 852 A x HRHA 4-2 A recorded high mean, below average stability to environments ($b > 1$) and non-significant deviation from regression line, thus, these genotypes were expected to do well under poor environments, and their performance would be predictable for plant height.

4.3.2 Head diameter (cm)

Among parents, higher mean value for head diameter was observed in CMSH 91 A (12.48 cm), CMS 11 A (11.94 cm) and ARG 3-A (10.64 cm) while among hybrids CMS 17 A x HRHA 5-3 (17.7 cm), CMS 148 A x HRHA 4-2 (16.8 cm), CMS 207 A x RHA 297 (16.64 cm) recorded higher mean value with significant deviation from regression line.

Parents CMS 302 A, CMS 852 A, CMS 207 A and hybrids DV-10 x RHA 297, ARG 6A x HRHA 4-2, ARG 6A x RHA 297, CMS 11 A x RHA 271 and CMS 11 A x HRHA 4-2 had lower mean, above average stability to environment ($b < 1$) with non significant deviation from regression line, so these genotypes were suitable for favourable environments. However, the parents ARG 3 A, ARG 2 A, DV 10, CMS 234 A, RHA 4-2, HRHA 5-3 and hybrids CMS 44A x HRHA 5-3, CMS 148 A x HRHA 4-2, CMS 207 A x HRHA 4-2 and CMS 852 A x RHA 271 recorded higher mean, below average stability to environments ($b > 1$), non-significant deviation from regression line and therefore these genotypes were expected to perform well under poor environments, and their performance would be predictable.

4.3.3 Stem diameter (cm)

Stem diameter of the female parent ARG 6A (5.12 cm) and hybrids CMS 17 A x HRHA 5-3 (8.19 cm) had higher mean performance with less than unity regression while the hybrids CMS 44 A x RHA 297 (8.23 cm), CMS 234 A x RHA 271 (8.1 cm) showed maximum mean with unity regression and significant deviation from regression for this trait (Table 4.10).

Among parents CMS 607 A , HRHA 5-3 and hybrids CMS 207 A x RHA 271 , DV-10 x RHA 297 , DV-10 x HRHA 5-3, DV-10 x HRHA 4-2 and ARG 3 A x RHA 271 having low mean value for stem diameter, above average stability to environment ($b < 1$) with non significant deviation from regression line and therefore, these genotypes were appropriate for favourable environments while ARG 3A, CMS 302 A x RHA 297 , ARG 3A x HRHA 5-3 ,CMS 607 A x HRHA 5-3 showed higher mean , below average stability to environments ($b > 1$) with non-significant deviation from regression line and thus, these genotypes showed stability under poor environments, and their performance would be predictable.

4.3.4 Days to 50 % Flowering

The parents CMS 207 A (61.51) had higher mean value for days to 50 % flowering with non significant regression coefficient and significant deviation from regression line, while the parents RHA 4-2 (61.19) and CMS 11 A (59.02) had observed for early flowering with significant regression coefficient and non significant deviation from regression line. Hybrids DV -10 x HRHA 4-2 (62.82), CMS 607 A x RHA 271 (62.34) and CMS 103 A x HRHA 4-2 (62.17) were recorded for late flowering with significant regression coefficient and non significant deviation from regression line.

The parent CMS 234A and hybrids CMS 44A x RHA 297, CMS 148 A x RHA 297 , CMS 852 A x 6D-1 and ARG 2A x RHA 297 had recorded for late flowering , above average stability to environment ($b < 1$) with non significant deviation from regression line so these genotypes were fit for positive environments while the parents CMS 148 A, RHA 297, RHA 4-2 and hybrid CMS 302 A x RHA 271 and ARG 2A x 6D-1 observed for late flowering days, below average stability to environments ($b > 1$) and non-significant deviation from regression line, therefore these genotypes were expected to do well under poor environments and would be predictable for days to 50 % flowering.

4.3.5 Days to maturity

Among the parents, ARG 3 A (99.48), CMS 148 A (98.35) and ARG 6 A (97.95) and hybrids CMS 302 A x HRHA 5-3 (99.36), CMS 852 A x 6D-1 (98.62), CMS 852 A x HRHA 4-2 (98.3) have recorded early maturity.

CMS 207 A, RHA 271, CMS 11 A x RHA 271, CMS 44 A x RHA 297 and ARG 3 A x HRHA 4-2 were observed suitable for favorable environments as they had lower mean value, above average stability to environment ($b < 1$) with non significant deviation from regression line, while ARG 6A , CMS 103 A ,CMS 103 A x HRHA 4-2 and CMS 302 A x RHA 271 showed higher mean, below average stability to environments ($b > 1$) and non-significant deviation from regression line, thus, these genotypes are predictable to perform well under poor environments, and their performance would be predictable.

4.3.6 Hundred seed weight (g)

The test weight (table 4.11) of female parent ARG 2 A (6.07 g) and CMS 11 A (5.23 g) was observed higher with significant regression coefficient and deviation from regression line while the female parent CMS 852 A (5.61 g) and CMSH 91 A (5.29 g) recorded higher mean value with significant unity regression and non significant deviation from regression line. Among hybrids CMS 44A x 6D-1 (8.12 g), CMS 17 A x RHA 271 (8.00 g), CMS 44 A x RHA 297 (7.91 g) had higher test weight with significant regression coefficient and deviation from regression line.

For hundred seed weight parents CMS 44 A, HRHA 5-3, and hybrids CMS 148 A x 6D-1, CMS 302 A x RHA 297 and ARG 3A x HRHA 4-2 were appropriate for favourable environments as they had low mean value, above average stability to environment ($b < 1$), non significant deviation from regression line while CMS 852 A x HRHA 4-2, CMS 148 A x HRHA 5-3 and CMS 44 A x HRHA 4-2 were observed with higher mean, below average stability to environments ($b > 1$) and non-significant deviation from regression line, consequently, these genotypes were probably near to accomplish fine beneath the poor environments, and their act would be predictable.

4.3.7 Seed yield per plant (g)

The maximum seed yield per plant was observed (table 4.11) for parents ARG 2 A (24.89 g), CMS 607 A (23.45 g), CMSH 91 A (23.34 g) and RHA 271 (23.22 g) and hybrids CMS 207 A x HRHA 5-3 (40.13 g), CMS 148 A x HRHA 5-3 (38.44 g), CMSH 91 x 6D-1 (38.2 g) with significant regression coefficient and non significant regression from deviation line.

Though the parents CMS 852 A, ARG 6 A, RHA 271, and hybrids CMS 11 A x HRHA 4-2 , CMS 11 A x RHA 271 , CMS 148 A x RHA 271 , CMS 302 A x HRHA 5-3 , CMS 234 A x RHA 271 , ARG 2A x RHA 271, ARG 6 A x RHA 271 were detected with lower mean value for seed yield, above average stability to environment ($b < 1$) with non significant deviation from regression line. Therefore, they observed the stable performance in favorable environments while the female parents CMS 148 A, CMS 607 A, ARG 3 A and hybrid CMS 852 A x RHA 271, ARG 3 A x HRHA 5-3, CMS 302 A x 6D-1 had maximum seed yield per plant, below standard stability to environments ($b > 1$) and non-significant deviation from regression line, thus, these genotypes were expected to do well under poor environments, and their presentation would be predictable.

4.3.8 Oil content (%)

The oil content values was observed higher in some parents and hybrid viz., RHA 4-2 (43.16 %), CMS 148 A (41.42 %), ARG 2-A (41.39 %), CMS 607 A (41.28 %), CMS 207 A

x 6D-1 (40.21 %) and CMS 207 A x RHA 297 (40.17 %) respectively, with significant regression coefficient and significant deviation from regression line.

Parents CMS 207 A and HRHA 5-3 were suitable for good environments because they had lower mean value, above average stability to environment ($b < 1$) with non significant deviation from regression line, while the crosses CMS 207 A x RHA 271, CMS 207 A x 6D-1, CMS 852 A x 6D-1, CMS 607 A x 6D-1, CMS 234 A x 6D-1, CMSH 91 A x RHA 271, CMS 44 A x RHA 271 and CMS 17 A x RHA 271 observed with maximum oil content, below average stability to environments ($b > 1$) and non-significant deviation from regression line, therefore, these hybrids were expected to perform well under poor environments, and their performance would be predictable.

4.3.9 Hull content (%)

From the table 4.12 it was observed that the parents CMS 44A (23.54), CMS 148 A (48.04 %), CMS 17 A (45.84 %), CMS 607 A (41.04 %), and hybrids DV 10 x HRHA 4-2 (58.93 %), CMS 302 A x RHA 297 (56.95 %), CMS 302 A x HRHA 4-2 (56.92 %), DV 10 x 6D-1 (56.68 %) had higher mean value with significant regression coefficient and deviation from regression line.

The hull content of parent CMS 234 A and hybrids CMS 11 A x RHA 271 and ARG 6A x HRHA 5-3 were recorded with lower mean, above average stability to environment ($b < 1$), non significant deviation from regression line, thus these genotypes were appropriate for richer environments. Though the parent ARG 2 A and hybrid CMSH 91 A x HRHA 4-2 and CMS 302 A x RHA 297 had higher mean, below average stability to environments ($b > 1$) and non-significant deviation from regression line, hence, these were expected to do well under poor environments, and their act would be predictable.

4.3.10 Percent seed filling

Higher mean value for percent seed filling were observed in parents and hybrids viz., CMS 17 A (72.08), CMS 148 A (63.99), CMSH 91 A (61.24), ARG 6 A x RHA 297(93.77), ARG 2A x 6D-1(93.11), CMS 207 A x RHA 297 (92.19) respectively, with significant regression coefficient and deviation from regression line except ARG 6A x RHA 297 which had non significant deviation from regression line for stability mean.

From the table 4.12 it was concluded that the parent CMS 11 A and CMS 234 A and crosses CMS 234 A x HRHA 4-2, CMS 234 A x RHA 297, ARG 6A x RHA 297 had higher mean value for percent seed filling, below average stability to environments ($b > 1$) and non-significant deviation from regression line, thus, these were suitable for poor environments, and their performance would be predictable.

4.3.11 Germination (%)

Maximum germination was observed in parents ARG 6-A (91.25 %), CMS 148 A (91.04 %) and RHA 271 (90.6%) with significant regression coefficient and deviation from regression line while hybrids CMS 852 A x 6D-1(94.08%), CMS 607 A x HRHA 4-2 (94.45%) ARG 6 A x RHA 297 (94.08 %) had higher mean with significant regression coefficient and non significant deviation from regression line.

The hybrids CMS 103 A x RHA 297, CMS 852 A x HRHA 5-3, DV -10 x RHA 297 had lower mean, above average stability ($b < 1$) with non significant deviation from regression line. Though they were suitable for good environments while the hybrids CMS 607 A x HRHA 4-2 , CMS 852 A x 6D-1, ARG 2A x 6D-1 , ARG 6 A x RHA 297 ,CMS 44 A x 6 D-1 and CMS 148 A x HRHA 4-2 CMS 11 A, CMS 234 A , CMS 234 A x HRHA 4-2, CMS 234 A x RHA 297 and ARG 6A x RHA 297 recorded higher mean, below average stability over environments ($b > 1$) and non-significant deviation from regression line, therefore, these genotypes were likely to perform good under poor environments, and their performance would be predictable.

4.3.12 Electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$)

From the table 4.12 it was evident that the parent RHA 297 (1.28), CMS 852 A(1.11) and the hybrids CMS 234 A x 6 D-1(1.09), CMS 607 A x 6D-1 (1.05) recorded the higher mean value for electrical conductivity with significant regression coefficient and deviation from regression line.

The hybrids CMS 17 A x 6D-1, CMS 44 A x 6 D-1, CMS 44 A x HRHA 4-2, CMS 148 A x 6D-1, CMS 103 A x HRHA 4-2, CMS 302 A x 6 D-1 ,ARG 2A x 6 D-1 and ARG 6 A x 6 D-1 were suitable for the better environment as they had lower mean, above average stability to environment ($b < 1$) with non significant deviation from regression line. On the other hand the parents CMS 17 A , CMS 302 A , ARG 2 A ,DV-10 and RHA 297 were suitable for poor environment because they had higher mean, below average stability to environments ($b > 1$), non-significant deviation from regression line and their performance would be predictable.

4.3.13 Viability (%)

The parents RHA 271 (85.91), ARG 6 A (85.35), CMS 148 A (83.73), DV-10 (82.63), CMS 103 A (82.72) and hybrid CMS 17 A x 6D-1 (91.32),ARG 2 A x 6D-1(91.23) were observed maximum for viability with less than unity regression coefficient and significant deviation from regression line except the cross CMS 148 A x 6D-1 (92.07) which had higher mean value with non significant deviation from regression line.

The hybrids CMS 148 A x 6D-1, CMS 852 A x RHA 271 and DV 10 x RHA 271 would perform well under the poor environment as they had higher mean, below average stability to environments ($b > 1$) and non-significant deviation from regression line and their act would be conventional.

4.3.14 Vigour index –I

The maximum value for seedling vigour index I was observed (table 4.13) by parent ARG 3A (43913.09) and hybrids CMS 11A x HRHA 5-3 (3211.83), CMS 302 A x RHA 297 (3057.92), CMS 17 A x 6D-1 (3004.92) with significant regression coefficient and deviation from regression line.

The hybrids CMS 11 A x RHA 297, CMS 17 A x RHA 297 and CMS 44 A x 6D-1 had lower mean value, above average stability to environment ($b < 1$) with non significant deviation from regression line thus, these hybrids were appropriate for favourable environments. Though the hybrids CMS 44A x HRHA 5-3, CMS 103 A x HRHA 4-2 and DV 10 x RHA 271 were good performer for stability under the poor environment as they had higher mean, below average stability to environments ($b > 1$) and non-significant deviation from regression line.

4.3.15 Vigour index –II

The maximum value for seedling vigour index II were observed by parents ARG 3 A (27.77), CMSH 91 A (25.03), CMS 148 A (24.77) and hybrids CMS 103 A x 6D-1 (48.19), CMS 103 A x RHA 271 (47.12) and CMS 148 A x 6D-1 (46.39) with significant regression coefficient and deviation from regression line.

The hybrids CMS 11 A x 6D-1 and CMSH 91 A x 6D-1 had lower mean value, above average stability to environment ($b < 1$) with non significant deviation from regression line thus, these hybrids were appropriate for constructive environments. Though the female parent CMS 302 A and hybrid CMS 302 A x 6D-1 were probably good performer for stability under the poor environment as they had higher mean, below average stability to environments ($b > 1$) and non-significant deviation from regression line.

4.3.16 Palmitic acid (%)

From table 4.13 the parents ARG 3A (7.22), CMS 852 (6.69), CMS 302 A (7.56) and crosses CMS 207 A x HRHA 4-2 (11.89), ARG 6 A x RHA 271 (9.13) and DV 10 x RHA 271 (9.04) were observed with higher mean value for palmitic acid, with significant regression coefficient and deviation from regression line.

For palmitic acid the parent ARG 6 A and the hybrids CMS 44A x RHA 271, CMS 148 A x 6D-1, CMS 148 A x RHA 297 and CMS 103 A x 6D-1 showed lower mean value, above average stability to environment ($b < 1$) with non significant deviation from regression line, hence, these were suitable for favorable environments while CMS 302 A, CMS 234 A x HRHA 5-3, CMS 607 A x RHA 297 and ARG 2 A x RHA 271 had higher mean, below average stability to environments ($b > 1$) and non-significant deviation from regression line, thus, these would probably perform good under poor environments, and their presentation would be predictable.

4.3.17 Stearic acid (%)

For stearic acid, CMS 207 A (8.03), HRHA 5-3(6.26) and ARG 6 A (5.74) were observed maximum mean value, with less than unity regression and significant deviation from regression line while CMS 234 A x RHA 297 (7.09), ARG 2 A x RHA 271 (7.74), ARG 3A x RHA 297 (7.14) recorded higher mean, with more than unity regression coefficient and significant deviation from regression lines.

The parents and hybrids viz., DV-10 , CMS 207 A x 6D-1, CMS 103 A x RHA 271 , CMS 148 A x RHA 297, CMS 17 A x HRHA 5-3 , CMS 11 A x RHA 297 were observed suitable for the favorable environment with lower mean, above average stability to environment ($b < 1$), non significant deviation from regression line. Though ARG 2 A , CMS 103 A x HRHA 5-3 and CMS 103 A x RHA 297 had higher mean, below average stability to environments ($b > 1$), non-significant deviation from regression line, hence, these would likely to carry out fine under poor environments.

4.3.18 Oleic acid (%)

From the table 4.13. it was observed that the parents ARG 3 A (43.36), RHA 271 (43.19) and hybrids CMS 234 A x HRHA 4-2 (49.05),CMSH 91 A x HRHA 4-2 (47.06), ARG 2 A x 6D-1 (46.87) had maximum oleic acid with significant regression coefficient and deviation from regression line.

The hybrids viz., CMS 148 A x HRHA 4-2 , CMS 302 A x HRHA 5-3, CMS 607 A x RHA 271 and CMS 852 A x RHA 271 were fit for the richer environment as they had lower mean, above average stability to environment ($b < 1$), with significant deviation from regression line while the parents CMS 607A, ARG 3 A and crosses CMS 17 A x 6D-1 ,CMS 607 A x RHA 297 and CMS 852 A x HRHA 4-2 would perform better under the poor environment because they had higher mean, below average stability to environments ($b > 1$),non significant deviation from regression line and their performance would be predictable .

4.3.19 Linoleic acid (%)

The parents ARG 3 A (45.83), CMS 44 A (45.82) and hybrids ARG 2 A x HRHA 5-3 (57.93), DV -10 x RHA 297 (56.82) were observed for higher linoleic acid with significant regression coefficient and deviation from regression line except CMSH 91 A x HRHA 5-3 (57.04), ARG 2 A (45.34) showed significant regression unity but non significant regression from deviation.

For linoleic acid, hybrid ARG 6 A x HRHA 5-3 and parent CMS 207 A had lower mean, above average stability to environment ($b < 1$), non significant deviation from regression line, so these were appropriate for favorable environments, though CMS 11 A , CMS 44A,

Table 4.10 Stability analysis of (96) genotypes for Plant Height, Head Diameter, Stem Diameter, Days to 50 % Flowering in sunflower

Sr. No	Hybrids	Plant Height (cm)			Head Diameter (cm)			Stem Diameter (cm)			Days to 50% Flowering		
		Mean	(b _i)	(δ^2_{di})	Mean	Bi	(δ^2_{di})	Mean	bi	(δ^2_{di})	Mean	bi	(δ^2_{di})
1	CMS 11 A	106.12	0.5**	53.16**	11.94	0.8**	0.22**	4.13	0.24**	-0.15	59.02	0.51	-0.63
2	CMS 17 A	115.7	0.52**	48.92**	9.85	0.69**	1.46**	4.53	-0.26**	-0.14	60.34	-0.08**	1.61**
3	CMS 44 A	112.22	0.57**	63.14**	10.61	0.28**	-0.53	3.98	0.34**	0.29**	59.42	0.4**	-0.88
4	CMS148 A	109.77	0.4**	24.14**	11.19	0.11**	-0.46	3.74	0.20**	0.02	61	0.69	-0.14
5	CMSH 91 A	82.27	0.2**	9.62**	12.48	0.46**	-0.49	4.59	0.28**	-0.1	60.76	0.05**	-0.71
6	CMS 103 A	98.94	0.43**	42.03**	10.38	0.35**	-0.54	4.15	0.44**	-0.11	58.42	0.69	0.95**
7	CMS 234 A	105.48	0.58**	54.08**	10.79	0.53**	1.84**	4.09	0.47**	-0.14**	57.7	0.81	-0.33
8	CMS 302 A	112.32	0.22**	4.6	9.71	1.04	-0.21	4.95	0.99	0.1**	58.81	0.63	1.36**
9	CMS 607 A	115.36	0.5**	54.62**	11.06	0.45**	-0.35	4.67	1.12	-0.08	57.18	0.37**	-0.51
10	CMS 852 A	119.19	0.15**	-0.19	9.14	1.11	0.27	4.35	-0.46**	-0.01	57.12	0.27**	0.99**
11	ARG 2-A	94.15	0.61**	29.75	10.61	-0.31**	-0.07	4.35	0.95	-0.05	59.26	0.01**	-0.44
12	ARG 3-A	95.15	0.43**	45.09**	10.64	0.12**	-0.37	4.48	0.9	-0.15	60.87	0.39**	4.28**
13	ARG 6-A	111.01	0.15**	-1.46	8.39	0.71**	-0.11	5.12	0.5**	-0.15	58.5	1.05	11.96**
14	DV -10	100.22	0.42**	17.39**	10.46	0.02**	-0.46	4.34	0.59**	-0.08	57.58	0.58	6.88**
15	CMS 207 A	111.54	0.1**	14.87**	9.11	1.09	-0.27	4.51	-0.07**	-0.12	61.51	0.61	1.27**
16	6D-1	115.23	0.3**	17.41**	8.73	0.45**	0.63**	4.39	0.25**	0.01**	59.17	0.87	1.94**
17	RHA 271	108.63	0.44**	20.8**	9.39	0.22**	-0.56	4.6	0.79	-0.13	59.84	0.44	-0.48
18	RHA 4-2	97.55	0.8**	75.68**	10.98	-0.11**	-0.5	3.56	0.49**	-0.15	61.19	0.43	0.53
19	HRHA 5-3	98.87	0.42**	15.43**	10.06	0.1**	-0.19	4.71	1.07	-0.1	56.16	0.9	2.89**
20	RHA 297	108.88	0.17**	1.93**	7.51	0.29**	-0.56	4.55	-0.02**	0.01	58.19	0.85	4**
21	CMS 11 A x 6D-1	134.62	1.14**	147.76**	14.27	0.98	0.67**	7.04	1.09	0.44**	57.98	1.61**	6.59**
22	CMS 11 A x RHA 271	137.97	1.1	13.52**	14.14	1.18	0	6.59	0.74	0.15**	58.32	1.48	8.78**
23	CMS 11 A x HRHA 4-2	136.02	1.18**	52.51**	14.46	1.06	-0.38	6.9	1.17	0.15**	58.16	2.03**	7.21**
24	CMS 11 A x HRHA 5-3	141.93	1.3**	36.48**	16	1.27	0.08**	7.72	0.72	1.16**	58.5	1.92**	2.94**
25	CMS 11 A x RHA 297	137.07	1.15**	59.33**	14.15	1.33**	4.09**	7.12	1.82**	0.5**	60.21	2.29**	6.08**

Sr. No	Hybrids	Plant Height (cm)			Head Diameter (cm)			Stem Diameter (cm)			Days to 50% Flowering		
		Mean	(b _i)	(δ^{-2}_{di})	Mean	Bi	(δ^{-2}_{di})	Mean	bi	(δ^{-2}_{di})	Mean	bi	(δ^{-2}_{di})
26	CMS 17-A x 6D-1	146.33	1.28**	34.11**	16.47	0.73	4.65**	7.47	0.78	1.17**	58.96	1.85**	0.65**
27	CMS 17-A x RHA 271	137.88	1.22**	38.97**	15.75	1.08	-0.36	7.57	0.73	0.8**	60.82	2.13**	1.04**
28	CMS 17 -A x HRHA 4-2	141.55	1.31**	14.19**	14.55	1.22	0.53**	7.07	1.06	-0.01	59.64	1.92**	-0.01**
29	CMS 17 -A x HRHA 5-3	138.1	1.45**	54.34**	17.7	-0.56**	4.57**	8.19	0.53**	1.42**	58	1.58**	7.37**
30	CMS 17 A x RHA 297	134.38	1.12**	92.66**	15.12	1.38**	-0.25	7.92	0.27**	2.41**	58.46	1.77**	5.79**
31	CMS 44 A x 6D-1	137.42	1.01	28.48**	15.85	0.32**	-0.6	7.54	0.71	2.66**	58.16	1.15	10.25**
32	CMS 44 A x RHA 271	130.15	1.32**	73.75**	14.18	0.85	0.59**	6.66	0.69	-0.16	58.43	1.19	7.24**
33	CMS 44 A x HRHA 4-2	128.73	1.1	80.42**	14.39	0.78	15.91**	6.21	0.65	0.26**	59.12	1.36	7.01**
34	CMS 44 A x HRHA 5-3	138.2	1.42**	75.14**	16.5	0.84	0.04	7.86	2.13**	-0.15	58.04	1.69**	-0.22
35	CMS 44 A x RHA 297	138.6	1.28**	116.59**	15.7	1.33**	-0.28	8.23	1.3	0.72**	58.86	1.19	-0.9
36	CMS 148 A x 6D-1	130.22	1.32**	25.72**	13.8	1.05	5.94**	7.12	1.8**	0.79**	58.15	1.41	1.22**
37	CMS 148 A x RHA 271	130.53	1.4**	-3.32	15.3	1.02	-0.54	7.61	1.53**	0.2	58.25	1.51	5.77**
38	CMS 148 A x HRHA 4-2	139.17	1.39**	37.88**	16.8	0.61**	-0.27	7.72	1	1.59**	57.27	1.35	0.73**
39	CMS 148 A x HRHA 5-3	129.93	1.3**	102.01**	14.78	1.87**	-0.23	7.71	1.24	2.99**	60.42	2.1**	13.72**
40	CMS 148 A x RHA 297	134.58	1.13**	153.79**	15.3	1.78**	1.07**	7.67	1.56**	0.25**	58.64	1.21	0.8**
41	CMSH 91 A x 6D-1	139.07	1.3**	282.3**	16.28	2.19**	2.94**	7.62	1.59**	-0.05	58.82	1.58**	0.32**
42	CMSH 91 A x RHA 271	135.97	1.35**	1.54**	15.02	1.23	1.93**	7.83	1.99**	0.87**	59.15	1.64**	8.92**
43	CMSH 91 A x HRHA 4-2	139.77	1.34**	67.01**	16.05	0.87	4.55**	7.97	1.05	0.8**	59.36	1.53	16.68**
44	CMSH 91 A x HRHA 5-3	139.13	1.15**	37.08**	14.95	1.45**	0.91**	7.54	0.84	0.92**	59.88	0.95	20.88**
45	CMSH 91 x RHA 297	127	0.99	-4.52	15.47	1.28	-0.55	7.62	0.62**	0.62**	58.54	0.77	6.5**
46	CMS 103 A x 6D-1	135.47	1.11	107.52**	14.77	1.19	0.01	7.68	1.87**	-0.01	61.83	-0.3**	16.37**
47	CMS 103 A x RHA 271	135.65	0.9	82.9**	14.27	1.84**	0.66**	7.18	1.44**	0.83**	61.02	0.58	33.42**
48	CMS 103 A x HRHA 4-2	138.05	0.91	18.95**	15.25	1.33**	1.57**	7.19	1.53**	1.37**	60.38	0.25**	15.62**
49	CMS 103 A x HRHA 5-3	140.57	1.18**	20.19**	14	1.47**	0.87**	6.84	1.51**	0.93**	62.17	-0.65**	8.82**
50	CMS 103 A x RHA 297	134.32	1.02	53.28**	12.58	0.97	9.45**	6.44	1.38**	1.47**	59.09	0.72	18.33**

Sr. No	Hybrids	Plant Height (cm)			Head Diameter (cm)			Stem Diameter (cm)			Days to 50% Flowering		
		Mean	(bi)	(δ^{-2}_{di})	Mean	Bi	(δ^{-2}_{di})	Mean	bi	(δ^{-2}_{di})	Mean	bi	(δ^{-2}_{di})
51	CMS 234 A x 6D-1	142.28	1.01	65.73**	15.32	1.63**	2.84**	7.03	1.4**	0.22	57.84	1.67	1.61**
52	CMS 234A x RHA 271	138.08	1.12**	260.24**	14.55	1.69**	-0.07	8.1	1.73**	0.19	60.01	1.86	3.76**
53	CMS 234 A x HRHA 4-2	120.6	1.03	55.4**	13.63	0.87	-0.25	7.16	1.49**	-0.07	59.38	1.45	20.87**
54	CMS 234 A x HRHA 5-3	134.78	1.06	50.03**	13.92	-0.08**	3.13**	7.23	0.21**	1.5**	58.59	0.5	21.36**
55	CMS 234 A x RHA 297	135.13	1.01	15.98**	14.72	1.55**	0.32**	7.04	0.43**	0.24	57.19	0.61	0.19
56	CMS 302 A x 6D-1	131.12	1.07	291.72**	14.53	1.56**	-0.36	7.46	1.62**	0.27**	56.13	0.67	-1.07
57	CMS 302 A x RHA 271	143.47	1.39**	273.56**	15.1	1.52**	-0.23	7.44	1.6	-0.01	57.26	0.84	-0.9
58	CMS 302 A x HRHA 4-2	133.63	1.17**	126.88**	15.65	0.75	1.2**	7.66	0.89	0.29**	58.1	0.94	1.49**
59	CMS 302 A x HRHA 5-3	143.87	1.22**	110.68**	15.42	1.05	0.57**	7.57	1.31	-0.09	60.82	1.22	15.81**
60	CMS 302 A x RHA 297	144.93	1.11	208.35**	14.85	1.43**	-0.44	7.52	0.96	0.13	60.24	2.09**	-0.73
61	CMS 607 A x 6D-1	135.82	1.09	89.96**	15.1	1.22	2.52**	7.87	1.42**	0.4**	62.34	1.41	19.36**
62	CMS 607 A x RHA 271	145.48	1.25**	141.95**	16.2	1.29**	2.69**	7.58	0.97	1.5**	58.98	1.53	1.89**
63	CMS 607 A x HRHA 4-2	138.68	1.45**	79.82**	15.12	1.42**	-0.09	6.95	1.5**	0.33	57.64	1.35	1.01**
64	CMS 607 A x HRHA 5-3	152.7	1.23**	-4.95	14.47	0.89	1.68**	7.08	1.44**	-0.08	58.79	2.06**	12.82**
65	CMS 607 A x RHA 297	131.3	1.09	3.05**	13.22	0.71**	2.15**	6.95	0.97	-0.14	58.64	1.76**	14.93**
66	CMS 852 A x 6D -1	135	1.02	55.32**	14.17	1.65**	3.19**	6.38	0.91	0.26	57.86	1.19	-0.02
67	CMS 852 A x RHA 271	134.32	1.19**	56.86**	15.12	0.71**	0.78	7.26	0.96	1.53**	56.42	0.57	0.12
68	CMS 852 A x HRHA 4-2	139.75	0.98	0.06	13.98	1.64**	1.45**	7.53	1.68**	0.24**	56.72	0.59	-0.76
69	CMS 852A x HRHA 5-3	132.23	1.13**	152.9**	12.44	0.86	15.54**	6.98	1.48**	0.13	59.2	0.05	25.61**
70	CMS 852 A x RHA 297	135.82	1	83.02**	14.62	1.03	1.69**	6.86	1.49**	0.17**	59.87	1.13	32.76**
71	ARG 2A x 6D-1	135.78	1.13**	10.72**	15.22	1.81**	0.13	7.43	1.04	0.96**	57.51	0.74	-0.98
72	ARG 2A x RHA 271	139.75	1.15**	183.86**	15.61	1.05	-0.19	7.43	1.57**	0.13	60.28	0.62	15.24**
73	ARG 2A x HRHA 4-2	134.6	1.01	4.59**	14.48	1.48**	0.96**	7.1	1.3	-0.13	61.04	0.62	27.58**
74	ARG 2A x HRHA 5-3	134.5	1.06	44.66**	13.82	1.44**	3.65**	7.02	1.5**	0.01	59.46	1.29	8.48**
75	ARG 2A x RHA 297	135.92	1.26**	34.85**	13.22	1.42**	4.01**	6.71	1.26	0.84**	59.85	1.15	-1.09

Sr. No	Hybrids	Plant Height (cm)			Head Diameter (cm)			Stem Diameter (cm)			Days to 50% Flowering		
		Mean	(bi)	(δ^{-2}_{di})	Mean	Bi	(δ^{-2}_{di})	Mean	bi	(δ^{-2}_{di})	Mean	bi	(δ^{-2}_{di})
76	ARG 3A x 6D -1	129.4	1	7.33**	14.43	1.46**	3.82**	7.21	1.6**	0.46**	60.44	1.09	4.6**
77	ARG 3A x RHA 271	129	1.17**	74.04**	14.73	1.22	-0.01	6.97	1.1	0	61.48	1.42	1.76**
78	ARG 3A x HRHA 4-2	130.47	0.94	14.11**	13.83	0.97	-0.28	6.66	0.99	0.47**	61.06	1.27	0.8**
79	ARG 3A x HRHA 5-3	128.43	1.14**	22.47**	14.83	0.63**	1.24**	7.07	0.89	0.08	61.59	1.37	0.17**
80	ARG 3A x RHA 297	134.85	1.16**	178.67**	13.88	1.5**	0.23**	7.03	1.25	0.32	60.53	0.97	1.46**
81	ARG 6A x 6D-1	128.93	1.12**	80.29**	14.98	0.91	-0.65	7.01	0.64	-0.12	58.31	0.23**	2.37**
82	ARG 6A x RHA 271	130.12	1.48**	111.5**	15.4	1.33**	2.3**	6.99	1.14	0.36**	61.65	-0.09**	11.61**
83	ARG 6A x HRHA 4-2	133.22	0.99	24.36**	13.85	1.25	0.1	7.3	1.5**	-0.05	61.03	0.27**	10.28**
84	ARG 6A x HRHA 5-3	132.67	1.07	12.5**	14.03	1.32**	-0.03	7.03	1.31	-0.14	61.47	1.09	2.15**
85	ARG 6 A x RHA 297	129.12	1.2	1.97	14.08	1.27	0.81	7.43	1.27	0.04	60.81	0.99	1.95**
86	DV 10 x 6D -1	139.1	1.52**	5.68**	14.83	1.37**	4.36**	7.59	0.97	1.27**	59.5	1.36	2.38**
87	DV 10 x RHA 271	136.53	1.14**	123.48**	14.13	1.19	2.75**	6.98	1.15	0.34**	60.54	1.52	27.03**
88	DV 10 x HRHA 4-2	138.18	1.05	4.12**	13.7	1.23	1.2**	6.88	1.05	0.22	62.82	1.45	26.85**
89	DV 10 x HRHA 5-3	132.7	1.3**	51.11**	13.15	1.38**	1.61**	6.68	1.15	0.08	60.06	1.54	4.12**
90	DV -10 x RHA 297	125.48	1.19**	48.74**	13.83	1.28	0.82**	6.67	1.09	0.12	60.55	0.21**	10.53**
91	CMS 207A x 6D -1	133.47	1.28**	70.02**	13.72	0.78	2.71**	6.75	1.1	0.05	61.47	0.26**	11.6**
92	CMS 207 A x RHA 271	130.55	1.37**	25.18**	14.48	0.84	1.73**	7.01	0.53**	0.16	61.11	0.72	0.01**
93	CMS 207 A x HRHA 4-2	135.9	1.13**	122.23**	15.3	0.84	-0.15	7.57	0.13**	0.58**	61.13	1.27	11.49**
94	CMS 207 A x HRHA 5-3	133.02	1.1	39.43**	16.15	0.66**	7.52**	7.33	0.74	1.18**	61.73	-0.35**	2.06**
95	CMS 207 A x RHA 297	131.53	0.79**	- 0.67	16.64	1.05	5.21	7.86	0.55**	5.33**	60.41	0.57	24.68**
96	HSFH 848	114.92	0.53**	50.35**	12.83	0.58**	1.11	6.65	0.79	2.05**	56.96	0.72	2.56**

Table 4.11 Stability analysis of (96) genotypes for days to maturity, 100 seed weight (g), seed yield (g) and oil content (%) over the environments

Sr. No.	Hybrids	Days to maturity			100 seed weight (g)			Seed Yield (g)			Oil content (%)		
		Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}
1	CMS 11 A	94.37	-0.66**	2.44**	5.23	2.59**	0.19**	20.64	0.56**	0.89	32.3	2**	0.51**
2	CMS 17 A	95.81	0.16	2.16**	4.23	2.27	-0.02**	20.43	0.53**	-0.97	37.61	5.21**	2.92**
3	CMS 44 A	90.34	-0.74**	3.9**	4.28	1.33	-0.17	18.14	0.11**	-0.73	38.66	5.9**	0.52**
4	CMS148 A	98.35	0.05	5.47**	5.10	1.89	0.02**	21.19	0.27**	-0.56	41.42	4.68**	2.12**
5	CMSH 91 A	93.41	0.19	1.21**	5.29	2.38**	-0.1	23.34	0.67**	3.71	37.89	3.29**	5.69**
6	CMS 103 A	97.14	0.25	-0.25	4.60	0.59	-0.21	18.06	0.1**	-1.19	39.79	5.55**	3.84**
7	CMS 234 A	91.32	-0.59**	10.09**	4.42	0.75	0.24**	17.59	0.21**	-1.33	37.38	3.8**	4.88**
8	CMS 302 A	95.08	-0.44**	0.5**	4.67	0.76	-0.25	15.74	0.29**	-0.1	40.48	6.28**	0.88**
9	CMS 607 A	90.49	-0.16**	9.82**	5.08	1.99	-0.1	23.45	0.9	-0.84	41.28	3.16**	7.53**
10	CMS 852 A	97.05	0.46	6.88**	5.62	3.83**	-0.15	21.33	1.29**	-1.41	37.87	6.25**	0.19**
11	ARG 2-A	96.34	0.2	3.33**	6.07	3.39**	0.14**	24.89	0.74**	-1.51	41.39	3.35**	9.71**
12	ARG 3-A	99.48	-0.25**	1.89**	4.98	2.07	0.68**	22.13	0.47**	-0.18	38.32	3.51**	-0.33
13	ARG 6-A	97.95	-0.13**	-0.41	4.38	1.82	0.11**	21.25	1.05	-1.75	40.34	6.46**	2.08**
14	DV -10	97	-0.04**	3.96**	4.29	0.49	-0.12	21.24	0.42**	0.88	38.1	4.22**	6.75**
15	CMS 207 A	95.36	-1.27**	-0.38	4.52	3.45**	0.26**	20.52	0.92	-1.21	36.1	4.18**	-0.51
16	6D-1	92.23	-0.07**	2.54**	4.77	0.63	-0.12	17.41	0.25**	3.67	37.61	3.72**	9.24**
17	RHA 271	95.34	1.03	-0.49	4.82	2.13	0.08**	23.22	1.01	0.36	37.17	4.97**	-0.36
18	RHA 4-2	96.97	0.5	3.57**	4.48	-1.85	0.56**	15.95	-0.54**	-1.45	43.16	3.79**	4.47**
19	HRHA 5-3	89.66	-0.65**	5.41**	4.85	1.03	-0.06	19.67	0.34**	1.72	35.62	3.44**	-0.29
20	RHA 297	96.08	0.26	0.17**	4.65	0.74	-0.22	18.75	0.78	-0.91	39.78	5.5**	0.15**
21	CMS 11 A x 6D-1	93.49	1.74	6.9**	7.28	4.15**	-0.12	30.69	0.75	0.3	37.89	-0.17**	0.29**
22	CMS 11 A x RHA 271	93.32	2.38**	-0.27	7.00	-0.23**	-0.17	33.01	1.07	0.99	39.05	-0.08**	1**
23	CMS 11 A x HRHA 4-2	95.42	2.46**	12.44**	6.22	1.99	0.15**	34.54	1.28**	0.29	38.82	-0.42**	2.11**
24	CMS 11 A x HRHA 5-3	94.33	0.97	0.99	7.62	1.03	0.51**	36.42	1.36**	7.34	38.14	0.6**	-0.54

Sr. No.	Hybrids	Days to maturity			100 seed weight (g)			Seed Yield (g)			Oil content (%)		
		Mean	b _i	δ^2_{di}	Mean	b _i	δ^2_{di}	Mean	b _i	δ^2_{di}	Mean	b _i	δ^2_{di}
25	CMS 11 A x RHA 297	95.25	1.63	11.52**	7.25	2.79**	0.64**	35.78	0.84	14.43	39.08	-0.11**	0.04**
26	CMS 17-A x 6D-1	95.95	0.39	19.27**	7.18	-0.16**	0.72**	36.27	1.13	10.93	39.7	-0.05**	0.2**
27	CMS 17-A x RHA 271	94.62	0.23	11.29**	8.00	0.84	0.11**	37.58	1.37**	-1.34	38.23	-0.37**	-0.23
28	CMS 17 -A x HRHA 4-2	94.32	0.47	5.68**	7.13	0.49	0.34**	35	1.39**	11.09	38.96	-0.26**	0.08**
29	CMS 17 -A x HRHA 5-3	93.75	2.72**	2.03**	7.26	1.4	0.52**	34.1	0.99	19.4	38.47	-0.02**	-0.82
30	CMS 17 A x RHA 297	94.46	2.92**	5.83**	6.48	0.59	3.28**	35.15	0.96	49.43	38.1	-0.09**	-0.22
31	CMS 44 A x 6D-1	95.04	3.16**	1.52**	8.12	-0.05**	0.68**	35.31	1.09	4.04	38.28	0.32**	0.65**
32	CMS 44 A x RHA 271	94.38	2.54**	2.56**	7.22	1.55	0.34**	30.45	0.49**	8.83	39.23	0.23**	-0.78
33	CMS 44 A x HRHA 4-2	95.15	1.83	13.22**	7.71	-0.84	0	37.78	1.59**	-1.58	38.34	-0.17**	-0.5
34	CMS 44 A x HRHA 5-3	93.75	1.37**	1.6**	6.00	2.79**	0.62**	34.78	1.3**	19.06**	38.77	0.59**	-0.11
35	CMS 44 A x RHA 297	94.54	1.52**	-0.03	7.91	1.07	-0.03	35.86	1.12	61.71**	38.5	-0.47**	1.44**
36	CMS 148 A x 6D-1	95.79	1.36**	1.32**	7.36	1.69	-0.18	33.45	1.14	3.21	38.48	0.26**	-0.58
37	CMS 148 A x RHA 271	94.93	2.87**	1.18**	7.51	0.8	0.05**	34.13	1.02	0.25	38.38	0.18**	2.27**
38	CMS 148 A x HRHA 4-2	96.4	1.6	-0.22	7.84	1.86	-0.09	36.15	1.43**	2.46	38.15	0.21**	-0.61
39	CMS 148 A x HRHA 5-3	95.22	0.57	8.76**	5.00	0.41	-0.09	38.44	1.42**	-1.01	38.18	0.46**	4.03**
40	CMS 148 A x RHA 297	93.32	1.92	1.25**	7.81	1.7	0.13**	37.99	1.71**	0	38.67	0.4**	3.59**
41	CMSH 91 A x 6D-1	95.5	2.24**	-0.34	6.00	2.73**	0.68**	38.2	1.85**	4.17	39.52	0.41**	-0.64
42	CMSH 91 A x RHA 271	97.88	1.66	10.2**	7.47	0.32	0.74**	34.05	1.03	3.23	38.93	0.48**	-0.57
43	CMSH 91 A x HRHA 4-2	95.57	3.18**	7.65**	6.33	0.41	0.06**	33.31	1	1.97	38.47	0.43**	-0.44
44	CMSH 91 A x HRHA 5-3	96.44	0.68	3.08**	7.63	1.25	0.65**	38.06	1.34**	63.94**	38.2	-0.15**	0.1**
45	CMSH 91 A x RHA 297	94.57	2.48**	10.14**	7.58	-0.03**	0.97**	36.56	1.42**	13.21	37.54	-0.16**	-0.43
46	CMS 103 A x 6D-1	96.4	0.87	1.43**	7.10	-0.18**	0.59**	35.48	1.19	1.04	37.68	-0.24**	2.68**
47	CMS 103 A x RHA 271	93.36	3.24**	0.58**	6.00	1.54	1.29**	34.33	1.17	5.21	39.25	-0.17**	1.74**
48	CMS 103 A x HRHA 4-2	94.35	0.34	-0.14	7.72	1.68	-0.04	34.59	1.2	17.23**	38.47	-0.11**	1.48**
49	CMS 103 A x HRHA 5-3	95.01	2.78**	14.06**	6.00	1.07	0.63**	34.9	1.3**	14.13**	38.17	0.05**	-0.8

Sr. No.	Hybrids	Days to maturity			100 seed weight (g)			Seed Yield (g)			Oil content (%)		
		Mean	b _i	δ^2_{di}	Mean	b _i	δ^2_{di}	Mean	b _i	δ^2_{di}	Mean	b _i	δ^2_{di}
50	CMS 103 A x RHA 297	97.51	1.45	2.06**	7.85	1.62	-0.04	32.73	1.03	2.48	38.3	0.1**	-0.41
51	CMS 234 A x 6D-1	96.19	0.69	6.13**	7.22	0.98	0.5**	35.23	1.45**	16.11**	38.34	0.13**	-0.61
52	CMS 234A x RHA 271	96.46	-0.2**	1.72**	7.20	0.72	0.07**	33.14	1.09	-1.39	37.79	-0.02**	-0.76
53	CMS 234 A x HRHA 4-2	97.61	1.23	1**	7.36	0.3	0.28**	32.34	0.93	1.94	38.1	0.16**	0.25**
54	CMS 234 A x HRHA 5-3	97.73	2.43**	25.64**	7.71	-1.04	0.62**	31.79	0.95	0.28	37.99	-0.2**	-0.43
55	CMS 234 A x RHA 297	96.49	0.57	0.53**	6.85	-1.27	2.58**	34.29	0.81	11	38.15	0.27**	1.29**
56	CMS 302 A x 6D-1	96.47	0.56	0.49**	6.67	-2.75	3.44**	33.69	0.96	0.26	38.41	0.26**	0.05**
57	CMS 302 A x RHA 271	94.55	-0.94**	0.58**	7.64	0.48	0.13**	35.46	1.39**	13.97	39.17	0.02**	0.79**
58	CMS 302 A x HRHA 4-2	94.9	-0.72**	2.16**	7.18	-3.19	2.1**	33.69	0.83	0.36	39.02	0.13**	0.54**
59	CMS 302 A x HRHA 5-3	99.36	2.19**	51.13**	7.04	0.42	0.63**	32.8	1	-1.32	38.71	0.41**	-0.72
60	CMS 302 A x RHA 297	95.51	0.07	1.73**	7.21	2.31	-0.2	34.69	1.32**	8.98	38.85	0.44**	-0.58
61	CMS 607 A x 6D-1	97.1	1.45	30.42**	7.43	0.93	0.72**	35.24	1.24**	18.42**	38.23	0.24**	-0.18
62	CMS 607 A x RHA 271	94.19	1.29	14.41**	7.48	-0.22**	0.61**	34.39	1.07	-1.65	39	0.26**	1.15**
63	CMS 607 A x HRHA 4-2	96.78	1.27	-0.21	7.86	0.21	1**	34.47	1.11	1.31	38.53	0.32**	3.54**
64	CMS 607 A x HRHA 5-3	98.13	1.85	2.26**	6.36	1.56	0.82**	32.1	1.25**	10.47	38.48	0.33**	-0.09
65	CMS 607 A x RHA 297	95.75	-0.53**	16.6**	7.67	0.01	2.73**	33.3	0.85	-1.66	38.41	0.08**	0.37**
66	CMS 852 A x 6D -1	98.62	2.18**	6.26**	7.29	0.66	-0.07	33.79	1.17	18.82	38.17	0.31**	-0.72
67	CMS 852 A x RHA 271	94.41	-0.62**	21.42**	7.74	-0.1**	0.14**	35.09	0.89	-1.16	38.02	0.3**	0.35**
68	CMS 852 A x HRHA 4-2	98.3	1.7	6.98**	6.02	-0.52	-0.23	32.58	1.07	3.16	38.23	-0.21**	-0.79
69	CMS 852A x HRHA 5-3	97.53	1.69	-0.31	7.03	3.01**	-0.23	32.5	1.14	1.24	38.5	0.32**	0.12**
70	CMS 852 A x RHA 297	94.62	-0.51**	16.56**	6.58	1.98	1.2**	32.23	1.04	-0.02	39.39	0.28**	1.53**
71	ARG 2A x 6D-1	96.95	1.39	-0.31	7.30	1.27	0.23**	33.65	1.08	47.58**	37.67	0.19**	-0.84
72	ARG 2A x RHA 271	95.18	-0.06**	16.22**	7.83	0.1	-0.22	33.3	1.31**	-0.43	38.79	-0.16**	2.95**
73	ARG 2A x HRHA 4-2	96.97	2.92**	10.72**	7.54	-0.73	0.12**	34.56	1.22**	5.08	39.13	0.21**	0.73**
74	ARG 2A x HRHA 5-3	94.3	1.03	28.58**	5.66	1.54	-0.14	34.44	1.23**	11.14	38.91	-0.08**	-0.09

Sr. No.	Hybrids	Days to maturity			100 seed weight (g)			Seed Yield (g)			Oil content (%)		
		Mean	b _i	δ^2_{di}	Mean	b _i	δ^2_{di}	Mean	b _i	δ^2_{di}	Mean	b _i	δ^2_{di}
75	ARG 2A x RHA 297	96.42	-0.72**	19.11**	7.09	1.35	3.26**	36.49	1.38**	1.98	39.43	0.26**	-0.63
76	ARG 3A x 6D -1	96.44	0.47	1.57**	7.48	2.3	0.55**	35.34	1.26**	1.21	38.58	-0.06**	0.11**
77	ARG 3A x RHA 271	96.26	0.8	1.05**	4.67	2.86**	-0.2	33.04	1.02	-0.5	38.92	0.6**	-0.05
78	ARG 3A x HRHA 4-2	96.38	1.27	-0.32	6.74	3.3**	-0.12	32.39	0.75	1.09	38.74	-0.17**	-0.65
79	ARG 3A x HRHA 5-3	95.19	0.38	0.53**	6.90	2.32**	0.33**	33.93	0.84	0.7	38.56	0.04**	1.26**
80	ARG 3A x RHA 297	95.57	1.09	1.57**	7.83	2.43**	-0.23	34.93	1.09	0.05	37.78	0.07**	-0.78
81	ARG 6A x 6D-1	95.25	1.2	5.06**	5.55	1.31	-0.24	36.3	1.12	-0.52	38.89	-0.61**	1.46**
82	ARG 6A x RHA 271	96.45	1.81	1.73**	7.52	0.21	1.93**	33.65	1.07	8.96	38.14	0.15**	-0.66
83	ARG 6A x HRHA 4-2	97.16	1.91	0.5**	5.89	2.17	0.11**	32.77	1.08	0.54	39.59	0.06**	-0.79
84	ARG 6A x HRHA 5-3	96.7	1.63	4.69**	6.67	1.91	0.97**	32.8	1.1	4.24	39.21	0.24**	1.08**
85	ARG 6 A x RHA 297	97.25	1.62	1.18**	7.35	0.14	2.23**	36.3	1.51**	-0.08	38.32	-0.47**	-0.41
86	DV 10 x 6D -1	97.74	0.62	4.42**	6.22	-0.19**	0.14**	32.48	0.99	-0.84	39.15	-0.03**	2.12**
87	DV 10 x RHA 271	97.31	0.15	3.2**	7.85	2.44**	-0.18	32.97	1.01	2.77	38.65	-0.35**	1.76**
88	DV 10 x HRHA 4-2	96.54	1.25	0.72**	6.16	-1.37	1.32**	31.13	0.96	0.04	38.58	0.34**	0.08**
89	DV 10 x HRHA 5-3	96.97	1.31	0.25**	6.45	1.37	0.73**	33.02	1.11	0.41	38.4	0.11**	0.22**
90	DV -10 x RHA 297	97.85	1.66	2.97**	7.13	2.7**	2.04**	33.36	0.69**	5.93	39.23	0.71	-0.5
91	CMS 207 A x 6D -1	97.82	1.35	0.4	6.71	-0.56	1.27**	34.31	0.84	11.79	40.21	0.7	-0.81
92	CMS 207 A x RHA 271	97.75	1.01	1.28**	7.00	-1.65	1.14**	33.64	0.89	7.18	39.12	0.07**	0.7**
93	CMS 207 A x HRHA 4-2	96.92	1.6	1.63**	7.15	-0.81	4.82**	33.22	0.77	0.95	38.97	0.15**	1.14**
94	CMS 207 A x HRHA 5-3	95.83	0.62	5.14**	6.03	-1.09	2.41**	40.13	1.44**	62.85**	39.22	-0.07**	-0.43
95	CMS 207 A x RHA 297	95.68	0.01**	4.69**	6.34	2.02	0.62**	37.46	1.27**	0.01	40.17	-0.57**	0.95**
96	HSFH 848	92.43	2.26**	2.24**	6.31	-0.34	0.23**	28.96	1.06	1.59	37.71	0.65**	18.95**

Table 4.12. Stability analysis of (96) genotypes for Hull content (%), Seed filling (%), Germination (%) and Electrical conductivity over the environments

Sr. No.	Hybrids	Hull content (%)			Seed filling (%)			Germination (%)			Electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$)		
		Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}
1	CMS 11 A	37.87	0.92	1.3**	58.3	0.03	-3.37	83.36	-0.39	2.43**	0.8	-0.5	0.9**
2	CMS 17 A	45.84	1.27	16.41**	72.08	-0.82	21.53**	83.74	-0.94	26.38**	0.77	-0.46	0
3	CMS 44 A	23.54	-1.3	15.26**	29.45	0.04	8.25**	84.78	-1.38	79.04**	0.73	-0.63	0.6**
4	CMS148 A	48.04	1.32	-2.23	63.99	0.21	2.27**	91.04	-0.78	16.71**	0.82	-0.4	0.7**
5	CMSH 91 A	36.9	1.82	28.51**	61.24	-1.98	11.43**	86.33	-0.42	13.59**	0.66	-0.79	0.8**
6	CMS 103 A	34.48	0.89	8.54**	59.95	-1.24	46.36**	87.97	-0.65	3.73**	0.67	0.37	0
7	CMS 234 A	34.87	1.05	-4.36	60.4	-0.63	-1.39	48.93	-0.44	-0.04	1.06	0.13	0.54**
8	CMS 302 A	29.75	0.51	3.46**	47.34	-0.71	10.11**	89.95	-0.11	-3.33	0.72	0.39	0
9	CMS 607 A	41.04	0.99	7.61**	46.79	-1.33	161.47**	73.78	-0.76	3.77**	0.98	-1.88**	0.02**
10	CMS 852 A	33.97	0.15	25.41**	42.05	-0.65	17.93**	71.46	0.35	-3.2	1.11	-4.19**	0.08**
11	ARG 2-A	40.64	0.94	-4.77	52.36	-0.95	9.09**	78.73	-0.34	5.71**	0.78	-0.56	0
12	ARG 3-A	32.96	0.28	4.34**	43.64	-0.2	13.62**	85.12	-0.7	2.11**	0.75	-0.11	0.08**
13	ARG 6-A	28.11	0.13	-3.03	36.13	-0.14	1.35**	91.25	-0.62	20.63**	0.83	-0.27	0.01**
14	DV -10	40.54	1.71	4.66**	59.09	-0.82	10.47**	88.58	-0.46	1.98**	0.77	-0.24	0
15	CMS 207 A	38.12	0.91	-4.97	60.59	-0.9	2.51**	80.48	-0.35	1.02**	0.87	-0.3	0.05**
16	6D-1	32.07	0.08	46.01**	41.86	-0.66	-0.06	85.73	-1.03	30.1**	0.23	0.82	0
17	RHA 271	40.62	0.47	8.09**	53.2	1.47	31.6**	90.6	-0.65	4.63**	0.27	2.13	0.01**
18	RHA 4-2	39.61	1.62	1.55**	56.27	1.03	14.08**	84.08	-1.15	25.85**	0.46	-0.02**	0
19	HRHA 5-3	41	0.51	9.91**	55.86	0.35	-0.26	83.22	-1.04	25.12**	0.61	-0.67	0.03**

Sr. No.	Hybrids	Hull content (%)			Seed filling (%)			Germination (%)			Electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$)		
		Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}
20	RHA 297	35.71	1.8	26.95**	47.43	-0.67	2.21**	54.62	-0.49	5.31**	1.28	-0.27	0.02**
21	CMS 11 A x 6D-1	45.61	3.23**	8.5**	84.71	1.69	1.51**	90.29	1.51	41.43**	0.43	0.68	0.03**
22	CMS 11 A x RHA 271	49.72	3.09**	-0.15	86.47	0.84	2.59**	90.37	-0.16	51.02**	0.38	0.77	0.03**
23	CMS 11 A x HRHA 4-2	47.26	2.12**	11.6**	87.94	0.39	22.01**	85.21	0.89	207.31**	0.63	3.02**	0.5**
24	CMS 11 A x HRHA 5-3	44.03	5.46**	35.37**	83.68	0.45	308.39**	93.83	0.05	-4.04	0.37	1.43	0.01**
25	CMS 11 A x RHA 297	51.6	1.53	34.1**	90.31	0.63	6.55**	92.17	0.73	-2.76	0.44	3.76**	0
26	CMS 17-A x 6D-1	52.27	0.24	43.25**	86.41	-0.12	32.85**	94.22	0.23	-2.35	0.39	2.71	0.02**
27	CMS 17-A x RHA 271	44.55	1.84	78.84**	80.94	3.3**	367.35**	69.45	5.71**	138.19**	0.96	-8.67**	0.04**
28	CMS 17 -A x HRHA 4-2	45.21	3.66**	55.01**	73.26	3.41**	395.91**	84.9	2.72	1.82**	0.65	-4.74**	0.01**
29	CMS 17 -A x HRHA 5-3	46.26	2.54**	137.09**	88.13	0.5	86.71**	90.35	0.71	130.49**	0.45	4.96**	0.01**
30	CMS 17 A x RHA 297	48.03	4.31**	92.92**	85.26	0.4	102.54**	90.88	0.45	42.57**	0.41	2.76	0.01**
31	CMS 44 A x 6D-1	50.56	0.74	18.41**	87.93	0.9	39.55**	94.18	0.38	-3.48	0.39	3.98**	0
32	CMS 44 A x RHA 271	46.99	1.79	28.77**	88.99	-0.25	7.22**	92.35	0.42	-2.01	0.45	5.02**	0.01**
33	CMS 44 A x HRHA 4-2	44.93	-0.33	24.08**	89.06	0.13	20.5**	93.19	0.06	7.61**	0.53	3.34**	0
34	CMS 44 A x HRHA 5-3	42.24	0.88	2.18**	79.28	1.56	53.68**	89.88	1.31	4.6**	0.43	3.82**	0.03**
35	CMS 44 A x RHA 297	46.74	1.88	9.28**	91.82	0.54	31.65**	81.38	2.16	438.69**	0.68	2.93	0.38**
36	CMS 148 A x 6D-1	44.66	3**	17.35**	82.4	1.12	582.04**	93.96	0.01	-3.82	0.44	-1.52**	0
37	CMS 148 A x RHA 271	46.32	3.51**	2.57**	85.69	1.88	109**	82.7	3.06	16.67**	0.37	1.63	0.05**
38	CMS 148 A x HRHA 4-2	55.64	-0.59	2.8**	88.26	0.77	200.82**	94.61	-0.34	-0.7	0.41	2.83	0.05**
39	CMS 148 A x HRHA 5-3	42.82	-0.23	298.34**	85.64	1.47	16.41**	85.06	1.72	5.53**	0.57	0.2	0.01**

Sr. No.	Hybrids	Hull content (%)			Seed filling (%)			Germination (%)			Electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$)		
		Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}
40	CMS 148 A x RHA 297	45.72	-0.06	17.33**	74.91	4.02**	167.84**	67.34	6.2**	135.19**	0.81	1.23	0.46**
41	CMSH 91 A x 6D-1	44.53	-1.65	210.34**	77.89	1.32	875.28**	91.24	-0.04	28.64**	0.51	1	0.04**
42	CMSH 91 A x RHA 271	49.45	1.2	26.27**	83.76	1.52	3.91**	83.69	2.11	11.82**	0.51	2.07	0.03**
43	CMSH 91 A x HRHA 4-2	52.96	0.59	-1.2	85.09	0.61	104.43**	89.24	-0.69	49.35**	0.58	2.59	0.02**
44	CMSH 91 A x HRHA 5-3	50.11	0.31	22.38**	89.44	0.92	3.73**	90.42	1.1	0.74**	0.42	2.63	0.06**
45	CMSH 91 x RHA 297	49.46	0.38	19.76**	84.67	2**	84.82**	83.13	2.52	2.77**	0.74	-4.1**	0.01**
46	CMS 103 A x 6D-1	51.36	0.81	31**	82.31	1.97	4.5**	90.01	1.76	55.77**	0.54	5.45**	0.04**
47	CMS 103 A x RHA 271	54.1	1.96	56.26**	86.02	0.84	20.41**	93.81	0.59	-4.18	0.6	3.65**	0.02**
48	CMS 103 A x HRHA 4-2	52.24	-0.1	0.41**	87.86	0.58	16.47**	91.08	0.72	6.24**	0.53	4.95**	0
49	CMS 103 A x HRHA 5-3	48.45	1.61	10.94**	77.38	3.88**	508.66**	64.14	6.69**	132.17**	1.04	-3.17**	0.12**
50	CMS 103 A x RHA 297	47.19	2.33**	4.17**	72.06	2.89**	597.22**	86.29	2.1	-3.92	0.61	4.91**	0.02**
51	CMS 234 A x 6D-1	53.5	0.53	29.69**	78.23	3.09**	99.95**	70.57	4.47**	104.36**	1.09	-3.63**	0.13**
52	CMS 234A x RHA 271	53.54	0.28	0.21**	76.77	2.4**	380.61**	90.11	1.8	-2.36	0.54	3.37**	0
53	CMS 234 A x HRHA 4-2	54.47	1.79	29.54**	89.66	0.68	-1.43	92.08	0.42	-0.94	0.56	2.35	0.01**
54	CMS 234 A x HRHA 5-3	52.64	1.33	-2.01	89.61	0.01	1.44**	90.45	0.35	4.73**	0.61	2.42	0
55	CMS 234 A x RHA 297	50.58	0.23	47.61**	85.07	0.36	-0.09	90.24	0.8	7.26**	0.44	2.9	0.01**
56	CMS 302 A x 6D-1	53.76	0.59	38.43**	89.57	0.82	4.77**	90.12	0.91	7.54**	0.42	2.22	0
57	CMS 302 A x RHA 271	56.5	0.99	18.89**	82.02	2.06**	45.86**	85.6	2.57	24.68**	0.69	-4.96**	0.02**
58	CMS 302 A x HRHA 4-2	56.95	0.49	24.52**	74.96	3.49**	352.01**	64.04	5.89**	107.47**	0.8	4.22**	0.37**
59	CMS 302 A x HRHA 5-3	53.72	0.69	11.15**	74.88	3.04**	591.16**	89.38	1.39	27.77**	0.52	3.93**	0.06**

Sr. No.	Hybrids	Hull content (%)			Seed filling (%)			Germination (%)			Electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$)		
		Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}
60	CMS 302 A x RHA 297	56.95	-0.02**	-2.97	90.57	0.67	1.04**	91.4	0.49	11.24**	0.58	4.02**	0.01**
61	CMS 607 A x 6D-1	52.94	-0.05**	16.53**	80.53	2.86**	407.95**	70.73	5.04**	64.32**	1.05	-3.81**	0.12**
62	CMS 607 A x RHA 271	55.33	-1.32	11.52**	76.68	2.6**	296.12**	91.31	1.45	20.53**	0.52	2.07	0.06**
63	CMS 607 A x HRHA 4-2	52.59	0.25	22.83**	89.59	0.22	23.73**	94.45	0.37	-2.76	0.46	3.93**	0.05**
64	CMS 607 A x HRHA 5-3	54.54	-0.5	36.42**	77.31	3.3**	144.61**	78.98	3.94**	33.77**	0.69	-6.67**	0.02**
65	CMS 607 A x RHA 297	49.81	-1.3	25.15**	71.59	3.95**	202.29**	65.43	6.58**	145.43**	0.84	-5.04**	0.18**
66	CMS 852 A x 6D -1	49.07	-0.96	64.7**	75.08	1.17	912.79**	94.98	0.06	-3.55	0.55	4.01**	0.02**
67	CMS 852 A x RHA 271	51.22	-1.49	6.93**	90.26	0.33	42.51**	90.99	0.18	4.91**	0.56	3.38**	0.04**
68	CMS 852 A x HRHA 4-2	54.44	0.05	49.46**	87.52	1.2	-2.49	90.63	1.08	20.81**	0.56	4.04**	0.02**
69	CMS 852A x HRHA 5-3	55.67	1.64	30.34**	85.25	1.6	103.68**	86.93	1.81	65.04**	0.76	-3.35**	0.08**
70	CMS 852 A x RHA 297	54.11	0.3	20.64**	81.51	1.86	96.95**	86	1.57	178.92**	0.75	-4.26**	0.02**
71	ARG 2A x 6D-1	55.58	0.25	1.07**	93.11	0.27	16.54**	94.03	-0.01	-1.35	0.49	3.9**	0
72	ARG 2A x RHA 271	55.73	0.47	27.08**	77.14	2.26**	361.28**	70.21	4.95**	51.01**	0.93	-5.58**	0.14**
73	ARG 2A x HRHA 4-2	55.29	2.61**	22.54**	74.17	3.13**	178.66**	86.59	2.22	127.05**	0.75	-2.42	0.09**
74	ARG 2A x HRHA 5-3	55.55	-0.13	39.47**	85.88	1.15	15.81**	85.52	1.32	36.94**	0.49	4.5**	0.01**
75	ARG 2A x RHA 297	54.45	1.5	9.97**	83.57	1.57	14.94**	90.53	1.07	21.55**	0.51	4.94**	0.01**
76	ARG 3A x 6D -1	47.48	1.25	3.49**	90.52	0.08	20.4**	91.62	-0.3	21.34**	0.57	5.86**	0.04**
77	ARG 3A x RHA 271	51.51	-0.72	-1.91	85.41	1.56	96.19**	82.36	2.57	12.2**	0.79	-5.49**	0.03**
78	ARG 3A x HRHA 4-2	49.46	0.91	61.65**	85.21	1.97	50.83**	86.58	1.18	4.73**	0.41	2.19	0.01**
79	ARG 3A x HRHA 5-3	51.86	0.52	80.94**	90.62	0.65	27.69**	91.39	0.29	11.06**	0.43	2.83	0.01**

Sr. No.	Hybrids	Hull content (%)			Seed filling (%)			Germination (%)			Electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$)		
		Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}
80	ARG 3A x RHA 297	49.22	1.06	19.51**	91.99	1.07	3.46**	89.02	0.78	-1.67	0.45	3.02**	0.02**
81	ARG 6A x 6D-1	56.15	2.39**	-5.14	84.9	1.81	31.52**	82.78	2.29	3.35**	0.48	2.91	0
82	ARG 6A x RHA 271	56.36	3.16**	5.15**	87.55	1.27	55.53**	93.09	0.27	-4.36	0.48	2.1	0.02**
83	ARG 6A x HRHA 4-2	52.46	1.31	80.03**	83.17	0.62	91.94**	86.67	1.31	70.86**	0.49	3.41**	0.04**
84	ARG 6A x HRHA 5-3	49.51	2.34**	-3.4	89.62	0.57	3.62**	93.83	0.72	13.84**	0.54	3.54**	0.02**
85	ARG 6 A x RHA 297	54.89	1.15	2.98**	93.77	0.54	-0.5	94.08	0.19	-2.91	0.49	2.93	0.01**
86	DV 10 x 6D -1	56.68	0.02**	13.6**	77.47	0.18	377.39**	83.8	-0.15	184.9**	0.51	3.46**	0.07**
87	DV 10 x RHA 271	55.12	2.86**	10.57**	86.23	0.92	30.35**	86.63	0.43	27.61**	0.44	2.41	0
88	DV 10 x HRHA 4-2	58.93	0.43	17.63**	81.04	1.32	64.7**	86.65	1.2	96.65**	0.4	2.09	0
89	DV 10 x HRHA 5-3	56.61	1.38	-0.24	87.56	0.53	112.18**	83.09	-1.31**	88.07**	0.6	4.52**	0.08**
90	DV -10 x RHA 297	53.25	3.41**	13.17**	87.88	1.96	146.25**	79.36	2.93	12.11**	0.96	-5.49**	0.02**
91	CMS 207 A x 6D -1	41.39	-0.51	8.94**	82.04	2.11**	65.77**	89.61	1.95	15.37**	0.56	1.04	0.01**
92	CMS 207 A x RHA 271	51.75	-0.65	1.05**	90.11	0.94	5.75**	81.69	-0.53	215.62**	0.7	4.23**	0.04**
93	CMS 207 A x HRHA 4-2	51.6	3.16**	19.65**	86.83	0.12	25.32**	85.12	-0.23	120.09**	0.6	1.74	0.04**
94	CMS 207 A x HRHA 5-3	54.68	1.33	-1.05	91.25	0.65	19.73**	93.34	0.11	13.01**	0.58	3.86**	0.01**
95	CMS 207 A x RHA 297	51.81	-1	13.78**	92.19	0.11	44.57**	92.12	-0.68	4.12**	0.75	0.71	0.02**
96	HSFH 848	44.14	1.86	27.93**	58.0	1.33	78.98**	67.63	-0.04	31.11**	0.85	-5.02**	0.02**

Table 4.13 Stability analysis of (96) genotypes for Viability (%), Vigour index I, Vigour index II and Palmitic acid (%) over the environments

Sr. No.	Hybrids	Viability (%)			Vigour index I			Vigour index II			Palmitic acid (%)		
		Mean	b _i	δ^2_{di}	Mean	b _i	δ^2_{di}	Mean	b _i	δ^2_{di}	Mean	b _i	δ^2_{di}
1	CMS 11 A	79.59	-1.62**	31.23**	2142.17	0.32	-14457.00	22.58	-0.58**	22.47**	6	3.09**	0.7**
2	CMS 17 A	75.87	-1	31.08**	2058.67	0.22	-13394.00	22.47	-0.27**	12.05**	5.56	1.43	0.08**
3	CMS 44 A	78.81	-0.92	7.06**	2141.83	0.46	-142.00	21.5	-0.2**	9.75**	5.41	2.62**	0.52**
4	CMS148 A	83.73	-0.99	12.14**	2431.33	0.52	5271.00**	24.77	0.05	1.78**	6.18	2.35	0.11**
5	CMSH 91 A	76.87	-0.91	67.04**	2275.67	-0.29**	-10713.00	25.03	-0.47**	19.57**	6.68	2.91**	0.18**
6	CMS 103 A	82.72	-0.88	2.95**	2348.5	0.51	14133.00**	28.88	-0.52**	67.33**	6.2	0.73	-0.07
7	CMS 234 A	43.58	-0.53	8.86**	1724.5	0.58	-1498.66	15.88	-0.06**	0.81**	6.61	-0.55	0.18**
8	CMS 302 A	82	-0.62	18.39**	2337.83	0.45	-10297.00	23.84	0.21	-1.07	7.56	0.27	-0.09
9	CMS 607 A	63.16	-0.32	6.52**	2406.58	-0.06	3458.00**	14.37	-0.36**	6.01**	6.23	1.02	1.87**
10	CMS 852 A	65.69	-0.77	6.27**	2098.5	0.01	-14193.00	18.55	-0.29**	6.64**	6.69	2.3	0.31**
11	ARG 2-A	69.71	-0.39	6.83**	2107.89	0.73	-1062.00	22.24	-0.4**	1.86**	6.81	1.6	0.31**
12	ARG 3-A	78.08	-1.24**	22.89**	43913.09	20.44**	718.00**	27.77	-0.44**	8.85**	7.22	1.1	0.33**
13	ARG 6-A	85.35	-0.44	10.35**	2312.42	0.8	1404.7**	27.52	-0.04**	67.21**	6.94	1.65	-0.03
14	DV -10	82.63	-1.33**	4.11**	2112.92	-0.9	2667.1**	21.01	-0.22**	18.44**	6.22	1.58	2.17**
15	CMS 207 A	72.68	-0.4	2.11**	2178.33	0.73	-1136.98	21.82	0.04	-2.89	6.51	0.9	-0.04
16	6D-1	78.53	-1.54**	37.3**	2264.25	-0.14**	5882.7**	19.79	0.05	-1.02	6.49	2	0.07**
17	RHA 271	85.91	-0.67	6.46**	239.5	-0.54**	-1768.8	21.85	0.07	-4.02	5.69	-2.43**	0.65**
18	RHA 4-2	77.43	-0.92	31.09**	2118.0	0.33	-8350.0	15.98	0.06	1.47**	6.19	-0.65**	0.82**
19	HRHA 5-3	76.28	-1.39**	33.64**	2442.83	0.11	1194.9**	18.81	0.05	-4.49	5.65	0.74	0.75**
20	RHA 297	47.27	0.2	-0.74	2141.42	0.35	7427.7**	13.84	-0.42**	-5.06	6.18	0.66	0.22**

Sr. No.	Hybrids	Viability (%)			Vigour index I			Vigour index II			Palmitic acid (%)		
		Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}
21	CMS 11 A x 6D-1	87.64	2.01	45.64**	301.83	0.28	134.7**	38.07	1	4.85**	5.89	-1.56**	0.14**
22	CMS 11 A x RHA 271	90.83	0.79	5.11**	237.17	0.25	-1596.8	38.21	1.73	3.45**	6.53	-1.64**	0.57**
23	CMS 11 A x HRHA 4-2	79.99	1.8	122.12**	281.92	2.4**	-3604.97	32.7	-1.13**	6.11**	6.36	-1.06**	1.12**
24	CMS 11 A x HRHA 5-3	90.46	-0.32	5.22**	3211.83	1.81	-1215.0	34.26	-0.9**	51.03**	6.12	-0.49**	0.31**
25	CMS 11 A x RHA 297	86.59	0.88	19.68**	312.17	3.37**	-1542	35.51	-2.35**	13.31**	5.74	-2.02**	1.14**
26	CMS 17-A x 6D-1	91.32	0.14	4.41**	3004.92	-0.26**	-1212.5	34.9	-0.03**	5.56**	5.86	-0.51	-0.06
27	CMS 17-A x RHA 271	65.53	6.39**	195.52**	2591.92	-0.97	1889.2**	31.35	-0.84**	170.75**	6.11	-0.22**	0.49**
28	CMS 17 -A x HRHA 4-2	80.72	2.81**	-1.58	2671.58	1.06	498.3**	34.68	2.13**	67.65**	6.35	-0.64	0.56**
29	CMS 17 -A x HRHA 5-3	85.01	0.52	106.2**	2748.17	1.84	-154.6	35.61	2.33**	4.92**	6.42	0.05	0.13**
30	CMS 17 A x RHA 297	87.89	0.72	38.27**	216.08	2.65**	-1066.0	40.81	-1.49**	0.4**	5.86	-0.02	0.12**
31	CMS 44 A x 6D-1	89.57	-0.23	7.87**	299.33	2.42**	-149.4	39.74	-0.42**	62.58**	6.26	0.26	2.23**
32	CMS 44 A x RHA 271	89.26	0.98	2.89**	2556.08	1.45	-5942.5	36.45	1.28	10.39**	5.83	1.3	-0.04
33	CMS 44 A x HRHA 4-2	89.52	0.18	16.42**	2919.17	1.57	-1006.4	33.36	0.31	74.59**	6.19	0.28	0.4**
34	CMS 44 A x HRHA 5-3	86.99	1.07	3.3**	2913.67	-0.44**	-1097.5	31.4	-0.51**	0.13**	6.03	-1.71**	0.11**
35	CMS 44 A x RHA 297	79.9	1.94	522.54**	2689.25	2.01	1752.0**	29.28	0.3	-2.59	5.71	2.1	0.27**
36	CMS 148 A x 6D-1	92.07	0.16	-1.76	28516.5	3.55**	-14668.0	46.39	0.68	34.26**	6.1	1.19	-0.11
37	CMS 148 A x RHA 271	79.75	3.76**	24.93**	2410.58	2.01	57118.9**	35.35	1	69.5**	6.18	1.95	0.04**
38	CMS 148 A x HRHA 4-2	89.48	-0.01**	7.72**	2779.58	2.42**	-15147.7	35.21	1.8	65.66**	6.03	-0.99	0.68**
39	CMS 148 A x HRHA 5-3	82.76	2.53**	36.14**	2518.92	1.36	-6820.4	32.51	-0.24**	9.96**	6.48	-1.81	0.38**
40	CMS 148 A x RHA 297	65.38	7.02**	293.09**	2182.42	1.92	63757.6**	23.92	0.01	16.12**	6.11	1.14	-0.03
41	CMSH 91 A x 6D-1	85.36	-0.21	87.24**	275.25	3.56**	-6532.9	26.91	1.81	32.28**	6.81	-0.63	0.18**

Sr. No.	Hybrids	Viability (%)			Vigour index I			Vigour index II			Palmitic acid (%)		
		Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}
42	CMSH 91 A x RHA 271	78.94	1.86	29.22**	2541.42	1.02	-1550.1	31.36	-0.16**	116.6**	6.42	-0.52	-0.1
43	CMSH 91 A x HRHA 4-2	87.65	-0.65	28.72**	269.33	0.51	-1204.2	36.77	0.74	12.31**	6.58	-0.9	0.23**
44	CMSH 91 A x HRHA 5-3	83.38	0.31	2.79**	283.17	3.34**	-1093.5	44.14	1.98	5.07**	7.26	-1.25**	1.1**
45	CMSH 91 x RHA 297	79.51	2.68**	14.1**	253.08	0.9	-322.1	41.95	2.48**	33.54**	6.58	0.08	-0.05
46	CMS 103 A x 6D-1	89.92	-0.48	11.26**	292.67	0.44	-1920.9	48.19	3.83**	22.17**	6.83	1.17	-0.06
47	CMS 103 A x RHA 271	90.31	0.79	0.51**	2978.42	2.1	-5619.0	47.12	1.95	80.18**	6.69	-0.23**	0.42**
48	CMS 103 A x HRHA 4-2	87.38	0.89	17.54**	2743.92	-0.17**	-7367.4	41.21	2.69**	21.3**	6.82	-1.27**	-0.01
49	CMS 103 A x HRHA 5-3	62.12	7.57**	190.63**	2646.33	0.66	-5264.8	38.23	2.06**	14.7**	7.24	1.5	0.34**
50	CMS 103 A x RHA 297	83.47	2.07**	4.84**	2526.67	0.61	5702.1**	33.88	3.42**	45.86**	7.61	-0.63	0.16**
51	CMS 234 A x 6D-1	66.35	4.47**	118.08**	2491.58	3**	3285.6**	33.31	1.49	147.01**	6.42	-2.55**	0.94**
52	CMS 234A x RHA 271	85.91	1.46	12.67**	278.42	-0.01	-13208.2	39.33	4.03**	11.39**	7.24	-1.51**	0.33**
53	CMS 234 A x HRHA 4-2	87.33	0.53	11.66**	2981.08	2.39**	-9487.3	39.8	0.87	7.3**	7.52	4.02**	0.28**
54	CMS 234 A x HRHA 5-3	87.95	0.08	22.3**	2968.33	1.86	-8823.9	34.48	1.21	51.32**	7.61	-0.36	-0.11
55	CMS 234 A x RHA 297	86.81	0.81	24.76**	2811.25	2.74**	-5425.3	38.32	0.19	85.77**	7.35	2.77	0.01**
56	CMS 302 A x 6D-1	87.55	0.98	5.8**	2735.92	0.68	-14622.1	32.52	0.57	140.99**	7.24	-0.83	-0.11
57	CMS 302 A x RHA 271	80.86	2.83**	33.75**	3109.25	1.85	23815.3**	32.06	-0.51**	46.83**	7.97	0.42	0.27**
58	CMS 302 A x HRHA 4-2	64.29	6.83**	226.53**	2802.92	-1.3**	45212.4**	27.96	1.28	12.65**	7.28	1.58	0.15**
59	CMS 302 A x HRHA 5-3	85.58	2.01	61**	2806.08	-1.36**	16673.3**	31.48	2.08**	156.17**	6.45	-2.18**	0.42**
60	CMS 302 A x RHA 297	87.61	0.23	15.13**	3057.92	-0.11**	4062.02**	32.52	1.55	16.03**	7.41	0.7	0.36**
61	CMS 607 A x 6D-1	66.75	5.77**	78.53**	2925.75	3**	-10283.0	26.66	-0.3**	108.02**	7.73	2.65	0.89**
62	CMS 607 A x RHA 271	88.07	1.47	23.62**	2676.83	-0.44**	-15357.0	30.08	2.54**	8.97**	7.4	0.24	1.29**

Sr. No.	Hybrids	Viability (%)			Vigour index I			Vigour index II			Palmitic acid (%)		
		Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}
63	CMS 607 A x HRHA 4-2	91.12	0.04	0.49**	2681.33	1.13	-13658.9	28.65	0.68	15.01**	8.16	-4.18**	0.23**
64	CMS 607 A x HRHA 5-3	75.94	4.56**	23.03**	2675.09	3.7**	-12967.6	28.81	-0.6**	16.84**	7.12	4.63**	1.4**
65	CMS 607 A x RHA 297	62.66	7.58**	223.9**	2520.92	-0.97	-70570.2	27.65	1.38	91.22**	7.43	0.17	-0.06
66	CMS 852 A x 6D -1	89.72	0.46	20.48**	2424.5	1.45	-14105.5	32.6	3.3**	13.29**	7.07	1.23	-0.11
67	CMS 852 A x RHA 271	87.51	-0.08	-1.32	2557.67	0.05	-8559.38	34.95	2.24**	39.14**	8.42	3.7**	0.48**
68	CMS 852 A x HRHA 4-2	85.46	1.37	42.52**	2739.92	1.1	-14629.9	41.35	2.1**	25.26**	7.11	5.49**	0.06**
69	CMS 852A x HRHA 5-3	83.64	2.1	78.62**	2620.25	1.29	-98164.1	37.45	0.37	54.18**	7.25	4.26**	0.48**
70	CMS 852 A x RHA 297	79.52	0.77	204.41**	2666.75	-1.05**	-14310.06	34.78	2.64**	34.65**	6.77	1.76	5.47**
71	ARG 2A x 6D-1	91.23	0.13	5.42**	2733.83	-1.59**	-1218.61	27.23	2.24**	8.88**	7.04	0.93	-0.12
72	ARG 2A x RHA 271	67.64	5.46**	60**	2605.25	0.27	-1296.2	23.58	0.14	1.59**	7.42	1.74	0.08**
73	ARG 2A x HRHA 4-2	83.46	2.57**	110.23**	2739.5	-0.29**	-7959.5	29.04	2.4**	98.08**	6.98	0.71	0.27**
74	ARG 2A x HRHA 5-3	83.01	1.24	38.75**	2544.25	2.33**	4516.07**	23.43	0.9	77.76**	7.39	-0.24**	0.89**
75	ARG 2A x RHA 297	83.45	0.84	6.77**	2885.83	1.08	-1368.8	28.51	0.84	56.62**	8.38	-0.18**	3.47**
76	ARG 3A x 6D -1	86.53	0.25	7.23**	2763.33	0.01	-3838.8	30.75	2.43**	5.5**	7.51	6.05**	0.41**
77	ARG 3A x RHA 271	77.82	2.38**	22.71**	2528.25	0.08	2637.7**	31.51	1.09	6.77**	8.59	0.64	0.08**
78	ARG 3A x HRHA 4-2	80.95	1.37	30.22**	264.42	0.73	-11319.2	28.07	2.62**	127.05**	8.21	-1.56**	0.28**
79	ARG 3A x HRHA 5-3	85.81	-0.41	-2.03	3001.83	0.42	-12767.6	30.7	2.98**	155.12**	7.02	2.22	1.19**
80	ARG 3A x RHA 297	83.21	0.5	4.37**	2784.75	0.87	-1327.5	31.6	2.43**	167.32**	7.75	3.98**	1.63**
81	ARG 6A x 6D-1	76.47	1.87	15.42**	2557.17	0.2	-11135.9	35.99	3.72**	65.69**	7.42	8.92**	0.7**
82	ARG 6A x RHA 271	84.93	-0.05	1.58**	2734.25	1.21	-1434.6	32.74	2.13**	133.99**	9.13	6.99**	0.73**
83	ARG 6A x HRHA 4-2	81.57	1.96	29.75**	2803.5	1.45	-14758.2	34.78	1.14	48.69**	7.4	4.22**	5.94**

Sr. No.	Hybrids	Viability (%)			Vigour index I			Vigour index II			Palmitic acid (%)		
		Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}
84	ARG 6A x HRHA 5-3	89.03	0.17	40.21**	2783.17	0.69	2796.7**	41.33	2.49**	122.05**	8.76	2.42	11.27**
85	ARG 6 A x RHA 297	88.41	1.06	-0.48	2631.92	-0.72	9534.1**	39.98	2.18**	96.02**	6.58	0.78	0.4**
86	DV 10 x 6D -1	77.81	-1.35**	84.45**	2739.92	-0.07	-12630.5	34.06	1.8	102.76**	7.18	0.72	0.4**
87	DV 10 x RHA 271	81.61	-0.16	-0.56	2678.1	-0.31**	-1117.5	29.67	1.96	36.15**	9.04	3.36**	0.04**
88	DV 10 x HRHA 4-2	81.92	1.64	81.34**	2739.75	0.64	-9774.1	34.9	1.43	15.71**	8.14	-1.91**	0.19**
89	DV 10 x HRHA 5-3	77.99	-1.53**	127.45**	2580.83	0.94	4989.3**	30.18	0.6	4.7**	7.27	0.17	0.01**
90	DV -10 x RHA 297	75.49	2.9**	35.25**	2483.67	0.06	-10741.0	28.28	0.11	70.26**	7.73	-0.14	0.49**
91	CMS 207 A x 6D -1	82.36	1.8	9.23**	2633.33	0.01	-5995.4	29.14	0.91	13.32**	8.37	3.32**	1.74**
92	CMS 207 A x RHA 271	79.02	0.21	210.82**	276.67	0.9	-9317.0	37.17	1.83	358.51**	8.15	1.42	0
93	CMS 207 A x HRHA 4-2	81.19	-0.48	70.9**	2634.67	0.42	-3199.5	35.31	0.56	12.57**	11.89	16.87**	5.17**
94	CMS 207 A x HRHA 5-3	87.5	-0.34	6.18	2960.08	0.18	-12332.4	42.04	3.02**	17.25**	6.51	0.14	0.89**
95	CMS 207 A x RHA 297	90.27	-0.82	9.56**	2977.33	-0.71	5675.9**	37.6	1.98	2.01**	8.98	-7.89**	3.52**
96	HSFH 848	59.15	-0.52	32.72**	2309.33	-0.13**	-1379.2**	35.95	3.25**	7.58**	6.53	4.09**	2.52**

Table 4.14 Stability analysis of (96) genotypes for Stearic acid (%), Oleic acid and Linoleic acid over the environments

Sr.No.	Hybrids	Stearic acid (%)			Oleic acid (%)			Linoleic acid (%)		
		Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}	Mean	b_i	δ^2_{di}
1	CMS 11 A	4.5	0.47	0.08**	34.29	0.94	81.23**	45.31	0.99	-0.67
2	CMS 17 A	5.32	1.29	0.03**	38.28	0.42**	0.67**	38.93	1.42**	30.45**
3	CMS 44 A	4.06	0.66	-0.04	39.84	0.84	24.36**	45.82	0.76	-0.17
4	CMS148 A	5.1	1.04	0.61**	40.66	0.74**	15.06**	44.4	0.9	13.7**
5	CMSH 91 A	3.99	0.93	0.48**	37.13	0.91	0.15**	46.4	1.01	1.47**
6	CMS 103 A	4.15	0.95	0.22**	35.64	0.59**	1.34**	44.68	1.23	3.1**
7	CMS 234 A	4.26	0.31	0.37**	37.21	0.81	34.14**	38.1	0.45**	71.83**
8	CMS 302 A	5.72	0.7	0.03**	39.04	0.52**	0.41**	38.93	0.55**	139.5**
9	CMS 607 A	4.45	0.59	0.25**	41.47	0.97	8.36**	41.57	1.06	6.2**
10	CMS 852 A	4.63	0.63	0.22**	40.22	0.77**	2.34**	42	0.82	2.57**
11	ARG 2-A	5.16	0.89	-0.03	41.91	0.97	32.87**	45.34	1.29**	-0.63
12	ARG 3-A	5.01	0.06**	0.1**	43.36	0.72**	4.44**	45.83	0.85	6.08**
13	ARG 6-A	5.74	0.44	0.19**	41.49	0.87	41.22**	45.22	0.98	1.78**
14	DV -10	4.21	1.07	0	35.79	0.79**	15.49**	44.8	0.62	13.54**
15	CMS 207 A	8.03	-0.25**	0.11**	39.03	0.73**	53.74**	40.54	1.02	-0.71
16	6D-1	4.26	0.2**	-0.04	40.36	0.77**	2.75**	36.36	1.41**	4.98**
17	RHA 271	4.05	0.67	1.9**	43.19	0.7**	17.29**	37.3	1.13	2.69**
18	RHA 4-2	4.7	0.55	0.04**	39.84	0.7**	11.07**	34.68	0.66	154.61**
19	HRHA 5-3	6.26	0.98	1.85**	38.44	0.46**	-1.2	39.77	0.97	1.49**
20	RHA 297	4.12	1.16	0.66**	41.72	0.49**	0.26**	38.86	1.44**	1.96**

Sr.No.	Hybrids	Stearic acid (%)			Oleic acid (%)			Linoleic acid (%)		
		Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}
21	CMS 11 A x 6D-1	4.59	0.88	1.42**	42.4	1.21**	8.19**	49.88	1.65**	5.36**
22	CMS 11 A x RHA 271	3.6	0.55	-0.05	38.24	1.06	21.46**	52.12	1.17	5.15**
23	CMS 11 A x HRHA 4-2	5.49	-0.08**	-0.06	33.91	0.97	9.79**	54.92	1.09	10.53**
24	CMS 11 A x HRHA 5-3	4.87	0.85	0.52**	39.09	1.05	4.21**	49.8	1.16	2.47**
25	CMS 11 A x RHA 297	4.48	1.46	-0.01	36.9	1.21**	6.66**	52.65	1.29**	-0.27
26	CMS 17-A x 6D-1	5.24	1.07	0.19**	43.71	0.96	61.86**	45.87	1.05	72.98**
27	CMS 17-A x RHA 271	4.08	0.73	2.09**	41.13	0.74**	79.2**	50.22	0.7**	73.62**
28	CMS 17 -A x HRHA 4-2	5.47	-2.23**	0.2**	41.89	0.85	114.09**	42.34	0.82	3.05**
29	CMS 17 -A x HRHA 5-3	4.24	1.22	-0.05	36.8	1.3**	25.86**	56.52	1.14	1.01**
30	CMS 17 A x RHA 297	5.39	0.48	0.08**	35.22	1.09	20.07**	56.04	1	3.37**
31	CMS 44 A x 6D-1	5.35	0.82	0.07**	43.16	1.59**	14.48**	44.09	1.81**	8.84**
32	CMS 44 A x RHA 271	4.89	0.85	0.71**	35.9	1.19	5.7**	54.76	1.37**	-1.07
33	CMS 44 A x HRHA 4-2	4.65	0.69	0.17**	38.91	1.27**	10.16**	46.39	1.15	39.46**
34	CMS 44 A x HRHA 5-3	4.91	0.34	-0.07	36.95	1.19	24.47**	55.57	1.01	3.29**
35	CMS 44 A x RHA 297	4.74	0.55	1.89**	40.34	0.81	16.51**	52.74	1.19	99.55**
36	CMS 148 A x 6D-1	4.47	1.02	4.31**	40.77	0.53**	1.47**	50.22	0.66**	-1.25
37	CMS 148 A x RHA 271	4.22	-0.36**	0.02**	41.42	0.94	214.84**	40.43	0.6**	-1.16
38	CMS 148 A x HRHA 4-2	4.07	0.76	0.46**	31.26	1.07	12.8**	52.48	0.69**	278.51**
39	CMS 148 A x HRHA 5-3	5.48	-0.23**	0.01**	35.55	0.75**	3.67**	51.12	0.62**	46.25**
40	CMS 148 A x RHA 297	4.75	1.1	-0.03	40.55	1.18	47.73**	50.08	1.37**	6.35**

Sr.No.	Hybrids	Stearic acid (%)			Oleic acid (%)			Linoleic acid (%)		
		Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}
41	CMSH 91 A x 6D-1	6.19	-1.59**	0.15**	40.14	1.01	33.07**	51.59	1.6**	19.02**
42	CMSH 91 A x RHA 271	5.11	0.11	0.28**	36.95	0.82	110.81**	54.78	1.17	15.85**
43	CMSH 91 A x HRHA 4-2	5.49	-0.16**	-0.06	47.06	1.85**	33.98**	35.16	1.94**	230.43**
44	CMSH 91 A x HRHA 5-3	4.96	0.93	0.6**	40.84	1.01	241.5**	57.04	1.13	-0.38
45	CMSH 91 x RHA 297	4.47	0.38	0	39.1	0.97	29.94**	50.54	1.1	14.08**
46	CMS 103 A x 6D-1	5.55	-1.17**	0.93**	38.31	0.78**	143.61**	52.08	0.94	129.95**
47	CMS 103 A x RHA 271	4.97	1.24	-0.03	37.39	1.02	49.58**	51.27	1.06	35.92**
48	CMS 103 A x HRHA 4-2	5.56	-0.05**	0.83**	35.74	1.07	62.34**	50.25	0.85	132.63**
49	CMS 103 A x HRHA 5-3	5.15	0.03	-0.06	36.1	1.1	42.95**	48.73	0.74**	133.89**
50	CMS 103 A x RHA 297	6.2	0.43	0	41.27	0.92	146.81**	37.57	0.43**	8.73**
51	CMS 234 A x 6D-1	6.2	-0.3**	0.09**	37.58	0.99	148.71**	41.52	0.41**	74.84**
52	CMS 234A x RHA 271	4.75	0.3	-0.02	39.5	1.02	4.51**	46.99	0.94	6.98**
53	CMS 234 A x HRHA 4-2	5.36	2.56**	13.5**	49.05	1.31	76.68**	45.91	0.5**	112.28**
54	CMS 234 A x HRHA 5-3	4.25	0.5	1.16**	44.05	1.09	13.52**	50.14	0.69**	126.21**
55	CMS 234 A x RHA 297	7.09	3.08**	0.88**	46.2	0.73**	1.4**	51.31	1.49**	24.7**
56	CMS 302 A x 6D-1	6.31	1.88**	2.58**	43.43	1.18	72.79**	55.46	1.07	1.52**
57	CMS 302 A x RHA 271	6.92	3.83**	2.65**	42.95	0.6	8.85**	44.67	0.44**	33.4**
58	CMS 302 A x HRHA 4-2	5.03	1.39	0.13**	40.41	0.97	12.92**	47.54	0.73**	101.3**
59	CMS 302 A x HRHA 5-3	4.72	1.49	0.88**	35.8	1.02	11.11**	51.21	0.56**	216.73**
60	CMS 302 A x RHA 297	3.57	0.06	0.12**	43.75	1.52**	4.51**	53.08	0.93	66.45**

Sr.No.	Hybrids	Stearic acid (%)			Oleic acid (%)			Linoleic acid (%)		
		Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}
61	CMS 607 A x 6D-1	6.72	3.4**	0.93**	38.1	1.49**	4.71**	48.85	1.7**	1.17**
62	CMS 607 A x RHA 271	5.08	0.96	0.16**	34.51	1.21	6.82**	50.97	1.2	26.62**
63	CMS 607 A x HRHA 4-2	6.27	0.87	0.82**	43.47	0.81	30.08**	40.87	0.31**	84.13**
64	CMS 607 A x HRHA 5-3	4.42	0.32	1.1**	41.48	0.75**	30.21**	45.93	0.9	57.92**
65	CMS 607 A x RHA 297	6.13	0.16	2**	45.42	0.81	48.71**	36.78	0.49**	7**
66	CMS 852 A x 6D -1	6.38	-0.52**	0.08**	33.99	1.16	3.28**	44.75	0.98	201.87**
67	CMS 852 A x RHA 271	4.97	0.86	0.71**	40.6	0.99	107.05**	50.51	0.8	40.24**
68	CMS 852 A x HRHA 4-2	4.53	-0.35**	1.02**	38.78	1.2	24.7**	49.48	1.23	38.78**
69	CMS 852A x HRHA 5-3	5.71	0.88	0.87**	44.35	0.86	99.14**	49.13	0.69**	69.67**
70	CMS 852 A x RHA 297	5.98	0.81	0.69**	39.76	0.81	98.99**	52.53	1.3**	-0.97
71	ARG 2A x 6D-1	6.55	2.99**	17.86**	46.87	0.82	107.74**	49.47	0.47**	267.84**
72	ARG 2A x RHA 271	7.74	2.19**	0.18**	41.37	1.21	13.91**	53.24	0.89	1.07**
73	ARG 2A x HRHA 4-2	4.6	0.81	0.22**	45.04	0.55**	58.41**	45.21	0.61**	126.76**
74	ARG 2A x HRHA 5-3	4.65	1.29	0.61**	37.43	1.24**	70.46**	57.93	1.08	4.48**
75	ARG 2A x RHA 297	6.89	3.66**	0.87**	43.76	1.19	200.42**	52.11	0.77	213.7**
76	ARG 3A x 6D -1	5.3	1.37	5.69**	40.59	1.41	15.73**	41.73	0.93	16.23**
77	ARG 3A x RHA 271	6.73	2.68**	28.98**	39.44	1.3	97.44**	44.18	0.42**	-1.18
78	ARG 3A x HRHA 4-2	5.92	1.34	0.34**	43.69	1.12	85.53**	40.01	0.58**	-1.23
79	ARG 3A x HRHA 5-3	6.84	3.8**	8.08**	39.19	1.1	19.7**	50.37	0.91	3.25**
80	ARG 3A x RHA 297	7.14	2.05	6.71**	41.54	0.91	150.44**	55.64	1.14	7.75**

Sr.No.	Hybrids	Stearic acid (%)			Oleic acid (%)			Linoleic acid (%)		
		Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}	Mean	b _i	δ^{-2}_{di}
81	ARG 6A x 6D-1	5.46	2.59	20.24**	39.92	1.16	97.15**	53.27	1.1	6.7**
82	ARG 6A x RHA 271	5.89	4.03**	7.56**	43.2	1.04	19.99**	46.84	1.14	87.29**
83	ARG 6A x HRHA 4-2	4.37	0.92	-0.03	44.07	0.99	99.86**	49.25	1.56**	-0.68
84	ARG 6A x HRHA 5-3	5.42	2.33**	1.35**	41.18	1.24**	19.01**	44.97	1.03	-0.68
85	ARG 6 A x RHA 297	4.24	1.49	0.45**	38.03	1.01	18.78**	51.92	0.72**	-0.03
86	DV 10 x 6D -1	4.34	0.43	0.06**	39.02	1.04	18.61**	52.6	1	-1.2
87	DV 10 x RHA 271	4.25	0.9	0.05**	42.45	0.77**	183.67**	45.16	0.53**	124.81**
88	DV 10 x HRHA 4-2	5.54	2.12**	0.13**	36.97	1.2**	3.42**	52.29	1.43**	2.56**
89	DV 10 x HRHA 5-3	5.36	2.9**	0.18**	38.81	1.49**	6.06**	52.06	1.55**	4.77**
90	DV -10 x RHA 297	4.32	2.2**	0.14**	38.14	1.22**	67.32**	56.82	0.97	45.2**
91	CMS 207 A x 6D -1	4.18	1.01	0	35.06	1.24**	3.24**	51.1	1.55**	3.73**
92	CMS 207 A x RHA 271	3.44	1.04	0.08**	39.89	1.35**	18.82**	47.44	1.47**	23.05**
93	CMS 207 A x HRHA 4-2	3.37	1.38	0.49**	40.92	1.25**	77.66**	48.32	1.43**	1.8**
94	CMS 207 A x HRHA 5-3	4.17	0.66	-0.02	41.35	1.18	20.74**	52.26	1.4**	9.74**
95	CMS 207 A x RHA 297	4.62	2.33**	0.27**	42.17	1.33**	13.03**	52.39	1.33**	60.32**
96	HSFH 848	3.85	1.35	0.42**	29	0.91	0.55**	35.81	0.57**	2.4**

CMS 148 A x 6D-1 and ARG 6A x RHA 297 were expected to carry out well under poor environments as they had higher mean, below average stability to environments ($b > 1$) and non-significant deviation from regression line, and their performance would be predictable.

4.4 Combining ability analysis

4.4.1. Analysis of variance for combining ability over all the environments and for E₁, E₂, E₃ and E₄

The mean square for seed yield and its component traits were computed and the results are presented in table 4.15 to 4.19.

In E₁ (table 4.15), Mean sum of squares due to partitioning of components of treatments *viz.*, lines, testers and line x testers were found highly significant except electrical conductivity and thus, these were subjected to combining ability analysis of line x tester design as proposed by Kempthorne (1957). In E₂ (table 4.16), the mean sum of square due to partitioning of components of treatments *viz.*, lines, testers and line x testers were found significant except stem diameter and electrical conductivity. In E₃ (table 4.17), mean sum of square due to partitioning of components of treatments *viz.*, lines, testers and line x testers were found significant except electrical conductivity. In E₄ (table 4.18), the mean sum of square due to partitioning of components of treatments *viz.*, lines, testers and line x testers were found significant except hundred seed weight and electrical conductivity, these were subjected to combining ability analysis.

Over the environments (table 4.19), mean sum of square due to treatments were found highly significant for all the traits studied and thus, these were subjected to combining ability analysis of line x tester design. The mean sum of square due to partitioning of components of treatments *viz.*, lines, testers and line x testers were found highly significant for all the traits except electrical conductivity. This indicates that generated experimental material had sufficient genetic variation for seed yield and all its components characters.

Table 4.15 Analysis of variance for combining ability in E₁

		MSS									
SOURCE	D.F.	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
REPL/LOC	2	1.53	2.61	0.06	0.34	0.53	0.29	43.90**	50.60**	51.83**	49.60**
FEMALES	14	103.06**	25.86**	4.29*	72.29**	53.10**	3.83*	30.33**	4.47*	198.58**	257.83**
MALES	4	135.08**	5.29**	4.58*	5.65**	4.10*	1.95	25.24**	3.06*	52.71**	47.03**
FEMALE x MALE	56	201.02**	10.70**	1.78	8.84**	10.84**	3.09*	9.87**	1.63	64.56**	78.42**
ERROR	148	3.02	1.25	0.21	0.69	1.65	0.82	9.25	1.20	40.54	23.32

		MSS								
SOURCE	D.F.	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
REPL/LOC	2	29.08**	0.01	50.97**	3452.53**	9.08**	35.31**	33.69**	55.31**	42.97**
FEMALES	14	169.19**	0.20	171.61**	7641.00**	252.24**	5.78**	27.43**	245.59**	508.89**
MALES	4	11.11**	0.01	17.31**	1750.00**	31.47**	3.88*	7.92**	176.25**	165.74**
FEMALE x MALE	56	42.15**	0.04	56.25**	11210.00**	155.18**	3.53*	9.85**	207.81**	312.16**
ERROR	148	14.74	0.02	12.21	571.00	60.39	0.10	0.12	0.69	0.55

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid. * at 5% level of significance, ** at 1% level of significance.

Table 4.16 Analysis of variance for combining ability in E₂

		MSS									
SOURCE	D.F.	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW(g)	SY (g)	OC (%)	HC (%)	% SF
REPL/LOC	2	1.53	2.26	1.40	0.74	4.76*	0.09	1.50	28.74**	163.96**	14.54**
FEMALES	14	486.92**	9.47**	1.75	91.25**	33.17**	2.07	3.97*	4.89**	611.74**	33.05**
MALES	4	202.74**	12.19**	2.31	15.89**	15.62**	3.48*	4.95**	5.76**	61.65**	27.82**
FEMALE x MALE	56	219.81**	7.29**	2.05	23.60**	18.85**	2.14	6.50**	4.02*	136.32**	40.97**
ERROR	148	3.66	1.28	0.27	0.73	0.58	0.74	2.41	1.19	15.47	5.66

		MSS								
SOURCE	D.F.	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
REPL/LOC	2	5.48**	0.01	29.65**	4660.34**	13.00**	27.94**	28.65**	52.07**	51.21**
FEMALES	14	180.58**	0.12	256.48**	6276.00**	856.20**	10.18**	15.98**	161.39**	700.55**
MALES	4	60.15**	0.01	66.59**	8119.00**	37.70**	6.14**	4.94**	35.49**	454.91**
FEMALE x MALE	56	72.16**	0.07	76.78**	15498.00**	183.73**	6.18**	15.52**	172.58**	238.60**
ERROR	148	11.76	0.01	4.15	527.57	4.52	0.05	0.07	0.17	0.11

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid. * at 5% level of significance, ** at 1% level of significance.

Table 4.17. Analysis of variance for combining ability in E₃

		MSS									
SOURCE	D.F.	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW(g)	SY (g)	OC (%)	HC (%)	% SF
REPL/LOC	2	1.20	13.29**	3.37*	44.95**	11.20**	0.19	265.45**	22.74**	29.74**	3.84*
FEMALES	14	734.37**	13.75**	3.53*	68.52**	42.96**	8.03**	65.31**	5.65**	249.81**	361.63**
MALES	4	339.38**	6.14**	0.48	46.33**	4.89**	3.61*	49.15**	4.28*	43.11**	421.84**
FEMALE x MALE	56	205.78**	7.92**	2.05	20.41**	14.60**	2.31	48.86**	4.19*	77.54**	832.32**
ERROR	148	71.18	2.45	0.52	4.31	1.27	0.63	6.14	1.01	13.05	9.68

		MSS								
SOURCE	D.F.	GERM. (%)	EC (µScm ¹ g ¹)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
REPL/LOC	2	1.65	0.01	4.07*	94267.00**	118.14**	19.55**	21.41**	932.12**	66.93**
FEMALES	14	610.93**	0.21	528.09**	7040.00**	499.06**	19.39**	8.16**	358.32**	132.49**
MALES	4	433.75**	0.35	514.31**	1330.00**	160.62**	4.88**	4.46*	44.58**	197.40**
FEMALE x MALE	56	853.20**	0.44	813.63**	42849.00**	220.70**	6.70**	3.22*	123.51**	85.03**
ERROR	148	14.80	0.06	9.15	406.49	5.78	0.52	0.10	2.25	0.24

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid. * at 5% level of significance, ** at 1% level of significance.

Table 4.18 Analysis of variance for combining ability in E₄

		MSS									
SOURCE	D.F.	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
REPL/LOC	2	3.07	19.89**	5.05**	11.65**	0.96	1.39	4.47*	37.69**	13.28**	74.76**
FEMALES	14	501.79**	12.45**	3.05	68.76**	42.35**	2.35	97.34**	5.83**	348.48**	789.10**
MALES	4	734.93**	15.67**	3.18*	12.08**	47.88**	0.89	82.11**	1.41	167.10**	274.41**
FEMALE x MALE	56	290.83**	9.63**	2.69	14.65**	20.55**	2.49	53.50**	2.89	141.20**	756.61**
ERROR	148	8.06	2.78	1.23	7.89	1.05	0.77	3.20	1.06	16.09	10.06

		MSS								
SOURCE	D.F.	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
REPL/LOC	2	28.18**	0.02	43.66**	9367.00**	141.43**	43.20**	0.84	225.06**	78.32**
FEMALES	14	774.51**	0.42	646.57**	3812.00**	450.93**	25.60**	11.30**	195.56**	137.62**
MALES	4	239.44**	0.31	234.54**	4323.00**	22.97**	5.54**	5.09**	103.21**	215.96**
FEMALE x MALE	56	770.29**	0.49	690.53**	5712.00**	164.92**	6.32**	2.50	112.31**	87.00**
ERROR	148	16.87	0.01	10.02	350.00	3.79	0.25	0.41	1.15	0.08

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid. * at 5% level of significance, ** at 1% level of significance.

Table 4.19 Analysis of variance for combining ability over the environments

		MSS									
SOURCE	D.F.	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
LOCATIONS	3	502620.3**	2531.27**	466.88**	2304.51**	778.68**	25.44**	18177.6**	14.33**	2352.19**	14793.74**
REPL/LOC	8	414.44**	41.02**	2.47**	14.44**	4.27*	0.49	78.84**	34.94**	64.74**	35.61**
FEMALES	14	567.38**	20.72**	3.68*	71.54**	50.46**	3.21*	65.37**	6.36**	655.02**	473.72**
MALES	4	191.61**	5.68**	0.44	18.14**	25.47**	2.21*	54.05**	1.19	126.00**	78.59**
FEMALE x MALE	56	276.93**	9.86**	2.07*	17.36**	16.88**	2.71*	36.70**	3.18*	102.02**	376.82**
FEMALE x LOC	42	419.54**	13.60**	2.98**	76.42**	40.34**	4.36**	43.86**	4.82**	251.21**	322.62**
MALE x LOC	12	406.91**	11.21**	3.37*	20.61**	15.76**	2.58**	35.81**	4.44*	66.18**	230.87**
F x M x LOC	168	213.50**	8.57**	2.17**	16.72**	15.90**	2.44**	27.34**	3.18*	105.87**	443.85**
ERROR	592	21.48	1.94	0.56	3.40	1.17	0.74	5.25	1.12	21.28	12.18

SOURCE	D.F.	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
LOCATIONS	3	10967.23**	1.47	7946.52**	6999.00**	6342.59**	26.00**	266.08**	1944.20**	599.31**
REPL/LOC	8	16.14**	0.01	32.05**	23331.00**	70.40**	31.50**	21.15**	316.14**	59.86**
FEMALES	14	510.25**	0.33	427.02**	8083.00**	917.81**	38.49**	23.28**	166.83**	255.22**
MALES	4	264.00**	0.17	224.43**	3143.00**	19.13**	9.79**	8.51**	81.78**	645.77**
FEMALE x MALE	56	800.66**	0.37	754.78**	3521.00**	225.38**	6.02**	8.13**	140.03**	276.73**
FEMALE x LOC	42	408.32**	0.21	391.95**	5519.00**	380.21**	7.49**	13.19**	264.68**	408.09**
MALE x LOC	12	160.18**	0.17	202.76**	1165.00**	77.87**	3.55*	4.63*	92.58**	129.40**
F x M x LOC	168	312.38**	0.22	294.12**	3049.00**	166.38**	5.57**	7.65**	158.72**	148.69**
ERROR	592	14.54	0.01	8.89	230.00	18.62	0.23	0.18	1.07	0.25

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid. * at 5% level of significance, ** at 1% level of significance.

Table 4.20 Estimation of GCA and SCA variance for yield and its component traits in sunflower

	E₁			E₂			E₃			E₄			Pooled		
CHARACTERS	σ^2_{gca}	σ^2_{sca}	$\sigma^2_{\text{gca}/\sigma^2_{\text{sca}}}$	σ^2_{gca}	σ^2_{sca}	$\sigma^2_{\text{gca}/\sigma^2_{\text{sca}}}$	σ^2_{gca}	σ^2_{sca}	$\sigma^2_{\text{gca}/\sigma^2_{\text{sca}}}$	σ^2_{gca}	σ^2_{sca}	$\sigma^2_{\text{gca}/\sigma^2_{\text{sca}}}$	σ^2_{gca}	σ^2_{sca}	$\sigma^2_{\text{gca}/\sigma^2_{\text{sca}}}$
PH (cm)	-2.71	66.00	-0.041	4.16	72.05	0.058	11.63	44.87	0.259	10.91	94.26	0.116	-0.81	21.29	-0.038
HD (cm)	1.62	3.15	0.514	0.12	2.01	0.059	0.07	1.82	0.037	0.14	2.28	0.061	0.00	0.66	-0.006
SD (cm)	0.01	0.53	0.016	-0.01	0.59	-0.013	0.00	0.51	-0.003	0.01	0.49	0.029	-0.01	0.13	-0.065
DF	1.00	2.72	0.368	1.00	7.62	0.131	1.23	5.37	0.229	0.86	2.26	0.380	-0.04	1.16	-0.031
DM	0.59	3.06	0.193	0.18	6.09	0.030	0.31	4.44	0.070	0.82	6.50	0.126	0.07	1.31	0.057
100 SW (g)	-0.01	0.75	-0.009	0.02	0.47	0.045	0.12	0.56	0.209	-0.03	0.57	-0.051	-0.01	0.16	-0.054
SY (g)	0.54	0.20	2.700	-0.68	1.36	-0.500	0.28	14.24	0.020	1.21	16.77	0.072	-0.09	2.62	-0.033
OC (%)	0.07	0.14	0.507	0.04	0.94	0.046	0.03	1.06	0.024	0.02	0.61	0.040	-0.03	0.17	-0.176
HC (%)	2.04	8.01	0.254	6.67	40.28	0.166	2.29	21.50	0.107	3.58	41.70	0.086	1.96	6.73	0.291
% SF (%)	2.47	18.37	0.134	-3.57	11.77	-0.303	14.68	274.21	0.054	7.49	248.85	0.030	0.55	30.39	0.018
GERMN. (%)	1.60	9.13	0.175	1.61	20.13	0.080	-11.03	279.47	-0.039	-8.87	251.14	-0.035	-3.21	65.57	-0.049
EC ($\mu\text{Scm}^1\text{g}^1$)	0.00	0.01	0.214	0.00	0.02	0.015	-0.01	0.15	-0.036	0.00	0.16	-0.026	0.00	0.07	-0.010
VIAB. (%)	1.27	14.68	0.087	2.83	24.21	0.117	9.74	268.19	0.036	-8.23	226.84	-0.036	-3.60	62.16	-0.058
VG – I	739489	6430323	0.115	664802	5166057	0.129	32455	14282990	0.002	538467	17873740	0.030	172876	3045848	0.057
VG – II	0.44	31.60	0.014	8.77	59.74	0.147	3.63	71.64	0.051	2.40	53.71	0.045	1.50	17.23	0.087
PALM. (%)	0.04	1.14	0.038	0.07	2.04	0.032	0.18	2.06	0.088	0.31	2.02	0.152	0.15	0.48	0.315
STER. (%)	0.26	3.24	0.081	-0.17	5.15	-0.033	0.10	1.04	0.099	0.19	0.70	0.270	0.05	0.66	0.082
OLEIC (%)	0.10	69.04	0.002	-2.47	57.47	-0.043	2.59	40.42	0.064	1.23	37.05	0.033	-0.30	11.58	-0.026
LINO. (%)	0.84	103.87	0.008	11.30	79.49	0.142	2.66	28.56	0.093	2.99	28.97	0.103	0.45	23.05	0.019

The magnitude of GCA and SCA variance was presented in the table 4.20. The variance of SCA was found higher than GCA for all the observed traits in E₁, E₂, E₃, E₄ and over the environments. The ratio of $\sigma^2_{\text{GCA}}/\sigma^2_{\text{SCA}}$ was less than one for all the characters (except seed yield in E₁) indicating that these traits were mainly under the control of non-additive gene action. So, one can go for hybrid breeding for exploitation of heterosis. Further, the parents involved in the crosses containing low value of SCA can be used as inbred line in the development of synthetic varieties.

4.4.2 Estimation of general combining ability for parents over the environments and in E₁, E₂, E₃ and E₄

The estimates of general combining ability effects of female and male parents for all the traits are presented in Table 4.21 to 4.25 and discussed as follows:

4.4.1 Plant height (cm)

For plant height, the female parents ARG 3 A (-3.89), CMS 44 A (-3.63), CMS 148 A (-3.04), ARG 6A (-2.04) and CMS 607A (-1.87) were found good general combiner for dwarf plant stature, whereas among male parents RHA 271 (-2.57) exhibited good general combining ability effects in E₁ (table 4.21). The lines CMS 148A (-10.87), DV-10 (-7.88), ARG 6A (-7.29), CMS 207 (-2.03) and the testers RHA 271 (-1.88) and 6D-1 (-1.69) were recorded as a good general combiner for plant height in E₂ (table 4.22).

In E₃ (table 4.23), the female parents ARG 3A (-7.86), CMS 207A (-7.68), CMS 852 (-6.99), ARG 6A (-6.58), CMS 44A (-5.23) and male parent RHA 4-2 (-4.03) were found to have significant negative *gca* effects for plant height. In E₄ (table 4.24), the female parents ARG 3A (-8.29), CMS 103 A (-8.17), ARG 2A (-6.64), CMS 234A (-6.36), ARG 6A (-2.75) and CMS 302 A (-1.91) were found good general combiner while in pollen parents 6D-1 (-1.97) and RHA 297 (-5.79) exhibited significant negative *gca* effects for plant height.

Over the environments, it was observed (table 4.25) that the female parent ARG 3A (-5.04), ARG 6A (-4.66), CMS 148A (-2.59), CMS 207 A (-2.58) and male parent RHA 297 (-1.47) were found to be good general combiner for this trait.

4.4.2 Head diameter (cm)

The significant positive *gca* effects for head diameter were recorded in female parents CMS 17 A (2.68), CMS 207 A (2.30), CMS 44A (1.51) and male parents HRHA 5-3 (0.55) in E₁ (table 4.21). The female parents CMS 17 A (1.54), CMS 44 A (1.38) and male parents RHA 4-2 (0.40), HRHA 5-3 (0.52) were good general combiner in E₂ (table 4.22) for head diameter.

In E₃ (table 4.23), female parents CMS 148A (1.46), CMSH 91A (1.47) and ARG 2A (0.87) exhibited significant positive *gca* effects for head diameter, whereas the female parents CMSH 91 A (1.29), CMS 17 A (1.22), DV-10 (0.95) and pollen parent RHA 271 (0.84) were found good general combiner for head diameter in E₄ (table 4.24).

For the pooled analysis (table 4.25), for head diameter the female parents, namely; CMS 17 A (1.14), CMS 207 A (0.48), CMSH 91 (0.78), CMS 44 A (0.55), CMS 148 A (0.42) and CMS 302 A (0.33) exhibited significant positive *gca* effects while the male parents were non significant for this trait.

Table 4.21: General combining ability effects of parents for seed yield, oil content and its component traits of E₁ in sunflower.

FEMALES	PH (cm)	HD (cm)	SD (cm)	DF	DM	100SW(g)	SY(g)	OC (%)	HC (%)	%SF	GERM. (%)	EC (µScm¹g¹)	VIAB (%).
CMS 11 A	-0.64	0.12	-0.43	-2.20*	-2.53*	-0.38	-0.20	-0.63	-2.09	-0.44	-1.18	-0.20*	0.45
CMS 17 A	0.36	2.68*	0.91*	-1.73*	-2.43*	0.53*	2.40*	0.63*	1.57	4.33*	2.77*	-0.07	3.39*
CMS 44 A	-3.638	1.51*	-0.02	-1.29*	-2.79*	0.31	1.77*	0.00	-2.75	1.90	2.43*	-0.04	1.98*
CMS148 A	-3.04*	0.38	0.32*	-1.26*	-0.90*	0.13	0.53	-0.22	-2.01	4.18*	1.24	-0.27*	2.59*
CMSH 91 A	2.92*	0.22	0.75*	0.11	1.72*	-0.51	-0.13	-0.03	-3.46*	-0.92	-2.71	0.04	-3.08
CMS 103 A	4.85*	-0.89	-0.43	3.04*	-1.07*	0.14	-1.38	-0.50	1.56	-2.54	2.61*	0.12*	3.13
CMS 234 A	3.87*	-0.37	0.14	-1.84*	-0.80*	-0.14	-0.34	-0.52	0.38	0.04	1.43	-0.01	-0.60
CMS 302 A	-0.13	0.07	0.13	-1.50*	0.89*	0.44*	-1.10	-0.18	3.82*	0.68	0.08	-0.03	3.39*
CMS 607 A	-1.87*	-0.53	-0.18	-2.00*	-0.70*	-0.03	-1.00	-0.19	4.18*	-0.90	1.98	0.06	2.37*
CMS 852 A	1.33*	-1.41	-0.69	-0.64*	2.82*	-0.13	-1.84	-0.30	-0.33	-3.56	-1.56	0.12*	-2.24
ARG 2-A	1.15*	-1.84	-0.49	-0.26*	2.88*	0.49*	-0.50	0.28	0.74	-2.79	1.41	0.08*	1.23
ARG 3-A	-3.89*	-0.68	-0.27	1.94*	0.77*	-0.29	0.32	-0.06	-7.53*	4.41*	-2.66	0.00	-2.92
ARG 6-A	-2.04*	-0.08	-0.13	3.82*	-0.60*	-0.05	-1.05	0.76*	3.06*	3.50*	1.23	0.06	-1.17
DV -10	0.59	-1.46	-0.57	-0.49*	2.28*	-1.27	-0.59	-0.40	6.40*	-11.32	-9.98	-0.01	-9.17
CMS 207 A	0.19	2.30*	0.96*	4.30*	0.46	0.77*	3.10*	1.36*	-3.54*	3.44*	2.92*	0.14*	0.66
SE	0.39	0.25	0.10	0.18	0.28	0.20	0.67	0.24	1.41	1.07	0.85	0.04	0.77
CD at 5 %	0.84	0.54	0.22	0.39	0.60	0.43	1.44	0.52	3.03	2.30	1.83	0.08	1.66
MALE	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW(g)	SY(g)	OC (%)	HC (%)	%SF	GERM. (%)	EC(µScm¹g¹)	VIAB (%).
6D-1	1.87*	0.05	-0.25	0.08	-0.08	-0.19	-0.33	-0.36	-1.25	-1.28	-0.49	-0.01	-0.78
RHA 271	-2.57*	-0.08	-0.09	0.11	-0.37*	0.19	-0.2	-0.12	0.21	-0.65	0.09	-0.01	0.84
RHA 4-2	-0.19	-0.17	-0.19	-0.52*	0.16	0.22	-0.74	0.35*	1.29	0.02	-0.51	-0.01	0.25
HRHA 5-3	1.31*	0.55*	-0.02	0.46*	-0.13	0.01	0.02	0.04	0.71	0.58	0.56	0.03	0.07
RHA 297	-0.41	-0.36	0.55*	-0.12	0.42*	-0.23	1.24*	0.08	-0.95	1.33	0.35	0	-0.37
SE	0.21	0.13	0.05	0.10	0.15	0.11	0.36	0.13	0.75	0.57	0.45	0.02	0.41
CD at 5 %	0.51	0.32	0.12	0.25	0.37	0.27	0.88	0.32	1.84	1.40	1.10	0.05	1.00

Table 4.21 (contd.) General combining ability effects of parents for seedling vigour and fatty acids of E₁ in sunflower

FEMALES	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
CMS 11 A	1,954.2*	-1.73	0.14	-0.99	-0.85	4.68*
CMS 17 A	1,664.0*	-0.17	-0.34	-1.00	0.84*	1.91*
CMS 44 A	1,957.8*	-0.23	-0.42	-1.06	-2.98	5.23*
CMS148 A	-3,514.7	0.82	-0.46	-1.81	2.02*	0.62*
CMSH 91 A	-2,884.9	3.86*	-0.41	-1.27	-6.53	9.00*
CMS 103 A	2,758.8*	8.86*	0.47*	-0.47	-2.09	3.22*
CMS 234 A	109.1	4.92*	0.76*	-0.06	7.24*	-8.68
CMS 302 A	5,034.0*	3.03	0.77*	0.40*	2.15*	1.96*
CMS 607 A	-235.1	-5.30	0.19*	0.90*	2.89*	-5.14
CMS 852 A	-874.4	-0.88	-0.86	-0.29	-2.00	2.56*
ARG 2-A	-451.8	-4.82	-0.13	1.45*	6.67*	-10.20
ARG 3-A	-1,625.6	-6.55	0.09	2.83*	1.02*	-8.64
ARG 6-A	-1,688.7	1.30	-1.22	2.31*	-2.74	-1.39
DV -10	-1,291.9	-2.86	0.62*	-0.01	1.04*	-1.17
CMS 207 A	-910.6	-0.25	0.80*	-0.94	-6.66	6.03*
SE	259.70	1.72	0.07	0.08	0.18	0.16
CD at 5 %	571.9	3.70	0.15	0.17	0.39	0.34
MALES	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
6D-1	194.3	-0.65	-0.18	0.13*	-1.35	1.98*
RHA 271	-149.9	-1.04	0.23*	-0.05	0.55*	-1.68
RHA 4-2	529.1*	0.28	0.35*	-0.63	1.63*	-1.74
HRHA 5-3	-512.4	1.04	-0.37	0.02	-2.71	2.12
RHA 297	-61.0	0.37	-0.05	0.54*	1.88*	-0.68
SE	138.82	0.92	0.04	0.04	0.10	0.09
CD at 5 %	305.7	2.25	0.10	0.10	0.25	0.22

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

Table 4.22 General combining ability effects of parents for seed yield, oil content and its component traits of E₂ in sunflower

FEMALES	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
CMS 11 A	3.80*	-0.52	0.03	-3.05*	-2.23*	-0.52	0.37	1.02*	-13.21*	-0.87
CMS 17 A	0.40	1.54*	0.74*	-2.75*	-3.17*	-0.36	-0.60	0.33	-11.58*	-3.06
CMS 44 A	-0.79	1.38*	0.30*	-1.35*	-0.68*	0.33	-0.45	-0.13	-4.69*	-2.74
CMS 148 A	-10.87*	0.06	-0.26	-2.74*	-0.99*	0.16	-0.33	-0.88	-4.21*	0.48
CMSH 91 A	-4.61*	0.13	-0.07	-1.42*	-0.30	0.58*	0.21	-0.62	2.75*	0.38
CMS 103 A	6.87*	-1.20	-0.67	6.25*	1.09*	0.54*	0.49	0.59*	-1.43	1.61*
CMS 234 A	1.80*	-0.11	0.27*	-0.36	2.24*	0.18	-0.62	-0.61	2.68*	-1.20
CMS 302 A	4.20*	0.08	0.15	-0.55*	0.79*	0.15	0.64	-0.08	6.65*	1.40*
CMS 607 A	8.09*	0.73*	-0.15	-1.18*	1.85*	0.02	-0.01	-0.61	9.14*	0.89
CMS 852 A	6.59*	-0.10	-0.03	-0.51*	0.62*	-0.10	0.38	-0.46	7.03*	0.30
ARG 2-A	1.87*	-0.28	-0.18	2.56*	1.77*	0.15	-0.66	0.10	4.17*	1.18*
ARG 3-A	-0.13	-0.31	-0.33	0.27	-0.58*	-0.79	0.50	-0.22	0.72	1.57*
ARG 6-A	-7.29*	-0.79	-0.16	1.12*	0.23	0.02	0.29	0.40	-1.82	-0.79
DV -10	-7.88*	-1.10	-0.05	2.59*	-0.30	-0.09	-0.77	0.70*	2.35*	1.17*
CMS 207 A	-2.03*	0.48	0.42*	1.12*	-0.34	-0.24	0.55	0.48	1.44	-0.31
SE	0.42	0.25	0.12	0.19	0.17	0.19	0.34	0.24	0.87	0.53
CD at 5%	0.90	0.54	0.26	0.41	0.37	0.41	0.73	0.52	1.87	1.14
MALES	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
6D-1	-1.69*	-0.23	0.08	-0.64*	0.20	0.15	0.40	0.21	1.17*	-0.55
RHA 271	-1.88*	0.09	-0.06	-0.18	-0.59*	0.33*	-0.01	0.32*	0.28	0.45
RHA 4-2	2.75*	0.40*	0.13	0.54*	-0.20	0.09	-0.06	0.01	0.80	-1.09
HRHA 5-3	-0.95*	0.52*	0.21*	0.70*	0.92*	-0.33	-0.50	-0.60	-1.79*	0.39
RHA 297	1.78	-0.77	-0.37	-0.43*	-0.33*	-0.25	0.16	0.07	-0.46	0.79*
SE	0.23	0.13	0.06	0.10	0.09	0.10	18.00	0.13	0.47	0.28
CD at 5%	0.56	0.32	0.15	0.25	0.22	0.25	44.10	0.32	1.15	0.69

Table 4.22 (contd.) General combining ability effects of parents for seedling vigour and fatty acids of E₂ in sunflower

FEMALES	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
CMS 11 A	1.92*	-0.10*	5.38*	4551.41*	-5.90	-0.83	-0.78	-4.59	7.38*
CMS 17 A	2.03*	-0.12*	1.55*	649.08*	1.80*	-0.94	-1.14	1.44*	-2.29
CMS 44 A	1.42	-0.06*	4.19*	455.55*	-6.52	-1.48	-0.18	-4.14	5.28*
CMS 148 A	1.45	-0.04*	5.24*	425.88*	-1.80	-1.04	-0.32	-0.95	-7.96
CMSH 91 A	1.61	-0.07*	0.33	1434.15*	-1.56	0.45*	-0.60	5.25*	1.49*
CMS 103 A	1.32	0.20*	1.08*	1652.75*	10.41*	-0.17	-0.71	-0.37	-12.32
CMS 234 A	-0.10	0.09*	0.77	-937.72	5.57*	-0.21	1.14*	-0.11	-0.58
CMS 302 A	0.72	0.06*	-0.66	2794.21	-10.64	0.10	1.00*	0.35*	-7.44
CMS 607 A	1.62	-0.11*	1.88*	-1542.39	-5.92	0.81*	0.13*	-0.27	-6.73
CMS 852 A	1.77*	0.05*	0.11	-1700.25	6.97*	-0.37	-0.49	3.75*	-3.33
ARG 2-A	-0.80	-0.01	-0.05	-947.19	-13.01	0.82*	2.34*	2.16*	9.13*
ARG 3-A	1.33	0.02*	-1.44	-207.05	6.20*	0.29*	1.33*	-2.03	-2.70
ARG 6-A	0.52	-0.04*	-0.94	-1230.12	12.95*	0.19*	-0.82	5.28*	4.08*
DV -10	-3.28	0.01	-7.67	-1897.32	0.86	1.15*	0.31*	-5.55	8.86*
CMS 207 A	-11.52	0.11*	-9.77	-3500.99	0.60	1.22*	-1.20	-0.21	7.14*
SE	0.76	0.01	0.45	5.09	0.47	0.05	0.06	0.09	0.08
CD at 5 %	1.63	0.02	0.97	10.94	1.01	0.11	0.13	0.19	0.17
MALES	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
6D-1	1.47*	-0.01	0.46	247.52*	1.26*	-0.58	0.23*	0.31*	-0.07
RHA 271	-0.19	0.01	-0.41	-678.28	0.18	0.08*	0.33*	0.38*	-1.46
RHA 4-2	-1.32	0.03*	-0.42	-153.45	-0.24	-0.11	-0.39	-1.58	-4.12
HRHA 5-3	-0.83	0.01	-1.44	346.39*	-1.29	0.28*	-0.32	0.44*	1.19*
RHA 297	0.86	-0.02*	1.81*	237.81*	0.10	0.33*	0.15*	0.46*	4.46*
SE	0.41	0.01	0.24	2.72	0.25	0.03	0.03	0.05	0.04
CD at 5 %	1.00	0.01	0.59	6.66	0.61	0.07	0.07	0.12	0.10

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

4.4.3 Stem diameter (cm)

For stem diameter, the female parents namely; CMS 207A (0.96), CMS 17A (0.91), CMSH 91 A (0.75) and CMS 148 A (0.32) recorded significant positive *gca* effects while among male parents, RHA 297 (0.55) was good general combiner in E₁ (table 4.21). In E₂, it was observed (table 4.22) that the parents CMS 17 A (0.74), CMS 234 A (0.27), CMS 207 A (0.42) and HRHA 5-3 (0.21) exhibited significant positive *gca* effects for stem diameter.

In E₃, the female parents CMS 148 A (0.86), CMS 103 A (0.68), CMS 302 A (0.48) and CMSH 91 A (0.44) were observed as a good general combiner. The parents CMSH 91A (0.67), CMS 607 A (0.59) and pollen parent RHA 271 (0.36) exhibited significant positive *gca* effects in E₄.

The female parents, namely, CMS 17 A (0.37), CMS 148 A (0.30), CMSH 91 A (0.45) and CMS 302A (0.26) showed significant positive *gca* effects for stem diameter over all the environments.

4.4.3 Days to 50 % flowering

It was observed that among the lines CMS 11 A (-2.20), CMS 17 A (-1.73), CMS 44 A (-1.29), CMS 148A (-1.26) and among testers RHA 4-2 (-0.52), RHA 297 (-0.12) showed significant negative *gca* effects for flowering in E₁. The lines CMS 11 A (-3.05), CMS 17 A (-2.75), CMS 148A (-2.75), CMSH 91 A (-1.42) CMS 44 A (-1.35), CMS 607 (-1.18) and testers 6D-1(-0.64), RHA 297 (-0.43) were good general combiner for flowering in E₂.

In E₃ (table 4.23), the lines CMS 103 A (-3.46), CMSH 91A (-2.81), CMS 44 A (-1.99), CMS 11 A (-1.48), CMS 148 (-1.26), and tester 6D-1 (-1.62) exhibited significant negative *gca* effects and acted as good general combiner for early flowering, whereas, the lines CMS 852A (-4.37), CMS 234 A (-2.15), CMS 302A (-1.85), DV-10 (-1.43) and CMS 207A (-1.39) were found to be good general combiner in E₄ for early flowering.

In pooled analysis (table 4.25) the lines CMS 852A (-1.48), CMS 302 A (-0.99), CMS 44A (-0.98), CMS 148 A (-0.95), CMS 234A (-0.90), CMS 11 A (-0.87) and tester 6D-1 (-0.48) exhibited significant negative *gca* effects for this trait.

4.4.5 Days to maturity

The significant negative *gca* effects are desirable for this trait. In E₁ (table 4.21), the female parents CMS 44A (-2.79), CMS 11A (-2.53), CMS 17A (-2.43), CMS 103 A (-1.07) and male parent RHA 271 (-0.37) showed early maturity. The female parents, CMS 17A (-3.17), CMS 11A (-2.23), CMS 148 A (-0.99), CMS 44A (-0.68) and the male parents RHA 271 (-0.59), RHA 297 (-0.33) exhibited significant negative *gca* effects in E₂ (table 4.22).

In E₃ (table 4.23), the female parents, namely; CMS 44A (-2.31), CMSH 91 A (-2.31), CMS 11A (-2.18), CMS 148A (-1.51), CMS 103 A (-1.38) and CMS 17A (-0.78) showed early maturity with significant negative *gca* effects. In E₄ (table 4.19), the female parents

ARG 2A (-3.73), CMS 302 A (-2.73), CMS 103 A (1.00), CMS 852 A (-0.80) and pollen parents RHA 271 (-0.91), RHA 297(-1.07) exhibited as a good general combiner for early maturity.

Over the environments, it was observed (table 4.25) that the female parents CMS 11A (-1.55), CMS 44A (-1.34), CMS 17 A (-1.30), CMS 148 A (-0.59) and the male parents RHA 271 (-0.51), RHA 297 (-0.26) showed early to maturity with significant negative *gca* effects.

4.4.6 Hundred seed weight (g)

In E₁, the female parents CMS 17 A (0.53), CMS 207 A (0.77) and CMS 852 A (0.49) showed significant positive *gca* effects whereas male parents were non significant for this trait. Among female parent CMSH 91A (0.58), CMS103 A (0.54) and among male parent RHA 271 (0.33) were good general combiner for test weight in E₂.

In E₃ (table 4.23), it was observed that the female parents CMS 103A (0.98), ARG 3A (0.96), CMSH 91A (0.63) and CMS 148A (0.57) exhibited good general combining ability effects with significant positive *gca* effects. In E₄, the female parents CMS 11A (0.61), CMS 17 A (0.54) and male parent RHA 4-2 (0.25) were found to be good general combiner for test weight.

Over the environments (table 4.25), the female parents CMS 103 A (0.40), CMS 44A (0.34), CMS 148 A (0.28) and pollen parent RHA 271 (0.17) exhibited significant positive *gca* effects for test weight.

4.4.7 Seed yield per plant (g)

In E₁, highest *gca* effects were observed in line CMS 207 A (3.10) followed by CMS 17 A (2.40) and tester RHA 271 (1.24) with significant positive *gca* effects while in E₂ (table 4.22) neither female parents nor male parent showed the significant positive *gca* effects.

Among lines, ARG 2A (3.80), CMS 148 A (3.03), CMS 44A (2.07), ARG 6 A (1.63) exhibited significant positive *gca* effects and tester 6D-1 (0.90) showed significant positive *gca* effect for seed yield in E₃, whereas in E₄, the lines CMSH 91 A (5.39), CMS 207 A (3.51), CMS 148A (3.12) CMS 17 A (2.42) and tester HRHA 5-3 (2.25) were observed to have significant positive *gca* effects for seed yield.

Over the environments (table 4.25), it was observed that lines CMS 148 A (1.59), CMSH 91 A (1.59), CMS 207 A (1.30), CMS 17 A (1.17) and tester RHA 297 (0.69) exhibited significant positive *gca* effects.

4.4.8 Oil content (%)

In E₁ (table 4.21), the female parents CMS 207 A (1.36), ARG 6 A (0.76), CMS 17 A (0.63) and male parent HRHA 4-2 showed significant positive *gca* effects. The male parent RHA 271 (0.32) and female parents CMS 11A (1.02), DV-10 (0.70), CMS 103 A (0.59) exhibited good general combining ability effects in E₂.

In E₃ (table 4.23) the female parents CMS 148 A (1.21) and CMS 607 A (0.64) marked significant positive *gca* effects for oil content, while in E₄, the female parents CMS 207 A (1.40), ARG 2A (0.71) and CMS 302 (0.57) were observed as good general combiners for this trait.

Over the environments (table 4.25), among female parents CMS 207 A (0.99), CMS 103 A (0.26) and CMS 148 A (0.26) had significant positive *gca* effects whereas male parents were non significant for this trait.

4.4.9 Hull content (%)

The significant negative *gca* effect are desirable for this trait. The females parents ARG 3A (-7.53), CMS 207 A (-3.54), CMSH 91 A (-3.46), CMS 44A (-2.75) and CMS 11 A (-2.09) were observed having significant negative *gca* effects in E₁. In E₂ (table 4.22), the female parents, CMS 11A (-13.21), CMS 17A (-11.58), CMS 44A (-4.69), CMS 148A (-4.21) and among male parents, HRHA 5-3 (-1.79) exhibited significant negative *gca* effects.

In E₃ (table 4.23), the female parents CMS 17 A (-7.71), CMS 44A (-5.83), CMS 607A (-4.03), CMS 207A (-2.95), CMS 148 A (-2.44) were found good general combiners for this trait whereas, in E₄, the female parents CMS 148A (-8.05), CMSH 91 A (-7.51), CMS 44A (-6.40), CMS 103A (-4.28), and male parent 6D-1 (-3.16) exhibited significant negative *gca* effects.

Over the environments (table 4.25), it was recorded that the female parents CMS 44A (-4.92), CMS 148 A (-4.18), CMS 17 A (-3.95), CMS 11 A (-3.56) CMSH 91 A (-1.91) and male parent 6D-1 (-0.84) had significant negative *gca* effects for this trait.

4.4.10 Percent seed filling

In E₁, the female parents CMS 17A (4.33), CMS 148A (4.18), ARG 3A (4.41), ARG 6A (3.50) and CMS 207 A (3.44) showed significant positive *gca* effects. In E₂ the female parents, CMS 103 A (1.61), CMS 302A (1.40), ARG 2A (1.18), ARG 3A (1.57) and among male parents, RHA 297 (0.79) exhibited significant positive *gca* effects.

In E₃ (table 4.23), the female parents, DV-10 (7.99), ARG 6A (7.00), ARG 3A (5.52), CMS 207 A (4.71), CMS 44A (3.70), CMS 11 A (2.99) and in male parents, RHA 297 (2.93), RHA 271 (2.39) showed maximum *gca* effects. In E₄, the female parents CMS 44A (9.03), CMS 207 A (8.31), CMS 11 A (7.03), ARG 3A (5.71), CMSH 91 A (4.25), 6D-1 (2.76) and male parent HRHA 4-2 (1.66) showed significant positive *gca* effects.

Over the environments analysis showed that female parents, ARG 3A (4.30), CMS 207 A (4.04), ARG 3A (3.35), CMS 44A (2.97), CMS 11 A (2.18) and male parents RHA 297 (0.70), HRHA 5-3 (0.59) exhibited significant positive *gca* effects for this trait (Table 4.25).

4.4.11 Germination (%)

In E_1 , the female parents CMS 207 A (2.92), CMS 17 A (2.77), CMS 103 A (2.61) and CMS 44A (2.43) showed significant positive *gca* effects and male parents were non significant to this trait. In E_2 (table 4.22), the female parents CMS 17A (2.03), CMS 11 A (1.92), CMS 852 A (1.77) and the male parent 6D-1 (1.47) were found to be good general combiner for germination.

In E_3 , the female parents, namely, ARG 6A (7.53), CMS 207 A (7.50), CMS 11 A (5.49), ARG 3A (2.94), DV-10 (2.57) and male parents, HRHA 4-2(3.07), 6D-1 (2.07), HRHA 5-3 (1.22) exhibited significant positive *gca* effects. In E_4 (table 4.24), the female parents, namely, CMS 11A (8.41), CMS 44A (9.51), CMS 207 A (7.75), CMSH 91A (4.41), ARG 3A (4.31), ARG 2A (4.23) and the male parents 6D-1(2.67) and RHA 4-2 (1.51) were observed as good general combiners for this trait.

Over the environments (table 4.25), the female parents, CMS 607A (6.53), CMS 44 A (3.48), ARG 6A (3.38), CMS 852 A (3.19), CMS 207 A (1.66) and male parents 6D-1 (1.43), RHA 297 (1.42), RHA 4-2 (0.69) exhibited significant positive *gca* effects for germination.

4.4.12 Electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$)

The significant negative *gca* effects is desirable for electrical conductivity. In E_1 , female parents, CMS 148 A (-0.27), CMS 11A (-0.20), CMS 17 A (-0.07), CMS 44A (-0.04) were found as good general combiners. In E_2 the female parents, CMS 17A (-0.12), CMS 607 A (-0.11), CMS11 A (-0.10), CMSH 91A (-0.07), CMS 44A (-0.06) and male parent, RHA 297 (-0.02) exhibited significant negative *gca* effects.

In E_3 , only the male parents, HRHA 5-3 (-0.07), RHA 271 (-0.05) and HRHA 4-2 (-0.03) were found to have significant negative *gca* effects, whereas in E_4 (table 4.24), the female parents, CMS 44A (-0.31), CMS 11 A (-0.21), ARG 6A (-0.17), CMS 148 A (-0.08) and male parents HRHA 4-2 (-0.09), 6D-1 (-0.06) exhibited significant negative *gca* effects.

Over the environments (table 4.25), the female parents, CMS 11 A (-0.13), CMS 44 A (-0.09), ARG 6A (-0.09), CMS 148 A (-0.06) and the male parents 6D-1(-0.02), HRHA 4-2(-0.02), HRHA 5-3 (-0.02) were found to have significant negative *gca* effects for electrical conductivity.

4.4.13 Viability (%)

In E_1 , the female parents CMS 17 A (3.39), CMS 302 A (3.39), CMS 148 A (2.59), CMS 607A (2.37) and CMS 44 A(1.98) were observed to have significant positive *gca* effects, whereas in E_2 the female parents CMS 11A (5.38), CMS 148 A (5.24), CMS 44A (4.19), CMS 607A (1.88), CMS 17 A (1.55) and male parent RHA 297 (1.81) were found good general combiners .

In E₃ (table 4.23), it was recorded that the female parents, CMS 852 A (11.52), CMS 607 A (6.12), CMS 11 A (5.76), ARG 6 A (5.67) and the male parents HRHA 4-2 (2.61), HRHA 5-3 (2.20), 6D-1 (2.10) were found significant positive *gca* effects for this trait. In E₄, the female parents CMS 44A (10.45), CMS 207 A (8.18), CMS 11A (5.72), CMSH 91 A (4.82) and the male parent 6D-1 (3.31) were found to be good general combiners.

Over the environments (table 4.25), for seed viability, the female parents, CMS 11 A (4.33), CMS 44A (4.27), CMS 852 A (2.40), ARG 6A (1.31), CMS 207 A (1.30) and the male parents RHA 297 (1.43), 6D-1 (1.27) were observed as good general combiners with significant positive *gca* effects.

4.4.14 Vigour index I

In E₁, the lines CMS 302A (5,034.0), CMS 103A (2,758.8), CMS 44A (1,957.8) and the tester RHA 4-2 (529.1) were observed to have significant and positive *gca* effects. In E₂, the female parents CMS 11A (4551.41), CMS 103A (1652.75), CMSH 91A (1434.15) and pollen parents HRHA 5-3 (346.39), 6D-1 (247.52), RHA 297 (237.81) were found to be good general combiners for this trait.

In E₃, the lines CMS 207 A (3292.70), ARG 6A (2254.24), ARG 3A (2919.17) and testers 6D-1 (802.99), HRHA 5-3 (173.77) showed significant positive *gca* effects for seedling vigour I whereas, in E₄, the lines CMS 11 A (3,602.9), CMS 234A (2,393.5), CMS 44A (2,070.1) and the testers 6D-1 (1,009.7), HRHA 5-3 (877.0) exhibited significant and positive *gca* effect.

Over the environments (table 4.25), the lines CMS 11A (2,925.4), CMS 302 A (1,610.8), CMS 103 A (504.3) and the testers 6D-1 (563.6) and HRHA 5-3 (221.2) were observed to be good general combiners with significant positive *gca* effects for this trait.

4.4.15 Vigour index II

In E₁, the female parents CMS 103 A (8.86), CMS 234 A (4.92) and CMSH 91 A (3.86) were found to have significant and positive *gca* effects. In E₂, the female parents ARG 6A (12.95), CMS 103A (10.41), CMS 852 A (6.97), ARG 3A (6.20) and male parent 6D-1 (1.26) exhibited significant positive *gca* effects for seedling vigour index II.

In E₃ (table.4.23), the female parents, CMS 103 A (12.53), CMS 207 A (7.77), CMSH 91 A (4.92), CMS 852 A (4.31), CMS 11 A (2.44), and male parent 6D-1 (1.46) were found to be good general combiners. In E₄, the female parents, CMS 11 A (11.55), CMS 17A (6.80), CMS 44A (6.16), CMS 148 A (4.17), CMSH 91 A (1.05) and the male parents RHA 297 (0.76), HRHA 5-3 (0.62) were observed to have significant positive *gca* effects.

Over the environments, it was recorded (table 4.25) that only among the female parents, CMS 103 A (7.57), CMS 234 A (2.89), ARG 6A (2.81), CMS 207 A (2.09) and CMS 11A (1.59) exhibited significant positive *gca* effects for this trait.

4.4.16 Palmitic acid (%)

In E_1 (table.4.21), the female parents, CMS 207 A (0.80), CMS 302 A (0.77), CMS 234 A (0.76), DV-10 (0.62), and the male parents HRHA 4-2 (0.35), RHA 271 (0.23) were found to have good general combiner for palmitic acid. Whereas female parents in E_2 , viz., CMS 207 A (1.22), DV-10 (1.15), ARG 2A (0.82), CMS 607A (0.81), CMSH 91 A (0.45) and male parents RHA 297 (0.33), HRHA 5-3(0.28) exhibited significant positive *gca* effects.

In E_3 , the female parents, CMS 207A (2.20), ARG 6A (1.64), ARG 3A (1.22), CMS852 A (0.88) and male parents RHA 271 (0.40), HRHA 5-3 (0.29) were observed as good general combiners. In E_4 , the female parents CMS 207 A (2.27), ARG 6A (2.19), ARG 3A (1.04), CMS 852 A (1.01) and male parents HRHA 4-2 (0.45), RHA 271 (0.29) were found to be good combiners.

However, over the environments (table.4.25), only the pollen parents RHA 271 (0.25) and HRHA 4-2 (0.24) exhibited significant positive *gca* effects for this trait.

4.4.17 Stearic acid (%)

In E_1 , the female parents ARG 3A (2.83), ARG 6A (2.31), ARG 2A (1.45), CMS 607 A (0.90) and male parents RHA 297 (0.54), 6D-1(0.13) were observed good general combiners for stearic acid. In E_2 (table.4.22) the female parents ARG 2A (2.34), ARG 3A (1.33), CMS 234A (1.14), CMS 302 A (1.00), 6D-1 (0.23) and male parents RHA 271 (0.33), RHA 297 (0.15) exhibited significant positive *gca* effects.

In E_3 , it was recorded from the table 4.23, that the female parents CMS 103 A(1.35), CMSH 91 A (1.12), CMS 852 A(0.71), CMS 17A (0.40) and male parent HRHA 4-2 (0.23) were observed to be good general combiners. In E_4 , the female parents CMS 852 A(1.32),CMS 103 A(0.96), CMSH 91 A(0.90), ARG 3A (0.78) and male parent 6D-1 (0.49) were found to be good general combiners.

Over the environments (table 4.25), the female parents ARG 3A (1.18), ARG 2A (0.88), CMS 607 A (0.52), CMS 234A (0.33) and male parents 6D-1 (0.32), RHA 297 (0.13) exhibited significant positive *gca* effects.

4.4.18 Oleic acid (%)

In E_1 , the female parents CMS 234A (7.24), ARG 2A (6.67), CMS 607A (2.89), CMS 302 A (2.15) and male parents RHA 297 (1.88), HRHA 4-2 (1.63) showed significant positive *gca* effects. In E_2 , the female parents ARG 6A (5.28), CMSH 91 A (5.25), CMS 852A (3.75), ARG 2A (2.16) and pollen parents RHA 297 (0.46), HRHA 5-3 (0.44) were found to be good general combiners.

In E_3 (table.4.23), the female parents, ARG 3A (7.34), ARG 2A (7.20), CMS 207 A (4.79), ARG 6A (4.44) and testers RHA 297 (1.28), HRHA 4-2 (0.37) exhibited significant positive *gca* effects. In E_4 , the female parents CMSH 91 A (7.37), CMS 234A (5.59), CMS 302 A (2.38), CMS 103 A (2.20) and male parent 6D-1 (1.22) were found to be good combiners for oleic acid.

Table 4.23 General combining ability effects of parents for seed yield, oil content and its component traits of E₃ in sunflower

FEMALES	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY(g)	OC (%)	HC (%)	%SF
CMS 11 A	4.01	-0.89	-0.60	-1.48*	-2.18*	0.24	-0.85	-0.27	-0.55	2.99*
CMS 17 A	7.18*	-0.89	-0.54	0.68	-0.78*	-0.71	0.46	-0.82	-7.71*	-7.05
CMS 44 A	-5.23*	0.35	0.13	-1.99*	-2.31*	0.36	2.07*	-0.19	-5.83*	3.70*
CMS 148 A	-3.02	1.46*	0.86*	-1.26*	-1.51*	0.57*	3.03*	1.21*	-2.44*	-5.53
CMSH 91 A	-2.72	1.47*	0.44*	-2.81*	-2.31*	0.63*	0.88	0.34	0.60	-4.81
CMS 103 A	1.80	0.62	0.68*	-3.46*	-1.38*	0.98*	0.12	-0.42	2.00*	-4.79
CMS 234 A	-4.50*	0.32	0.14	0.76	2.49*	-0.87	-1.17	-1.22	1.60	-1.77
CMS 302 A	13.56*	0.60	0.48*	-0.07	2.02*	-0.84	-0.26	0.46	3.62*	-2.66
CMS 607 A	10.70*	-0.38	-0.19	2.75*	1.42*	-0.41	-1.97	0.64*	-4.03*	-3.25
CMS 852 A	-6.99*	0.35	0.16	-0.41	0.56*	0.16	-0.23	0.46	0.48	-1.06
ARG 2-A	6.17*	0.87*	0.00	-0.97*	-0.71*	0.28	3.80*	-0.49	2.38*	-0.99
ARG 3-A	-7.86*	-1.16	-0.30	1.63*	0.69*	0.96*	-1.40	0.15	0.06	5.52*
ARG 6-A	-6.58*	-0.45	-0.14	-0.14	0.56*	0.46*	1.63*	-0.16	6.68*	7.00*
DV -10	1.13	-1.78	-0.87	4.11*	1.56*	-0.32	-4.20	-0.07	6.16*	7.99*
CMS 207 A	-7.68*	-0.50	-0.26	2.65*	1.89*	-1.47	-1.94	0.38	-2.95*	4.71*
SE	1.87	0.35	0.16	0.46	0.25	0.18	0.55	0.22	0.80	0.69
CD at 5 %	4.02	0.75	0.34	0.99	0.54	0.39	1.18	0.47	1.72	1.48
MALES	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY(g)	OC (%)	HC (%)	%SF
6D-1	2.30	0.36	0.04	-1.62	0.58*	0.08	0.90*	0.01	-0.11	-4.56
RHA 271	2.45*	-0.23	-0.17	0.10	-0.18	0.21	-1.05	0.29	1.23*	2.39*
RHA 4-2	-4.03*	-0.18	-0.02	0.28	-0.09	-0.49	-0.31	-0.42	0.74	-1.41
HRHA 5-3	0.74	-0.38	0.06	0.05	-0.24	0.05	-0.83	0.31	-0.95	0.65
RHA 297	-1.46	0.43	0.08	1.19*	-0.07	0.15	1.30*	-0.19	-0.91	2.93*
SE	1.00	0.19	0.09	0.25	0.13	0.09	0.29	0.13	0.43	0.37
CD at 5 %	2.45	0.47	0.22	0.61	0.32	0.22	0.71	0.32	1.05	0.91

Table 4.23 (contd.) General combining ability effects of parents for seedling vigour and fatty acids of E₃ in sunflower

FEMALE	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
CMS 11 A	5.49*	0.03	5.76*	1593.10*	2.44*	-1.28	-0.16	-3.31	-0.39
CMS 17 A	-8.13	-0.01	-7.89	-661.96	-3.17	-1.41	0.40*	-1.44	1.82*
CMS 44 A	0.58	0.05	0.48	-1048.83	0.14	-1.47	0.14	0.71*	-2.53
CMS 148 A	-6.88	0.13	-6.85	-4018.03	-1.11	-1.23	-0.05	-8.21	2.63*
CMSH 91 A	0.02	-0.14	-1.29	-2411.16	4.92*	-0.67	1.12*	-3.37	-4.29
CMS 103 A	-3.41	0.07	-2.23	-1659.76	12.53*	-0.34	1.35*	-9.24	1.76*
CMS 234 A	-1.53	0.14	-0.05	-2859.70	0.10	-0.28	0.29*	-0.16	0.25*
CMS 302 A	-3.26	0.08	-2.00	-315.43	-1.14	-0.15	-0.64	-0.35	4.81*
CMS 607 A	-12.60	0.18	-11.34	-486.03	-9.27	0.15	0.37*	-1.48	-3.47
CMS 852 A	10.63	-0.11	11.52*	961.10*	4.31*	0.88*	0.71*	0.74*	0.11
ARG 2-A	-1.43	0.05	-1.53	1000.57*	-4.64	0.35*	-0.32	7.20*	4.96*
ARG 3-A	2.94*	-0.20	1.75*	2919.17*	-5.48	1.22*	-0.21	7.34*	-0.33
ARG 6-A	7.53*	-0.20	5.67*	2254.24*	-0.36	1.64*	-0.98	4.44*	-1.61
DV -10	2.57*	0.06	1.88*	1440.04*	-7.04	0.41*	-0.79	2.33*	0.96*
CMS 207 A	7.50*	-0.04	6.12*	3292.70*	7.77*	2.20*	-1.21	4.79*	-4.67
SE	0.85	0.10	0.67	4.47	0.53	0.16	0.07	0.33	0.11
CD at 5 %	1.83	0.22	1.44	9.61	1.14	0.34	0.15	0.71	0.24
MALES	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
6D-1	2.07*	0.01	2.10*	802.99*	1.46*	-0.09	0.42	0.09	-1.81
RHA 271	-1.92	-0.05*	-1.75	-344.23	0.81*	0.40*	-0.34	-1.45	0.67*
RHA 4-2	3.07*	-0.03*	2.61*	-8.19	0.42	0.29*	0.23*	0.37*	-2.45
HRHA 5-3	1.22*	-0.07*	2.20*	173.77*	0.61	-0.28	-0.23	-0.29	2.62*
RHA 297	-4.43	0.15*	-5.16	-624.34	-3.31	-0.32	-0.08	1.28*	0.97*
SE	0.46	0.01	0.36	2.39	0.28	0.09	0.04	0.18	0.06
CD at 5 %	1.13	0.02	0.88	5.86	0.69	0.22	0.10	0.44	0.15

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

Table 4.24 General combining ability effects of parents for seed yield, oil content and its component traits of E₄ in sunflower

FEMALES	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
CMS 11 A	1.01	0.60	0.23	3.27*	0.73*	0.61*	-0.76	-0.29	1.60	7.03*
CMS 17 A	8.76*	1.22*	0.37	2.50*	1.20*	0.54*	2.42*	0.08	1.93*	-0.80
CMS 44 A	6.23*	-1.05	-0.29	0.71	0.40	0.37	-1.84	0.26	-6.40*	9.03*
CMS 148 A	6.57*	-0.22	0.27	1.44*	0.27	0.28	3.12*	-1.17*	-8.05*	-3.39
CMSH 91 A	7.27*	1.29*	0.67*	2.73*	1.20*	-0.12	5.39*	-0.11	-7.51*	4.25*
CMS 103 A	-8.17*	-0.94	-0.38	-0.24	-1.00*	-0.06	0.62	-0.72*	-4.28*	-7.56
CMS 234 A	-6.36*	-1.24	-0.37	-2.15*	0.04	0.13	-2.23	0.10	2.30*	0.62
CMS 302 A	-1.91*	0.58	0.28	-1.85*	-2.73*	-0.94	-0.80	0.57*	3.38*	-7.61
CMS 607 A	4.36*	0.36	0.59*	-0.46	-0.67*	0.09	0.79	-0.26	-1.96*	-17.97
CMS 852 A	-1.13*	-1.69	-0.51	-4.37*	-0.87*	-0.36	-3.15	-0.40	-0.42	2.23*
ARG 2-A	-6.64*	0.02	0.15	-0.81	-3.73*	-0.33	-2.49	0.71*	9.16*	-4.07
ARG 3-A	-8.29*	0.41	-0.23	2.24*	-0.67*	0.00	-1.51	-0.36	1.61	5.71*
ARG 6-A	-2.75*	0.09	-0.03	-0.18	2.40*	-0.36	-1.20	-0.24	2.73*	3.70*
DV -10	1.87*	0.95*	0.25	-1.43*	1.93*	0.01	-1.86	0.42	4.73*	0.51
CMS 207 A	-0.80	-0.35	-0.97	-1.39*	1.53*	0.16	3.51*	1.40*	1.20*	8.31*
SE	0.63	0.37	0.25	0.62	0.23	0.19	0.40	0.23	0.89	0.70
CD at 5 %	1.35	0.80	0.54	1.33	0.49	0.41	0.86	0.49	1.91	1.51
MALES	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
6D-1	-1.97*	0.38	0.16	0.26	0.91*	-0.04	-0.24	0.04	-3.16*	2.76*
RHA 271	2.90*	0.84*	0.36*	0.31	-0.91*	-0.04	-1.01	-0.19	0.96	-2.90
RHA 4-2	0.46	-0.21	-0.24	-0.21	1.20*	0.25*	-1.08	0.20	1.52*	1.66*
HRHA 5-3	4.40*	-0.55	-0.02	0.45	-0.13	-0.11	2.25*	-0.19	-0.49	0.73
RHA 297	-5.79*	-0.44	-0.26	-0.80	-1.07*	-0.06	0.07	0.13	1.18*	-2.25
SE	0.34	0.20	0.13	0.33	0.12	0.10	0.21	0.13	0.48	0.38
CD at 5 %	0.83	0.49	0.32	0.81	0.29	0.25	0.51	0.32	1.18	0.93

Table 4.24 (contd.) General combining ability effects of parents for seedling vigour and fatty acids of E₄ in sunflower

FEMALES	GERM. (%)	EC (µScm¹g¹)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
CMS 11 A	8.41*	-0.21*	5.72*	3,602.9*	11.55*	-2.14	-0.47	0.63*	-1.59
CMS 17 A	0.30	0.15*	0.23	-37.3	6.80*	-1.46	0.46*	-2.38	1.93
CMS 44 A	9.51*	-0.31*	10.45*	2,070.1*	6.16*	-1.24	-0.09	2.078	-2.55
CMS 148 A	-3.72	-0.08*	-4.53	-197.9	4.17*	-1.17	-0.25	-1.77	2.76*
CMSH 91 A	4.41*	0.05*	4.82*	235.3	1.05*	-1.09	0.90*	7.37*	-4.31
CMS 103 A	-7.10	-0.05*	-2.50	-734.7	-1.52	-0.44	0.96*	2.20*	1.85
CMS 234 A	0.11	0.04*	0.26	2,393.5*	0.98*	0.02	-0.07	5.59*	0.30
CMS 302 A	-7.95	-0.04*	-7.11	-1,069.5	-2.65	-0.28	-0.34	2.38*	4.83*
CMS 607 A	-17.13	0.39*	-16.38	855.3	-2.65	0.50*	0.68*	0.69*	-3.36
CMS 852 A	1.94	0.15*	0.20	-798.1	-2.13	1.01*	1.32*	-5.04	0.37
ARG 2-A	-4.53	0.09*	-3.71	-1,614.4	-8.74	0.11	0.06	-5.00	5.07*
ARG 3-A	4.31*	-0.03	2.98*	-1,072.2	-8.70	1.04*	0.78*	-3.31	-0.19
ARG 6-A	4.23*	-0.17*	1.68*	-673.5	-2.66	2.19*	-1.02	-2.41	-1.50
DV -10	-0.54	0.03	-0.28	-2,316.0	-1.91	0.68*	-1.28	-2.04	1.09
CMS 207 A	7.75*	0.01	8.18*	-643.6	0.27	2.27*	-1.64	1.04	-4.70
SE	0.91	0.02	0.70	467.20	0.43	0.11	0.14	0.24	1.06
CD at 5 %	1.96	0.04	1.51	1028.8	0.92	0.24	0.30	0.52	2.28
MALES	GERM. (%)	EC (µScm¹g¹)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
6D-1	2.67*	-0.06	3.31*	1,009.7*	-0.98	-0.12	0.49*	1.22*	-2.18
RHA 271	-2.34	0.11*	-2.31	-1,157.7	-0.33	0.29*	-0.33	-1.38	0.67*
RHA 4-2	1.51*	-0.09*	0.35	109.2	-0.08	0.45*	0.17	2.018	-2.32
HRHA 5-3	0.62	-0.02*	0.65	877.0*	0.62*	-0.29	-0.25	-0.93	2.73
RHA 297	-2.46	0.06*	-1.99	-838.2	0.76*	-0.33	-0.09	-0.93	1.09*
SE	0.49	0.01	0.37	249.73	0.23	0.06	0.08	0.13	0.03
CD at 5 %	1.20	0.02	0.91	549.9	0.56	0.15	0.20	0.32	0.07

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

Table 4.25 General combining ability effects of parents for seed yield, oil content and its component traits over the environments in sunflower

Parents	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY(g)	OC (%)	HC (%)	%SF
CMS 11 A	2.05*	-0.17	-0.19	-0.87*	-1.55*	-0.02	-0.36	0.04	-3.56*	2.18*
CMS 17 A	4.18*	1.14*	0.37*	-0.32	-1.30*	0.00	1.17*	0.05	-3.95*	-1.65
CMS 44 A	-0.85	0.55*	0.03	-0.98*	-1.34*	0.34*	0.39	0.01	-4.92*	2.97*
CMS 148 A	-2.59*	0.42*	0.30*	-0.95*	-0.78*	0.28*	1.59*	0.26*	-4.18*	-1.07
CMSH 91 A	0.71	0.78*	0.45*	-0.35	0.08	0.14	1.59*	0.10	-1.91*	-0.28
CMS 103 A	1.34*	-0.60	-0.20	1.40*	-0.59*	0.40*	-0.04	0.26*	-0.54	-3.32
CMS 234 A	-1.30*	-0.35	0.04	-0.90*	0.98*	-0.18	-1.09	0.56*	1.74*	-0.58
CMS 302 A	3.93*	0.33*	0.26*	-0.99*	0.24	-0.30	-0.38	0.19	4.37*	-2.05
CMS 607 A	5.32*	0.04	0.02	-0.22	0.48*	-0.09	-0.55	0.11	1.83*	-5.31
CMS 852 A	-0.05	-0.71	-0.27	-1.48*	0.78*	-0.11	-1.21	0.18	1.69*	-0.52
ARG 2-A	0.64	-0.31	-0.13	0.13	0.05	0.15	0.04	0.15	4.11*	-1.67
ARG 3-A	-5.04*	-0.43	-0.28	1.52*	0.05	-0.03	-0.52	0.12	-1.30*	4.30*
ARG 6-A	-4.66*	-0.31	-0.12	1.16*	0.65*	0.01	-0.08	0.19	2.66*	3.35*
DV -10	-1.07	-0.85	-0.31	1.20*	1.37*	-0.42	-1.86	0.17	4.91*	-0.41
CMS 207 A	-2.58*	0.48*	0.04	1.67*	0.88*	-0.19	1.30*	0.90*	-0.96	4.04*
SE	0.51	0.15	0.08	0.20	0.12	0.10	0.25	0.12	0.51	0.39
CD at 5 %	1.10	0.32	0.17	0.43	0.26	0.22	0.54	0.26	1.10	0.84
MALES	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY(g)	OC (%)	HC (%)	%SF
6D-1	0.13	0.14	0.01	-0.48*	0.40*	0.00	0.18	0.02	-0.84*	-0.91
RHA 271	0.22	0.15	0.01	0.08	-0.51*	0.17*	-0.56	0.07	0.67*	-0.18
RHA 4-2	-0.25	-0.04	-0.08	0.02	0.27*	0.02	-0.55	0.04	1.09*	-0.21
HRHA 5-3	1.38*	0.03	0.06	0.42*	0.10	-0.09	0.23	0.11	-0.63	0.59*
RHA 297	-1.47*	-0.29	0.00	-0.04	-0.26*	-0.10	0.69*	0.02	-0.29	0.70*
SE	0.27	0.08	0.04	0.11	0.06	0.05	0.14	0.06	0.27	0.21
CD at 5 %	0.66	0.20	0.10	0.27	0.15	0.12	0.34	0.15	0.66	0.51

Table 4.25 (contd.) General combining ability effects of parents for seedling vigour and fatty acids over the environments in sunflower

Parents	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
CMS 11 A	3.66*	-0.13*	4.33*	2,925.4*	1.59*	-1.03	-0.60	-2.03	2.52*
CMS 17 A	-0.76	-0.01	-0.68	403.5*	1.31*	-1.04	-0.32	-0.39	0.84*
CMS 44 A	3.48*	-0.09*	4.27*	858.8*	-0.11	-1.15	-0.30	-1.08	1.36*
CMS 148 A	-1.98	-0.06*	-0.89	-1,826.2	0.52	-0.98	-0.61	-2.23	-0.49
CMSH 91 A	0.83	-0.03*	0.20	-906.8	2.07*	-0.43	0.04	0.68*	0.47*
CMS 103 A	-1.65	0.08*	-0.13	504.3*	7.57*	-0.12	0.28*	-2.37	-1.37
CMS 234 A	-0.02	0.06*	0.09	-323.8	2.89*	0.07	0.33*	3.14*	-2.18
CMS 302 A	-2.60	0.02*	-1.60	1,610.8*	-2.85	0.11	0.10	1.13*	1.04*
CMS 607 A	6.53*	0.13*	-5.87	-352.0	-5.79	0.41	0.52*	0.46*	-4.67
CMS 852 A	3.19*	0.05*	2.40*	-602.9	2.07*	0.17	0.31*	-0.64	-0.07
ARG 2-A	1.34*	0.05*	-1.02	-503.2	-7.80	0.29	0.88*	2.76*	2.24*
ARG 3-A	1.48*	-0.05*	0.09	3.6	-3.63	0.66	1.18*	0.75*	-2.97
ARG 6-A	3.38*	-0.09*	1.31*	-334.6	2.81*	0.70	-0.13	1.14*	-0.10
DV -10	2.81*	0.01	-3.81	-1,016.4	-2.74	0.71	-0.44	-1.06	2.43*
CMS 207 A	1.66*	0.06*	1.30*	-440.6	2.09*	1.62	-1.25	-0.26	0.95*
SE	0.42	0.01	0.53	136.43	0.48	5.00	0.05	0.11	0.06
CD at 5 %	0.90	0.02	1.14	300.4	1.03	10.75	0.11	0.24	0.13
MALES	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
6D-1	1.43*	-0.02*	1.27*	563.6*	0.27	-0.24	0.32*	0.07	-0.52
RHA 271	-1.09	0.01*	-0.91	-582.6	-0.10	0.25*	-0.10	-0.48	-0.45
RHA 4-2	0.69*	-0.02*	0.69*	119.1	0.10	0.24*	-0.16	0.61*	-2.66
HRHA 5-3	0.39	-0.02	0.37	221.2*	0.25	-0.16	-0.19	-0.87	2.17*
RHA 297	1.42*	0.05*	1.43*	-321.4	-0.52	-0.09	0.13*	0.67*	1.46*
SE	0.23	0.01	0.18	72.93	0.26	0.03	0.02	0.06	0.04
CD at 5 %	0.56	0.01	0.44	160.6	0.64	0.07	0.05	0.15	0.09

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

Over the environments (table.4.25), it was observed that the female parents CMS 234 A (3.14), ARG 2A (2.76), ARG 6A (1.14), CMS 302 A (1.13) and the pollen parents RHA 297 (0.67), HRHA 4-2 (0.61) exhibited significant positive *gca* effects for oleic acid.

4.4.19 Linoleic acid (%)

In E₁, the lines CMS 302 A (6.03), CMS 44A (5.23), CMS 11 A (4.68), CMS 103 A (3.22) and tester 6D-1 (1.98) were found to be good general combiners. In E₂ (table.4.22), the lines ARG 2A (9.13), DV-10 (8.86), CMS 11A (7.38), CMS 207 A (7.14) and testers RHA 297 (4.46), HRHA 5-3 (1.19) exhibited significant positive *gca* effects for this trait.

In E₃, the lines, ARG 2A (4.96), CMS 302 A (4.81), CMS 148 A (2.63), CMS 17 A (1.82) and testers HRHA 5-3 (2.62), RHA 297 (0.97) were found good general combiners. In E₄ (table.4.19), the female parents ARG 2A (5.07), CMS 302 A (4.83), CMS 148 A (2.76) and male parents RHA 297 (1.09), RHA 271 (0.67) showed significant positive *gca* effects.

Over the environments (table.4.25), the lines CMS 11 A (2.52), DV-10 (2.43), ARG 2A (2.24), CMS 44A (1.36) and testers HRHA 5-3 (2.17), RHA 297 (1.46) exhibited significant positive *gca* effects for this trait.

4.4.3. Estimation of specific combining ability (SCA) for hybrids over the environment and in E₁, E₂, E₃ and E₄

The estimate of specific combining ability of 75 hybrids for seed yield and its component traits are presented in table 4.26 to 4.30 and discussed below:

4.4.3.1 Plant height (cm)

In E₁ (table 4.26), the highest negative and significant *sca* effects were recorded by hybrids, CMS 302 A x HRHA 4-2 (-12.39), CMS 607 A x HRHA 4-2 (-11.99), CMS 44A x RHA 271 (-11.91) while lowest was recorded by CMS 148 A x HRHA 5-3 (-0.04) for dwarf plant stature. In E₂ (table 4.27), the highest negative and significant *sca* effects were observed by hybrids CMS 302 A x 6D-1 (-18.28), CMS 234 A x HRHA 4-2 (-16.32), CMS 17 A x HRHA 5-3 (-13.36) whereas, the hybrid CMS 852 A x RHA 297 (-0.14) showed the lowest negative and significant *sca* effects for this trait.

In E₃ (table 4.28), the cross combinations CMS 234 A x HRHA 4-2 (-16.92), CMS 17 A x RHA 271 (-11.74), CMS 607 A x RHA 297 (-11.42) showed highest negative *sca* effects, while the hybrid CMS 207 A x RHA 297 (-0.10) was found significant and negative *sca* effects for dwarf plant stature. In E₄ (table 4.29), the hybrids CMSH 91 A x RHA 297 (-17.59), CMS 302 A x 6D-1 (-16.23), CMS 607 A x 6D-1 (-13.23) exhibited highest negative and significant *sca* effects and the hybrid ARG 2A x RHA 271 (-0.23) showed lowest negative and significant *sca* effects.

Over the environments (table 4.30), the cross combinations CMS 234 A x HRHA 4-2 (-13.32), CMS 302 A x 6D-1 (-8.41) and CMS 607 A x RHA 297 (-8.02) showed highest

negative and significant *sca* effects while the hybrid ARG 6A x RHA 297 (-0.22) was recorded for lowest *sca* effects for this trait.

4.4.3.2 Head diameter (cm)

In E₁, the hybrids CMS 17 A x HRHA 5-3 (4.93), CSMH 91 A x HRHA 4-2 (3.91) and CMS 148 A x HRHA 4-2 (2.95) exhibited maximum positive and significant *sca* effects while the hybrid DV-10 x 6D-1 (1.04) was found minimum *sca* effects for head diameter. In E₂, the hybrids CMS 17A x HRHA 5-3 (4.28), CMS 148 A x HRHA 4-2 (3.21) and ARG 3A x HRHA 5-3 (2.67) showed the maximum positive and significant *sca* effects while hybrid CSMH91 A x RHA 271 (1.33) was observed to have minimum value for *sca* effects.

In E₃, the hybrids CSMH 91 A x 6D-1 (4.31), CMS 207 A x RHA 297 (3.74) and CMS 234 A x 6D-1 (2.92) were recorded maximum positive and significant *sca* effects while the hybrid CMS17 A x RHA 271 (1.39) had minimum *sca* effects for head diameter. In E₄, the hybrids CMS 852 A x HRHA 4-2 (2.89), CMS 44 A x HRHA 5-3 (2.33) and CMS 103 A x RHA 271 (2.28) were exhibited maximum positive and significant *sca* effects while the hybrid CMS 234 A x RHA 297 (1.47) had minimum *sca* effects for this trait.

Over the environments (table 4.30), it was recorded that the hybrids CMS 17 A x HRHA 5-3 (1.75), CMS 207 A x RHA 297 (1.67) and CMS 148 A x HRHA 4-2 (1.64) exhibited significant and positive *sca* effects while the hybrid CMS 44 A x RHA 297 (0.44) showed the minimum *sca* effects for the trait.

4.4.3.3 Stem diameter (cm)

In E₁, the hybrids CMS 148 A x HRHA 5-3 (1.70), CMS 17 A x RHA 297 (1.67) and ARG 2 A x 6D-1 (1.47) showed highest positive and significant *sca* effects while the hybrid CSMH 91 A x RHA 297 (0.43) had lowest and significant *sca* effects for stem diameter. In E₂, the hybrids CMS 148 A x HRHA 4-2 (2.11), CMS 44 A x 6D-1 (2.04), CMS 17 A x HRHA 5-3 (1.84) exhibited maximum positive and significant *sca* effects, whereas, the hybrid CMS 607 A x RHA 297 (0.47) was observed to have minimum *sca* effects for this trait.

In E₃, the hybrids CSMH 91 A x RHA 271 (2.27), CMS 44A x HRHA 5-3 (1.82), CMS 207 A x RHA 297 (1.53) showed maximum positive and significant *sca* effects while the hybrid CMS 852 A x RHA 271 (0.76) had minimum *sca* effects for this trait. In E₄, the hybrids CMS 852 A x HRHA 4-2 (2.07), CMS 44A x RHA 297 (1.81), CMS 44A x HRHA 5-3 (1.51) were found significant and positive *sca* effects while the hybrid ARG 3A x 6D-1 (1.03) showed minimum *sca* effects for stem diameter.

Over the environment, the hybrids CMS 44 A x RHA 297 (0.93), CMS 234 A x RHA 271 (0.78) and DV-10 x 6D-1 (0.62) exhibited maximum positive and significant *sca* effects while hybrid CMS 207 A x HRHA 4-2 (0.35) was found minimum *sca* effects for this trait.

4.4.3.4 Days to 50 % flowering

The significant negative *sca* effect was desirable for this trait. In E_1 (4.26), the cross combinations CMS 207 A x HRHA 4-2 (-2.60), CMSH 91 A x 6D-1 (-2.29) and CMS 44 A x HRHA 5-3 (-1.94) showed maximum negative and significant *sca* effects while hybrid CMS 148 A x HRHA 4-2 (-0.82) exhibited minimum *sca* effects for days to 50% flowering. In E_2 , the hybrids ARG 2A x 6D-1 (-3.73), CMS 607 A x HRHA 4-2 (-3.25), CMS 607 A x HRHA 5-3 (-3.12) showed maximum negative and significant *sca* effects while hybrid ARG 6A x HRHA 5-3 (-0.98) exhibited significant negative *sca* effects for this trait.

In E_3 (table 4.27), the cross combinations DV-10 x RHA 297 (-6.94), CMS 234 x RHA 297 (-4.28), CMS 607 A x HRHA 4-2 (-4.25) were recorded maximum negative and significant *sca* effects while hybrid ARG 3 A x RHA 271 (-0.04) showed minimum negative *sca* effects for this trait. In E_4 , the cross combinations CMS 302 A x 6D-1 (-3.53), CMS 234 A x HRHA 5-3 (-3.10), CMS 207 A x RHA 297 (-2.68) were recorded maximum and negative *sca* effects for days to flowering while the hybrid ARG 6A x 6D-1 (-2.51) exhibited minimum negative *sca* effects for this trait.

Over the environments, the hybrids CMS 302 A x 6D-1 (-1.90), ARG 6A x 6D-1 (-1.87), CMS 103 A x RHA 297 (-1.77) were found to exhibit significant and negative *sca* effects while the hybrid CMS 44A x HRHA 5-3 (-0.90) had minimum *sca* effects and indicated as good specific combination for this trait.

4.4.3.5 Days to maturity

The significant and negative *sca* effect was desirable for this trait. In E_1 , the cross combinations CMS 607 A x RHA 271 (-5.38), CMS 207 A x RHA 297 (-3.38) and ARG 3A x RHA 297 (-3.30) were found maximum negative and significant *sca* effects while the hybrid ARG 2A x 6D-1 (-1.32) was recorded for early maturity, indicated as good specific combination. In E_2 , the hybrids, CMS 148 A x HRHA 5-3 (-3.71), CMS 103 A x HRHA 4-2 (-3.63) and CMS 207 A x HRHA 5-3 (-3.14) were observed for late maturity while the hybrid ARG 2A x 6D-1 (-0.68) was observed as good specific combiner for early maturity.

In E_3 , the hybrids, CMS 103 A x RHA 271 (-5.22), CMS 17 A x RHA 297 (-4.93) and CMS 44A x 6D-1 (-3.38) exhibited maximum negative and significant *sca* effects for earliness while the hybrid ARG 3 A x 6D-1 (-0.04) showed the minimum *sca* effects for this trait. In E_4 , the hybrids, CMS 852A x RHA 271 (-6.76), CMS 852 A x RHA 297 (-5.60) and CMS 607 A x RHA 297 (-4.80) were recorded for maximum negative and significant *sca* effects for early maturity while the hybrid CMSH 91 A x 6D-1 (-0.98) was recorded for early maturity and act as good specific combiner.

Over the environments, the cross combinations CMS 852 A x RHA 297 (-1.81), CMS 852 A x RHA 271 (-1.78) and ARG 2A x HRHA 5-3 (-1.77) exhibited maximum negative

and significant *sca* effects while the hybrid ARG 3A x HRHA 5-3 (-0.88) had minimum *sca* effects, indicated as good specific combiner for this trait.

4.4.3.6 Hundred seed weight (g)

The significant positive *sca* effect was desirable for this trait. In E_1 , the hybrids ARG 6A x RHA 271 (1.74), DV-10 x 6D-1 (1.57) and CMS 607 A x RHA 297 (1.55) were observed maximum positive and significant *sca* effects while the hybrid CMS 44A x HRHA 5-3 (0.86) had minimum positive *sca* effects. In E_2 , the cross combinations CMS 234 A x HRHA 5-3 (1.95), ARG 6 A x RHA 297 (1.54) and CMS 44 A x 6D-1 (1.43) exhibited highest positive and significant *sca* effects while hybrid DV-10 x 6D-1 (0.78) had lowest *sca* effects, indicated as good specific combiner for 100 seed weight.

In E_3 , the hybrids CMS 207 A x RHA 297 (2.41), CMS 17 A x RHA 271 (1.32) and CMS 302 A x RHA 297 (1.24) showed maximum positive and *sca* effects while the hybrid ARG 6A x HRHA 4-2 (0.82) had minimum *sca* effects for this trait. In E_4 , the hybrids CMS 607 A x RHA 297 (1.49), CMS 302 A x RHA 271 (1.46) and ARG 6A x 6D-1 (1.25) exhibited good specific combiner having maximum positive and significant *sca* effects and the hybrid ARG 3A x RHA 297 (0.78) had minimum *sca* effects.

Over the environment (table 4.30), the hybrids CMS 17 A x RHA 271 (0.85), ARG 6A x 6D-1 (0.72) and CMS 852 A x HRHA 4-2 (0.70) exhibited maximum positive and significant *sca* effects and the hybrid CMS 17 A x HRHA 5-3 (0.38) had minimum *sca* effect act as good specific combiner for this trait.

4.4.3.7 Seed yield per plant (g)

The significant positive *sca* effect was desirable for seed yield per plant. In E_1 , it was recorded (table 4.26) that the cross combinations CMS 234 A x RHA 297 (4.59), DV 10 x RHA 297 (3.79) and CMS 852 A x RHA 271 (3.67) were observed highest positive and significant *sca* effects while hybrid CMS 148 A x HRHA 5-3 (2.67) had lowest significant *sca* effects for this trait. In E_2 , the cross combinations ARG 3 A x HRHA 5-3 (2.77), CMS 852 A x RHA 271 (2.47) and CMS 11 A x RHA 297 (2.34) exhibited maximum positive and significant *sca* effects while hybrid CMS 17 A x RHA 271 (1.46) was observed to have minimum positive and significant *sca* effects for this trait.

In E_3 , the hybrids, CMSH 91 A x 6D-1 (9.81), CMS 11 A x HRHA 5-3 (8.31) and CMS 302 A x RHA 271(8.06) showed highest positive and significant *sca* effects while hybrid DV-10 x HRHA 5-3 (2.20) was observed to have lowest significant *sca* effects. In E_4 (table 4.24), the hybrids CMS 207 A x HRHA 5-3 (10.15), CMS 44A x HRHA 4-2 (8.78) and CMSH 91 A x HRHA 5-3 (5.61) exhibited maximum yield and the hybrid ARG 2A x HRHA 4-2 (1.84) had minimum *sca* effects, indicated as a good specific combiner for seed yield.

Over the environments (4.30), the hybrids CMS 207 A x HRHA 5-3 (4.14), CMS 44A x HRHA 5-3 (3.49) and CMS 852 A x RHA 271 (2.42) exhibited maximum positive and significant *sca* effects while the hybrids CMS 207 A x RHA 297 (1.01) showed minimum significant *sca* effects for this trait.

4.4.3.8 Oil content (%)

The significant positive *sca* effect was desirable for oil content. In E₁, hybrids ARG 3 A x HRHA 5-3 (1.36), CMS 207 A x RHA 297 (1.17) and CMS 103 A x RHA 271 (1.06) showed maximum positive and significant *sca* effects while hybrid ARG 6A x HRHA 5-3 (1.01) was observed to have minimum significant *sca* effects. In E₂, hybrids ARG 6A x HRHA 5-3 (2.23), CMS 44A x RHA 297 (2.20) and CMS 207 A x RHA 297 (2.19) were observed highest significant *sca* effects and the hybrid CMS 103 A x RHA 271 (0.96) was observed lowest significant *sca* effects for this trait.

In E₃, the cross combinations, CMS 207 A x 6D-1 (2.40), ARG 2A x RHA 297 (2.07) and CMS 607 A x HRHA 4-2 (1.87) were found to be good specific combiner having maximum positive and significant *sca* effects and the hybrid CMS 302 A x RHA 297 (0.89) showed minimum significant and positive *sca* effects. In E₄, the hybrids CMS 607 A x HRHA 5-3 (1.69), ARG 3A x RHA 271 (1.56) and CMSH 91 A x RHA 271 (1.54) showed significant positive *sca* effects having maximum value for oil content and the hybrid CMS 148 A x 6D-1 (0.97) was observed to have minimum *sca* effects, act as good specific combiner for oil content.

Over the environment, the hybrids CMS 17 A x 6D-1 (1.03), CMSH 91 A x 6D-1 (1.01) and CMS 852 A x RHA 297 (0.91) exhibited maximum positive and significant *sca* effects while the hybrid ARG 6A x HRHA 5-3 (0.49) was observed to have minimum and significant *sca* effects for this trait.

4.4.3.9 Hull content (%)

The significant negative *sca* effect was desirable for hull content. In E₁, the cross combinations CMS 852 A x 6D-1 (-12.36), CMS 44 A x HRHA 4-2 (-7.54) and CMS 852 A x RHA 271 (-7.23) showed maximum negative and significant *sca* effects while hybrid ARG 6A x HRHA 5-3 (-5.69) was observed to have minimum negative and significant *sca* effects for hull content. In E₂, the hybrids CMS 11 A x HRHA 5-3 (-13.31), CMS 148 A x 6D-1 (-12.25) and CMS 148 A x RHA 271 (-12.21) were observed maximum negative and significant *sca* effects while the hybrid CMS 852 A x RHA 297 (-0.09) had minimum *sca* effects, act as good specific combiner.

In E₃, the hybrids CMS 207 A x 6D-1 (-13.20), CMS 852 A x HRHA 4-2 (-7.66) and CMS 852 A x RHA 271 (-6.69) showed maximum negative and significant *sca* effects while In E₄, the cross combinations CMS 148 A x HRHA 5-3 (-20.60), CMS 17 A x RHA 271

(-18.77) and CMSH 91 A x 6D-1 (-16.60) were observed maximum negative and significant *sca* effects while the hybrid ARG 3A x 6D-1 (-3.65) had minimum *sca* effects, act as good specific combiner for this trait.

Over the environments, it was concluded that the hybrids CMS 207 A x 6D-1 (-8.02), CMSH 91 A x 6D-1 (-3.93) and ARG 6A x HRHA 5-3 (-3.74) were found to be maximum negative and significant *sca* effects while the hybrid ARG 6A x HRHA 4- 2(-2.50) was observed minimum negative and significant *sca* effects for this trait.

4.4.3.10 Percent seed filling

The significant positive *sca* effect was desirable for percent seed filling. In E₁, the hybrids DV10 x RHA 297 (17.77), CMS 607 A x 6D-1 (6.38) and DV -10 x RHA 271 (5.49) observed positive and significant *sca* effects while the hybrid CMS 852 A x HRHA 5-3 (4.93) had minimum positive and significant *sca* effects. In E₂, the hybrids CMS 17 A x RHA 271 (5.61), CMS 17 A x HRHA 4-2 (5.17), CMS 44 A x 6D-1 (5.15) exhibited maximum positive and significant *sca* effects while the hybrid CMS 103 A x 6D-1 (2.08) had minimum *sca* effects.

In E₃, the cross combinations, CMS 607 A x 6D-1 (20.39), ARG 2 A x 6D-1 (18.08), CMS 103 A x HRHA 4-2 (17.07) showed maximum positive and significant effects while the hybrid ARG 6A x 6D-1 (2.80) had minimum *sca* effects. In E₄, the hybrids CMS 607 A x HRHA 4-2 (31.89), CMS 148 A x HRHA 4-2(19.81) and ARG 2A x 6D-1 (18.56) were found good specific combiner having highest positive and significant *sca* effects while the hybrid ARG 6A x HRHA 5-3 (3.21) had lowest and significant *sca* effects.

Over the environment, the cross combinations ARG 2 A x 6D-1 (11.24), CMS 607 A x HRHA 4-2 (10.65) and CMS 302 A x 6D-1 (8.08) exhibited maximum positive and significant *sca* effects and the hybrid CMS 11 A x HRHA 4-2 (1.52) showed minimum and significant positive *sca* effects for this trait.

4.4.3.11 Germination (%)

The significant positive *sca* effect was desirable for germination. In E₁, the hybrids DV 10 x RHA 297 (10.72), CMS 11 A x 6D-1 (4.60) and CMS 852 A x HRHA 4-2 (4.59) were observed maximum germination while the hybrid CMS 852 A x 6D-1 (4.06) showed minimum and significant *sca* effects. In E₂, the cross combinations CMS 207 A x 6D-1 (11.29), CMS 207 A x HRHA 5-3 (8.83) and DV 10 x HRHA 4-2 (8.61) exhibited maximum positive and significant *sca* effects while the hybrid CMSH 91 A x HRHA 5-3 (3.04) had minimum and significant *sca* effects.

In E₃, the hybrids CMS 607 A x RHA 271 (25.60), CMS 302 A x RHA 297 (19.93) and CMS 607 A x HRHA 4-2 (19.03) were observed highest positive and significant *sca* effects whereas the hybrid CMS 302 A x 6D-1 (3.46) had lowest positive and significant

positive *sca* effects. In E_4 , the hybrids CMS 607 A x HRHA 4-2 (29.98), CMS 103 A x RHA 271 (20.52) and CMS 607 A x RHA 271 (19.84) showed maximum positive and significant *sca* effects while the hybrid CMS 44A x RHA 271 (4.66) had lowest value of germination and perform as good specific combiner for this trait.

In pooled analysis, the hybrids CMS 607 A x HRHA 4-2 (13.58), CMS 607 A x RHA 271 (12.22), CMS 103 A x RHA 271 (9.83) exhibited maximum positive and significant *sca* effects while the hybrid ARG 3A x 6D-1 (1.99) had minimum and significant *sca* effects for this trait.

4.4.3.12 Electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$)

The significant negative *sca* effect was desirable for electrical conductivity. In E_1 , the hybrids CMS 607 A x HRHA 5-3 (-0.21), CMS 234 A x RHA 297 (-0.19) and CMS 852 A x RHA 297 (-0.18) were observed to have maximum negative and significant *sca* effects while the hybrid DV-10 x RHA 271 (-0.14) had minimum and significant *sca* effects. In E_2 , the cross combinations DV-10 x 6D-1 (-0.26), CMS 302 A x 6D-1 (-0.22) and CMS 11 A x HRHA 5-3 (-0.21) were observed to have maximum negative and significant *sca* effects and the hybrid CMS 44A x 6D-1 (-0.02) had minimum and significant *sca* effects, indicated as good specific combiner for this trait.

In E_3 , the hybrids CMS 17 A x RHA 297 (-0.36), CMS 11 A x 6D-1 (-0.33) and CMS 234 A x RHA 297 (-0.32) exhibited negative and significant *sca* effects while the hybrid CMS 17 A x HRHA 4-2 (-0.02) had minimum and significant *sca* effects. In E_4 , the cross combinations CMS 607 A x HRHA 4-2 (-0.55), CMS 607 A x RHA 271 (-0.54) and CMS 17 A x HRHA 5-3 (-0.52) were found significant having highest negative *sca* effects while the hybrid ARG 6A x RHA 297 (-0.08) had minimum and significant *sca* effects for this trait.

Over the environments, the cross combinations CMS 234 A x RHA 297 (-0.26), CMS 607 A x HRHA 4-2 (-0.22) and CMS 17 A x RHA 297 (-0.21) exhibited maximum negative and significant *sca* effects while the hybrid CMS 207 A x HRHA 5-3 (-0.04) was found minimum and significant *sca* effects for this trait.

4.4.3.13 Viability (%)

The significant positive *sca* effect was desirable for viability. In E_1 , the cross combinations DV 10 x RHA 297 (13.07), CMS 44A x HRHA 4-2(8.55) and CMS 852 A x 6D-1 (7.03) showed maximum viability, having significant positive *sca* effects while the hybrid CMS 234 A x HRHA 4-2 (3.96) had minimum and significant *sca* effects, act as good specific combiner. In E_2 , maximum positive and significant *sca* effects were recorded in hybrids DV-10 x HRHA 4-2 (15.23), CMS 207 A x HRHA 5-3 (9.62) and CMS 852 A x RHA 297 (6.33) while minimum and significant *sca* effects was observed in hybrid CMS 44A x RHA 271 (2.04).

In E₃, the hybrids CMS 607 A x RHA 271 (25.36), CMS 607 A x HRHA 4-2 (20.17) and CMS 302 A x RHA 297 (19.82) exhibited significant and positive *sca* effects while the hybrid DV-10 x RHA 271 (3.17) was recorded to have minimum and significant *sca* effects. In E₄, the cross combinations CMS 607 A x HRHA 4-2 (30.56), CMS 607 A x RHA 271 (19.95) and CMS 148 A x HRHA 4-2 (17.27) were found to observe positive and significant *sca* effects and the hybrid CMS 44 A x HRHA 4-2 (4.82) had minimum and positive significant *sca* effects.

Over the environments, the cross combinations CMS 607 A x HRHA 4-2 (13.52), CMS 607 A x RHA 271 (12.07) and CMS 148 A x 6D-1 (8.92) were observed to have maximum positive and significant *sca* effects while the hybrid ARG 6A x RHA 271 (1.75) showed minimum and significant *sca* effects for this trait.

4.4.3.14 Vigour index I

The significant positive *sca* effect was desirable for vigour index I. In E₁, the hybrids, CMS 302 A x HRHA 4-2 (6,174.7), CMS 103 A x 6D-1 (5,322.0) and CMS 44 A x HRHA 5-3 (4,632.1) exhibited maximum positive and significant *sca* effects while the hybrid CMS 207 A x HRHA 5-3 (1,046.8) was observed minimum significant *sca* effects. In E₂, the cross combinations CMS 207 A x 6D -1(3897.61), ARG 6A x HRHA 5-3 (3684.21) and CMS 103 A x RHA 271 (3362.34) showed maximum positive and significant *sca* effects while the hybrid CMS 234 A x HRHA 4-2(30.65) was observed to have minimum and significant *sca* effects for this trait.

In E₃, the hybrids CMS 207 A x RHA 297 (6701.94), CMS 17-A x 6D-1 (6507.94) and CMS 148A x 6D-1(5958.68) were found maximum positive and significant *sca* effects and the hybrid CMS 607 A x RHA 297 (299.01) had minimum and significant *sca* effects. In E₄, the maximum positive and significant *sca* effects were observed in the hybrids, CMS 302 A x RHA 271 (10,102.2), CMS 17A X RHA 297(7,858.8) and CMS 148A x 6D-1(7,225.5) while the minimum and significant *sca* effect was observed in ARG 3A x HRHA 5-3 (1,899.5).

Over the environments, the hybrids CMS 302 A x RHA 271 (2,692.2), CMS 207 A x RHA 297 (2,626.1) and CMS 302 A x RHA 297 (2,544.3) exhibited highest positive and significant *sca* effects and the hybrid DV 10 x 6D -1(569.5) had lowest and significant *sca* effects for this trait.

4.4.3.15 Vigour index II

The significant positive *sca* effect was desirable for this trait. In E₁, the cross combinations CMS 103 A x RHA 271 (16.14), ARG 6A x HRHA 5-3 (11.81) and CMS 207 A1 x HRHA 4-2 (11.07) showed maximum positive and significant *sca* effects while the hybrid CMS 148 A x 6D-1 (6.88) showed the minimum and significant *sca* effects. In E₂, the

hybrids CMS 148 A x 6D-1 (17.04), CMS 207 A x HRHA 5-3 (15.52) and CMSH 91 A x RHA 297 (12.66) were observed to have maximum positive and significant *sca* effects while the hybrid CMS 103 A x RHA 271 (1.88) was observed minimum and significant *sca* effects.

In E₃, the maximum positive and significant *sca* effects were observed for the hybrids CMS 234 A x RHA 271 (15.86), CMS 207 A x RHA 271 (17.78) and ARG 2A x HRHA 4-2 (12.87) whereas the hybrid CMS 852 A x RHA 297 (2.24) was observed to have minimum and significant *sca* effects. In E₄, the hybrid CMS 17 A x RHA 297 (16.33), CMS 148 A x 6D-1 (13.92) and CMS 44 A x 6D-1 (12.39) were recorded to have maximum positive and significant *sca* effects while the hybrid DV -10 x HRHA 5-3 (1.65) showed minimum and significant positive *sca* effects.

Over the environments, it was recorded that the hybrids CMS 148 A x 6D-1 (11.44), CMSH 91 A x HRHA 5-3 (7.67) and CMSH 91 A x RHA 297 (6.24) exhibited maximum positive and significant *sca* effects while the hybrid CMS 11 A x 6D-1 (2.04) had minimum and significant *sca* effects for this trait.

4.4.3.16 Palmitic acid (%)

The significant positive *sca* effect was desirable for palmitic acid. In E₁, the cross combinations CMS 607 A x HRHA 5-3 (2.33), ARG 3A x HRHA 4-2 (1.99) and ARG 3A x RHA 271 (1.73) showed maximum positive and significant *sca* effects while the hybrid CMSH 91 A x RHA 297 (0.32) had minimum and significant *sca* effects. In E₂, the hybrids CMS 207 A x RHA 297 (4.78), ARG 6A x HRHA 5-3 (3.82) and ARG 2 A x RHA 297 (2.15) showed the maximum positive and significant *sca* effects while the hybrid CMS 17 A x HRHA 4-2 (0.24) showed minimum positive and significant *sca* effects.

In E₃, the hybrid CMS 207 A x HRHA 4-2 (7.80), ARG 6A x RHA 271 (2.08) and DV 10 x RHA 271 (1.32) exhibited maximum positive and significant *sca* effects while the hybrid CMS 11 A x HRHA 5-3 (0.68) had minimum and significant *sca* effects. In E₄, the maximum positive and significant *sca* effects were observed in hybrids CMS 207 A x HRHA 4-2 (7.00), DV 10 x RHA 271 (2.05) and CMS 234 A x 6D-1 (1.61) while the hybrid CMS 11 A x HRHA 5-3 (0.48) was found minimum and significant *sca* effects.

Over the environments, the hybrids CMS 207 A x HRHA 4-2 (2.87), ARG 6A x HRHA 5-3 (1.06) and ARG 2A x RHA 297 (1.03) showed maximum positive and significant *sca* effects while the hybrid CMS 207 A x RHA 297 (0.29) had minimum and significant *sca* effects for this trait.

4.4.3.17 Stearic acid (%)

The significant positive *sca* effect was desirable for stearic acid. In E₁, the maximum positive and significant *sca* effects were recorded in hybrids ARG 3A x HRHA 5-3 (4.09), ARG 6A x RHA 271 (3.91) and ARG 6A x 6D-1 (3.25) whereas the hybrid CMS 148 A x

HRHA 4-2 (0.32) was observed to have minimum and significant *sca* effects. In E_2 , the cross combinations ARG 3 A x RHA 271 (6.86), ARG 3 A x 6D-1 (4.73) and CMS 234 A x HRHA 4-2 (4.47) were found to be good specific combiner as they had the highest positive and significant *sca* effects and the hybrid CMS 103 A x HRHA 5-3 (0.24) showed minimum positive and significant *sca* effects.

In E_3 , the hybrids CMS 17 A x HRHA 4-2 (2.68), ARG 2A x RHA 271 (2.37) and CMSH 91 A x 6D-1 (1.83) were observed highest positive and significant *sca* effects and the hybrid CMS 17 A x RHA 297 (0.29) showed lowest and significant *sca* effects. In E_4 , the hybrids CMS 17 A x HRHA 4-2 (2.37), CMSH 91 A x 6D-1 (1.72) and CMS 234 A x 6D-1 (1.71) exhibited highest positive and significant *sca* effects while the hybrid DV 10 x RHA 271 (0.59) showed lowest and significant *sca* effects.

In pooled analysis, the hybrids ARG 2 A x RHA 271 (1.75), CMS 302 A x RHA 271 (1.70) and CMS 234 A x RHA 297 (1.43) were found to be good specific combiner as they recorded highest positive and significant *sca* effects while the hybrid CMS 103 A x HRHA 4-2 (0.23) showed lowest and significant *sca* effects for this trait.

4.4.3.18 Oleic acid (%)

The significant positive *sca* effect was desirable for oleic acid. In E_1 , the maximum positive and significant *sca* effects were recorded in hybrids DV 10 x RHA 271 (19.02), CMS 852 A x HRHA 5-3 (18.30), CMS 103 A x RHA 297 (15.95) and CMSH 91 A x HRHA 5-3 (1.16) had minimum and significant *sca* effects. In E_2 , the hybrids ARG 3 A x RHA 297 (14.66), CMS 17 A x RHA 271 (13.53) and CMSH 91 A x RHA 297 (12.00) exhibited positive and significant *sca* effects while the hybrid CMSH 91 A x 6D-1 (0.51) had minimum and significant *sca* effects.

In E_3 , the cross combinations CMSH 91 A x HRHA 4-2 (19.58), CMS 234 A x HRHA 4-2 (10.72), CMS 44A x 6D-1 (9.48) exhibited positive and significant *sca* effects while the hybrid ARG 3 A x 6D-1 (1.99) had lowest and significant *sca* effects. In E_4 , the hybrids CMSH 91 A x HRHA 4-2 (15.18), CMS 302 A x RHA 297 (11.25) and DV10 x HRHA 5-3 (10.75) exhibited maximum positive and significant *sca* effects while the hybrid CMS 207 A x HRHA 5-3 (1.33) showed minimum and significant *sca* effects.

Over the environments, the hybrids CMS 852 A x HRHA 5-3 (5.73), CMSH 91 A x HRHA 4-2 (5.63) and CMS 234 A x HRHA 4-2 (5.17) exhibited maximum positive and significant *sca* effects, whereas the hybrid CMS 207 A x RHA 271 (0.49) had minimum and significant *sca* effects for this trait.

4.4.3.19 Linoleic acid (%)

The significant positive *sca* effect was desirable for linoleic acid. In E_1 , the hybrids CMS 607 A x RHA 271 (15.43), ARG 2A x RHA 271 (14.83) and ARG 2A x HRHA 5-3

(14.77) exhibited significant positive *sca* effects having maximum value while the hybrid CMS 44A x HRHA 4-2 (0.99) was observed to have minimum and significant *sca* effects. In E₂, the cross combinations CMS 607 A x 6D-1 (13.56), CMS 302 A x 6D-1 (13.30) and CMSH 91 A x 6D-1 (13.20) showed maximum positive and significant *sca* effects while the hybrid CMS 11 A x 6D-1 (1.59) observed minimum and significant *sca* effects.

In E₃, the hybrid CMS 148 x HRHA 4-2 (7.92), CMSH 91 A x HRHA 5-3 (7.85) and CMSH 91 A x RHA 271 (7.16) exhibited maximum positive and significant *sca* effects while the hybrid CMS 852 A x HRHA 5-3 (0.50) had minimum and significant *sca* effects. In E₄, the hybrids CMS 11 A x HRHA 4-2 (8.31), CMSH 91 A x HRHA 5-3 (7.80) and CMS 148 A x HRHA 4-2 (7.75) exhibited maximum positive and significant *sca* while the hybrid CMS 207 A x HRHA 4-2 (0.43) had minimum positive and significant *sca* effects.

Over the environments (table 4.30), the cross combination ARG 3 A x RHA 297 (7.79), CMS 607 A x RHA 271 (6.74) and CMS 148 A x HRHA 4-2 (6.28) showed maximum positive and significant *sca* effects while the hybrid CMS 234 A x RHA 271 (0.26) had minimum and significant *sca* effects for this trait.

Table 4.26 Estimation of SCA effects for hybrids in E₁.

Sr.No.	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY(g)	OC (%)	HC (%)	%SF
1	CMS 11 A x 6D-1	-10.40*	-0.14	0.24	0.02	3.08*	-0.42	-0.83	-0.14	0.87	1.95
2	CMS 11 A x RHA 271	4.64*	-1.62	-0.08	0.63	-0.63	0.27	-1.04	0.43	1.82	-1.31
3	CMS 11 A x HRHA 4-2	1.72*	0.34	-0.12	-0.25	-1.66*	-0.73	-0.98	-0.05	0.23	-2.95
4	CMS 11 A x HRHA 5-3	1.02	1.15*	0.41	-0.63	0.13	1.05	0.57	-0.86	0.77	1.01
5	CMS 11 A x RHA 297	3.01*	0.26	-0.46	0.22	-0.92	-0.17	2.28	0.62	-3.67	1.30
6	CMS 17-A x 6D-1	2.13*	1.63*	-1.17	-0.43	-0.52	-1.33	-0.85	0.37	0.08	2.55
7	CMS 17-A x RHA 271	4.91*	-1.38	0.74*	0.59	-0.23	1.00*	-0.19	-0.53	0.52	1.07
8	CMS 17 -A x HRHA 4-2	4.72*	-3.29	-0.76	0.15	-0.76	0.27	-0.95	0.73	-0.44	0.83
9	CMS 17 -A x HRHA 5-3	-3.84*	4.93*	-0.49	-0.64	-0.97	-0.59	-0.43	-0.26	-0.26	-0.02
10	CMS 17 A x RHA 297	-7.92*	-1.90	1.67*	0.33	2.48*	0.65	2.42	-0.30	0.10	-4.43
11	CMS 44 A x 6D-1	13.19*	1.07*	-0.30	1.11	2.67*	-0.35	-0.64	-0.44	6.54*	1.35
12	CMS 44 A x RHA 271	-11.91*	-1.20	0.08	-0.26	-0.71	-1.72	0.07	0.76	4.91	2.14
13	CMS 44 A x HRHA 4-2	-3.89*	-0.51	-0.49	0.88	-0.87	0.41	-0.84	0.59	-7.54*	1.28
14	CMS 44 A x HRHA 5-3	2.68*	1.10*	-0.39	-1.94*	-1.12	0.86*	0.40	-0.46	-5.19	-5.16
15	CMS 44 A x RHA 297	-0.07	-0.46	1.10*	0.22	0.02	0.80	1.01	-0.44	1.28	0.39
16	CMS 148 A x 6D-1	-7.87*	0.27	-0.24	-0.15	-0.88	-0.43	-1.70	0.62	-6.53*	1.21
17	CMS 148 A x RHA 271	-8.36*	0.60	-0.40	-0.94*	1.23*	-0.34	-0.73	0.62	-3.34	1.03
18	CMS 148 A x HRHA 4-2	-0.68	2.95*	-0.60	-0.82*	1.70*	0.37	2.18	0.18	4.74	2.09
19	CMS 148 A x HRHA 5-3	-0.04	-2.03	1.70*	0.70	-1.01	0.58	2.67*	-0.97	5.86*	-1.06
20	CMS 148 A x RHA 297	16.95*	-1.79	-0.47	1.20	-1.04	-0.18	-2.37	-0.45	-0.73	-3.27
21	CMSH 91 A x 6D-1	7.44*	-0.70	-0.61	-2.29*	-2.67*	-0.63	-0.55	0.50	0.18	-0.33

Sr.No.	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY(g)	OC (%)	HC (%)	%SF
22	CMSH 91 A x RHA 271	-7.45*	-1.84	-1.03	-1.25*	2.13*	-0.77	-1.48	-0.64	-5.21	0.66
23	CMSH 91 A x HRHA 4-2	-1.97*	3.91*	1.10*	0.05	-0.42	0.30	1.03	-0.95	0.77	-5.35
24	CMSH 91 A x HRHA 5-3	5.66*	-2.21	0.10	2.51	1.37*	1.18*	3.28*	0.94	-0.26	1.33
25	CMSH 91 A x RHA 297	-3.68*	0.84	0.43*	0.98	-0.41	-0.08	-2.29	0.16	4.52	3.70
26	CMS 103 A x 6D-1	-3.69*	-0.06	0.05	3.60	3.12*	0.26	0.89	-1.07	4.94	2.11
27	CMS 103 A x RHA 271	-1.12	-1.07	0.09	-2.19*	-0.98	-1.08	1.27	1.06*	6.07*	-2.55
28	CMS 103 A x HRHA 4-2	8.43*	2.55*	0.56	-0.61	-0.98	-0.38	0.81	-0.81	-3.06	-0.18
29	CMS 103 A x HRHA 5-3	2.60*	-0.83	-0.28	4.14*	-1.32*	1.16*	-0.53	0.04	-6.38*	2.12
30	CMS 103 A x RHA 297	-6.21*	-0.59	-0.42	-4.94*	0.16	0.04	-2.44	0.79	-1.57	-1.50
31	CMS 234 A x 6D-1	1.16	-0.12	-0.66	-1.22*	-1.62*	1.11*	-1.60	0.72	7.34*	-0.79
32	CMS 234A x RHA 271	19.40*	-1.19	0.62*	0.87*	1.04	-0.90	-0.75	-0.05	-0.58	0.93
33	CMS 234 A x HRHA 4-2	-10.85*	-0.77	-0.52	0.37	0.79	-0.83	-1.60	-0.29	-2.65	3.15
34	CMS 234 A x HRHA 5-3	-7.95*	1.85*	0.05	-0.72	-0.10	-0.49	-0.65	-0.07	0.88	-1.22
35	CMS 234 A x RHA 297	-1.76*	0.22	0.51*	0.70	-0.11	1.12*	4.59*	-0.32	-5.00	-2.08
36	CMS 302 A x 6D-1	8.36*	-1.62	-0.15	-0.57	-1.30*	1.53*	1.45	0.38	0.02	0.98
37	CMS 302 A x RHA 271	6.53*	0.10	-0.48	0.37	-0.55	0.12	-0.10	0.17	-3.72	-6.49
38	CMS 302 A x HRHA 4-2	-12.39*	0.26	0.46*	1.52*	0.44	1.02*	1.50	-0.80	3.23	-2.50
39	CMS 302 A x HRHA 5-3	-3.02*	1.27*	-0.01	-0.86	1.21*	-1.87	-0.44	0.02	-0.44	4.07
40	CMS 302 A x RHA 297	0.51	-0.02	0.18	-0.46	0.20	-0.79	-2.40	0.24	0.90	3.94
41	CMS 607 A x 6D-1	-3.31*	-0.62	0.83*	0.71	-2.69*	-0.73	0.05	-0.08	1.38	6.38*
42	CMS 607 A x RHA 271	0.60	0.04	-0.03	0.89*	-5.38*	-1.04	1.16	0.45	0.14	0.71
43	CMS 607 A x HRHA 4-2	-11.99*	-0.34	0.00	0.98*	2.02*	0.43	0.38	0.51	-0.41	-1.42

Sr.No.	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY(g)	OC (%)	HC (%)	%SF
44	CMS 607 A x HRHA 5-3	15.25*	1.67*	-0.20	-1.92*	2.80*	-0.20	-1.74	-0.10	3.07	0.41
45	CMS 607 A x RHA 297	-0.56	-0.75	-0.60	-0.65	3.26*	1.55*	0.15	-0.78	-4.18	-6.09
46	CMS 852 A x 6D -1	-5.24*	-0.21	0.34	-0.48	0.74	0.06	0.19	0.10	-12.36*	1.82
47	CMS 852 A x RHA 271	4.53*	1.98*	0.95*	-0.51	-0.49	0.75	3.67*	-0.07	-7.23*	-0.51
48	CMS 852 A x HRHA 4-2	1.61*	-1.73	0.28	0.31	1.52*	0.69	-0.18	0.19	4.87	4.93*
49	CMS 852A x HRHA 5-3	-5.68*	-3.38	-0.49	0.00	-0.72	-0.50	-1.31	0.44	6.44*	0.30
50	CMS 852 A x RHA 297	4.77*	3.33*	-1.09	0.68	-1.06	-0.99	-2.37	-0.64	8.28*	-6.55
51	ARG 2A x 6D-1	3.15*	1.35*	1.47*	-0.30	-1.32*	0.31	0.55	-1.04	3.63	5.13*
52	ARG 2A x RHA 271	-5.48*	3.48*	-0.08	-0.15	-0.55	-0.07	-0.64	-0.15	-1.30	-2.65
53	ARG 2A x HRHA 4-2	2.13*	-0.30	0.28	0.34	-0.08	0.03	-0.44	0.95	1.45	1.15
54	ARG 2A x HRHA 5-3	-0.10	-2.55	-0.55	-0.59	0.76	0.54	-0.81	-0.40	-2.84	-2.31
55	ARG 2A x RHA 297	0.29	-1.98	-1.12	0.70	1.18*	-0.81	1.34	0.65	-0.95	-1.32
56	ARG 3A x 6D -1	5.52*	-1.14	-0.61	-0.12	1.79*	-0.14	-0.15	-0.04	2.69	-5.78
57	ARG 3A x RHA 271	-4.71*	0.78	-0.14	-0.09	1.57*	0.25	-0.78	-1.21	2.80	-5.39
58	ARG 3A x HRHA 4-2	4.11*	0.81	-0.04	0.48	0.03	-1.08	2.28	0.65	-3.12	3.69
59	ARG 3A x HRHA 5-3	-6.19*	-0.31	0.83*	-0.31	-0.09	0.43	-0.46	1.36*	-2.80	3.61
60	ARG 3A x RHA 297	1.27	-0.14	-0.04	0.03	-3.30*	0.54	-0.89	-0.75	0.43	3.86
61	ARG 6A x 6D-1	2.33*	0.66	0.81*	-1.92*	-2.79*	0.99	3.16*	-0.10	3.90	1.36
62	ARG 6A x RHA 271	-6.89*	2.12*	-0.25	4.62*	-0.07	1.74*	1.41	-1.47	5.13	3.14
63	ARG 6A x HRHA 4-2	11.65*	-1.73	-0.12	-0.81*	0.40	0.41	-1.20	-0.17	-1.58	-5.17
64	ARG 6A x HRHA 5-3	0.02	-1.78	-0.39	-1.24*	0.69	-2.11	-1.37	1.01*	-5.69*	-1.71
65	ARG 6 A x RHA 297	-7.12*	0.73	-0.06	-0.66	1.76*	-1.03	-2.00	0.73	-1.76	2.38

Sr.No.	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY(g)	OC (%)	HC (%)	%SF
66	DV 10 x 6D -1	-10.36*	1.04*	1.41*	-0.58	-0.23	1.57*	-0.65	0.83	-5.56	-20.43
67	DV 10 x RHA 271	14.01*	0.04	0.02	-0.62	0.74	1.06*	-0.68	-0.01	2.04	5.49*
68	DV 10 x HRHA 4-2	9.96*	-1.01	0.06	0.00	-1.48*	-0.77	-2.22	-0.41	0.46	-2.07
69	DV 10 x HRHA 5-3	-4.34*	-1.33	-0.45	-1.40*	-0.18	-1.00	-0.24	0.24	0.78	-0.76
70	DV -10 x RHA 297	-9.28*	1.25*	-1.05	2.59*	1.15*	-0.85	3.79*	-0.64	2.28	17.77*
71	CMS 207 A x 6D -1	-2.43*	-1.38	-1.41	2.60*	2.60*	-1.81	0.70	-0.62	-7.12*	2.49
72	CMS 207 A x RHA 271	-8.72	-0.86	0.00	-1.96*	2.88*	0.75	-1.19	0.64	-2.06	3.72
73	CMS 207 A x HRHA 4-2	-2.57*	-1.17	-0.14	-2.60*	-0.65	-0.15	0.22	-0.30	3.05	2.51
74	CMS 207 A x HRHA 5-3	3.93*	2.45 *	0.16	2.89*	-1.45*	0.96*	1.10	-0.88	6.06*	-0.62
75	CMS 207 A x RHA 297	9.79*	0.96	1.39*	-0.93*	-3.38*	0.24	-0.83	1.17*	0.07	-8.11
	SE	0.77	0.50	0.20	0.37	0.57	0.40	1.34	0.48	2.82	2.14
	CD at 5 %	1.53	1.00	0.40	0.74	1.13	0.80	2.67	0.96	5.61	4.26

Table 4.26 (contd.)

Sr.No.	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^1\text{g}^1$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
1	CMS 11 A x 6D-1	4.60*	0.06	4.90*	-2,356.1	4.43	-0.04	1.04*	4.86*	2.31*
2	CMS 11 A x RHA 271	-8.13	-0.15*	2.90	2,545.4*	4.14	-1.12	-1.23	2.08*	-0.93
3	CMS 11 A x HRHA 4-2	-1.27	-0.09	-3.06	-2,437.5	-6.01	0.46*	0.59*	-2.51	-0.06
4	CMS 11 A x HRHA 5-3	2.23	0.06	-2.33	2,604.0*	-4.29	0.18	-0.30	2.66*	-3.08
5	CMS 11 A x RHA 297	2.57	0.18*	-2.42	-355.8	1.72	0.54*	-0.10	-7.09	1.76*
6	CMS 17-A x 6D-1	1.74	-0.15*	1.83	508.8	4.24	-0.12	0.70*	-1.50	0.62
7	CMS 17-A x RHA 271	-0.47	-0.05	-1.06	1,461.7*	-9.88	0.25	0.81*	-2.96	3.67*
8	CMS 17 -A x HRHA 4-2	-0.56	-0.05	-0.45	1,393.7*	1.62	0.40*	-1.34	13.39*	-12.61
9	CMS 17 -A x HRHA 5-3	1.22	0.17*	0.50	-3,661.8	2.64	-0.26	0.15	-4.93	5.66*

Sr.No.	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
10	CMS 17 A x RHA 297	-1.93	0.08	-0.83	297.5	1.38	-0.27	-0.32	-4.00	2.66*
11	CMS 44 A x 6D-1	1.81	-0.06	-3.60	-2,467.6	-3.86	1.56*	0.93*	-4.65	1.41*
12	CMS 44 A x RHA 271	0.62	0.12*	1.73	-1,043.1	5.76	-1.48	-0.23	-4.37	6.10*
13	CMS 44 A x HRHA 4-2	-0.84	0.08	1.08	-1,245.7	8.55*	0.09	1.09*	-0.65	0.99*
14	CMS 44 A x HRHA 5-3	-0.91	0.01	-0.92	4,632.1*	-6.16	0.47*	-0.05	-0.05	0.26
15	CMS 44 A x RHA 297	-0.68	-0.15	1.72	124.4	-4.29	-0.65	-1.74	9.72*	-8.75
16	CMS 148 A x 6D-1	0.22	-0.05	1.57	-1,519.2	6.88*	-0.32	-0.96	9.79*	-7.70
17	CMS 148 A x RHA 271	1.85	-0.16*	1.59	-438.7	-0.14	-0.59	-0.44	15.26*	-14.12
18	CMS 148 A x HRHA 4-2	1.66	-0.01	0.36	-1,540.9	2.79	0.47*	0.32*	-14.02	14.78*
19	CMS 148 A x HRHA 5-3	-1.68	0.09	-1.34	3,581.9*	-2.41	0.70*	0.44*	0.09	-0.89
20	CMS 148 A x RHA 297	-2.05	0.13*	-2.19	-83.2	-7.12	-0.26	0.63*	-11.11	7.92*
21	CMSH 91 A x 6D-1	1.00	-0.11	5.01*	1,097.4*	-6.26	0.15	-1.05	3.70*	-5.06
22	CMSH 91 A x RHA 271	1.76	-0.06	-1.15	469.9	-9.79	-0.24	0.59*	-2.76	3.67*
23	CMSH 91 A x HRHA 4-2	-9.88	0.16*	-5.59	-34.1	-0.05	-0.59	0.90*	-2.63	5.81*
24	CMSH 91 A x HRHA 5-3	2.67	0.06	-2.64	-61.6	5.56	0.36*	0.11	1.16*	-1.57
25	CMSH 91 A x RHA 297	4.44*	-0.05	4.36*	-1,471.6	10.55*	0.32*	-0.55	0.54	-2.85
26	CMS 103 A x 6D-1	-0.35	0.06	-0.04	5,322.0*	6.74	-0.87	-0.87	-3.03	6.64*
27	CMS 103 A x RHA 271	1.34	0.07	0.02	-470.5	16.14*	-0.04	0.25	-6.76	6.12*
28	CMS 103 A x HRHA 4-2	1.93	-0.02	2.29	-806.7	4.81	-0.66	1.07*	-5.60	7.32*
29	CMS 103 A x HRHA 5-3	-3.10	-0.11	-0.58	-2,798.6	-10.84	0.52	-0.65	-0.56	0.45
30	CMS 103 A x RHA 297	0.19	0.05	-1.69	-1,246.3	-16.86	1.06*	0.21	15.95*	-20.52
31	CMS 234 A x 6D-1	1.13	0.12*	-3.85	1,181.4*	-10.54	0.67*	-0.24	4.53*	-2.26
32	CMS 234A x RHA 271	3.23	0.06	-0.52	-593.8	3.58	0.53*	-1.15	-7.83	9.08*
33	CMS 234 A x HRHA 4-2	1.71	0.01	3.96*	1,991.3*	2.23	-1.16	-0.79	3.71*	-11.12
34	CMS 234 A x HRHA 5-3	-2.30	0.02	1.38	-1,181.9	0.58	0.54*	-0.58	-3.83	-8.59
35	CMS 234 A x RHA 297	-3.76	-0.19	-0.97	-1,397.0	4.14	-0.59	2.76	3.41*	12.90*

Sr.No.	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
36	CMS 302 A x 6D-1	0.54	-0.09	-0.78	-7,269.9	8.50*	0.12	0.08	-1.32	3.94*
37	CMS 302 A x RHA 271	0.87	-0.03	-1.10	-577.7	1.56	-0.49	2.78*	11.87*	-19.53
38	CMS 302 A x HRHA 4-2	-3.01	0.01	2.87	6,174.7*	-9.67	-0.57	0.65*	-3.09	2.72*
39	CMS 302 A x HRHA 5-3	2.21	0.03	1.84	-1,774.8	3.93	0.57*	0.28	0.14	4.52*
40	CMS 302 A x RHA 297	-0.61	0.07	-2.84	3,447.8*	-4.32	0.38*	-3.79	-7.60	8.35*
41	CMS 607 A x 6D-1	-3.03	0.06	-1.15	-182.1	-4.11	0.81*	2.04*	-10.11	13.47*
42	CMS 607 A x RHA 271	0.97	0.17*	-0.08	1,668.4*	7.28*	-1.16	-1.50	-11.89	15.43*
43	CMS 607 A x HRHA 4-2	2.74	0.02	-1.35	96.8	0.59	2.33*	1.38*	8.24*	-21.23
44	CMS 607 A x HRHA 5-3	0.82	-0.21	2.26	-3,645.7	-6.72	-2.11	-1.67	1.62*	4.62*
45	CMS 607 A x RHA 297	-1.49	-0.05	0.31	2,062.6*	2.96	0.14	-0.25	12.15*	-12.29
46	CMS 852 A x 6D -1	4.06*	0.11	7.03*	-1,689.1	4.75	0.82*	-0.17	-4.15	3.16*
47	CMS 852 A x RHA 271	-1.57	0.15*	0.67	1,985.7*	1.16	0.50*	0.48*	-2.04	2.57*
48	CMS 852 A x HRHA 4-2	4.59*	0.03	4.16*	-1,123.2	2.13	-0.26	-0.85	-6.95	7.79*
49	CMS 852A x HRHA 5-3	0.34	-0.11	1.01	1,276.6*	-3.89	1.07*	-0.30	18.30*	-18.13
50	CMS 852 A x RHA 297	-7.43	-0.18*	-12.88	-450.1	-4.16	-2.13	0.84*	-5.15	4.62*
51	ARG 2A x 6D-1	1.77	-0.14*	2.12	2,256.6*	-5.16	0.27	-1.92	8.52*	-15.75
52	ARG 2A x RHA 271	-0.63	-0.01	0.34	-1,578.6	-2.87	-0.46	1.97*	-10.88	14.83*
53	ARG 2A x HRHA 4-2	-1.16	0.04	-0.08	630.8	0.69	0.34*	-2.05	13.52*	-9.41
54	ARG 2A x HRHA 5-3	-2.17	0.01	-0.12	-472.0	3.24	0.08	-1.19	-11.44	14.77*
55	ARG 2A x RHA 297	2.19	0.09	-2.25	-836.8	4.10	-0.23	3.19*	0.28	-4.44
56	ARG 3A x 6D -1	-3.81	0.19*	5.19*	-11.6	5.28	-0.77	-0.63	-1.88	-6.77
57	ARG 3A x RHA 271	1.12	0.03	-0.82	-2,063.5	0.40	1.73*	-4.33	0.19	-4.50
58	ARG 3A x HRHA 4-2	1.56	-0.21*	-3.63	-3,594.4	-5.69	1.99*	-0.87	9.03*	-6.10
59	ARG 3A x HRHA 5-3	-0.73	-0.05	-1.80	3,255.1*	-1.28	-1.36	4.09*	-1.42	3.35*
60	ARG 3A x RHA 297	1.87	0.04	1.06	2,414.4*	1.29	-1.59	1.74*	-5.92	14.02*
61	ARG 6A x 6D-1	-1.29	-0.12*	-6.39	2,525.8*	-7.20	-0.30	3.25*	-2.48	1.30*

Sr.No.	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
62	ARG 6A x RHA 271	0.37	-0.05	-5.25	845.0	-7.50	1.48*	3.91*	4.07*	-7.15
63	ARG 6A x HRHA 4-2	0.81	0.10	2.09	893.7	-7.65	-2.21	-2.53	-3.20	9.90*
64	ARG 6A x HRHA 5-3	0.28	0.04	4.94*	-26.4	11.81*	-0.49	-1.76	0.31	-4.80
65	ARG 6 A x RHA 297	-0.17	0.03	4.61*	-4,238.2	10.53*	1.53*	-2.87	1.30*	0.75*
66	DV 10 x 6D -1	-12.32	0.29*	-14.19	2,954.0*	2.11	-0.55	-1.79	-1.17	1.70*
67	DV 10 x RHA 271	0.94	-0.14*	1.72	962.5	-0.73	0.85*	-1.38	19.02*	-19.63
68	DV 10 x HRHA 4-2	1.56	-0.10	0.61	-1,067.4	5.02	0.41*	1.80*	-8.11	9.53*
69	DV 10 x HRHA 5-3	-0.89	-0.04	-1.21	-2,773.9	-3.26	-0.25	1.84*	-6.59	6.74*
70	DV -10 x RHA 297	10.72*	-0.01	13.07*	-75.3	-3.15	-0.46	-0.47	-3.16	1.66*
71	CMS 207 A x 6D -1	3.95*	-0.11	2.35	-350.6	-5.81	-1.42	-0.43	-1.11	2.99*
72	CMS 207 A x RHA 271	-2.27	0.03	1.04	-3,172.8	-9.12	0.25	-0.53	-3.00	4.39*
73	CMS 207 A x HRHA 4-2	0.17	0.04	-3.28	668.9	0.64	-1.05	0.64*	-1.11	1.69*
74	CMS 207 A x HRHA 5-3	2.03	0.02	-1.02	1,046.8*	11.07*	-0.01	-0.40	4.54*	-3.29
75	CMS 207 A x RHA 297	-3.88	0.01	0.91	1,807.7*	3.21	2.22	0.72*	0.67	-5.78
	SE	1.70	0.06	1.55	519.4	3.44	0.14	0.16	0.37	0.33
	CD at 5 %	3.38	0.12	3.08	1039.8	6.85	0.28	0.32	0.74	0.66

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

Table 4.27 Estimation of SCA effect for hybrids in E₂

Sr.No.	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
1	CMS 11 A x 6D-1	4.59*	0.50	-0.22	0.54	-1.48*	-1.18	-1.59	-0.66	-4.09*	3.58*
2	CMS 11 A x RHA 271	6.17*	0.45	0.02	0.94*	1.27*	0.97*	-1.26	0.50	2.42	0.31
3	CMS 11 A x HRHA 4-2	-5.72*	-0.27	-0.04	-1.60*	1.47*	0.24	-0.36	1.54*	2.96	-0.02
4	CMS 11 A x HRHA 5-3	0.57	0.22	1.45*	-1.47*	-1.18*	0.43	0.86	-1.84	-13.31*	-4.72
5	CMS 11 A x RHA 297	-5.62*	-0.90	-1.21	1.59*	-0.08	-0.45	2.34*	0.45	12.03*	0.85
6	CMS 17-A x 6D-1	11.65*	-0.03	0.86	0.62	-0.55	0.66	2.09*	1.40*	14.18*	-8.56
7	CMS 17-A x RHA 271	1.11	-0.55	-0.96	1.24*	-1.06*	0.68	1.46*	0.29	1.66	5.61*
8	CMS 17 -A x HRHA 4-2	-6.72*	-2.13	-1.19	0.34	-0.68	0.35	-2.75	-0.24	-8.24*	5.17*
9	CMS 17 -A x HRHA 5-3	-13.36*	4.28*	1.84*	-1.15*	0.44	-0.13	-0.03	-0.12	-0.10	0.64
10	CMS 17 A x RHA 297	7.32*	-1.56	-0.55	-1.05*	1.85*	-1.54	-0.77	-1.33	-7.49*	-2.85
11	CMS 44 A x 6D-1	6.37*	2.53*	2.04*	-0.71	0.50	1.43*	1.75*	-1.01	4.72*	5.15*
12	CMS 44 A x RHA 271	0.16	-1.46	-0.46	1.43*	2.62*	-0.68	0.14	-0.25	-3.73*	-6.91
13	CMS 44 A x HRHA 4-2	-1.47	-0.97	-0.58	0.53	-1.72*	0.32	0.69	-0.51	4.75*	-0.08
14	CMS 44 A x HRHA 5-3	-8.84*	0.11	-0.92	-2.69*	-1.89*	-1.19	-2.94	-0.43	-2.05	-0.95
15	CMS 44 A x RHA 297	3.77*	-0.20	-0.08	1.44*	0.49	0.13	0.37	2.20*	-3.69*	2.79*
16	CMS 148 A x 6D-1	1.45	-1.42	-1.14	0.28	1.14*	-0.60	-1.01	-0.36	-12.25*	-1.59
17	CMS 148 A x RHA 271	0.77	0.66	0.17	1.12*	1.99*	-0.18	1.28	-0.47	-12.21*	-0.10
18	CMS 148 A x HRHA 4-2	5.35*	3.21*	2.11*	-0.60	2.14*	-0.61	-1.94	-0.16	15.04*	1.48
19	CMS 148 A x HRHA 5-3	-4.89*	-2.84	-1.43	-1.23*	-3.71*	1.18*	1.78*	0.52	4.73*	-1.42
20	CMS 148 A x RHA 297	-2.68*	0.38	0.28	0.42	-1.56*	0.20	-0.12	0.48	4.70*	1.63
21	CMSH 91 A x 6D-1	-5.27*	-1.29	-0.22	0.96*	0.45	-0.98	-1.73	0.88	3.57*	-1.71
22	CMSH 91 A x RHA 271	2.05*	1.33*	0.22	-0.30	-0.10	0.07	1.71*	0.17	-5.46*	-1.04
23	CMSH 91 A x HRHA 4-2	-0.71	-0.25	-0.27	-0.45	-0.35	0.17	-0.94	-0.36	0.21	1.00
24	CMSH 91 A x HRHA 5-3	4.65*	-0.57	-0.11	-1.02*	-1.18*	-0.27	0.58	0.29	2.11	2.05
25	CMSH 91 A x RHA 297	-0.74	0.78	0.39	0.81*	1.18*	1.02*	0.39	-0.98	-0.43	-0.31

Sr.No.	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
26	CMS 103 A x 6D-1	-7.15*	1.98*	0.44	0.21	-0.67	1.22*	0.94	0.50	1.86	2.08*
27	CMS 103 A x RHA 271	12.97*	-1.41	0.05	1.28*	-0.33	-0.79	-1.27	0.96*	0.77	-1.15
28	CMS 103 A x HRHA 4-2	1.21	-0.25	0.03	-1.00*	-3.63*	-0.79	0.52	0.70	7.29*	-1.30
29	CMS 103 A x HRHA 5-3	-6.56*	-1.04	-0.05	0.21	2.89*	0.30	-0.10	-0.38	-1.49	1.91
30	CMS 103 A x RHA 297	-0.48	0.72	-0.47	-0.71	1.75*	0.06	-0.09	-1.79	-8.43*	-1.54
31	CMS 234 A x 6D-1	15.79*	-0.25	-0.37	-1.77*	-2.86*	-1.16	0.03	-0.26	1.26	4.73*
32	CMS 234A x RHA 271	-11.49*	-1.57	-0.53	-2.13*	-1.03*	-0.44	-0.12	-0.30	2.60	1.93
33	CMS 234 A x HRHA 4-2	-16.32*	0.05	-0.65	-0.90	-0.09	0.17	1.47*	-0.43	-2.86	3.01*
34	CMS 234 A x HRHA 5-3	8.31*	2.27*	1.61*	4.79*	5.46*	1.95*	-0.82	1.52*	-1.04	-2.41
35	CMS 234 A x RHA 297	3.72*	-0.51	-0.05	0.02	-1.48*	-0.52	-0.56	-0.52	0.04	-7.27
36	CMS 302 A x 6D-1	-18.28*	-0.83	-0.35	-1.49*	-0.63	-0.22	-0.16	-1.19	-2.23	1.79
37	CMS 302 A x RHA 271	-9.89*	-1.29	-0.38	-1.78*	-2.99*	-0.50	-0.46	1.27*	-0.78	1.98
38	CMS 302 A x HRHA 4-2	1.75*	2.87*	0.87*	-2.19*	-3.52*	0.97	2.09*	1.24*	0.13	-1.30
39	CMS 302 A x HRHA 5-3	12.44*	-0.52	-0.27	5.71	10.40*	0.45	-0.28	-0.28	-1.25	-0.06
40	CMS 302 A x RHA 297	13.98*	-0.23	0.13	-0.26	-3.26*	-0.69	-1.20	-1.05	4.14*	-2.41
41	CMS 607 A x 6D-1	1.03	0.58	0.05	9.55*	4.83*	0.48	0.22	-0.33	-3.27	-1.52
42	CMS 607 A x RHA 271	10.35*	1.53*	1.22*	-1.52*	-2.08*	0.86	0.71	0.33	5.20*	1.41
43	CMS 607 A x HRHA 4-2	-9.01*	-0.85	-1.20	-3.25*	-0.70	0.20	1.67*	-1.06	-4.61*	0.45
44	CMS 607 A x HRHA 5-3	8.28*	-2.04	-0.54	-3.12*	-1.55*	-1.41	-3.47	0.12	2.68	0.47
45	CMS 607 A x RHA 297	-10.64*	0.78	0.47*	-1.65*	-0.50	-0.12	0.87	0.95	0.00	-0.82
46	CMS 852 A x 6D -1	4.87*	-1.53	-0.50	-1.88*	0.17	-0.18	-0.31	-0.98	-0.31	-6.83
47	CMS 852 A x RHA 271	-10.35*	2.42*	0.74*	-2.34*	-0.04	0.48	2.47*	-1.35	4.14*	2.04
48	CMS 852 A x HRHA 4-2	9.23*	-1.29	-0.28	-2.61*	-0.07	1.25*	-0.48	0.46	-1.03	2.93*
49	CMS 852A xHRHA 5-3	-3.61*	0.59	-0.22	6.66*	0.60	-1.03	-0.82	-0.23	-2.72	1.09
50	CMS 852 A x RHA 297	-0.14	-0.19	0.25	0.18	-0.67	-0.51	-0.86	2.10*	-0.09	0.77
51	ARG 2A x 6D-1	-3.55*	-1.21	-0.42	-3.73*	-0.68*	-1.06	0.37	-1.54	2.36	3.21*

Sr.No.	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
52	ARG 2A x RHA 271	14.31*	0.87	0.22	3.56*	-0.09	0.23	-2.54	0.62	2.16	-7.31
53	ARG 2A x HRHA 4-2	0.81	-0.17	-0.27	5.18*	3.33*	0.23	1.48*	-0.54	-8.65*	2.65*
54	ARG 2A x HRHA 5-3	0.04	-0.09	-0.14	-2.98*	-2.33*	0.42	1.33	1.74*	6.62*	0.78
55	ARG 2A x RHA 297	-11.62*	0.60	0.60*	-2.02*	-0.24	0.18	-0.63	-0.27	-2.50	0.68
56	ARG 3A x 6D -1	-3.15*	-0.25	0.17	0.61	-0.04	0.48	-1.04	0.94	-6.14*	-0.99
57	ARG 3A x RHA 271	-2.29*	-0.23	0.31	0.25	0.56	0.30	-1.07	-0.06	7.67*	-0.76
58	ARG 3A x HRHA 4-2	3.35*	-0.95	0.09	-0.57	1.31*	-0.99	-0.90	0.44	-3.24	2.36*
59	ARG 3A x HRHA 5-3	-1.49	2.67*	-0.22	-0.66	-2.79*	-0.54	2.77*	-0.51	3.66*	-2.15
60	ARG 3A x RHA 297	3.58*	-1.24	-0.35	0.36	0.96*	0.75	0.25	-0.81	-1.95	1.53
61	ARG 6A x 6D-1	-1.65	2.03*	0.26	-0.37	-0.98*	0.31	1.51*	2.23*	-0.43	2.13*
62	ARG 6A x RHA 271	-9.67*	-0.62	-0.06	-1.62*	0.84*	-0.80	-0.85	-1.11	-3.48	2.66*
63	ARG 6A x HRHA 4-2	3.17*	-0.13	-0.09	4.44*	1.62*	-0.87	-0.14	0.63	2.34	-8.12
64	ARG 6A x HRHA 5-3	8.40*	-0.85	-0.26	-0.98	-1.99*	-0.18	-0.15	-1.09	-3.83*	-0.46
65	ARG 6 A x RHA 297	-0.26	-0.43	0.15	-1.47*	0.51	1.54*	-0.37	-0.66	5.40*	3.80*
66	DV 10 x 6D -1	-0.80	0.54	-0.01	-2.58*	-0.94*	0.78*	-0.26	0.59	6.57*	-3.75
67	DV 10 x RHA 271	3.45*	0.75	0.00	-2.31*	-0.86*	-0.53	0.65	1.15*	-7.57*	0.68
68	DV 10 x HRHA 4-2	7.96*	0.51	-0.09	4.11*	-0.01	-0.13	-0.13	-0.11	8.06*	0.62
69	DV 10 x HRHA 5-3	-2.35*	-1.74	-0.33	-2.97*	-0.03	-0.17	-0.61	-0.66	3.14	1.65
70	DV 10 x RHA 297	-8.27*	-0.06	0.44	3.75*	1.84*	0.05	0.35	-0.97	-10.20*	0.80
71	CMS 207 A x 6D -1	-5.92*	-1.37	-0.58	-0.23	1.76*	0.03	-0.82	-0.22	-5.82*	2.29*
72	CMS 207 A x RHA 271	-7.67*	-0.89	-0.58	2.16*	1.29*	0.35	-0.85	-1.76	6.62*	0.64
73	CMS 207 A x HRHA 4-2	7.11*	0.66	1.57*	-1.43*	0.89*	-0.51	-0.28	-1.62	-12.14*	-8.85
74	CMS 207 A x HRHA 5-3	-1.60	-0.46	-0.41	0.91*	-3.14*	0.21	1.92*	1.40*	2.86	3.56*
75	CMS 207 A x RHA 297	8.08*	2.06*	0.00	-1.42*	-0.80*	-0.07	0.02	2.19*	8.48*	2.35*
	SE	0.85	0.50	0.23	0.38	0.34	0.38	0.69	0.48	1.74	1.05
	CD at 5 %	1.69	1.00	0.46	0.76	0.68	0.76	1.37	0.96	3.46	2.09

Table 4.27 (contd.)

Sr.No.	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^1\text{g}^1$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
1	CMS 11 A x 6D-1	-1.84	0.12*	-1.27	2753.88*	4.65*	0.41*	-1.38	1.34*	1.59*
2	CMS 11 A x RHA 271	0.18	0.09*	0.78	-2676.32	9.53*	1.67*	-1.35	-1.63	2.13*
3	CMS 11 A x HRHA 4-2	0.75	-0.03	-0.87	-1821.15	-0.52	-0.34	0.81*	-1.60	7.59*
4	CMS 11 A x HRHA 5-3	0.35	-0.21*	1.69	1149.34*	-5.18	-0.70	1.50*	3.39*	-7.71
5	CMS 11 A x RHA 297	0.56	0.03*	-0.33	594.25*	-8.48	-1.04	0.42*	-1.49	-3.61
6	CMS 17-A x 6D-1	-2.06	0.04*	2.71*	865.54*	-9.02	0.39*	1.07*	11.57*	-9.01
7	CMS 17-A x RHA 271	-0.26	0.05*	-1.52	1871.34*	2.90*	-0.64	-2.13	13.53*	-7.37
8	CMS 17 -A x HRHA 4-2	3.41*	-0.03	-1.41	-753.81	8.58*	0.24*	-0.74	-5.70	0.03
9	CMS 17 -A x HRHA 5-3	0.05	0.03*	-2.39	-738.66	-0.34	0.59*	0.63*	-8.67	8.93*
10	CMS 17 A x RHA 297	-1.14	-0.09*	2.61*	-1244.41	-2.12	-0.58	1.18*	-10.73	7.41*
11	CMS 44 A x 6D-1	-0.87	-0.02	-0.69	-700.92	4.98*	-0.13	-0.28	0.80*	-3.69
12	CMS 44 A x RHA 271	-1.19	0.07*	2.04*	-4097.12	3.57*	0.10	0.39*	-2.29	6.83*
13	CMS 44 A x HRHA 4-2	1.91	0.00	-0.45	1079.39*	-4.24	0.16	-0.67	-2.13	-8.40
14	CMS 44 A x HRHA 5-3	1.04	-0.07*	0.53	1269.88*	-2.45	1.01*	-0.24	-0.06	-1.73
15	CMS 44 A x RHA 297	-0.90	0.01	-1.42	2448.79*	-1.86	-1.14	0.80*	3.67*	6.99*
16	CMS 148 A x 6D-1	-1.01	-0.16*	0.66	-1821.26	17.04*	0.30*	1.66*	9.53*	5.65*
17	CMS 148 A x RHA 271	1.96	0.04	0.43	1892.54*	10.09*	-0.82	-2.22	-11.37	-3.98
18	CMS 148 A x HRHA 4-2	-1.68	0.14*	-5.97	-685.61	-5.21	-0.08	0.20	-5.41	-5.35
19	CMS 148 A x HRHA 5-3	-0.91	-0.03	3.75*	-755.46	-7.83	1.37*	0.38	2.71*	-2.64
20	CMS 148 A x RHA 297	1.64	0.01	1.13	1369.79*	-14.10	-0.77	-0.03	4.55*	6.33*
21	CMSH 91 A x 6D-1	-1.59	0.05*	-4.51	1600.14*	-12.83	0.73*	0.01	0.51*	13.20*
22	CMSH 91 A x RHA 271	-0.08	0.15*	0.49	165.94*	-15.64	-0.72	-1.01	5.26*	3.66*
23	CMSH 91 A x HRHA 4-2	1.02	0.04*	5.21*	789.79*	5.01*	0.17	0.44*	-9.60	-15.83
24	CMSH 91 A x HRHA 5-3	3.04*	-0.17*	-0.56	115.61*	10.81*	1.01*	1.51*	4.32*	6.12*
25	CMSH 91 A x RHA 297	-2.39	-0.07*	-0.63	-2671.48	12.66*	-1.19	-0.95	-0.49	-7.15
26	CMS 103 A x 6D-1	1.17	0.04*	-3.89	-516.12	3.97*	0.44*	-1.70	12.00*	2.98*
27	CMS 103 A x RHA 271	1.66	-0.05*	4.69*	3362.34*	1.88*	-0.62	0.51*	4.25*	10.55*

Sr.No.	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
28	CMS 103 A x HRHA 4-2	-2.36	-0.10*	-3.28	97.52*	-1.25	0.83*	-0.29	-2.12	4.02*
29	CMS 103 A x HRHA 5-3	0.49	0.02	1.15	-886.99	-2.20	-0.97	0.24*	-4.94	-4.13
30	CMS 103 A x RHA 297	-0.96	0.10*	1.33	-2056.75	-2.41	0.31*	1.23*	-9.19	-13.41
31	CMS 234 A x 6D-1	-8.06	0.12*	-5.06	221.34*	5.53*	0.47*	-1.66	-14.09	-22.66
32	CMS 234A x RHA 271	4.26*	-0.03	5.34*	2018.14*	2.22*	0.33*	-2.41	-0.27	-3.39
33	CMS 234 A x HRHA 4-2	0.43	0.03	-3.05	30.65*	-5.42	-0.54	4.47*	-2.20	7.22*
34	CMS 234 A x HRHA 5-3	0.93	0.05*	-2.00	373.14*	-2.35	0.70*	-3.34	5.90*	9.03*
35	CMS 234 A x RHA 297	2.44	-0.13*	4.76*	-2643.28	0.01	-0.97	2.93*	10.66*	9.81*
36	CMS 302 A x 6D-1	1.20	-0.22*	5.59*	-3251.26	-5.32	0.96*	2.18*	1.22*	13.30*
37	CMS 302 A x RHA 271	2.86	-0.13*	-1.40	108.54*	-4.28	1.29*	4.03*	6.24*	4.38*
38	CMS 302 A x HRHA 4-2	-1.91	0.03*	-2.38	-120.61	8.00*	-0.66	-0.97	5.18*	-3.53
39	CMS 302 A x HRHA 5-3	-0.60	0.17*	0.70	900.54*	-2.55	-0.76	-1.90	-6.94	-11.97
40	CMS 302 A x RHA 297	-1.56	0.17*	-2.51	2362.79*	4.14*	-0.83	-3.34	-5.70	-2.19
41	CMS 607 A x 6D-1	-1.91	0.24*	-3.96	438.68*	2.78*	-0.56	3.69*	-10.12	13.56*
42	CMS 607 A x RHA 271	2.46	-0.07*	3.05*	751.14*	3.91*	0.63*	-0.19	-8.26	7.17*
43	CMS 607 A x HRHA 4-2	2.58	0.15*	4.69*	-1397.35	-6.64	1.74*	0.21	4.85*	4.52*
44	CMS 607 A x HRHA 5-3	-2.78	-0.10*	-2.97	-153.86	-5.87	-1.34	-2.20	11.74*	-6.51
45	CMS 607 A x RHA 297	-0.35	-0.21*	-0.81	361.39*	5.81*	-0.47	-1.50	1.80*	-18.74
46	CMS 852 A x 6D -1	0.05	-0.14*	-0.40	630.88*	-3.19	0.78*	0.12	-12.20	-15.84
47	CMS 852 A x RHA 271	0.30	-0.15*	0.47	1488.34*	2.65*	0.98*	-1.07	4.82*	-2.63
48	CMS 852 A x HRHA 4-2	-0.51	0.05*	-1.52	1917.85*	6.75*	-1.56	-1.39	-1.12	4.24*
49	CMS 852A x HRHA 5-3	-0.62	0.16*	3.82*	-3624.32	-9.00	-1.72	2.22*	-1.17	7.74*
50	CMS 852 A x RHA 297	0.79	0.08*	-2.37	-412.75	2.79*	1.52*	0.11	9.67*	6.49*
51	ARG 2A x 6D-1	0.01	0.09*	6.33*	-1110.86	6.87*	-0.46	4.73*	7.42*	2.60*
52	ARG 2A x RHA 271	-2.33	-0.21	-4.19	-3082.06	-3.85	-0.61	1.07*	-0.58	-6.03
53	ARG 2A x HRHA 4-2	3.30*	0.18*	1.63	2529.79*	0.32	-1.50	-2.37	4.49*	-1.28
54	ARG 2A x HRHA 5-3	0.77	-0.09*	1.65	1044.28*	-0.23	0.41*	-3.26	-4.65	2.32*
55	ARG 2A x RHA 297	-1.75	0.03*	-5.42	618.86*	-3.11	2.15*	-0.16	-6.67	2.39*

Sr.No.	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
56	ARG 3A x 6D -1	-0.10	0.28*	-2.48	-2180.32	-11.88	-1.51	-3.84	-6.30	-0.70
57	ARG 3A x RHA 271	1.54	0.01	2.38*	1949.14*	-8.19	0.65*	6.86*	-8.37	-6.89
58	ARG 3A x HRHA 4-2	-2.39	-0.09*	1.66	-1182.35	3.45*	1.16*	-0.57	-2.46	-6.55
59	ARG 3A x HRHA 5-3	3.06*	-0.13*	1.45	1571.47*	9.23*	-0.23	-0.72	2.48*	4.24*
60	ARG 3A x RHA 297	-2.11	-0.07*	-3.01	-157.95	7.39*	-0.07	-1.73	14.66*	9.90*
61	ARG 6A x 6D-1	-1.81	0.06*	-1.17	-2849.59	-0.40	-2.54	-3.11	-0.73	4.64*
62	ARG 6A x RHA 271	0.95	0.00	0.98	-3274.79	-0.10	-0.82	0.13	0.55*	6.96*
63	ARG 6A x HRHA 4-2	-5.79	-0.04*	-3.07	1473.72*	-5.70	1.37*	0.11	11.59*	7.70*
64	ARG 6A x HRHA 5-3	4.85*	0.09*	-1.28	3684.21*	5.44*	3.82*	3.47*	-3.77	-9.41
65	ARG 6 A x RHA 297	1.80	-0.11*	4.53*	966.46*	0.76	-1.82	-0.59	-7.64	-9.89
66	DV 10 x 6D -1	5.52*	-0.26*	2.49*	2022.28*	9.13*	-0.10	-1.61	6.21*	-5.05
67	DV 10 x RHA 271	4.74*	-0.09*	0.74	2522.41*	2.03*	-0.54	-1.32	-0.65	-4.75
68	DV 10 x HRHA 4-2	8.61*	-0.21*	15.23*	1233.25*	-5.15	1.32*	1.49*	1.33*	5.92*
69	DV 10 x HRHA 5-3	-18.50	0.43*	-15.18	-5727.26	-3.02	-0.80	1.69*	-4.05	2.31*
70	DV -10 x RHA 297	-0.37	0.13*	-3.28	-50.68	-3.00	0.12	-0.25	-2.85	1.57*
71	CMS 207 A x 6D -1	11.29*	-0.23*	5.66*	3897.61*	-12.31	0.80*	0.12	-7.15	-0.58
72	CMS 207 A x RHA 271	-17.06	0.31*	-14.26	-2999.59	-6.72	-0.89	-1.28	-1.22	-6.63
73	CMS 207 A x HRHA 4-2	-7.37	-0.08*	-6.41	-3191.08	2.00*	-2.29	-0.74	4.89*	-0.29
74	CMS 207 A x HRHA 5-3	8.83*	-0.14*	9.62*	1778.08*	15.52*	-2.40	0.04	3.72*	3.39*
75	CMS 207 A x RHA 297	4.31*	0.14*	5.40*	514.99*	1.50	4.78*	1.86*	-0.24	4.11*
	SE	1.52	0.02	0.90	10.18	0.94	0.10	0.12	0.19	0.15
	CD at 5 %	3.02	0.04	1.79	20.26	1.87	0.20	0.24	0.38	0.30

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

Table 4.28. Estimation of SCA effects for hybrids in E₃

Sr. No	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY(g)	OC (%)	HC (%)	%SF
1	CMS 11 A x 6D-1	3.38	-1.53	-0.40	0.20	-3.18*	0.94*	-5.28	-1.22	-3.71*	4.24*
2	CMS 11 A x RHA 271	-5.90	0.32	-0.88	-1.98*	-2.09*	-0.59	-1.44	0.37	5.12*	-0.44
3	CMS 11 A x HRHA 4-2	-6.09	0.21	0.56	-0.49	1.16*	0.78	3.46*	-0.62	-6.03*	10.62*
4	CMS 11 A x HRHA 5-3	-0.46	2.54*	-0.28	1.23	1.98*	-0.73	8.31*	0.95*	-2.48	-21.04
5	CMS 11 A x RHA 297	9.08*	-1.54	1.00*	1.04	2.13*	-0.40	-5.04	0.52	7.10*	6.61*
6	CMS 17-A x 6D-1	0.14	-0.47	-0.16	1.53	3.76*	-0.48	-2.73	0.97*	0.89	15.19*
7	CMS 17-A x RHA 271	-11.74*	1.39*	0.15	2.95*	2.84*	1.32*	5.14*	-0.54	3.05	15.52*
8	CMS 17 -A x HRHA 4-2	11.27*	0.08	-0.07	1.97	1.76*	0.86*	-0.50	0.06	-1.84	-30.18
9	CMS 17 -A x HRHA 5-3	9.96*	-2.12	0.25	-3.76*	-3.42*	-0.02	-5.07	0.07	-5.69*	2.60*
10	CMS 17 A x RHA 297	-9.63*	1.13	-0.17	-2.69*	-4.93*	-1.69	3.16*	-0.56	3.59*	-3.12
11	CMS 44 A x 6D-1	-3.31	-1.77	-0.03	-0.46	-3.38*	0.28	-0.10	-0.93	6.28*	-0.61
12	CMS 44 A x RHA 271	-0.13	-2.59	-1.21	-1.86*	-0.62	-0.19	-7.30	0.53	-3.38*	6.44*
13	CMS 44 A x HRHA 4-2	-6.52	2.17*	-1.44	-1.01	1.96*	-0.65	5.33*	-0.10	1.79	1.25
14	CMS 44 A x HRHA 5-3	6.64	1.04	1.82*	2.48*	1.11*	0.38	-3.05	1.77*	-5.05*	-17.98
15	CMS 44 A x RHA 297	3.32	1.16	0.87*	0.85	0.93	0.17	5.12*	-1.26	0.37	10.90*
16	CMS 148 A x 6D-1	-5.33	-1.15	0.48	1.57	1.49 *	-0.23	-6.82	-0.70	3.63*	-18.19
17	CMS 148 A x RHA 271	2.86	-1.36	-0.31	-1.84*	-3.09*	-0.29	-4.20	-0.01	3.12	14.34*
18	CMS 148 A x HRHA 4-2	10.74*	-0.20	-0.26	-1.88*	1.16*	0.58	1.95	-1.67	0.16	-3.04
19	CMS 148 A x HRHA 5-3	-7.24	1.40*	-0.34	1.81	3.31*	0.17	4.17*	0.80	-4.33*	10.09*
20	CMS 148 A x RHA 297	-1.03	1.32	0.44	0.34	-2.87*	-0.23	4.90*	1.57*	-2.58	-3.20
21	CMSH 91 A x 6D-1	-5.22	4.31*	0.22	3.61*	-0.38	0.28	9.81*	1.40*	-2.89	-29.88
22	CMSH 91 A x RHA 271	4.90	-0.71	2.27*	0.55	3.04*	-0.65	-2.03	0.23	-0.37	5.16*
23	CMSH 91 A x HRHA 4-2	7.64*	-1.95	-0.02	-0.86	-2.71*	0.42	-4.41	1.16*	-0.14	0.83
24	CMSH 91 A x HRHA 5-3	1.54	-0.88	-1.43	-0.88	3.11*	0.24	-2.29	-1.00	3.43*	13.75*
25	CMSH 91 A x RHA 297	-8.86*	-0.76	-1.05	-2.43*	-3.07*	-0.29	-1.09	-1.80	-0.03	10.14*
26	CMS 103 A x 6D-1	7.53*	-1.24	0.39	0.74	1.36*	0.00	-0.25	-0.93	-1.60	3.13*
27	CMS 103 A x RHA 271	-11.29*	-0.05	-0.99	-0.97	-5.22*	-0.07	-1.28	1.39*	6.46*	7.95*

Sr. No	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY(g)	OC (%)	HC (%)	%SF
28	CMS 103 A x HRHA 4-2	-6.01	1.10	0.78*	-0.40	2.02*	-0.16	4.96*	-0.50	-1.70	17.07*
29	CMS 103 A x HRHA 5-3	8.08*	0.97	0.17	0.37	-1.82*	0.26	-1.00	-0.56	2.32	14.33*
30	CMS 103 A x RHA 297	1.69	-0.78	-0.35	0.27	3.67*	-0.04	-2.43	0.60	-5.47*	-42.48
31	CMS 234 A x 6D-1	13.55*	2.92*	0.33	-1.11	-0.18	0.41	7.40*	0.46	0.99	6.52*
32	CMS 234A x RHA 271	-1.26	0.51	1.55*	3.17*	1.58*	0.28	1.21	-0.05	-3.32*	-33.15
33	CMS 234 A x HRHA 4-2	-16.92*	-2.07	0.46	4.90*	0.16	0.85*	-2.97	0.19	9.41*	9.72*
34	CMS 234 A x HRHA 5-3	-1.69	-2.47	-0.99	-2.69*	-1.69*	0.58	-3.22	-0.44	-0.19	11.98*
35	CMS 234 A x RHA 297	6.32	1.12	-1.34	-4.28*	0.13	-2.13	-2.42	-0.17	-6.89*	4.93*
36	CMS 302 A x 6D-1	-7.50*	0.31	0.86*	-2.01*	-0.04	-1.39	-1.28	-1.28	4.15*	16.83*
37	CMS 302 A x RHA 271	16.95*	1.29	0.17	-1.85*	0.71	0.21	8.06*	0.31	6.15*	4.17*
38	CMS 302 A x HRHA 4-2	-9.17*	-0.68	-0.02	0.26	-0.04	-0.21	-3.00	-0.08	-5.27*	8.33*
39	CMS 302 A x HRHA 5-3	-8.61*	-0.35	-0.23	1.53	0.11	0.14	-1.70	0.16	-4.89*	-39.59
40	CMS 302 A x RHA 297	8.33*	-0.56	-0.78	2.07*	-0.73	1.24*	-2.07	0.89*	-0.13	10.26*
41	CMS 607 A x 6D-1	-4.91	-0.71	0.56	1.21	0.89	1.02*	-1.18	-0.03	4.21*	20.39*
42	CMS 607 A x RHA 271	6.27	1.55*	-0.53	-0.82	-0.69	0.22	2.60*	1.07*	-1.37	-29.71
43	CMS 607 A x HRHA 4-2	1.42	1.50*	-0.02	-4.25*	-0.78	0.13	3.20*	1.87*	3.52*	11.68*
44	CMS 607 A x HRHA 5-3	8.64*	-0.90	0.57	2.67*	0.04	-0.08	-1.83	-1.46	0.36	2.28*
45	CMS 607 A x RHA 297	-11.42*	-1.44	-0.58	1.20	0.53	-1.29	-2.79	-1.46	-6.72*	-4.64
46	CMS 852 A x 6D -1	6.31	1.89*	-0.92	0.79	-0.58	-0.79	3.22*	-0.21	2.29	-37.00
47	CMS 852 A x RHA 271	-2.43	-0.05	0.76*	-2.06*	0.18	-0.15	-0.48	0.01	-6.69*	10.08*
48	CMS 852 A x HRHA 4-2	10.38*	-0.03	0.34	-2.46*	0.09	0.25	0.11	-1.35	-7.66*	8.01*
49	CMS 852A x HRHA 5-3	-10.06*	0.10	-0.21	-2.74*	0.24	0.38	0.61	0.29	10.99*	13.25*
50	CMS 852 A x RHA 297	-4.19	-1.91	0.04	6.48*	0.07	0.31	-3.45	1.26*	1.07	5.64*
51	ARG 2A x 6D-1	-6.38	1.71*	-0.70	-0.08	0.69	-0.44	0.81	-0.37	-1.59	18.08*
52	ARG 2A x RHA 271	5.27	-0.51	0.51	0.58	1.44*	-0.37	-1.72	-1.94	-2.35	10.49*
53	ARG 2A x HRHA 4-2	-2.92	0.38	-0.11	0.45	-2.64*	-0.83	-0.41	0.26	1.36	-27.90
54	ARG 2A x HRHA 5-3	-1.29	-0.55	0.14	-1.85*	-2.82*	0.69	1.21	-0.03	-2.57	5.87*
55	ARG 2A x RHA 297	5.32	-1.03	0.16	0.90	3.33*	0.95*	0.11	2.07*	5.14*	-6.54

Sr. No	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY(g)	OC (%)	HC (%)	%SF
56	ARG 3A x 6D -1	-1.62	-0.53	0.26	-1.10	-0.04	0.35	0.90	-0.24	0.74	10.62*
57	ARG 3A x RHA 271	9.23*	0.79	-0.22	-0.04	0.04	0.42	1.34	1.02*	-1.79	4.73*
58	ARG 3A x HRHA 4-2	-0.16	-0.39	0.09	-0.65	-0.38	0.19	-2.58	0.19	-3.78*	-11.56
59	ARG 3A x HRHA 5-3	-3.33	0.14	-0.12	1.67	0.11	-0.95	-1.29	0.20	1.08	-2.95
60	ARG 3A x RHA 297	-4.12	0.00	-0.01	0.13	0.27	-0.02	1.64	-1.17	3.76*	-0.85
61	ARG 6A x 6D-1	-10.23*	-0.37	-0.72	-2.67*	-0.24	0.35	0.35	-0.97	2.65	2.80*
62	ARG 6A x RHA 271	-3.11	1.15	-0.57	2.60*	-0.16	-1.02	1.28	-0.41	-1.34	-13.98
63	ARG 6A x HRHA 4-2	1.70	-0.43	0.94*	-1.80	0.09	0.82*	-3.36	1.43*	2.53	6.51*
64	ARG 6A x HRHA 5-3	6.66	-0.16	0.12	0.94	0.24	-0.29	-0.44	0.94*	-2.69	3.88*
65	ARG 6 A x RHA 297	5.00	-0.18	0.24	0.93	0.07	0.14	2.17	-1.00	-1.15	0.78
66	DV 10 x 6D -1	14.59*	-0.04	-0.03	0.41	1.09*	0.40	-0.47	1.65*	-2.84	0.82
67	DV 10 x RHA 271	-10.42*	-0.12	0.19	3.74*	1.84*	1.10*	1.01	-1.53	-3.77*	-4.49
68	DV 10 x HRHA 4-2	2.59	0.64	-0.10	2.88*	-0.91	-2.13	-0.62	-0.42	3.45*	-3.75
69	DV 10 x HRHA 5-3	-7.05	-0.23	-0.05	-0.09	-0.76	-0.24	2.20*	-1.48	-0.94	3.81*
70	DV -10 x RHA 297	0.29	-0.24	0.00	-6.94*	-1.27*	0.86*	-2.13	1.78*	4.10*	3.62*
71	CMS 207 A x 6D -1	-0.99	-3.32	-0.10	-2.63*	-1.24*	-0.72	-4.36	2.40*	-13.20*	-12.95
72	CMS 207 A x RHA 271	0.79	-1.60	-0.89	-2.16*	0.18	-0.22	-2.20	-0.47	0.47	2.89*
73	CMS 207 A x HRHA 4-2	2.07	-0.31	-1.11	3.34*	-0.91	-0.91	-1.16	-0.40	4.21*	2.39
74	CMS 207 A x HRHA 5-3	-1.77	1.49*	0.58	-0.69	0.24	-0.56	3.40*	-0.23	10.67*	-0.27
75	CMS 207 A x RHA 297	-0.10	3.74*	1.53*	2.15*	1.73*	2.41*	4.32*	-1.30	-2.15	7.95*
	SE	3.74	0.69	0.32	0.92	0.50	0.35	1.10	0.44	1.60	1.38
	CD at 5 %	7.44	1.37	0.64	1.83	1.00	0.70	2.19	0.88	3.18	2.75

Table 4.28 (contd.)

Sr.No	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^1\text{g}^1$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
1	CMS 11 A x 6D-1	4.60*	-0.33*	5.45*	805.54*	3.83*	-0.06	-0.11	9.31*	-2.63
2	CMS 11 A x RHA 271	9.80*	-0.22*	9.35*	2741.76*	5.84*	-0.07	-0.50	-0.43	0.34
3	CMS 11 A x HRHA 4-2	-24.68	0.96*	-23.01	-5712.95	-8.49	-0.06	1.32*	-7.20	6.98*
4	CMS 11 A x HRHA 5-3	3.67*	-0.13*	3.98*	1264.10*	1.12	0.68*	0.23	-0.37	-3.63
5	CMS 11 A x RHA 297	6.60*	-0.27*	4.22*	901.54*	-2.30	-0.49	-0.95	-1.32	-1.06
6	CMS 17-A x 6D-1	15.82*	-0.14*	14.44*	6507.94*	-0.52	0.12	-1.20	2.07*	-3.70
7	CMS 17-A x RHA 271	-29.76	0.64*	-30.22	-2394.50	-14.55	-0.22	-0.64	-3.71	2.91*
8	CMS 17 -A x HRHA 4-2	2.48	-0.02	3.61*	-4737.88	-2.70	-0.59	2.68*	-3.70	-4.05
9	CMS 17 -A x HRHA 5-3	-0.39	-0.11*	-0.92	-211.50	9.92*	0.89*	-1.13	7.36*	0.98*
10	CMS 17 A x RHA 297	11.85*	-0.36*	13.10*	835.94*	7.85*	-0.20	0.29*	-2.02	3.86*
11	CMS 44 A x 6D-1	9.09*	-0.23*	10.54*	1623.48*	8.18*	0.42	-0.39	9.48*	-11.25
12	CMS 44 A x RHA 271	8.86*	-0.25*	6.98*	-372.63	4.82*	-0.04	0.15	-3.90	2.50*
13	CMS 44 A x HRHA 4-2	2.82	-0.04	1.67	501.32*	-4.06	-0.16	-0.23	0.03	0.36
14	CMS 44 A x HRHA 5-3	5.98*	-0.15*	5.67*	3448.70*	-4.32	-0.35	0.57*	2.90*	6.19*
15	CMS 44 A x RHA 297	-26.75	0.67*	-24.86	-5200.86	-4.63	0.13	-0.10	-8.51	2.20*
16	CMS 148 A x 6D-1	15.87*	-0.25*	17.35*	5958.68*	7.92*	0.35	-1.22	-3.80	4.60*
17	CMS 148 A x RHA 271	-3.20	-0.23*	-2.22	-1309.10	-6.58	0.24	0.79*	6.96*	-6.88
18	CMS 148 A x HRHA 4-2	17.53*	-0.36*	15.92*	4538.85*	11.20*	-0.98	-0.98	-4.54	7.92*
19	CMS 148 A x HRHA 5-3	0.60	0.06*	-1.01	-253.77	-1.46	-0.29	1.80*	-3.90	2.03*
20	CMS 148 A x RHA 297	-30.81	0.78*	-30.04	-8934.66	-11.08	0.68*	-0.40	5.27*	-7.66
21	CMSH 91 A x 6D-1	0.34	-0.02	-4.82	-3001.19	-7.70	0.24	1.83*	-0.54	0.35
22	CMSH 91 A x RHA 271	-5.91	-0.08*	-6.18	-1214.30	1.05	-0.76	-0.08	-6.42	7.16*
23	CMSH 91 A x HRHA 4-2	4.96*	0.02	8.29*	1969.65*	-7.80	-0.44	0.19	19.58*	-19.08
24	CMSH 91 A x HRHA 5-3	4.50*	-0.12*	4.56*	4110.70*	10.29*	0.95*	-1.03	-8.86	7.85*
25	CMSH 91 A x RHA 297	-3.89	0.19*	-1.86	-1864.86	4.16*	0.01	-0.91	-3.77	3.71*
26	CMS 103 A x 6D-1	13.52*	-0.31*	12.93*	732.74*	12.79*	0.35	0.79*	-5.56	4.23*
27	CMS 103 A x RHA 271	15.80*	-0.15*	15.62*	771.96*	-4.69	-1.11	-1.40	3.82*	-0.84

Sr.No	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^1\text{g}^1$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
28	CMS 103 A x HRHA 4-2	9.39*	-0.14*	8.37*	2111.59*	-5.01	-0.92	0.03	-3.00	4.11*
29	CMS 103 A x HRHA 5-3	-44.63	0.86*	-44.24	-781.37	-3.41	1.06*	-0.07	-0.25	-0.77
30	CMS 103 A x RHA 297	5.92*	-0.27*	7.33*	-2834.93	0.31	0.61	0.64*	4.99*	-6.73
31	CMS 234 A x 6D-1	-34.24	0.80*	-34.18	-9415.32	-10.64	-1.66	1.59*	-6.59	2.20*
32	CMS 234A x RHA 271	8.51*	-0.18*	7.87*	4483.23*	15.86*	-0.55	0.59*	-2.48	-2.36
33	CMS 234 A x HRHA 4-2	8.46*	-0.22*	6.44*	2272.85*	7.21*	0.27	-1.93	10.72*	4.86*
34	CMS 234 A x HRHA 5-3	3.88*	-0.08*	11.54*	-1640.44	-7.51	0.72*	-0.24	2.04*	1.40*
35	CMS 234 A x RHA 297	13.40*	-0.32*	8.33*	4299.67*	-4.92	1.22*	-0.02	-3.68	-6.09
36	CMS 302 A x 6D-1	3.46*	-0.19*	3.88*	-413.92	-2.57	0.12	0.80*	-2.28	2.34*
37	CMS 302 A x RHA 271	8.10*	-0.12*	8.04*	1135.63*	-3.74	0.16	-0.17	-4.94	-2.93
38	CMS 302 A x HRHA 4-2	-43.67	0.92*	-43.82	-3646.41	-8.89	0.12	-0.23	0.82	0.15
39	CMS 302 A x HRHA 5-3	12.18*	-0.32*	12.08*	-60.70	6.41*	-1.04	-0.14	-2.89	1.02*
40	CMS 302 A x RHA 297	19.93*	-0.30*	19.82*	2985.41*	8.78*	0.63	-0.26	9.29*	-0.58
41	CMS 607 A x 6D-1	-21.72	0.70*	-22.18	-477.32	-12.94	-0.18	-2.03	5.30*	-4.21
42	CMS 607 A x RHA 271	25.60*	-0.37*	25.36*	2303.90*	5.50*	-0.38	-0.28	-2.76	2.19*
43	CMS 607 A x HRHA 4-2	19.03*	-0.51*	20.17*	1947.85*	6.52*	-0.89	0.91*	2.21*	6.00*
44	CMS 607 A x HRHA 5-3	5.96*	-0.15*	4.85*	-4073.44	4.67*	1.07*	-0.35	-4.52	-0.79
45	CMS 607 A x RHA 297	-28.86	0.33*	-28.19	299.01*	-3.74	0.38	1.75*	-0.23	-3.19
46	CMS 852 A x 6D -1	-0.63	0.09*	1.12	953.54*	-6.07	-0.73	1.45*	-7.48	-1.88
47	CMS 852 A x RHA 271	-2.20	0.02	-2.80	-2721.24	-6.86	1.14*	-0.64	6.43*	3.51*
48	CMS 852 A x HRHA 4-2	-2.32	-0.02	-2.31	-155.28	5.24*	-0.45	-0.86	2.15*	-0.20
49	CMS 852A xHRHA 5-3	-2.05	0.05	-2.69	-1000.24	5.44*	0.62	-0.11	7.47*	0.50*
50	CMS 852 A x RHA 297	7.19*	-0.08*	6.68*	2923.21*	2.24*	-0.57	0.16	-8.57	-1.94
51	ARG 2A x 6D-1	8.91*	-0.10*	8.11*	3604.74*	2.71*	-0.29	-0.93	3.52*	3.25*
52	ARG 2A x RHA 271	-28.82	0.72*	-26.01	1034.63*	-8.66	-0.13	2.37*	0.28	-0.24
53	ARG 2A x HRHA 4-2	10.52*	-0.23*	11.54*	414.59*	12.87*	-0.68	-0.64	-13.38	-2.08
54	ARG 2A x HRHA 5-3	-7.34	-0.03	-6.52	-8524.70	-13.17	-0.07	-0.35	0.55	-0.09
55	ARG 2A x RHA 297	16.73*	-0.36*	12.89*	3470.74*	6.26*	1.17*	-0.45	9.03*	-0.84

Sr.No	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
56	ARG 3A x 6D -1	5.07*	-0.02	3.91*	2240.14*	7.27*	0.98*	-0.65	1.99*	-4.70
57	ARG 3A x RHA 271	-10.25	0.21*	-10.05	-2232.30	3.62*	-0.25	-0.33	5.13*	2.26*
58	ARG 3A x HRHA 4-2	-1.19	0.02	0.30	-72.01	-4.61	-1.20	0.14	-0.39	-1.00
59	ARG 3A x HRHA 5-3	1.97	0.02	2.41	2728.70*	-4.22	-0.43	-0.30	-4.05	-0.13
60	ARG 3A x RHA 297	4.40*	-0.24*	3.43*	-2664.52	-2.06	0.91*	1.14*	-2.68	3.57*
61	ARG 6A x 6D-1	-17.50	0.06*	-13.62	-5366.26	9.45*	1.17*	-0.48	3.78*	6.00*
62	ARG 6A x RHA 271	4.58*	-0.02	2.59	808.96*	-7.32	2.08*	-0.33	2.59*	-3.75
63	ARG 6A x HRHA 4-2	-0.15	-0.06*	-2.59	678.92*	-1.65	-1.31	0.19	-3.46	-3.52
64	ARG 6A x HRHA 5-3	5.36*	0.06*	7.45*	1757.96*	-1.84	-0.11	0.43*	2.44*	-5.80
65	ARG 6 A x RHA 297	7.70*	-0.05	6.16*	2120.41*	1.36	-1.82	0.18	-5.35	7.07*
66	DV 10 x 6D -1	-0.43	-0.11*	1.76	-1337.72	-2.28	-1.01	0.47*	-0.59	4.17*
67	DV 10 x RHA 271	0.91	-0.04*	3.17*	1130.50*	-2.06	1.32*	0.46*	-0.13	-0.06
68	DV 10 x HRHA 4-2	3.83*	-0.18*	-0.86	1853.79*	12.39	-0.50	0.14	-5.50	-1.31
69	DV 10 x HRHA 5-3	8.28*	-0.05*	5.32*	1391.50*	-1.31	-0.11	-0.26	2.31*	-8.30
70	DV -10 x RHA 297	-12.59	0.38*	-9.39	-3038.06	-6.74	0.31	-0.81	3.92*	5.50*
71	CMS 207 A x 6D -1	-2.15	0.03	-4.69	-2415.06	-9.45	0.18	0.05	-8.63	1.25*
72	CMS 207 A x RHA 271	-2.02	0.07*	-1.48	-4166.50	17.78*	-1.43	0.01	-0.43	-3.81
73	CMS 207 A x HRHA 4-2	-7.02	-0.13*	-3.71	-1964.88	-12.25	7.80*	-0.75	5.63*	0.85*
74	CMS 207 A x HRHA 5-3	2.02	0.15*	-2.49	1844.50*	-0.61	-3.60	0.95*	-0.21	-0.46
75	CMS 207 A x RHA 297	9.18*	-0.11*	12.38*	6701.94*	4.52*	-2.96	-0.26	3.64*	2.17*
	SE	1.71	0.02	1.34	8.94	1.07	0.32	0.14	0.67	0.22
	CD at 5 %	3.40	0.04	2.67	17.79	2.13	0.64	0.28	1.33	0.44

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

Table 4.29 Estimation of SCA effects for hybrids in E₄

Sr. No.	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
1	CMS 11 A x 6D-1	-9.69*	-0.71	0.21	-1.46	-3.51*	0.08	-6.60	-0.71	2.16	-13.80
2	CMS 11 A x RHA 271	-4.02	-1.64	-1.03	-1.19	-0.69	-0.89	1.67*	0.22	-3.76*	1.55
3	CMS 11 A x HRHA 4-2	5.09*	-0.68	-0.79	0.36	2.20*	-0.27	1.87*	-0.13	-3.04	-1.57
4	CMS 11 A x HRHA 5-3	11.01*	1.54*	0.76	-1.32	-1.47*	0.38	-1.35	0.39	3.10	10.61*
5	CMS 11 A x RHA 297	-2.40	1.50	0.86	3.62*	3.47*	0.70	4.41*	0.23	1.53	3.20
6	CMS 17-A x 6D-1	12.30*	0.52	-0.27	-0.66	1.02*	0.08	3.37*	1.39*	8.25*	8.90*
7	CMS 17-A x RHA 271	-2.23	-0.74	-0.28	1.46	0.51	0.41	3.68*	-1.34	-18.77*	-28.93
8	CMS 17 -A x HRHA 4-2	-0.66	0.04	0.03	-0.71	-2.60*	0.03	3.89*	0.37	-2.04	-13.17
9	CMS 17 -A x HRHA 5-3	-4.47*	-0.09	0.38	-0.81	0.07	0.38	-1.47	-0.15	4.55*	15.76*
10	CMS 17 A x RHA 297	-4.95*	0.27	0.14	0.71	1.00*	-0.90	-9.47	-0.27	8.02*	17.44*
11	CMS 44 A x 6D-1	-5.57*	-0.27	-0.77	0.54	0.49	0.58	0.15	1.10*	2.88	-0.19
12	CMS 44 A x RHA 271	-6.90*	0.06	-1.01	0.04	-0.02	-0.38	-8.18	1.10*	2.31	5.33*
13	CMS 44 A x HRHA 4-2	-10.66*	-4.26	-1.54	1.91	1.87*	-0.47	8.78*	-1.25	-8.77*	4.94*
14	CMS 44 A x HRHA 5-3	8.33*	2.32*	1.51*	-1.44	-1.80*	0.49	4.44*	0.13	-1.40	-10.80
15	CMS 44 A x RHA 297	14.79*	2.15*	1.81*	-1.01	-0.53	-0.23	-5.20	-1.09	4.98*	0.73
16	CMS 148 A x 6D-1	0.55	-3.84	-0.93	-1.37	-0.71	-0.22	-1.53	0.97*	9.02*	18.26*
17	CMS 148 A x RHA 271	-5.58*	-0.11	0.66	0.12	1.11*	-0.76	-1.72	-0.43	6.91*	-5.31
18	CMS 148 A x HRHA 4-2	10.73*	0.62	-0.30	-1.90	-1.00*	0.06	0.46	0.62	10.17*	19.81*
19	CMS 148 A x HRHA 5-3	-5.15*	1.69*	0.42	4.56*	1.33*	-0.02	0.15	-0.67	-20.60*	-0.94
20	CMS 148 A x RHA 297	-0.56	1.65*	0.15	-1.42	-0.73	0.93*	2.64*	-0.49	-5.49*	-31.83
21	CMSH 91 A x 6D-1	14.06*	0.05	0.20	-1.68	-0.98*	1.04*	0.39	1.28*	-16.60*	10.40*
22	CMSH 91 A x RHA 271	-1.27	-1.54	-1.04	0.66	4.51*	0.17	-3.91	1.54*	8.97*	-5.69
23	CMSH 91 A x HRHA 4-2	10.37*	0.44	0.50	2.03	0.73	-0.35	-4.39	-0.24	9.44*	8.01*
24	CMSH 91 A x HRHA 5-3	-5.57*	1.11	0.52	0.64	-1.93*	-0.59	5.61*	-1.13	0.47	1.60
25	CMSH 91 A x RHA 297	-17.59*	-0.06	-0.18	-1.66	-2.33*	-0.27	2.30*	-1.45	-2.28	-14.32
26	CMS 103 A x 6D-1	-2.57	1.14	1.55*	1.10	-1.11*	0.15	2.00*	-1.21	0.94	1.04
27	CMS 103 A x RHA 271	-6.10*	2.28*	1.24*	2.04	0.71	-1.18	3.24*	-0.21	-2.25	16.04*

Sr. No.	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
28	CMS 103 A x HRHA 4-2	2.34*	1.07	-0.55	-0.15	-2.40*	0.77	-3.39	0.87	-0.61	12.14*
29	CMS 103 A x HRHA 5-3	5.40*	0.07	-0.97	-1.29	-1.40*	-0.11	2.66*	0.55	-0.78	-35.69
30	CMS 103 A x RHA 297	0.92	-4.57	-1.27	-1.70	4.20*	0.37	-4.51	0.00	2.70	6.46*
31	CMS 234 A x 6D-1	1.42	0.44	-0.46	2.97*	0.22	-0.54	0.92	0.24	-4.03*	-29.39
32	CMS 234A x RHA 271	8.09*	2.12*	1.47*	3.41*	-1.29*	0.09	1.06	-1.03	1.00	2.61
33	CMS 234 A x HRHA 4-2	-9.20*	-0.23	0.41	-1.37	0.93*	0.11	1.22	0.48	-2.14	8.11*
34	CMS 234 A x HRHA 5-3	-1.75	-3.80	-1.21	-3.10*	-0.73	0.10	-2.52	-0.90	1.63	12.23*
35	CMS 234 A x RHA 297	1.44	1.47*	-0.21	-1.91	0.87	0.25	-0.68	1.21*	3.54*	6.43*
36	CMS 302 A x 6D-1	-16.23*	-0.71	-0.68	-3.53	1.62*	-1.84	-2.23	0.50	-5.84*	12.72*
37	CMS 302 A x RHA 271	1.77	-0.77	0.28	-2.06	-1.56*	1.46*	0.35	-0.70	-0.63	-0.47
38	CMS 302 A x HRHA 4-2	-2.26	-0.12	-0.48	-1.34	-3.00*	-1.73	0.09	0.24	3.05	-33.47
39	CMS 302 A x HRHA 5-3	11.53*	0.69	0.47	1.18	0.67	1.23*	-3.58	0.06	1.68	3.13
40	CMS 302 A x RHA 297	5.19*	0.91	0.40	5.75*	2.27*	0.88*	5.37*	-0.09	1.74	18.10*
41	CMS 607 A x 6D-1	-13.23*	1.31	0.85	2.71*	-1.78*	-0.47	5.55*	-0.67	0.61	-16.07
42	CMS 607 A x RHA 271	0.64	1.78*	0.48	-0.07	1.38*	-0.27	-0.24	-0.27	2.51	18.45*
43	CMS 607 A x HRHA 4-2	12.14*	1.03	0.18	-0.13	-0.07	1.18*	-0.81	-1.46	-4.66	31.89*
44	CMS 607 A x HRHA 5-3	9.93*	-0.29	-0.87	-1.23	5.27*	-1.93	-1.11	1.69*	2.41	-12.84
45	CMS 607 A x RHA 297	-9.48*	-3.84	-0.64	-1.28	-4.80*	1.49*	-3.39	0.71	-0.87	-21.43
46	CMS 852 A x 6D -1	-8.14*	-0.30	-1.46	2.87*	5.76*	0.71	-1.62	0.04	-1.59	10.25*
47	CMS 852 A x RHA 271	2.93*	-0.76	-1.46	-1.77	-6.76*	-0.16	4.00*	-0.66	0.38	14.42*
48	CMS 852 A x HRHA 4-2	-2.90*	2.89*	2.07*	-0.50	3.80*	0.63	0.09	-0.38	5.63*	-0.65
49	CMS 852A x HRHA 5-3	1.09	-3.93	0.62	-0.84	2.80*	0.28	-2.36	0.10	-1.13	-11.71
50	CMS 852 A x RHA 297	7.01*	2.12*	0.22	0.24	-5.60*	-1.47	-0.11	0.91	-3.29	-12.31
51	ARG 2A x6D-1	4.97*	0.59	0.75	-2.44	3.62*	0.02	-5.81	-1.41	0.01	18.56*
52	ARG 2A x RHA 271	-0.43	0.11	0.48	-1.72	-1.89*	0.45	2.42*	1.19*	0.41	-22.38
53	ARG 2A x HRHA 4-2	-5.06*	0.31	0.25	-0.41	2.33*	0.30	1.84*	0.57	1.38	-9.48
54	ARG 2A x HRHA 5-3	-10.60*	0.45	-0.13	3.11*	-2.67*	1.16*	-2.86	-0.38	2.23	5.73*
55	ARG 2A x RHA 297	11.12*	-1.46	-1.36	1.47	-1.40*	-1.93	4.42*	0.03	-4.03*	7.58*

Sr. No.	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
56	ARG 3A x 6D -1	-5.38*	1.73*	1.03*	0.22	-1.44*	-0.44	5.22*	-0.30	-3.65*	6.85*
57	ARG 3A x RHA 271	-8.84*	-0.40	-0.07	1.39	1.04*	1.12*	-0.77	1.56*	-4.93*	-11.24
58	ARG 3A x HRHA 4-2	-6.14*	-1.35	-1.13	0.78	-0.40	-0.86	-2.75	-0.52	4.01*	-7.84
59	ARG 3A x HRHA 5-3	-2.48	-0.67	-0.38	-0.08	-0.73	-0.60	-1.93	-0.44	8.38*	6.61*
60	ARG 3A x RHA 297	22.84*	0.68	0.55	-2.31	1.53*	0.78*	0.24	-0.29	-3.82*	5.62*
61	ARG 6A x 6D-1	1.54	-0.82	-0.97	-2.51*	-2.84*	1.25*	2.02*	-0.83	6.35*	-14.28
62	ARG 6A x RHA 271	16.01*	0.46	0.20	-1.94	0.98	-0.38	-2.43	-0.06	6.94*	7.88*
63	ARG 6A x HRHA 4-2	-5.88*	-0.03	0.17	-0.44	-0.80	0.00	0.50	1.02*	-13.30*	-10.93
64	ARG 6A x HRHA 5-3	-13.16*	0.91	-0.18	2.89*	1.20*	-0.18	-5.24	1.10*	-2.73	3.21*
65	ARG 6 A x RHA 297	1.49	-0.53	0.78	1.99	1.47*	-0.69	5.15*	-1.22	2.74	14.13*
66	DV 10 x 6D -1	14.86*	1.52*	1.11*	-0.13	0.29	-0.72	0.20	-1.59	7.43*	0.74
67	DV 10 x RHA 271	0.60	-0.48	-0.16	-1.75	0.44	0.98*	2.79*	-0.52	2.63	7.79*
68	DV 10 x HRHA 4-2	-4.36*	-0.89	0.11	1.43	-1.67*	-0.51	-0.69	-0.08	-5.07*	-5.95
69	DV 10 x HRHA 5-3	1.43	0.05	-0.50	0.26	-0.67	-0.52	-0.58	0.74	1.50	7.05*
70	DV -10 x RHA 297	-12.52*	-0.20	-0.57	0.19	1.60*	0.77	-1.71	1.45*	-6.49*	-9.63
71	CMS 207 A x 6D -1	11.13*	-0.64	-0.16	3.37*	-0.64	0.32	-2.02	1.20*	-5.94*	-13.98
72	CMS 207 A x RHA 271	5.33*	-0.37	0.24	1.42	1.51*	-0.68	-1.96	-0.36	-1.71	-0.05
73	CMS 207 A x HRHA 4-2	6.44*	1.15	1.07*	0.42	0.07	1.11*	-6.71	-0.08	5.94*	-1.84
74	CMS 207 A x HRHA 5-3	-5.57*	-0.05	-0.44	-2.53*	0.07	-0.07	10.15*	-1.10	0.69	6.04*
75	CMS 207 A x RHA 297	-17.32*	-0.09	-0.71	-2.68*	-1.00*	-0.69	0.53	0.35	1.02	9.84*
	SE	1.26	0.74	0.49	1.24	0.45	0.39	0.79	0.46	1.78	1.41
	CD at 5 %	2.51	1.47	0.98	2.47	0.90	0.78	1.57	0.92	3.54	2.81

Table 4.29 (contd.)

Sr. No.	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^1\text{g}^1$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
1	CMS 11 A x 6D-1	-13.42	0.22*	-12.02	-6,426.0	-4.74	-0.28	-0.90	1.39*	-7.16
2	CMS 11 A x RHA 271	2.50	-0.05	5.52*	-1,381.6	-9.29	0.11	-0.55	2.40*	1.24*
3	CMS 11 A x HRHA 4-2	1.79	-0.02	-4.28	-435.5	2.45	-0.11	1.44*	-7.90	8.31*
4	CMS 11 A x HRHA 5-3	6.01*	0.03	8.60*	1,533.7	1.40	0.48*	0.40	1.74*	-2.55
5	CMS 11 A x RHA 297	3.13	-0.17*	2.18	6,709.5*	10.17*	-0.20	-0.40	2.38*	0.15
6	CMS 17-A x 6D-1	11.81*	-0.41*	12.84*	-773.8	1.92	-0.46	-0.42	3.44*	-3.14
7	CMS 17-A x RHA 271	-31.19	0.85*	-29.83	-6,383.7	5.43*	-0.45	-0.88	0.56	2.66*
8	CMS 17 -A x HRHA 4-2	-12.33	0.53*	-10.01	-1,698.9	-11.05	-0.09	2.37*	2.13*	-4.18
9	CMS 17 -A x HRHA 5-3	15.12*	-0.52*	12.97*	997.6	-12.64	0.62*	-1.43	-2.07	1.07*
10	CMS 17 A x RHA 297	16.58*	-0.46*	14.02*	7,858.8*	16.33*	0.38	0.36	-4.05	3.60*
11	CMS 44 A x 6D-1	0.20	-0.02	-1.23	3,112.1*	12.39*	0.13	0.24	10.55*	-10.87
12	CMS 44 A x RHA 271	4.66*	-0.19*	1.75	1,711.2	-4.14	-0.29	0.00	-0.17	2.55*
13	CMS 44 A x HRHA 4-2	5.34*	0.19*	4.82*	1,274.6	-3.39	-0.34	-0.61	-0.27	0.40
14	CMS 44 A x HRHA 5-3	-8.94	0.04	-7.02	-3,733.2	1.36	-0.38	0.51	-7.71	6.05*
15	CMS 44 A x RHA 297	-1.25	0.02	1.67	-2,364.7	-6.22	0.87*	-0.14	-2.41	1.86*
16	CMS 148 A x 6D-1	16.10*	0.22*	16.08*	7,225.5*	13.92*	0.31	-1.27	-4.35	4.94*
17	CMS 148 A x RHA 271	-4.39	-0.30*	-4.72	-2,292.8	-0.29	0.17	0.73*	5.08*	-6.97
18	CMS 148 A x HRHA 4-2	19.23*	-0.11*	17.27*	4,047.7*	-7.01	-0.99	-1.03	-5.05	7.75*
19	CMS 148 A x HRHA 5-3	1.71	0.15*	0.60	-2,561.5	2.04	0.07	1.70*	-4.86	1.85*
20	CMS 148 A x RHA 297	-32.66	0.04	-29.24	-6,418.9	-8.67	0.43	-0.13	9.18*	-7.58

Sr. No.	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^1\text{g}^1$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
21	CMSH 91 A x 6D-1	9.29*	-0.01	8.81*	3,749.9*	-11.56	0.17	1.72*	-6.66	0.67
22	CMSH 91 A x RHA 271	-6.83	-0.24*	-5.64	-2,518.0	5.31*	-0.52	0.35	-9.65	7.12*
23	CMSH 91 A x HRHA 4-2	7.94*	-0.01	8.02*	-4,367.6	4.66*	-0.73	0.07	15.18*	-18.90
24	CMSH 91 A x HRHA 5-3	-0.27	-0.22*	-1.20	5,540.9*	4.01*	0.44*	-0.95	6.96*	7.80*
25	CMSH 91 A x RHA 297	-10.14	0.48*	-9.98	-2,405.2	-2.41	0.64*	-1.19	-5.84	3.31*
26	CMS 103 A x 6D-1	-0.26	-0.19*	15.04*	1,469.0	1.25	0.22	0.76*	-1.48	4.65*
27	CMS 103 A x RHA 271	20.52*	-0.17*	13.99*	5,809.7*	8.64*	-0.61	-1.05	-0.91	-0.89
28	CMS 103 A x HRHA 4-2	12.34*	-0.18*	8.79*	-2,888.2	-1.02	-1.10	0.11	0.22	4.25*
29	CMS 103 A x HRHA 5-3	-38.05	0.78*	-39.89	-2,887.7	1.47	0.82*	-0.09	2.59*	-1.20
30	CMS 103 A x RHA 297	5.45*	-0.24*	2.06	-1,502.8	-10.35	0.67*	0.26	-0.42	-6.80
31	CMS 234 A x 6D-1	-29.02	0.81*	-28.09	-2,157.9	-0.40	-1.75	1.71*	-6.89	2.20*
32	CMS 234A x RHA 271	2.02	-0.33	3.10*	-3,679.8	-12.15	-1.26	0.23	-2.62	-2.27
33	CMS 234 A x HRHA 4-2	8.21*	-0.03	7.71*	3,765.3*	6.59*	1.61*	-1.81	8.44*	4.62*
34	CMS 234 A x HRHA 5-3	10.97*	-0.07	7.94*	-3,321.2	-1.98	0.21	-0.18	2.47*	1.35*
35	CMS 234 A x RHA 297	7.82*	-0.39*	9.34*	5,393.7*	7.93*	1.19*	0.05	-1.40	-5.90
36	CMS 302 A x 6D-1	13.14*	-0.14*	11.72*	-668.2	3.15*	-0.36	-0.33	10.77*	2.75*
37	CMS 302 A x RHA 271	-1.52	0.59*	-3.18	10,102.2*	9.86*	0.84*	0.16	-4.56	-3.01
38	CMS 302 A x HRHA 4-2	-34.44	-0.09*	-27.01	-4,466.4	-3.22	0.18	0.05	-8.78	-0.10
39	CMS 302 A x HRHA 5-3	5.72*	-0.15*	1.50	-6,349.2	-8.09	-1.38	0.20	-8.68	1.04*
40	CMS 302 A x RHA 297	17.09*	-0.22*	16.97*	1,381.7	-1.70	0.72*	-0.08	11.25*	-0.67
41	CMS 607 A x 6D-1	-16.85	0.45*	-18.42	6,081.3*	6.32*	1.56*	-1.00	4.69*	-4.07

Sr. No.	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^1\text{g}^1$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
42	CMS 607A x RHA 271	19.84*	-0.54*	19.95*	-3,164.3	-9.48	-0.77	-0.21	0.47	2.18*
43	CMS 607A x HRHA 4-2	29.98*	-0.55*	30.56*	109.5	0.27	-1.78	0.32	-6.23	6.12*
44	CMS 607 A x HRHA 5-3	-10.37	0.42*	-9.51	4,303.0*	8.71*	1.23*	-0.22	-1.82	-0.99
45	CMS 607 A x RHA 297	-22.60	0.23*	-22.58	-7,329.5	-5.82	-0.24	1.11*	2.90*	-3.23
46	CMS 852 A x 6D -1	11.09*	-0.31*	5.38*	2,790.3*	-11.09	-0.90	0.79*	1.53*	-1.49
47	CMS 852 A x RHA 271	12.17*	-0.40*	14.65*	-1,903.0	-1.69	0.75*	-0.57	-2.87	3.27*
48	CMS 852 A x HRHA 4-2	-1.64	-0.25*	-1.96	582.8	6.01*	0.42	-0.20	0.62	-0.39
49	CMS 852A x HRHA 5-3	-11.15	0.50*	-9.75	1,775.7	11.37*	0.39	-0.27	-1.68	0.61*
50	CMS 852 A x RHA 297	-10.48	0.46*	-8.32	-3,245.8	-4.60	-0.66	0.24	2.41*	-1.99
51	ARG 2A x 6D-1	18.22*	-0.33*	16.26*	-4,690.7	-2.03	-0.16	-1.30	-3.83	3.50*
52	ARG 2A x RHA 271	-24.52	0.62*	-22.98	1,606.7	4.67*	0.11	1.59*	6.98*	-0.18
53	ARG 2A x HRHA 4-2	-10.56	0.57*	-9.06	-2,500.5	-3.54	-1.00	-0.25	1.53*	-2.13
54	ARG 2A x HRHA 5-3	7.75*	-0.40*	8.51*	693.3	-2.53	0.03	-0.14	-2.81	-0.31
55	ARG 2A x RHA 297	9.11*	-0.46*	7.28*	4,891.2*	3.43*	1.03*	0.09	-1.88	-0.88
56	ARG 3A x 6D -1	6.82*	-0.22*	2.97	-765.6	-0.87	1.04*	-0.49	4.71*	-4.36
57	ARG 3A x RHA 271	-11.37	0.75*	-8.04	-3,810.8	8.48*	-0.04	-0.43	-0.84	2.09*
58	ARG 3A x HRHA 4-2	-7.20	-0.12*	-8.77	360.9	-3.35	-1.33	0.06	2.61*	-1.21
59	ARG 3A x HRHA 5-3	6.91*	-0.18*	8.25*	1,899.5*	-4.02	-0.51	-0.48	-0.33	-0.19
60	ARG 3A x RHA 297	4.83*	-0.23*	5.59*	2,316.0*	-0.24	0.85*	1.33*	-6.14	3.67*
61	ARG 6A x 6D-1	-14.35	0.02	-14.35	-2,891.6	-6.82	0.88*	0.61*	-6.28	6.21*
62	ARG 6A x RHA 271	10.46*	-0.05	8.69*	5,623.2*	-1.60	1.35*	-0.07	2.38*	-3.91

Sr. No.	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
63	ARG 6A x HRHA 4-2	-11.32	0.08*	-9.26	3,646.9*	5.86*	-0.63	0.04	3.80*	-3.44
64	ARG 6A x HRHA 5-3	2.89	0.03	7.19*	-1,704.9	1.07	1.03*	0.01	4.11*	-5.76
65	ARG 6 A x RHA 297	12.31*	-0.08*	7.73*	-4,673.7	1.49	-2.63	-0.59	-4.00	6.90*
66	DV 10 x 6D -1	1.08	-0.14*	0.23	-1,360.1	0.52	-0.15	-0.03	-4.94	4.55*
67	DV 10 x RHA 271	8.68*	-0.35*	8.59*	-521.4	-5.86	2.05*	0.59*	-2.86	-0.28
68	DV 10 x HRHA 4-2	-5.78	-0.14*	-5.94	1,292.1	1.27	-1.12	0.31	1.40*	-1.51
69	DV 10 x HRHA 5-3	6.28*	-0.19*	5.67*	2,680.3*	1.65*	-0.59	-0.11	10.75*	-8.32
70	DV -10 x RHA 297	-10.26	0.82*	-8.55	-2,090.9	2.42*	-0.18	-0.75	-4.35	5.56*
71	CMS 207 A x 6D -1	-13.87	0.06*	-15.22	-4,694.2	-1.97	-0.25	-0.11	-2.65	1.63*
72	CMS 207 A x RHA 271	-1.04	-0.20	-1.86	802.6	2.11*	-1.44	0.11	6.61*	-3.59
73	CMS 207 A x HRHA 4-2	-1.56	0.14*	-0.88	1,277.3	5.44*	7.00*	-0.88	-7.68	0.43*
74	CMS 207 A x HRHA 5-3	5.42*	-0.18*	6.13*	1,133.9	-3.81	-2.44	1.05*	1.33*	-0.47
75	CMS 207 A x RHA 297	11.06*	0.19*	11.83*	1,480.4	-1.78	-2.87	-0.17	2.39*	2.00*
	SE	1.82	0.03	1.40	934.4	0.80	0.22	0.28	0.47	0.12
	CD at 5 %	3.62	0.06	2.79	1870.7	1.59	0.44	0.56	0.94	0.24

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

Table 4.30 Estimation of SCA effects for hybrids over the environments

Sr. No.	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
1	CMS 11 A x 6D-1	13.03*	-0.47	-0.04	-0.18	-1.27*	-0.15	-3.58	-0.68	-1.19	-1.01
2	CMS 11 A x RHA 271	0.22	-0.62	-0.49	-0.40	-0.53*	-0.06	-0.52	0.38	1.40	0.03
3	CMS 11 A x HRHA 4-2	-1.25	-0.10	-0.10	-0.50	0.79*	0.01	1.00	0.19	-1.47	1.52*
4	CMS 11 A x HRHA 5-3	3.04*	1.36*	0.59*	-0.55	-0.13	0.28	2.10*	-0.34	-2.98*	-3.53
5	CMS 11 A x RHA 297	1.02	-0.17	0.05	1.62*	1.15*	-0.08	1.00	0.46	4.24*	2.99*
6	CMS 17-A x 6D-1	6.56*	0.41	-0.19	0.26	0.93*	-0.27	0.47	1.03*	5.85*	4.52*
7	CMS 17-A x RHA 271	-1.99	-0.32	-0.09	1.56*	0.51*	0.85	2.52*	-0.53	-3.39*	-1.68
8	CMS 17 -A x HRHA 4-2	2.15*	-1.33	-0.50	0.44	-0.57*	0.38	-0.08	0.23	-3.14*	-9.34
9	CMS 17 -A x HRHA 5-3	-2.93*	1.75*	0.49*	-1.59*	-0.97*	-0.09	-1.75	-0.11	-0.38	4.74*
10	CMS 17 A x RHA 297	-3.79*	-0.51	0.27	-0.68	0.10	-0.87	-1.17	-0.62	1.05	1.76*
11	CMS 44 A x 6D-1	2.67*	0.39	0.23	0.12	0.07	0.49	0.29	-0.32	5.10*	1.42*
12	CMS 44 A x RHA 271	-4.69*	-1.30	-0.65	-0.17	0.32	-0.74	-3.82	0.53*	0.03	1.75*
13	CMS 44 A x HRHA 4-2	-5.63*	-0.89	-1.01	0.58	0.31	-0.09	3.49*	-0.32	-2.44*	1.85*
14	CMS 44 A x HRHA 5-3	2.20*	1.14*	0.50*	-0.90*	-0.92*	0.13	-0.29	0.25	-3.42*	-8.72
15	CMS 44 A x RHA 297	5.45*	0.66*	0.93*	0.38	0.23	0.22	0.33	-0.15	0.73	3.70*
16	CMS 148 A x 6D-1	-2.80*	-1.53	-0.46	0.08	0.26	-0.37	-2.76	0.13	-1.53	-0.08
17	CMS 148 A x RHA 271	-2.58*	-0.05	0.03	-0.38	0.31	-0.39	-1.34	-0.07	-1.38	2.49*
18	CMS 148 A x HRHA 4-2	6.53*	1.64*	0.24	-1.30*	1.00*	0.10	0.66	-0.26	7.53*	5.08*
19	CMS 148 A x HRHA 5-3	-4.33*	-0.45	0.09	1.46*	-0.02	0.48	2.18*	-0.08	-3.58*	1.67*
20	CMS 148 A x RHA 297	3.17*	0.39	0.10	0.14	-1.55*	0.18	1.27*	0.28	-1.03	-9.17
21	CMSH 91 A x 6D-1	2.75*	0.59	-0.10	0.15	-0.90*	-0.07	1.98*	1.01*	-3.93*	-5.38

Sr. No.	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
22	CMSH 91 A x RHA 271	-0.44	-0.69	0.11	-0.08	2.40*	-0.30	-1.43	0.32	-0.52	-0.23
23	CMSH 91 A x HRHA 4-2	3.83*	0.54	0.33	0.19	-0.69*	0.14	-2.18	-0.10	2.57*	1.12
24	CMSH 91 A x HRHA 5-3	1.57	-0.64	-0.23	0.31	0.34	0.14	1.79*	-0.22	1.44	4.68*
25	CMSH 91 A x RHA 297	-7.71*	0.20	-0.10	-0.57	-1.16*	0.09	-0.17	-1.02	0.45	-0.20
26	CMS 103 A x 6D-1	-1.47	0.46	0.61*	1.41*	0.67*	0.41	0.89	-0.68	1.53	2.09*
27	CMS 103 A x RHA 271	-1.38	-0.06	0.10	0.04	-1.46*	-0.78	0.49	0.80*	2.76*	5.07*
28	CMS 103 A x HRHA 4-2	1.49	1.12*	0.20	-0.54	-1.25*	-0.14	0.73	0.06	0.48	6.94*
29	CMS 103 A x HRHA 5-3	2.38*	-0.21	-0.28	0.86	-0.41	0.40	0.26	-0.09	-1.59	-4.33
30	CMS 103 A x RHA 297	-1.02	-1.30	-0.63	-1.77*	2.44*	0.11	-2.37	-0.10	-3.19*	-9.77
31	CMS 234 A x 6D-1	7.98*	0.75*	-0.29	-0.28	-1.11*	-0.04	1.69*	0.29	1.39	-4.73
32	CMS 234A x RHA 271	3.68*	-0.03	0.78*	1.33*	0.07	-0.24	0.35	-0.36	-0.08	-6.92
33	CMS 234 A x HRHA 4-2	-13.32*	-0.75	-0.08	0.75	0.45	0.07	-0.47	-0.01	0.44	6.00*
34	CMS 234 A x HRHA 5-3	-0.77	-0.54	-0.14	-0.43	0.73*	0.53	-1.80	0.03	0.32	5.15*
35	CMS 234 A x RHA 297	2.43*	0.57	-0.27	-1.37*	-0.15	-0.32	0.23	0.05	-2.08*	0.50
36	CMS 302 A x 6D-1	-8.41*	-0.71	-0.08	-1.90*	-0.09	-0.48	-0.56	-0.40	-0.98	8.08*
37	CMS 302 A x RHA 271	3.84*	-0.16	-0.10	-1.33*	-1.10*	0.32	1.96*	0.26	0.26	-0.20
38	CMS 302 A x HRHA 4-2	-5.52*	0.58	0.21	-0.43	-1.53*	0.01	0.17	0.15	0.29	-7.23
39	CMS 302 A x HRHA 5-3	3.09*	0.27	-0.01	1.89*	3.10*	-0.01	-1.50	-0.01	-1.23	-8.11
40	CMS 302 A x RHA 297	7.00*	0.03	-0.01	1.77*	-0.38	0.16	-0.08	0.00	1.66	7.47*
41	CMS 607 A x 6D-1	-5.11*	0.14	0.57*	3.54*	0.31	0.07	1.16*	-0.28	0.74	2.30*
42	CMS 607 A x RHA 271	4.46*	1.22*	0.29	-0.38	-1.69*	-0.06	1.06*	0.39	1.62	-2.28
43	CMS 607 A x HRHA 4-2	-1.86	0.34	-0.26	-1.66*	0.12	0.48	1.11*	-0.03	-1.54	10.65*

Sr. No.	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
44	CMS 607 A x HRHA 5-3	10.53*	-0.39	-0.26	-0.90*	1.64*	-0.91	-2.03	0.06	2.13*	-2.42
45	CMS 607 A x RHA 297	-8.02*	-1.31	-0.34	-0.60	-0.38	0.41	-1.29	-0.15	-2.94*	-8.25
46	CMS 852 A x 6D -1	-0.55	-0.04	-0.64	0.32	1.52*	-0.05	0.37	-0.26	-2.99*	-7.94
47	CMS 852 A x RHA 271	-1.33	0.90*	0.25	-1.67*	-1.78*	0.23	2.42*	-0.52	-2.35*	6.51*
48	CMS 852 A x HRHA 4-2	4.58*	-0.04	0.60*	-1.31*	1.34*	0.70	-0.11	-0.27	0.45	3.81*
49	CMS 852A x HRHA 5-3	-4.57*	-1.66	-0.07	0.77	0.73*	-0.22	-0.97	0.15	3.40*	0.73
50	CMS 852 A x RHA 297	1.87	0.84*	-0.14	1.89*	-1.81*	-0.67	-1.70	0.91*	1.49	-3.11
51	ARG 2A x 6D-1	-0.45	0.61	0.28	-1.64*	0.58*	-0.29	-1.02	-1.09	1.10	11.24*
52	ARG 2A x RHA 271	3.42*	0.99*	0.28	0.57	-0.27	0.06	-0.62	-0.07	-0.27	-5.46
53	ARG 2A x HRHA 4-2	-1.26	0.05	0.04	1.39*	0.74*	-0.07	0.62	0.31	-1.11	-8.40
54	ARG 2A x HRHA 5-3	-2.99*	-0.69	-0.17	-0.58	-1.77*	0.70	-0.28	0.23	0.86	2.52*
55	ARG 2A x RHA 297	1.28	-0.97	-0.43	0.26	0.72*	-0.40	1.31*	0.62*	-0.58	0.10
56	ARG 3A x 6D -1	-1.16	-0.05	0.21	-0.10	0.07	0.06	1.23*	0.09	-1.59	2.68
57	ARG 3A x RHA 271	-1.65	0.24	-0.03	0.38	0.80*	0.52	-0.32	0.33	0.94	-3.16
58	ARG 3A x HRHA 4-2	0.29	-0.47	-0.25	0.01	0.14	-0.68	-0.99	0.19	-1.53	-3.34
59	ARG 3A x HRHA 5-3	-3.37*	0.46	0.03	0.15	-0.88*	-0.42	-0.23	0.15	2.58*	1.28
60	ARG 3A x RHA 297	5.89*	-0.17	0.04	-0.45	-0.14	0.51	0.31	-0.76	-0.40	2.54*
61	ARG 6A x 6D-1	-2.00	0.38	-0.16	-1.87*	-1.72*	0.72	1.76*	0.08	3.11*	-2.00
62	ARG 6A x RHA 271	-0.92	0.78*	-0.17	0.92*	0.40	-0.12	-0.15	-0.76	1.81	-0.08
63	ARG 6A x HRHA 4-2	2.66*	-0.58	0.23	0.35	0.33	0.09	-1.05	0.73*	-2.50*	-4.43
64	ARG 6A x HRHA 5-3	0.48	-0.47	-0.18	0.40	0.04	-0.69	-1.80	0.49*	-3.74*	1.23
65	ARG 6 A x RHA 297	-0.22	-0.10	0.28	0.20	0.95*	-0.01	1.24*	-0.54	1.31	5.27*

Sr. No.	Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
66	DV 10 x 6D -1	4.57*	0.77*	0.62*	-0.72	0.05	0.51	-0.30	0.37	1.40	-5.66
67	DV 10 x RHA 271	1.91	0.05	0.01	-0.23	0.54	0.65	0.94	-0.23	-1.67	2.37*
68	DV 10 x HRHA 4-2	4.04*	-0.19	-0.01	2.10*	-1.02*	-0.88	-0.91	-0.26	1.73	-2.79
69	DV 10 x HRHA 5-3	-3.08*	-0.81	-0.33	-1.05*	-0.41	-0.48	0.19	-0.29	1.12	2.94*
70	DV -10 x RHA 297	-7.44*	0.19	-0.29	-0.10	0.83	0.21	0.07	0.41	-2.58*	3.14*
71	CMS 207 A x 6D -1	0.45	-1.68	-0.57	0.78	0.62	-0.54	-1.62	0.69*	-8.02*	-5.54
72	CMS 207 A x RHA 271	-2.57*	-0.93	-0.31	-0.14	1.46*	0.05	-1.55	-0.49	0.83	1.80*
73	CMS 207 A x HRHA 4-2	3.26*	0.08	0.35*	-0.07	-0.15	-0.12	-1.98	-0.60	0.27	-1.45
74	CMS 207 A x HRHA 5-3	-1.25	0.86*	-0.03	0.15	-1.07*	0.14	4.14*	-0.20	5.07*	2.18*
75	CMS 207 A x RHA 297	0.11	1.67*	0.55*	-0.72	-0.86*	0.47	1.01*	0.60*	1.85	3.01*
	SE	1.03	0.31	0.17	0.41	0.24	0.19	0.51	0.23	1.02	0.77
	CD at 5 %	2.05	0.62	0.34	0.82	0.48	0.38	1.01	0.46	2.03	1.53

Table 4.30 (contd.)

Sr. No.	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^1\text{g}^1$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
1	CMS 11 A x 6D-1	-1.52	0.02	-0.73	-1,305.6	2.04*	0.00	-0.33	4.22*	-1.47
2	CMS 11 A x RHA 271	1.09	-0.08*	4.64*	307.3	2.56*	0.15	-0.91	0.60	0.69
3	CMS 11 A x HRHA 4-2	-5.85	0.20*	-7.80	-2,601.5	-3.14	-0.01	1.04*	-4.80	5.71*
4	CMS 11 A x HRHA 5-3	3.07*	-0.06*	2.99*	1,637.5*	-1.74	0.16	0.46*	1.85*	-4.24
5	CMS 11 A x RHA 297	3.22*	-0.06*	0.92	1,962.4*	0.28	-0.30	-0.26	-1.88	-0.69
6	CMS 17-A x 6D-1	6.83*	-0.16*	7.96*	1,777.3*	-0.84	-0.02	0.04	3.89*	-3.81
7	CMS 17-A x RHA 271	-15.42	0.37*	-15.66	-1,361.5	-4.02	-0.26	-0.71	1.85*	0.47
8	CMS 17 -A x HRHA 4-2	-1.75	0.11*	-2.06	-1,449.2	-0.89	-0.01	0.74*	1.53*	-5.20
9	CMS 17 -A x HRHA 5-3	4.00*	-0.11*	2.54*	-903.6	-0.10	0.46*	-0.45	-2.08	4.16*
10	CMS 17 A x RHA 297	6.34*	-0.21*	7.23*	1,937.0*	5.86*	-0.17	0.38*	-5.20	4.38*
11	CMS 44 A x 6D-1	2.56*	-0.08*	1.25	391.7	5.42*	0.50*	0.13	4.04*	-6.10
12	CMS 44 A x RHA 271	3.24*	-0.06*	3.12*	-950.4	2.50*	-0.43	0.08	-2.68	4.50*
13	CMS 44 A x HRHA 4-2	2.31*	0.06*	1.78*	402.2	-0.79	-0.06	-0.10	-0.75	-1.66
14	CMS 44 A x HRHA 5-3	-0.71	-0.05	-0.43	1,404.5*	-2.89	0.19	0.20	-1.23	2.69*
15	CMS 44 A x RHA 297	-7.40	0.14*	-5.72	-1,247.9	-4.25	-0.20	-0.29	0.62	0.57
16	CMS 148 A x 6D-1	7.80*	-0.06	8.92*	2,461.0*	11.44*	0.16	-0.45	2.79*	1.87*
17	CMS 148 A x RHA 271	-0.94	-0.16*	-1.23	-536.8	0.77	-0.25	-0.28	3.98*	-7.99
18	CMS 148 A x HRHA 4-2	9.19*	-0.09*	6.90*	1,589.8*	0.44	-0.40	-0.37	-7.26	6.28*
19	CMS 148 A x HRHA 5-3	-0.07	0.07	0.50	2.7	-2.42	0.46*	1.08*	-1.49	0.09
20	CMS 148 A x RHA 297	-15.97	0.24*	-15.08	-3,516.7	-10.24	0.02	0.02	1.97*	-0.25

Sr. No.	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^1\text{g}^1$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
21	CMSH 91 A x 6D-1	2.26*	-0.02	1.12	861.6*	-9.59	0.32*	0.63*	-0.75	2.29*
22	CMSH 91 A x RHA 271	-2.76	-0.06*	-3.12	-773.9	-4.77	-0.56	-0.04	-3.39	5.40*
23	CMSH 91 A x HRHA 4-2	1.01	0.05	3.98*	-410.6	0.45	-0.40	0.40*	5.63*	-12.00
24	CMSH 91 A x HRHA 5-3	2.49*	-0.11*	0.04	2,426.3*	7.67*	0.69*	-0.09	0.89	5.05*
25	CMSH 91 A x RHA 297	-2.99	0.14	-2.03	-2,103.4	6.24*	-0.06	-0.90	-2.39	-0.74
26	CMS 103 A x 6D-1	3.52*	-0.10*	6.01*	1,752.2*	6.19*	0.04	-0.25	0.48	4.62*
27	CMS 103 A x RHA 271	9.83*	-0.07*	8.58*	2,368.4*	5.49*	-0.60	-0.42	0.10	3.74*
28	CMS 103 A x HRHA 4-2	5.32*	-0.11*	4.05*	-371.7	-0.62	-0.46	0.23*	-2.63	4.92*
29	CMS 103 A x HRHA 5-3	-21.32	0.39	-20.89	-1,838.7	-3.74	0.36*	-0.14	-0.79	-1.41
30	CMS 103 A x RHA 297	2.65*	-0.10*	2.26*	-1,910.1	-7.32	0.66*	0.59*	2.84*	-11.87
31	CMS 234 A x 6D-1	-17.55	0.46*	-17.79	-2,542.8	-4.01	-0.57	0.35*	-5.76	-5.13
32	CMS 234A x RHA 271	4.51*	-0.12*	3.95*	556.8*	2.38*	-0.24	-0.68	-3.30	0.26*
33	CMS 234 A x HRHA 4-2	4.70*	-0.06*	3.76*	2,015.4*	2.66*	0.05	-0.01	5.17*	1.39*
34	CMS 234 A x HRHA 5-3	3.37*	-0.02	4.72*	-1,442.7	-2.81	0.54*	-1.09	1.65*	0.80*
35	CMS 234 A x RHA 297	4.97*	-0.26*	5.37*	1,413.3*	1.79	0.21	1.43*	2.25*	2.68*
36	CMS 302 A x 6D-1	4.59*	-0.16*	5.10*	-2,900.7	0.94	0.21	0.68*	2.10*	5.58*
37	CMS 302 A x RHA 271	2.58*	0.08*	0.59	2,692.2*	0.85	0.45*	1.70*	2.15*	-5.27
38	CMS 302 A x HRHA 4-2	-20.76	0.22*	-17.58	-514.9	-3.44	-0.23	-0.12	-1.47	-0.19
39	CMS 302 A x HRHA 5-3	4.88*	-0.07	4.03*	-1,820.9	-0.08	-0.65	-0.39	-4.59	-1.35
40	CMS 302 A x RHA 297	8.71*	-0.07	7.86*	2,544.3*	1.73	0.23	-1.87	1.81*	1.23*
41	CMS 607 A x 6D-1	-10.88	0.36*	-11.43	1,465.2*	-1.99	0.41*	0.68*	-2.56	4.69*

Sr. No.	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^1\text{g}^1$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
42	CMS 607 A x RHA 271	12.22*	-0.20*	12.07*	389.7	1.80	-0.42	-0.54	-5.61	6.74*
43	CMS 607 A x HRHA 4-2	13.58*	-0.22*	13.52*	189.0	0.18	0.35*	0.70*	2.27*	-1.15
44	CMS 607 A x HRHA 5-3	-1.59	-0.01	-1.34	-892.4	0.20	-0.29	-1.11	1.75*	-0.92
45	CMS 607 A x RHA 297	-13.33	0.08*	-12.82	-1,151.5	-0.20	-0.05	0.28*	4.15*	-9.36
46	CMS 852 A x 6D -1	3.64*	-0.06*	3.28*	671.4*	-3.90	-0.01	0.55*	-5.57	-4.01
47	CMS 852 A x RHA 271	2.17*	-0.09*	3.25*	-287.8	-1.18	0.84*	-0.45	1.58*	1.68*
48	CMS 852 A x HRHA 4-2	0.03	-0.05	-0.41	305.9	5.03*	-0.46	-0.83	-1.33	2.86*
49	CMS 852A x HRHA 5-3	-3.37	0.14*	-1.90	-393.2	0.98	0.09	0.39*	5.73*	-2.32
50	CMS 852 A x RHA 297	-2.48	0.07*	-4.22	-296.3	-0.93	-0.46	0.34*	-0.41	1.79*
51	ARG 2A x 6D-1	7.23*	-0.12*	8.20*	15.0	0.60	-0.16	0.15	3.91*	-1.60
52	ARG 2A x RHA 271	-14.08	0.28*	-13.21	-505.1	-2.68	-0.27	1.75*	-1.05	2.09*
53	ARG 2A x HRHA 4-2	0.53	0.14*	1.01	268.9	2.58*	-0.71	-1.33	1.54*	-3.73
54	ARG 2A x HRHA 5-3	-0.25	-0.12*	0.88	-1,814.5	-3.17	0.11	-1.24	-4.59	4.17*
55	ARG 2A x RHA 297	6.57*	-0.17*	3.12*	2,035.7*	2.67*	1.03*	0.67*	0.19	-0.94
56	ARG 3A x 6D -1	1.99*	0.06*	2.40*	-179.4	-0.05	-0.06	-1.40	-0.37	-4.13
57	ARG 3A x RHA 271	-4.74	0.25*	-4.13	-1,539.2	1.08	0.52*	0.44*	-0.97	-1.76
58	ARG 3A x HRHA 4-2	-2.30	-0.10*	-2.61	-1,121.9	-2.55	0.15	-0.31	2.20*	-3.72
59	ARG 3A x HRHA 5-3	2.80*	-0.08*	2.58*	2,363.7*	-0.07	-0.63	0.65*	-0.83	1.82*
60	ARG 3A x RHA 297	2.25*	-0.13*	1.77*	476.9	1.60	0.02	0.62*	-0.02	7.79*
61	ARG 6A x 6D-1	-8.74	0.01	-8.88	-2,145.6	-1.25	-0.20	0.07	-1.43	4.54*
62	ARG 6A x RHA 271	4.09*	-0.03	1.75*	1,000.7	-4.13	1.02*	0.91*	2.40*	-1.96

Sr. No.	Hybrids	GERM. (%)	EC ($\mu\text{Scm}^1\text{g}^1$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
63	ARG 6A x HRHA 4-2	-4.11	0.02	-3.21	1,673.3	-2.28	-0.70	-0.55	2.18*	2.66*
64	ARG 6A x HRHA 5-3	3.35*	0.06*	4.58*	927.9*	4.12*	1.06*	0.54*	0.77*	-6.44
65	ARG 6 A x RHA 297	5.41*	-0.06*	5.76*	-1,456.2	3.53*	-1.19	-0.97	-3.92	1.21*
66	DV 10 x 6D -1	-1.54	-0.06*	-2.43	569.5*	2.37*	-0.45	-0.74	-0.12	1.34*
67	DV 10 x RHA 271	3.82*	-0.15*	3.55*	1,023.7*	-1.65	0.92*	-0.41	3.85*	-6.18
68	DV 10 x HRHA 4-2	2.05*	-0.16*	2.26*	828.0*	3.38*	0.03	0.94*	-2.72	3.16*
69	DV 10 x HRHA 5-3	-1.21	0.03	-1.35	-1,107.4	-1.48	-0.44	0.79*	0.61*	-1.89
70	DV -10 x RHA 297	-3.13	0.33*	-2.04	-1,313.8	-2.62	-0.05	-0.57	-1.61	3.57*
71	CMS 207 A x 6D -1	-0.19	-0.06*	-2.98	-890.6	-7.38	-0.17	-0.09	-4.88	1.32*
72	CMS 207 A x RHA 271	-5.60	0.05*	-4.14	-2,384.0	1.01	-0.88	-0.42	0.49*	-2.41
73	CMS 207 A x HRHA 4-2	-3.95	-0.01	-3.57	-802.4	-1.04	2.87*	-0.43	0.44	0.67*
74	CMS 207 A x HRHA 5-3	4.57*	-0.04*	3.06*	1,450.9*	5.55	-2.11	0.41*	2.35*	-0.21
75	CMS 207 A x RHA 297	5.17*	0.06*	7.63*	2,626.1*	1.86	0.29*	0.54*	1.62*	0.63*
	SE	0.85	0.02	0.66	272.9	0.96	0.11	0.09	0.23	0.11
	CD at 5 %	1.69	0.04	1.31	546.3	1.91	0.22	0.18	0.46	0.22

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

4.5 Heterosis

Heterosis of hybrids (F_1) over their respective better parents and standard check HSFH 848 was calculated for seed yield and its component traits and expressed in percentage.

4.5.1 Analysis of variance for parents and hybrids over the environments and in E_1 , E_2 , E_3 , E_4

The mean sums of square for all the traits were computed and results are being presented in tables 4.31, 4.32, 4.33, 4.34 and 4.35.

The mean sum of square due to partitioning component parents, males, females, hybrids, location, hybrid x location, (parent vs. hybrid) x location were found significant for seed yield and its all component characters except electrical conductivity under all the environments.

Over the environments (table 4.35), the mean sum of squares, due to replications were found significant which emphasizes presence of enough variations in the environment. The mean sum of squares due to partitioning component parents, males, females, hybrids, location, hybrid x location, (parent vs. hybrid) x location were found significant for seed yield and its all component characters except electrical conductivity which was significant for male, female vs male and parents vs hybrids.

4.5.1 Plant height (cm)

Negative heterosis was desirable for the plant height. In E_1 , the results indicated that the heterosis over better parent were observed by the hybrids, namely, CMS 207 A x RHA 271 (-26.17%), CMS 302 A x HRHA 4-2 (-23.84%) and ARG 6A x RHA 271 (-23.34%) and the hybrids, CMS 44A x RHA 271 (-23.91%), CMS 607A x HRHA 4-2 (-19.84%) and CMS 148 A x RHA 271 (-19.77%) exhibited negative and significant heterosis over standard check HSFH 848 for this trait. In E_2 , sixty hybrids over better parent and sixty two hybrids over standard check showed negative and significant heterosis per cent. The major hybrids over better parent were ARG 6A x RHA 271 (-24.95 %), CMS 302 A x 6D-1 (-21.75%) and CMS 852 A x RHA 271 (-18.99%) whereas the hybrids ARG 6A x RHA 271 (-15.56%), CMS 148 A x HRHA 5-3 (-13.24%) and CMS 302 A x 6D-1 (-12.23%) were prominent over standard check showed negative and significant heterosis.

In E_3 , the hybrids, CMS 302 A x RHA 271 (57.08%), CMS 302 A x RHA 297 (53.34%) and CMS 11 A x RHA 297 (39.59%) were found to be positive and significant heterosis over better parent whereas, the hybrids CMS 302 A x RHA 271 (45.48%), CMS 607 A x HRHA 5-3 (35.99%) and CMS 17 A x HRHA 5-3 (34.37%) showed positive and significant heterosis over standard check.

Table 4.31 Analysis of variance for parents and hybrids in E₁

		MSS									
SOURCE	D.F.	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
REPL/LOC	2	18.53	1.56	0.06	0.14	1.18	0.82	32.07	44.00	82.58*	129.24
PARENTS	19	493.54*	10.26*	0.91	12.78*	53.74*	1.58	13.49*	39.47*	116.77*	376.99*
FEMALES	14	479.52*	11.70*	0.94	11.74*	52.71*	1.72	14.93*	38.33*	134.59*	389.18*
MALES	4	636.76*	7.77*	0.86	18.45*	57.14*	0.71	11.46*	50.50*	68.41*	361.56*
FEMALE VS MALES	1	116.95*	0.32	0.60	4.56*	54.60*	3.06*	1.42	11.26*	60.69*	268.138
HYBRIDS	74	178.92*	13.28*	2.41	20.67*	18.46*	3.17*	14.57*	2.24	89.28*	110.66*
PAR VS HYB	1	5.13*	550.28*	225.41*	153.11*	29.88*	367.94*	5151.47*	2592.28*	13133.52*	66678.22*
ERROR	188	3.67	1.29	0.23	1.51	2.18	0.82	8.39	3.01	33.56	19.99

		MSS								
SOURCE	D.F.	GERM. (%)	EC (μScm ¹ g ¹)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
REPL/LOC	2	59.62	0.02	84.29	277966.00	30.59	34.85	44.69	38.45	19.41
PARENTS	19	395.04*	0.13	357.02*	6530.00*	46.45*	3.00	4.63*	123.46*	237.57*
FEMALES	14	369.32*	0.03	333.68*	62814.00*	45.88*	3.00	3.11*	130.17*	209.82*
MALES	4	543.74*	0.44	523.27*	89513.00*	30.45*	3.60*	10.90*	21.66*	350.65*
FEMALE VS MALES	1	160.38*	0.36	18.73*	333312.00*	118.54*	0.73	0.93	436.58*	173.75*
HYBRIDS	74	64.51*	0.07	75.97*	22675.00*	166.85*	3.98*	13.07*	213.25*	341.46*
PAR VS HYB	1	6514.31*	0.15	13437.91*	18892.00*	10286.18*	17.94*	33.49*	1666.71*	5880.63*
ERROR	188	12.38	0.01	10.06	4846.00	48.19	0.25	0.19	2.84	7.18

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid. * at 5% level of significance, ** at 1% level of significance .

Table 4.32 Analysis of variance for parents and hybrids in E₂.

SOURCE	D.F.	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY(g)	OC (%)	HC (%)	%SF
REPL/LOC	2	8.08	3.58	0.97	0.10	8.51	0.57	4.30	31.84	156.06	21.81
PARENTS	19	473.30*	9.89*	0.96	11.54*	43.18*	1.00	21.68*	21.35*	57.06*	359.46*
FEMALES	14	460.96*	9.40*	0.86	8.62*	43.63*	0.96	19.90*	23.02*	56.61*	378.60*
MALES	4	634.79*	13.17*	1.50	20.76*	50.15*	1.09	33.15*	20.82*	71.01*	359.81*
FEMALE VS MALES	1	0.06	3.56*	0.15	15.57*	8.88*	1.27	0.80	0.00	7.54*	90.09*
HYBRIDS	74	269.42*	7.97*	2.01	35.98*	21.38*	2.20	5.94*	4.28*	222.23*	38.76*
PAR VS HYB	1	2781.50*	236.05*	194.78*	8.27*	143.31*	417.67*	4336.41*	3888.99*	8116.48*	94709.84*
ERROR	188	3.75	1.30	0.27	1.28	1.22	0.72	2.54	2.73	14.35	5.77

SOURCE	D.F.	GERM. (%)	EC (µS cm ⁻¹ g ⁻¹)	VIAB (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
REPL/LOC	2	50.19	0.02	59.62	40104.30	18.20	18.58	41.37	41.59	91.16
PARENTS	19	350.61*	0.14	338.09*	90491.00*	39.52*	2.53	2.38	63.22*	22.61*
FEMALES	14	306.44*	0.03	309.11*	96733.00*	39.54*	2.71	2.86	73.90*	24.30*
MALES	4	553.21*	0.43	506.55*	84511.00*	39.26*	2.10	1.24	29.13*	4.47*
FEMALE VS MALES	1	158.68*	0.46	69.81*	270694.00*	40.18*	1.80	0.21	49.93*	71.45*
HYBRIDS	74	92.02*	0.08	110.23*	24042.00*	303.06*	6.93*	15.03*	163.05*	337.69*
PAR VS HYB	1	13973.69*	0.60	14479.94*	39035.00*	19970.40*	70.57*	9.85*	690.73*	1027.77*
ERROR	188	12.00	0.04	3.64	4252.20	4.15	0.34	0.13	4.57	7.65

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II,PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid. * at 5% level of significance, ** at 1% level of significance .

Table 4.33 Analysis of variance for parents and hybrids in E₃

SOURCE	D.F.	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
REPL/LOC	2	1366.01	125.57	3.34	42.93	10.84	0.57	259.73	37.12	17.56	11.28
PARENTS	19	314.94*	8.02*	1.52	8.48*	13.13*	2.55	83.67*	44.17*	186.16*	463.27*
FEMALES	14	385.50*	7.40*	1.61	9.93*	13.69*	2.71	65.73*	49.41*	214.61*	560.30*
MALES	4	140.81*	3.98*	1.56	5.50*	7.07*	1.00	130.86*	35.93*	127.03*	60.58*
FEMALE VS MALES	1	23.72*	32.95*	0.01	0.21	29.59*	6.54*	146.14*	3.78*	24.36*	715.59*
HYBRIDS	74	312.99*	8.93*	2.25	30.91*	19.44*	3.47*	51.98*	4.47*	108.27*	721.08*
PAR VS HYB	1	87511.88*	2105.29*	703.56*	10.66*	160.31*	254.86*	16284.39*	3492.95*	7593.968	25709.45*
ERROR	188	60.79	2.53	0.49	4.21	1.64	0.69	6.63	2.51	11.12	9.78

SOURCE	D.F.	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
REPL/LOC	2	24.34	0.01	28.01	286720.00	111.19	14.67	22.09	659.62	76.13
PARENTS	19	455.57*	0.29	480.37*	286428.00*	110.05*	1.72	4.67*	45.79*	72.73*
FEMALES	14	410.52*	0.12	393.77*	31880.00*	96.77*	0.97	5.20*	52.55*	33.20*
MALES	4	725.33*	0.69	899.64*	15123.00*	45.51*	1.97	3.76*	30.61*	29.70*
FEMALE VS MALES	1	7.22*	1.11	15.68*	373934.00*	554.09*	11.23*	0.92	11.84*	798.17*
HYBRIDS	74	784.69*	0.39	743.43*	464728.00*	270.11*	9.00*	4.22*	163.67*	100.08*
PAR VS HYB	1	354.03*	2.52	12.09*	286720.00*	6554.94*	10.76*	2.20	3588.00*	1781.70*
ERROR	188	14.80	0.00	8.84	697.53	6.29	0.56	0.14	5.18	0.41

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II,PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid. * at 5% level of significance, ** at 1% level of significance .

Table 4.34 Analysis of variance for parents and hybrids in E₄

SOURCE	D.F.	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	%SF
REPL/LOC	2	17.40	9.04	6.10	11.23	0.22	1.78	3.65	56.47	1.40	60.66
PARENTS	19	295.86*	4.42*	1.70	8.49*	14.93*	1.73	69.50*	50.81*	181.59*	407.52*
FEMALES	14	374.28*	1.97	1.78	8.76*	14.31*	1.42	51.01*	57.33*	209.58*	495.64*
MALES	4	91.41*	1.78	1.77	8.43*	20.63*	2.13	135.01*	40.67*	127.11*	37.97*
FEMALE VS MALES	1	15.78*	49.20*	0.27	4.89*	0.78	4.62*	66.29*	0.13	7.68*	651.87*
HYBRIDS	74	354.73*	10.49*	2.79	24.75*	26.15*	2.38	63.34*	3.36*	181.81*	736.69*
PAR VS HYB	1	218106.10*	1816.39*	565.47*	562.19*	429.75*	279.33*	15796.47*	2861.64*	11082.53*	24298.30*
ERROR	188	7.46	2.71	1.02	6.90	1.76	0.74	3.66	2.03	13.78	9.27

SOURCE	D.F.	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
REPL/LOC	2	22.68	0.03	75.71	266720.00	112.75	39.70	1.27	123.54	107.41
PARENTS	19	420.87*	0.27	483.01*	936626.00*	70.75*	1.51	3.90*	47.67*	111.39*
FEMALES	14	382.07*	0.10	414.39*	125031.00*	63.63*	0.99	4.53*	51.54*	79.06*
MALES	4	655.81*	0.65	837.65*	107511.50*	17.61*	1.92	2.24	45.17*	57.98*
FEMALE VS MALES	1	24.20*	1.13	25.18*	248420.00*	382.99*	7.24*	1.86	3.59*	777.65*
HYBRIDS	74	742.39*	0.47	657.56*	528936.80*	211.36*	9.93*	4.31*	127.57*	103.55*
PAR VS HYB	1	784.91*	4.32*	0.31	320512.00*	717.82*	39.54*	1.83	688.13*	3433.28*
ERROR	188	14.75	0.05	8.57	1904.00	4.24	0.28	0.36	2.88	0.72

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid. * at 5% level of significance, ** at 1% level of significance.

Table 4.35 Analysis of variance for parents and hybrids over the environments

SOURCE	D.F.	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY(g)	OC (%)	HC (%)	%SF
LOCATIONS	3	471553.80*	2403.26*	445.64*	2270.48*	587.32*	45.37*	18084.43*	1338.61*	2655.00*	9770.52*
REPL/LOC	8	352.51*	34.94*	2.62*	13.64*	5.19*	0.93	74.93*	42.37*	64.41*	55.78*
PARENTS	19	1031.16*	17.39*	1.69	27.43*	97.80*	2.75*	78.15*	72.69*	412.93*	1302.84*
FEMALES	14	1208.69*	13.82*	1.55	24.83*	96.10*	3.59*	71.36*	69.38*	504.18*	1625.01*
MALES	4	667.40*	20.80*	2.57*	42.63*	110.84*	0.28	90.30*	102.40*	176.00*	457.30*
FEMALE VS MALES	1	0.50	53.68*	0.07	2.89*	69.50*	0.84	124.46*	0.27	83.13*	174.53*
HYBRIDS	74	327.27*	11.69*	2.29*	27.65*	23.70*	2.78*	43.06*	3.67*	207.94*	379.03*
PAR VS HYB	1	165380.50*	4052.98*	1571.11*	30.06*	162.00*	1306.71*	38204.08*	0.13	39423.75*	194564.30*
PAR x LOC	57	182.13*	5.07*	1.13	4.61*	9.04*	1.37	36.73*	27.71*	42.88*	101.45*
FEMALE x LOC	42	163.81*	5.55*	1.22	4.72*	9.39*	1.07	26.73*	32.91*	37.07*	66.21*
MALE x LOC	12	278.79*	1.97	1.04	3.51*	8.05*	1.55	73.40*	15.18*	72.52*	120.87*
(F VS M) x LOC	3	52.06*	10.68*	0.32	7.44*	8.11*	4.88*	30.05*	4.96*	5.72*	517.05*
HYBRIDS x LOC	222	262.93*	9.66*	2.39*	28.22*	20.57*	2.81*	30.92*	3.56*	131.21*	409.40*
(PAR VS HYB) x LOC	3	47674.67*	218.33*	39.37*	235.08*	201.01*	4.36*	1121.54*	4278.39*	167.75*	5611.38*
ERROR	752	18.90	1.95	0.50	3.47	1.69	0.74	5.31	2.57	18.20	11.20

SOURCE	D.F.	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
LOCATIONS	3	6707.42*	0.99	4465.76*	726135.00*	4540.15*	35.48*	284.37*	111499.70*	66843.22*
REPL/LOC	8	39.13*	0.01	61.81*	674804.00*	68.17*	26.95*	27.36*	215.79*	73.52*
PARENTS	19	1557.88*	0.76	1608.11*	3049624.00*	222.54*	3.66*	11.68*	75.31*	163.53*
FEMALES	14	1401.63*	0.22	1411.27*	4050480.00*	202.64*	3.97*	12.72*	81.72*	99.98*
MALES	4	2446.95*	2.16*	2669.80*	237296.00*	120.33*	1.56	10.11*	39.70*	48.78*
FEMALE VS MALES	1	188.84*	2.88*	117.25*	286986.00*	910.06*	7.71*	3.51*	127.93*	1512.28*
HYBRIDS	74	716.71*	0.36	664.11*	436387.00*	345.23*	12.36*	11.02*	141.95*	292.61*
PAR VS HYB	1	5783.38*	5.84*	13618.75*	31435570.00*	30711.53*	123.26*	19.34*	90.47*	10977.03*
PAR x LOC	57	21.36*	0.02	16.77*	2252955.00*	14.74*	1.70	1.30	68.27*	93.59*
FEMALE x LOC	42	22.16*	0.02	13.20*	29770200.00*	14.39*	1.23	0.99	75.47*	82.15*
MALE x LOC	12	10.38*	0.02	32.44*	6516088.00*	4.17*	2.68*	2.68*	28.96*	131.34*
(F VS M) x LOC	3	53.97*8	0.06	4.02*	8672208.00*	61.92*	4.43*	0.14	124.65*	102.88*
HYBRIDS x LOC	222	322.30*	0.22	307.68*	3414844.00*	202.05*	5.83*	8.54*	175.19*	196.72*
(PAR VS HYB) x LOC	3	5283.12*	0.58	4771.49*	8938517.00*	2272.59*	5.16*	9.33*	2181.01*	381.94*
ERROR	752	13.48	0.01	7.78	48929.00	15.72	0.36	0.20	3.87	3.99

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid. * at 5% level of significance, ** at 1% level of significance.

In E₄, the heterosis over better parent were found to be positive and significant for the hybrids, CMSH 91 A x HRH A 5-3 (70.45 %), CMS 302 A x HRHA 5-3 (67.44 %) and ARG 3A x RHA 297 (70.70 %) whereas the hybrids CMS 17 A x 6D-1 (55.90 %), CMS 44A x HRHA 4-2 (55.80%) and CMSH 91 A x 6D-1 (56.11 %) showed significant heterosis over standard check.

Over the environments, the heterosis over better parent and standard check had positive and significant heterosis. The prominent hybrids over better parent were CMS 103 A x HRHA 5-3 (42.07%), CMSH 91 A x HRHA 4-2 (43.27%) and CMSH 91 A x HRHA 5-3 (40.72%) showed positive and significant heterosis and major hybrids over standard check were CMS 17 A x 6D-1 (27.34%), CMS 607 A x RHA 271 (26.60%) and CMS 302 A x RHA 297 (26.12%) showed positive and significant heterosis for this trait.

4.5.2 Head diameter (cm)

Positive heterosis was desirable for head diameter. In E₁, sixty one hybrids over better parent showed high significant positive heterosis per cent. The cross combinations CMS 207 A x RHA 297 (127.92%), CMS 17 A x HRHA 5-3 (124.31%) and CMS 852 A x RHA 297 (108.19%) had high positive heterosis per cent for enlarge head diameter. Whereas sixty seven hybrids over standard check HSFH 848 showed high significant positive heterosis per cent. The hybrids CMS 17 A x HRHA 5-3 (96.21%), CMS 207 A x HRHA 5-3 (68.99%) , and CMS 17 A x 6D-1 (60.13%) had high positive heterosis. In E₂, the heterosis over better parent and standard check were positive significant for all the hybrids. The prominent hybrids showing heterosis over better parent were CMS 207 A x RHA 297 (93.69%), ARG 6A x 6D-1 (88.39%) and CMS 852 A x RHA 271 (62.14%) while major hybrids over standard check were CMS 17 A x HRHA 5-3 (45.61%), CMS 44 A x 6D-1 (23.63%) and CMS 148 A x HRHA 4-2 (23.63%) were found to be significant for head diameter.

In E₃, the result indicated that the heterosis over better parent and standard check were found to be positive and significant. The major hybrids over better parent were ARG 2A x 6D-1 (102.12%), ARG 2A x RHA 297 (101.62%) and CMS 234 A x 6D-1 (88.26%) and the hybrid superior over standard check were CMSH 91 A x 6D-1 (57.80%), CMS 234 A x 6D-1 (41.24%) and ARG 2A x 6D-1 (36.88%). In E₄, the hybrids DV-10 x 6D-1 (90.72%), DV-10 x RHA 271 (76.19%) and ARG 3A x 6D-1 (76.16%) were found to be recorded positive and significant heterosis over better parent and the hybrids DV 10 x 6D-1 (50.81%), ARG 3A x 6D-1 (48.31%) and CMS 17 A x 6D-1 (45.32%) were found to observe positive and significant heterosis over standard check.

Over the environments (table 4.40), the heterosis were positive and significant for all the hybrids. The major hybrids over better parent were CMS 207 A x RHA 297 (82.56%), CMS 17 A x HRHA 5-3 (75.95%) and ARG 6A x 6D-1(71.60%) and the prominent hybrids

over standard check were CMS 17 A x HRHA 5-3 (37.99%), CMS 148 A x HRHA 4-2 (30.97%) and CMS 207 A x RHA 297 (29.72%) for this trait .

4.5.3 Stem diameter (cm)

Positive heterosis was desirable for stem diameter. In E_1 (table 4.36), the results indicated that the heterosis over better parent were observed by the hybrids, namely, CMS 148 A x HRHA 5-3 (127.84%), CMS 207 A x RHA 297 (99.25%) and ARG 2 A x HRHA 4-2 (89.56%) and the hybrids, CMS 17 A x RHA 297 (43.69%), CMS 207 A x RHA 297 (40.01%), CMS 148 A x HRHA 5-3 (25.80%) were found positive to be significant heterosis over standard check HSFH 848. In E_2 , over better parent seventy five hybrids showed significant heterosis. The cross combinations, over better parent CMS 234 A x HRHA 5-3 (128.92%), CMS 11 A x HRHA 5-3 (94.54%) and CMS 148 A x HRHA 4-2 (94.11%) showed highly positive and significant heterosis. Whereas, seventy four hybrids over standard check showed positive and significant heterosis. The hybrids, CMS 44 A x 6D-1 (77.26%), CMS 207 A x HRHA 4-2 (71.05%) and CMS 234 A x HRHA 5-3 (70.53%) showed positive and significant heterosis over standard check for this trait.

In E_3 , the hybrids, CMS 148 A x HRHA 4-2 (127.20%), CMS 852 A x HRHA 4-2 (124.80%) and CMS 148 A x RHA 297 (114.93%) showed positive and significant heterosis over better parent while the hybrids CMSH 91 A x RHA 271 (67.96%), CMS 44A x HRHA 5-3 (60.13%) and CMS 234 A x RHA 271 (52.78%) were observed positive and significant heterosis over standard check. In E_4 , the extent of heterosis over better parent was observed by the hybrids, CMS 852 A x HRHA 4-2 (134.41%), CMS 44A x RHA 297 (125.44%) and DV-10 x 6D-1 (115.25%) and the heterosis over standard check was observed by the hybrids CMS 607 A x 6D-1 (11.98 %), DV-10 x 6D-1 (11.20 %) and CMS 234 A x RHA 271 (10.43%) were found to be positive and significant heterosis .

In pooled analysis, it was recorded (table. 4.40) that seventy five hybrids over better parent and seventy one hybrids over standard check showed positive and significant heterosis for stem diameter. The hybrids, CMS 148 A x HRHA 4-2 (106.55%), CMS 44 A x RHA 297 (80.93%) and CMS 234 A x RHA 271 (76.21%) showed positive and significant heterosis over better parent whereas, the hybrids CMS 44 A x RHA 297 (23.66%), CMS 17A x HRHA 5-3 (23.16%) and CMS 234 A x RHA 271 (21.77%) were found to be positive and significant heterosis over standard check.

4.5.4 Days to 50 % flowering

Negative heterosis was desirable for days to 50 % flowering. In E_1 , fifty six hybrids over better parent and thirty hybrids over standard check showed negative and significant heterosis. The hybrids, CMS 17 A x HRHA 4-2 (-10.85%), CMS 148 A x HRHA 4-2 (-9.68%) and CMS 11 A x HRHA 4-2 (-8.74%) observed to be negative and significant heterosis over

better parent for early flowering, while the hybrids CMS 607 A x HRHA 5-3 (-4.35%), CMS 148 A x HRHA 4-2 (-3.44%) and CMS 234 A x 6D-1 (-3.44%) were observed to express negative and significant heterosis over standard check. In E₂, the hybrids, CMS 148 A x HRHA 4-2 (-6.33%), CMS 11 A x HRHA 4-2 (-5.85%) and CMSH 91 A x RHA 271 (-5.35%) showed negative and significant heterosis over better parent whereas, the hybrids CMS 17 A x RHA 297 (-2.53%), CMS 11 A x HRHA 4-2 (-2.31%) and CMS 607 A x HRHA 4-2 (-1.91%) were observed to have negative and significant heterosis over standard check for this trait.

In E₃, the heterosis over better parent were observed by the hybrids ARG 6A x 6D-1 (-8.94%), CMS 148 A x HRHA 4-2 (-7.56%) and CMS 103 A x 6D-1 (-7.41%). The major hybrids over standard check were ARG 6A x 6D-1 (-6.21%), CMS 103 A x 6D-1 (-6.05%) and CMSH 91 A x RHA 297 (-5.59%) recorded negative and significant heterosis for early flowering. In E₄, the hybrids CMS 148 A x HRHA 5-3 (19.67%), CMS 11 A x RHA 297 (17.76%) and CMSH 91 A x HRHA 5-3 (15.13%) observed to be negative and significant heterosis over better parent and the magnitude of heterosis for the hybrids CMS 148 A x HRHA 5-3 (20.96%), CMS 11 A x RHA 297 (20.31%) and CMSH 91 A x HRHA 4-2 (17.61%) exhibited negative and significant heterosis over standard check.

Over the environments, fifty three hybrids over better parent showed negative and significant heterosis per cent. The hybrids, CMS 148 A x HRHA 4-2 (-6.11%), CMS 302 A x 6D-1 (-4.56%) and ARG 2A x 6D-1 (-2.81%) were found to be negative and significant over better parent whereas, sixty eight hybrid over standard check showed significant heterosis per cent, whereas but the only one hybrid viz., CMS 302 A x 6D-1 (-1.45%) observed negative and significant heterosis over the standard check for early flowering.

4.5.5 Days to maturity

Negative heterosis was desirable for days to maturity. The results indicated that the extent of heterosis in E₁, over better parent was observed by the hybrids, CMS 17 A x HRHA 4-2 (-4.98%), CMS 103 A x HRHA 4-2 (-2.83%) and CMS 11A x HRHA 4-2 (-2.66%) and over standard check HSFH 848 the hybrid CMS 607 A x RHA 271 (-3.17%) was found negative significant heterosis. In E₂, the hybrids, CMS 17 A x RHA 271 (-4.39%), CMS 17 A x HRHA 4-2 (-3.59%) and CMS 148 A x RHA 297 (-2.83%) showed negative and significant heterosis over better parent and the hybrids, CMS 302 A x HRHA 5-3 (17.44%), CMS 234 A x HRHA 5-3 (13.68) and CMS 607 A x 6D-1 (11.82) showed negative and significant heterosis over standard check.

In E₃, the magnitude of heterosis over better parent was observed by the hybrids, CMS 17 A x RHA 297 (-7.39%), CMS 148 A x RHA 297 (-7.29%) and CMS 103 A x RHA 271 (-7.14%), whereas the extent of heterosis over standard check was observed by the

hybrids CMS 17 A x 6D-1 (10.23), CMS 234 A x RHA 271 (10.61) and CMS 207 A x RHA 297 (10.23%) showed negative and significant heterosis for this trait. In E₄, sixty six hybrids over better parent showed significant heterosis but out of them only four hybrids showed the negative and significant heterosis percent. The hybrids, CMS 852 A x RHA 271 (-6.17%), CMS 852 A x RHA 297 (-5.12%) and ARG 2A x RHA 271 (-3.81%) were found to be negative and significant heterosis over better parent whereas thirty four hybrids showed significant heterosis over standard check out of them only seven hybrids showed negative and significant heterosis percent. The hybrids CMS 852 A x RHA 271 (-7.93%), CMS 852 A x RHA 297 (-6.90%) and ARG 2A x RHA 271 (-5.86%) were observed negative and significant heterosis over standard check for this trait.

Over the environments, fifty seven hybrids over better parent showed significant heterosis and three hybrids, namely, CMS 148 A x RHA 297 (-2.88%), CMS 103 A x RHA 271 (-2.08%) and CMS 103 A x HRHA 4-2 (-2.71%) exhibited negative and significant heterosis per cent, whereas, seventy three hybrids showed positive and significant heterosis per cent for early maturity over standard check.

4.5.6 Hundred seed weight (g)

Positive heterosis was desirable for 100 Seed weight. In E₁, over better parent seventy four hybrids showed high significant heterosis per cent. The hybrids, CMS 207 A x HRHA 5-3 (99.56%), CMS 607 A x RHA 297 (93.28%) and CMS 17 A x RHA 297 (90.51%) had high positive heterosis for test weight and over standard check sixty five hybrids showed positive significant heterosis. The hybrids, ARG 6A x RHA 271 (52.18%), CMS 207 A x HRHA 5-3 (49.99%) and CMS 207 A x RHA 271 (49.45%) observed positive and significant heterosis for this trait. In E₂, the extent of heterosis over better parent and standard parent were positive and significant for test weight. The major hybrids over better parent were CMS 17A x RHA 271 (123.52%), CMS 852 A x RHA 271 (116.82%) and CMS 207 A x RHA 271 (117.69%) while the prominent hybrids over standard check were CMS 44 A x 6D-1 (30.73%), CMS 103 A x 6D-1 (30.73%) and CMSH 91 A x RHA 297 (22.45%).

In E₃ (table 4.38), the hybrids CMS 103 A x HRHA 5-3 (82%) CMS 103 A x RHA 297 (78%) and CMS 44 A x HRHA 5-3 (72.00%) were found superior over better parent hybrids superior than standard check were ARG 3 A x RHA 271 (39.61%), ARG 2 A x RHA 297 (36.64%) and CMS 103 A x HRHA 5-3 (35.16%). In E₄, the magnitude of standard heterosis over better parent was observed by the hybrids viz., CMS 103 A x HRHA 4-2 (89.49%), CMS 44A x 6D-1 (80.21%) and ARG 6A x 6D-1 (77.42%) whereas the hybrids, CMS 607 A x HRHA 4-2 (62.21%), CMS 11A x RHA 297 (57.45%) and CMS 148 A x RHA 297 (55.67%).

Over the environments, seventy five hybrids over better parent and seventy four hybrids over standard check showed positive and significant heterosis percent. The prominent hybrids over better parent were CMS 17 A x RHA 271 (75.69%), CMS 17 A x HRHA 4-2 (74.85%) and CMS 44 A x 6D-1 (73.39%) while the major hybrids over standard check were CMS 17 A x RHA 271(34.16%), CMS 44 A x 6D-1(31.12%) and CMS 103 A x 6D-1 (30.73%) for this trait.

4.5.7 Seed yield per plant (g)

Positive heterosis was desirable for the seed yield per plant. In E₁, seventy five hybrids over better parent and over standard check showed positive and significant heterosis per cent. The hybrids, CMS 207 A x RHA 297 (108.00%), CMS 234 A x RHA 297 (107.14%) and CMS 17 x RHA 297 (106.55%) over better parent showed positive and significant heterosis and the hybrids, CMS 17 A x RHA 297 (60.01%), DV-10 x RHA 297 (52.28%) and CMS 207 A x HRHA 5-3 (51.24%) over standard check HSFH 848 observed positive and significant heterosis. In E₂, the hybrids, CMS 852 A x RHA 297 (112.92%), ARG 6A x 6D-1 (108.87%) and CMS 302 A x RHA 297 (100.50%) were found to be significant heterosis over better heterosis while the hybrids CMS 11A x RHA 297 (30.10%), CMS 852 A x RHA 271 (29.95%) and ARG 3A x HRHA 5-3 (29.65%) were observed to have positive and significant over standard check for this trait.

In E₃, seventy five hybrids showed positive and significant heterosis per cent over better parent and over standard check. The heterosis over better parent was observed by the hybrids, CMS 103A x HRHA 4-2 (159.22%), CMS 44 A x HRHA 4-2 (154.60%), CMS 234 A x 6D-1 (154.34%) whereas the heterosis over standard check was observed by the hybrids, CMS 148 A x RHA 297 (44.99%), CMS 44 A x RHA 297 (42.96%), CMS 234 A x 6D-1 (39.16%) exhibited positive and significant heterosis per cent. In E₄, the hybrids CMS 44A x HRHA 4-2 (162.64%), CMS 302 A x HRHA 4-2 (139.03) and CMS 103 A x 6D-1 (129.63) were found to be positive and significant heterosis over better parent whereas, the hybrids CMS 207 A x HRHA 5-3 (55.91%), CMSH 91 A x HRHA 5-3 (48.66%) and CMSH 91 A x RHA 297 (33.72%) were observed to have positive and significant over standard check.

In pooled analysis (table 4.40), seventy five hybrids showed the positive and significant heterosis over both the parents i.e. over better parent and over standard check. The hybrids, CMS 302 A x HRHA 4-2 (111.18%), CMS 44 A x HRHA 4-2 (108.34%) and CMS 234 A x 6D-1 (100.28%) showed positive and significant heterosis percent over better parent whereas the hybrids, CMS 207 A x HRHA 5-3 (38.55%), CMS 148 A x HRHA 5-3 (32.74%) and CMSH 91 A x 6D-1 (31.89%) were observed to have positive and significant heterosis percent over standard check for this trait .

4.5.8 Oil content (%)

Positive heterosis was desirable for the oil content. In E₁, fifty nine hybrids over better parent showed positive and significant heterosis. The hybrids, CMS 207 A x RHA 271 (42.54%), CMS 207 A x RHA 297 (41.31%) and ARG 6A x RHA 297 (37.74%) showed highly positive and significant heterosis percent whereas seventy five crosses over standard check HSFH 848 showed positive and significant heterosis per cent. The hybrids CMS 207 A x RHA 297 (27.28%), CMS 207 A x RHA 271 (25.00%) and ARG 6A x HRHA 5-3 (24.79%) were observed to have highly positive and significant heterosis percent. In E₂, the heterosis over better parent was observed in the hybrids ARG 6A x 6D-1 (49.17%), DV-10 x RHA 271 (47.37%) and CMS 103 A x RHA 271 (46.49%) showed positive and significant heterosis. Whereas, heterosis over standard check was observed in the hybrids CMS 607 A x HRHA 4-2 (-9.60%), CMSH 91 A x RHA 297 (-9.28%) and CMS 852 A x RHA 271 (-9.20%) showed negative and significant heterosis for this trait.

In E₃, the heterosis over better parent was observed in the hybrids, CMS 302 A x 6D-1 (-27.75%), CMS 852 A x HRHA 4-2 (-26.90%) and ARG 6A x RHA 297 (-27.93%) whereas the heterosis over standard check was observed in the hybrids CMS 207 A x 6D-1 (9.27%), CMS 148 A x RHA 297 (8.74%) and CMS 148 A x HRHA 5-3 (8.04%) showed significant heterosis per cent. In E₄, seventy five hybrids over better parent and fifty hybrids over standard check showed significant heterosis percent. The cross combinations, ARG 6A x RHA 297 (-29.28%), ARG 6A x 6D-1 (-28.71%) and ARG 6A x RHA 271 (-27.70%) were found to be negative and significant heterosis over better parent while the hybrids CMS 207 A x 6D-1 (4.38%), DV-10 x RHA 297 (2.78%) and CMS 207A x RHA 297 (2.44%) were observed positive and significant heterosis over standard check.

Over the environments, seventy five crosses over the better parent and sixty six crosses over standard check showed significant heterosis per cent. The hybrids, CMS 207 A x HRH A5-3 (8.67%), CMS 11 A x HRHA 5-3 (7.09%) and CMS 207 A x 6D-1 (6.90%) showed positive and significant heterosis over better parent whereas, the hybrids CMS 207 A x RHA 297 (6.52%), CMS 207 A x 6D-1 (6.63%) and CMS 17A x 6D-1 (5.28%) were observed to have positive and significant heterosis over the standard check for this trait.

4.5.9 Hull content (%)

Negative heterosis was desirable for hull content. In E₁, the heterosis over better parent were observed in hybrids CMS 852 A x RHA 297 (90.10%), CMS 302 A x RHA 297 (79.90%) and CMS 103 A x RHA 271 (64.90%) while the heterosis over standard check were observed by the hybrids DV10 x RHA 271 (50.59%), ARG 6A x RHA 271 (49.99%) and CMS 302 A x HRHA 4-2 (49.84%), but all this hybrids were positive significant. In E₂, seventy two hybrid over better parent and sixty six hybrid over standard check showed

significant heterosis per cent. The cross combinations, CMS 11A x HRHA 5-3 (-53.71%), CMS 17 A x RHA 297 (-33.43%) and CMS 17 A x HRHA 4-2 (-32.18%) were found to be negative and significant over better parent, whereas the hybrids CMS 11A x HRHA 5-3 (-50.05%), CMS 17 A x RHA 297 (-25.77%) and CMS 17 A x HRHA 4-2 (-24.38%) were observed to have negative and significant over standard check for this trait.

In E₃, the heterosis over better parent was observed in the hybrids CMS 17 A x HRHA 5-3 (-26.60%), CMS 17 A x HRHA 4-2 (-16.01%) and CMS 148 A x HRHA 5-3 (-13.36%) showed negative and significant heterosis while the hybrids CMS 17 A x HRHA 5-3 (-28.46%), CMS 44 A x HRHA 5-3 (-23.77%) and CMS 207 A x 6D-1 (-32.01%) were found to be negative and significant heterosis over standard check. In E₄, seventy one hybrids over better parent and sixty crosses over standard check showed negative and significant heterosis per cent. The hybrids CMS 148 A x HRHA 5-3 (-53.63%), CMSH 91 A x 6D-1 (-40.03%) and CMS 17 A x RHA 271 (-24.17%) were found to be negative and significant over better parent whereas, the hybrids CMS 148 A x HRHA 5-3 (-53.63%), CMSH 91 A x 6D-1 (-44.66%) and CMS 17 A x RHA 271 (-19.69%) were observed to have negative and significant over standard check.

Over the environments, seventy one hybrids over better parent and sixty eight hybrids over standard check showed negative and significant heterosis per cent. The results indicated that the heterosis over better parent was observed by the hybrids, CMS 148 A x HRHA 5-3 (-10.87%), CMS 148 A x 6D-1 (-7.03%) and CMS 148 A x RHA 297 (-4.83%) whereas the hybrids CMS 207 A x 6D-1 (-6.23%) and CMS 44 A x HRHA 5-3 (-4.30%) were found to be negative and significant heterosis over standard check for this trait.

4.5.10 Percent seed filling

Positive heterosis was desirable for this trait. The results indicated that the heterosis in E₁ over better parent was observed by the hybrids, CMS 607 A x 6D-1 (131.16%), ARG 6A x 6D-1 (129.59%) and CMS 44A x 6D-1 (125.50%) and the hybrids ARG 3A x RHA 297 (58.89%), ARG 3A x HRHA 5-3 (57.27%) and ARG 3A x HRHA 4-2 (56.48%) were found to be positive and significant heterosis over standard check HSFH 848. In E₂, seventy five hybrids over better parent and over standard check showed positive and significant heterosis per cent. The hybrids CMS 44A x 6D-1 (159.10%), ARG 6A x 6D-1 (156.21%) and CMS 852 A x 6D-1 (131.18%) were found to be highly positive and significant heterosis over better parent while the hybrids CMS 103 A x HRHA 5-3 (51.21%), CMS 302 A x RHA 271 (51.10%) and ARG 3A x RHA 297 (51.18%) were found to be positive and significant heterosis over standard check.

In E₃, the magnitude of heterosis over better parent was observed by the hybrids, ARG 3A x RHA 271 (104.50%), CMS 44A x RHA 271 (104.23%) and CMS 44 A x RHA

297 (86.45%) showed positive and significant heterosis whereas the hybrids CMS 44 A x RHA 297(51.97%), CMS 207 A x RHA 297 (48.93%) and DV-10 x RHA 297 (47.28%) were observed to have positive and significant heterosis over standard check. In E₄, seventy two hybrids over better parent showed positive and significant heterosis per cent, the hybrids CMS 852 A x 6D-1 (105.59%), CMS 852 A x RHA 271 (103.51%) and CMS 44 A x RHA 271 (98.32%) had positive and significant heterosis over better parent and the hybrids CMS 11 A x HRHA 5-3 (125.51%), CMS 148 A x HRHA 4-2 (124.82%) and CMS 148 A x 6D-1 (123.76%) had positive and significant heterosis over standard check for this trait.

Over the environments, seventy four hybrids over better parent and seventy five hybrid over standard check showed positive and significant heterosis per cent. The hybrids, CMS 44A x 6D-1 (110.07%), ARG 3A x 6D-1 (107.40%) and ARG 6A x 6D-1 (102. 81%) were observed to have positive and significant heterosis over better parent and the hybrids ARG 6A x RHA 297 (61.69%), ARG 2A x 6D-1 (60.55%) and CMS 207 A x RHA 297 (58.96%) showed positive and significant heterosis over standard check for this trait.

4.5.11 Germination (%)

Positive heterosis was desirable for germination. In E₁ (table 4.36), the hybrids CMS 234 A x RHA 297 (66.53%), CMS 207 A x HRHA 5-3 (20.45%) and ARG 3A x RHA 297 (20.30%) were found to be positive and significant heterosis over better parent and the hybrids CMS 207 A x HRHA 5-3 (47.31%), CMS 234 A x RHA 271 (46.17%) and CMS 17 A x HRHA 5-3 (45.88%) were observed to have positive and significant heterosis over standard check. In E₂, the heterosis over better parent were observed by the hybrids CMS 234 A x RHA 297 (91.88%), CMS 607 A x RHA 297 (39.81%) and CMS 852 A x HRHA 5-3 (30.92%) showed positive and significant heterosis whereas the hybrids CMS 17 A x HRHA 4-2 (47.02%), DV 10 x HRHA 4-2 (46.85%) and CMS 234 A x RHA 271 (46.79%) were found to be positive and significant heterosis over standard check.

In E₃, forty hybrids over better parent and sixty six hybrid over standard check showed significant heterosis per cent. The heterosis over better parent were observed by the hybrids CMS 234 A x RHA 297 (54.41%), CMS 852 A x RHA 297 (34.49%) and CMS 207 A x RHA 297 (16.38%) showed positive and significant heterosis and the hybrids CMS 148 A x HRHA 4-2 (29.05%), CMS 852 A x RHA 297 (28.60%) and CMS 11 A x RHA 271 (28.57%) were found to be positive and significant heterosis over standard check. In E₄, the hybrids CMS 234 A x RHA 297 (51.26%), CMS 207 A x RHA 297 (15.61%) and CMS 11 A x HRHA 5-3 (9.33%) were observed over better parent whereas the hybrids CMS 148 A x HRHA 4-2 (51.35%), ARG 2A x 6D-1 (50.32%) and CMS 207 A x RHA 297 (50.30%) were observed to have positive and significant heterosis over standard check for this trait.

In pooled analysis, fifty five hybrids over better parent and seventy three hybrids over standard check showed significant heterosis per cent. The hybrids CMS 234 A x RHA 297 (65.21%), CMS 852 A x RHA 297 (20.36%) and ARG 2 A x RHA 297 (14.98%) showed positive and significant heterosis over better parent and the hybrids CMS 852 A x 6D-1 (40.45%), CMS 148 A x HRHA 4-2 (39.90%) and CMS 607 A x HRHA 4-2 (39.66%) were observed to have positive and significant heterosis over standard check for this trait.

4.5.12 Electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$)

Negative heterosis was desirable for electrical conductivity. In E_1 , the heterosis over better parent were observed by the hybrids, CMS 148 A x RHA 271 (-72.32%), CMS 44A x RHA 297 (-62.37%) and CMS 11 A x RHA 271 (-60.65%) showed negative and significant heterosis whereas the hybrids, CMS 148 A x RHA 271 (-68.49%), CMS 11 A x RHA 271 (-56.93%) and CMS 148 A x 6D-1 (-50.84%) were found to be negative and significant over standard check. In E_2 , the heterosis recorded for hybrids CMS 607 A x RHA 297 (-76.68%), CMS 17 A x RHA 297 (-67.83%) and ARG 6A x RHA 297 (-63.27%) exhibited negative and significant heterosis over better parent while the hybrids CMS 607 A x RHA 297 (-64.50%), CMS 11 A x HRHA 5-3 (-62.06%) and DV 10 x 6D-1 (-55.94%) were found to have negative and significant heterosis over standard check.

In E_3 , the hybrids CMS 607 A x HRHA 4-2 (-81.10%), ARG 3A x RHA 297 (-77.61%) and CMS 17 A x RHA 297 (-73.13%) were found to be negative and significant heterosis over better parent however, the hybrids CMS 607 A x HRHA 4-2 (-65.72%), CMS 11 A x 6D-1 (-62.09%), CMSH 91 A x HRHA 5-3 (-60.51%) were observed to have negative and significant heterosis over standard check. In E_4 , the heterosis over better parent were observed by the hybrids CMS 44A x 6D-1 (-90.39%), CMS 44A x RHA 271 (-89.08%) and CMS 17 A x HRHA 4-2 (-89.03%) whereas the hybrids CMS 44A x 6D-1 (-94.37%), CMS 44A x RHA 271 (-93.60%) and CMS 17 A x HRHA 4-2 (-93.29%) were found to be negative and significant heterosis over standard check.

Over the environments (table 4.40), seventy three hybrids over better parent and seventy five hybrids over standard check showed negative and significant heterosis percent. The heterosis over better parent were observed by the hybrids CMS 17 A x RHA 297 (-67.80%), CMS 234 A x RHA 297 (-65.51%) and CMS 11A x RHA 297 (-65.38%) and the hybrids CMS 148 A x RHA 271 (-56.70%), CMS 11 A x HRHA 5-3 (-56.14%) and CMS 11 A x RHA 271 (-55.05%) were found to be negative and significant heterosis over standard check HSFH 848 for this trait.

4.5.13 Viability (%)

Positive heterosis was desirable for this trait. In E_1 , sixty seven hybrids over better parent and seventy four hybrids over standard check showed significant heterosis per cent.

The hybrids CMS 234 A x RHA 297 (78.56%), CMS 607 A x RHA 297 (46.44%) and ARG 2A x RHA 297 (27.48%) were found to be positive and significant heterosis over better parent and the hybrids CMS 302 A x HRHA 4-2 (53.15%), CMS 103 A x HRHA 4-2 (51.79%) and CMS 302 A x HRHA 5-3 (51.20%) were found to be positive and significant heterosis over standard check. In E₂, the heterosis over better parent were observed by the hybrids CMS 234 A x RHA 297 (102.67%), CMS 17 A x RHA 297 (32.14%) and CMS 11 A x RHA 297 (30.51%) while the heterosis over standard check were observed by the hybrids CMS 148 A x RHA 297 (77.06%), CMS 148 A x HRHA 5-3 (75.89%) and CMS 234 A x HRHA 5-3 (75.50%) showed positive and significant heterosis.

In E₃, the hybrids CMS 234 A x RHA 297 (70.80%), CMS 852 A x RHA 297 (31.80%) and CMS 207 A x RHA 297 (22.54%) were observed to have positive and significant heterosis over better parents, whereas the hybrids ARG 6A x HRHA 5-3 (69.79%), CMS 852 A x 6D-1 (68.73%) and CMS 234 A x HRHA 4-2 (66.86%) were observed to have positive and significant heterosis over standard check for this trait. In E₄, the heterosis over better parent were observed by the hybrids CMS 234 A x RHA 297 (83.27%), CMS 207 A x RHA 297 (28.41%) and CMS 607 A x HRHA 4-2 (15.84%) whereas heterosis over standard check were observed by the hybrids, CMS 207 A x RHA 297 (44.87%), CMS 17 A x 6D-1 (42.36%), ARG 2A x 6D-1 (41.55%) showed positive and significant heterosis.

Over the environments, sixty five hybrids over better parent and seventy five hybrid over standard check showed positive and significant heterosis per cent. The results indicated that the heterosis over better parent were observed by the hybrids CMS 234 A x HRHA 5-3 (83.65%), CMS 852 A x RHA 297 (21.05%) and CMS 207 A x RHA 271 (24.20%) exhibited positive and significant heterosis and the hybrids, CMS 148 A x 6D-1 (55.65%), ARG 2A x 6D-1 (54.23%) and CMS 607 A x HRHA 4-2 (54.04%) were found to be positive and significant heterosis over standard check HSFH 848 for this trait.

4.5.14 Vigour index –I

Positive heterosis was desirable for this trait. In E₁, the results indicated that the heterosis over better parent were observed by the hybrids, CMS 302 A x HRHA 4-2 (88.62%), CMS 302 A x RHA 297 (72.30%), CMS 103 A x 6D-1 (67.85%) showed positive and significant heterosis and the hybrids CMS 302 A x RHA 271 (43.76%), CMS 302 A x HRHA 4-2 (51.53%) and CMS 103 A x 6D-1 (39.27%) were found to be positive and significant heterosis over standard check HSFH 848. In E₂, the hybrids CMS 11 A x 6D-1 (74.38%), CMS 11 A x HRHA 5-3 (67.21%) and CMS 11 A x RHA 297 (64.05%) were observed to have positive and significant over better parent whereas the hybrids CMS 11 A x 6D-1 (74.00%), CMS 11 A x HRHA 5-3 (66.85%) and CMS 302 A x RHA 297 (63.75%) exhibited positive and significant heterosis over standard check.

In E₃, the heterosis was found to be positive and significant over better parent for the hybrid CMS 234 A x 6D-1 (48.51%) while the hybrids, CMS 207 A x RHA 297 (46.83%) and CMS 234 A x 6D-1 (41.15%) were observed to have positive and significant heterosis over standard check. In E₄, the heterosis were observed to have positive and significant over better parent by the hybrids, CMS 17 A x RHA 297 (47.00%), CMS 234 A x RHA 297 (46.85%) and CMS 44 A x 6D-1 (45.30%) whereas the hybrids CMS 11 A x RHA 297 (60.80%), CMS 148 A x 6D-1 (54.76%) and CMS 607 A x 6D-1 (54.38%) showed positive and significant heterosis over standard check.

Over the environments, the hybrids CMS 302 A x RHA 297 (45.84), CMS 11 A x HRHA 5-3 (42.67) and CMS 11 A x RHA 297 (41.71) were found to be positive and significant heterosis over better parent however, the hybrids, CMS 11 A x HRHA 5-3 (39.99), CMS 11 A x RHA 297 (38.78) and CMS 302 A x RHA 271 (38.68) were observed to have positive and significant heterosis over standard check for this trait.

4.5.15 Vigour index –II

Positive heterosis was desirable for this trait. In E₁, seventy two hybrids over better parent showed positive and significant heterosis. The hybrids CMS 234 A x RHA 297 (174.20%), CMS 234 A x HRHA 4-2 (157.40%) and CMS 607 A x RHA 297 (146.83%) had positive and significant heterosis over better parent whereas the hybrids, CMS 103 A x RHA 271 (74.42%), CMS 103 A x 6D-1 (47.91%) and CMSH 91 A x RHA 297 (47.44%) had positive and significant heterosis over standard check for this trait. In E₂, the hybrids, CMS 852 A x HRHA 4-2 (256.41%), CMS 234 A x RHA 297 (236.12%) and CMS 852 A x RHA 297 (231.60%) were found to be positive and significant heterosis over better parent and the hybrids ARG 6A x HRHA 5-3 (18.46%), CMS 148 A x 6D-1 (17.17%) and CMS 103 A x 6D-1 (15.34%) were observed to have positive and significant heterosis over standard check.

In E₃, the heterosis over better parent were observed by the hybrids, CMS 207 A x RHA 271 (170.50%), CMS 234 A x HRHA 4-2 (138.15%) and CMS 234 A x RHA 271 (129.09%) while the heterosis over standard check were observed by the hybrids CMS 103 A x 6D-1 (39.04%), CMS 207 A x RHA 271 (38.09%) and CMS 234 A x RHA 271 (16.95%) showed positive and significant heterosis. In E₄ the hybrids CMS 234 A x RHA 297 (121.16%), CMS 234 A x HRHA 4-2 (111.62%) and CMS 17 A x RHA 297 (106.62%) were observed to have positive and significant heterosis over better parent while the hybrids CMS 17 A x RHA 297 (188.53%), CMS 11 A x RHA 297 (180.49%) and CMS 44A x 6D-1 (152.29%) were found to be positive and significant heterosis over standard check.

In pooled analysis, seventy two hybrids over better parent and sixty four hybrid over standard check showed positive and significant heterosis per cent. The results indicated that the heterosis over better parent were observed by the hybrids CMS 234 A x HRHA 4-2

(149.07%), CMS 234 A x RHA 297 (141.29%) and CMS 852 A x HRHA 4-2 (122.91%) and heterosis over standard check HSFH 848 by hybrids, CMS 103 A x 6D-1 (34.06%), CMS 103 A x RHA 271 (31.09%), CMS 148A x 6D-1 (29.05%) were found to be positive and significant heterosis for seedling vigour index II.

4.5.16 Palmitic acid (%)

Positive heterosis was desirable for palmitic acid. In E_1 , the results indicated that the heterosis over better parent were observed by the hybrids, CMS 11 A x HRHA 4-3 (47.01%), CMS 44A x HRHA 5-3 (45.22%) and CMS 207 A x RHA 297 (48.69%) and the hybrids, CMS 207 A x RHA 297 (47.94%), ARG 3 A x RHA 271 (39.80%) and ARG 3A x RHA 271 (34.07%) were found to be positive and significant heterosis over standard check HSFH 848. In E_2 , the hybrids, CMS 207 A x RHA 297 (117.99%), ARG 2 A x RHA 297 (80.58%) and ARG 6A x HRHA 5-3 (77.91%) were observed to have positive and significant heterosis over better parent and the hybrids, CMS 207 A x RHA 297 (190.06%), ARG 6A x HRHA 5-3 (145.68%) and ARG 2 A x RHA 297 (123.93%) were found to be positive and significant heterosis over standard check.

In E_3 , the heterosis over better parent were observed by the hybrids, CMS 207 A x HRHA 4-2 (151.74%), ARG 6A x RHA 271 (50.62%) and DV-10 x 6D-1 (39.91%) had positive and significant heterosis while the hybrids CMS 207 A x HRHA 4-2 (209.75%), ARG 6A x RHA 271 (101.01%) and ARG 6A x 6D-1 (76.31%) were observed to have positive and significant heterosis over standard check. In E_4 , the hybrids, CMS 207 A x HRHA 4-2 (158.74%), DV 10 x RHA 271 (59.99%) and ARG 6A x RHA 271 (54.14%) were found to have positive and significant over better parent, and the heterosis over standard check were observed by the hybrids CMS 207 A x HRHA 4-2 (87.34%), ARG 6A x RHA 271 (23.56%) and DV 10 x RHA 271 (14.69%) showed positive and significant heterosis for this trait.

Over the environments, the heterosis over better parent were observed by the hybrids CMS 207 A x HRHA 4-2 (82.53%), DV 10 x RHA 271 (45.28%) and CMS 207 A x RHA 297 (37.84%) showed positive and significant heterosis whereas the heterosis over standard check were observed by the hybrids CMS 207 A x HRHA 4-2 (82.15%), ARG 6A x RHA 271 (39.91%) and DV 10 x RHA 271 (38.53%) showed positive and significant heterosis.

4.5.17 Stearic acid (%)

Positive heterosis was desirable for stearic acid. In E_1 , the heterosis over better parent were observed by the hybrids ARG 3 A x RHA 297 (111.95%), CMS 607 A x 6D-1 (105.52%) and ARG 6A x RHA 271 (89.04%) had positive and significant heterosis whereas the heterosis over standard check were observed by the hybrids, ARG 6A x RHA 271 (166.07%), ARG 6A x 6D-1 (155.90%) and ARG 2A x RHA 297 (145.16%) showed

positive and significant heterosis. In E₂, seventy three hybrids over better parent and seventy four hybrids over standard parent showed positive and significant heterosis per cent. The hybrids, ARG 3A x RHA 271 (139.15%), ARG 2 A x 6D-1 (134.82%) and CMS 234 A x HRHA 4-2 (134.37%) were found to be positive and significant heterosis over better parent while the hybrids ARG 3A x RHA 271 (163.05%), ARG 2 A x 6D-1 (140.69%) and CMS 302 A x RHA 271 (105.24%) were observed to have positive and significant heterosis over standard check.

In E₃, the heterosis over better parent were observed by the hybrids CMSH 91 A x 6D-1 (82.25%), CMS 103 A x RHA 297 (81.37%) and CMS 17 A x HRHA 4-2 (71.88%) and the heterosis over standard check were observed by the hybrids CMSH 91 A x 6D-1 (183.33%), CMS 17 A x HRHA 4-2 (180.93%) and CMS 852 A x 6D-1 (153.44%) showed positive and significant heterosis for this trait. In E₄, the hybrids, CMSH 91 A x 6D-1 (87.80%), CMS 17 A x HRHA 4-2 (75.33%) and CMS 103 A x RHA 297 (71.76%) were found to be positive and significant heterosis over better parent while the hybrids, CMSH 91 A x 6D-1 (194.30%), CMS 17A x HRHA 4-2 (190.19%) and CMS 852 A x 6D-1 (174.81%) were observed to have positive and significant heterosis over standard check.

In pooled analysis (table 4.40), it was recorded that the heterosis over better parent were observed by the hybrids CMS 234 A x RHA 297 (66.35%), CMS 607 A x 6D-1 (51.05%) and CMS 103 A x RHA 297 (49.34%) whereas the heterosis over standard check were observed by the hybrids, ARG 2A x RHA 271 (101.07%), ARG 3A x RHA 297 (85.52%) and CMS 234A x RHA 297 (84.23%) showed positive and significant heterosis for this trait.

4.5.18 Oleic acid (%)

Positive heterosis was desirable for oleic acid. In E₁, the results indicated that the heterosis over better parent was observed by the hybrids, ARG 2 A x HRHA 4-2 (41.37%), ARG 2 A x 6D-1 (17.53%) and CMS 17 A x HRHA 4-2 (15.10%) and the hybrids, ARG 2 A x HRHA 4-2(203.78%), DV-10 x RHA 271 (195.17%) and CMS 148 A x RHA 271 (175.27%) showed positive and significant heterosis over standard check HSFH 848. In E₂, the hybrids ARG 6A x HRHA 4-2(52.30%), CMS 103 A x 6D-1 (27.26%) and CMS 17 A x RHA 271 (27.22%) were observed to have positive and significant over better parent and the hybrids CMS 17 A x RHA 271 (193.69%), ARG 6A x HRHA 4-2(193.13%) and CMS 852 A x RHA 297 (182.44%) were observed to have positive and significant heterosis over standard check.

In E₃, sixty four hybrid over better parent and seventy five hybrids over standard check showed positive and significant heterosis per cent. The cross combinations, CMSH 91 A x HRHA 4-2 (44.27%), CMS 17 A x HRHA 5-3 (42.15%) and CMS 302 A x RHA 297 (40.37%) had positive and significant heterosis over better parent whereas the hybrids ARG 2 A x RHA 297 (69.45%), CMSH 91 A x HRHA 4-2 (67.44%) and CMS 234 A x HRHA 4-2

(55.35%) had positive and significant heterosis over standard check. In E₄, the heterosis over better parent and standard check were positive and significant for oleic acid. The major hybrids over better parent were CMSH 91 A x HRHA 4-2 (54.12%), CMS 302 A x HRHA 5-3 (38.32%) and CMS 234 A x HRHA 4-2 (37.59%) and the prominent hybrids over standard check were CMSH 91 A x HRHA 4-2 (88.78%), CMS 234 A x HRHA 4-2 (68.54%) and CMS 44A x 6D-1 (63.30%) for this trait.

Over the environments, it was recorded that sixty five hybrids over better parent had significant heterosis. The cross combinations CMS 234 A x HRHA 4-2 (23.11%), CMSH 91 A x HRHA 4-2 (18.11%) and CMS 234 A x HRHA 5-3 (14.60%) had positive and significant heterosis whereas seventy five hybrids over standard check had positive and significant heterosis. The hybrids CMS 234 A x HRHA 4-2 (69.16%), CMSH 91 A x HRHA 4-2 (62.28%) and ARG 2A x 6D-1 (61.64%) were found to be positive and significant heterosis for this trait.

4.5.19 Linoleic acid (%)

Positive heterosis was desirable for linoleic acid. In E₁ (table 4.36), seventy hybrids over better parent and seventy one hybrid over standard check had positive and significant heterosis per cent. The results indicated that the heterosis, over better parent were observed by the hybrids, CMS 148 A x HRHA 4-2 (45.47%), DV 10 x HRHA 4-2 (41.97%) and CMS 852 A x RHA 271 (40.14%) and the hybrids, CMS 148 A x HRHA 4-2 (85.51%), CMSH 91 A x HRHA 4-2 (84.11%) and CMS 103 A x 6D-1 (81.20%) showed positive and significant heterosis over standard check HSFH 848. In E₂, the hybrids, CMS 207 A x RHA 297 (40.66%), CMS 44A x RHA 297 (38.33%) and CMS 234 A x RHA 297 (36.93%) were found to be positive and significant over better parent and the hybrids CMS 44A x RHA 297 (73.54%), ARG 2A x RHA 297 (71.90%) and CMS 207 A x RHA 297 (71.27%) were observed to have positive and significant heterosis over standard check for this trait.

In E₃, seventy three hybrid over better parent had positive and significant heterosis per cent. The prominent hybrids over better parent were CMS 17 A x RHA 297 (63.06%), CMS 17 A x RHA 271 (58.30%) and CMS 17 A x HRHA 5-3 (52.22%) had positive and significant heterosis. Seventy three hybrids over standard check showed positive and significant heterosis and the major hybrids over standard check were CMS 302 A x HRHA 5-3 (57.57%), CMS 148 A x HRHA 4-2 (56.31%) and ARG 2 A x HRHA 5-3 (54.18%). In E₄ the hybrids, CMS 17 A x RHA 297 (129.69%), CMS 17 A x 6D-1 (111.26%) and CMS 17 A x RHA 271 (91.62%) were found to be positive and significant over better parent whereas, the hybrids, CMS 302 A x HRHA 5-3 (58.34%), CMS 148 A x HRHA 4-2 (56.92%) and DV10 X RHA 297 (55.30%) were found to be positive and significant over standard check.

Table 4.36.1. Estimation of heterotic effects of hybrids for morphological traits and 100 seed weight in E₁

Sr. No	Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
1	CMS 11 A x 6D-1	-19.18	-14.96	22.88	18.99*	48.48*	-12.63	-6.17*	-1.83	6.27*	4.35*	24.59*	4.94*	43.17*	24.71*
2	CMS 11 A x RHA 271	1.30	-4.34	7.19	3.80*	44.01*	-15.25	-6.13*	-0.68	-2.13	0.00	41.86*	22.52*	46.63*	24.41*
3	CMS 11 A x HRHA 4-2	2.78	-4.88	13.34	21.52*	40.43*	-17.37	-8.74*	-3.44*	-2.66*	-0.54	17.08*	6.59*	30.96*	22.10*
4	CMS 11 A x HRHA 5-3	3.64	-4.08	40.52	36.08*	59.21*	-6.32	-1.48	-2.34*	6.88*	1.09	76.17*	32.40*	56.83*	33.07*
5	CMS 11 A x RHA 297	-8.28	-3.81	22.88	18.99*	28.42*	-11.05	-3.02*	-1.83	-1.60	0.54	47.79*	8.24*	73.22*	46.97*
6	CMS 17-A x 6D-1	-6.30	-1.40	88.52	60.13*	13.18*	-13.67	-6.12*	-1.79	2.40	0.54	24.59*	4.94*	57.26*	36.99*
7	CMS 17-A x RHA 271	-5.48	-3.07	48.31	30.38*	55.97*	18.95*	-5.94*	0.13	-2.63*	0.54	73.03*	49.45*	81.75*	40.79*
8	CMS 17 -A x HRHA 4-2	-3.34	-0.87	3.90	11.39*	22.84*	-6.32	-10.85*	-1.83	-4.98*	0.54	51.48*	37.91*	44.40*	34.63*
9	CMS 17 -A x HRHA 5-3	-10.24	-7.95	124.31	96.21*	31.82*	0.54	-0.63	-1.49	5.73*	0.00	60.09*	20.32*	81.58*	40.67*
10	CMS 17 A x RHA 297	-17.77	-13.76	87.53	22.79*	88.41*	43.69*	-1.95	-0.76	0.97	4.35*	90.51*	36.81*	106.55*	60.01*
11	CMS 44 A x 6D-1	0.43	5.68	47.79	43.67*	43.74*	-14.73	-2.66*	1.83	8.24*	3.62*	39.60*	17.57*	55.02*	35.03*
12	CMS 44 A x RHA 271	-19.84	-23.91	24.35	20.89*	57.94*	-6.32	-6.62*	-0.62	4.08*	-0.36	17.05*	1.09	61.24*	39.02*
13	CMS 44 A x HRHA 4-2	-8.86	-13.49	18.06	26.58*	40.20*	-16.83	-5.75*	0.31	4.50*	0.04	50.27*	36.81*	41.76*	32.17*
14	CMS 44 A x HRHA 5-3	-0.34	-5.41	52.99	48.74*	47.29*	-12.63	-2.22*	-3.07*	5.15*	-0.54	87.13*	40.65*	64.25*	41.62*
15	CMS 44 A x RHA 297	-14.08	-9.89	28.91	25.32*	73.25*	20.01*	-1.37*	-0.17	5.79*	1.28	88.98*	35.70*	74.36*	50.34*
16	CMS 148 A x 6D-1	-19.06	-14.83	15.96	25.32*	55.77*	-8.42	-4.81*	-0.41	3.69*	1.81	25.23*	13.19*	26.89*	24.13*
17	CMS 148 A x RHA 271	-18.32	-19.77	17.72	27.22*	62.92*	-8.42	-7.77*	-1.82	0.53	3.80*	33.74*	20.87*	32.24*	29.35*
18	CMS 148 A x HRHA 4-2	-8.05	-9.69	37.63	48.74*	64.18*	-13.15	-9.68*	-2.75*	-1.53	4.89*	46.05*	32.97*	43.74*	40.60*
19	CMS 148 A x HRHA 5-3	-5.87	-7.55	0.15	8.23*	127.84*	25.80*	2.73*	1.83	7.45*	1.63	47.11*	32.978	49.51*	46.24*
20	CMS 148 A x RHA 297	2.74	7.75	-5.71	1.90*	45.14*	0.54	0.48	1.70	-1.12	2.18	28.88*	16.48*	31.30*	28.44*
21	CMSH 91 A x 6D-1	1.19	6.48	5.02	14.56*	34.97*	-7.36	-6.17*	-1.83	4.61*	2.72*	18.07*	-0.56	45.11*	26.40*
22	CMSH 91 A x RHA 271	-7.76	-12.89	-6.01	2.53*	28.83*	-11.57	-5.96*	0.11	5.33*	7.63*	19.59*	3.30*	50.22*	22.69*
23	CMSH 91 A x HRHA 4-2	21.52	-5.01	43.31	56.34*	75.61*	20.53*	-8.46*	1.34	3.18*	5.43*	33.37*	21.43*	41.59*	32.01*
24	CMSH 91 A x HRHA 5-3	21.47	4.14	-3.68	5.07*	56.44*	7.37*	8.61*	7.66*	13.20*	7.07	76.17*	32.40*	79.09*	46.26*
25	CMSH 91 A x RHA 297	-11.27	-6.95	14.88*	25.32*	75.53*	21.59*	2.54*	3.79*	3.46*	5.72*	43.59*	7.68*	53.88*	25.67*
26	CMS 103 A x 6D-1	-7.57	-2.74	23.84*	10.13*	43.24*	-15.79	11.01*	14.37*	7.93*	5.98*	48.08*	24.72	46.15*	27.30*
27	CMS 103 A x RHA 271	1.02	-4.61	11.74*	-0.63	55.43*	-12.63	0.73	3.78*	-1.99	1.21	25.95*	8.79*	51.00*	29.77*

Sr. No	Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
28	CMS 103 A x HRHA 4-2	24.53*	7.35*	23.97*	32.92*	68.09*	-6.84	2.42*	5.52*	-2.83*	1.79	32.77*	20.87*	34.10*	25.03*
29	CMS 103 A x HRHA 5-3	19.49*	3.01*	21.00*	7.60*	49.10*	-17.37	17.05*	16.04*	6.90*	1.11	90.06*	42.85*	42.25*	22.24*
30	CMS 103 A x RHA 297	-11.85	-7.55	13.88*	1.27	29.18*	-10.52	-2.87*	-1.69	-0.04	3.30*	61.50*	20.32*	38.46*	18.99*
31	CMS 234 A x 6D-1	-3.89	1.14	34.87*	14.56*	39.66*	-17.89	-4.55*	-3.44*	3.33*	1.12	59.17*	34.05*	38.27*	20.44*
32	CMS 234A x RHA 271	21.74*	14.96*	17.35*	3.17*	79.60*	4.74*	-0.73	0.43	5.98*	3.71*	24.05*	7.14*	63.87*	25.14*
33	CMS 234 A x HRHA 4-2	-1.40	-12.96	-0.83	6.33*	46.21*	-14.73	-2.77*	-1.64	6.28*	4.01*	19.49*	8.79*	27.16*	18.56*
34	CMS 234 A x HRHA 5-3	3.59*	-8.55	57.74*	37.98*	66.06*	-3.16	-0.97	-1.83	8.60*	2.72*	47.66*	10.98*	66.79*	26.65*
35	CMS 234 A x RHA 297	-8.54	-4.08	44.17*	13.93*	63.37*	13.17*	-1.44	-0.30	5.56*	3.30*	85.92*	33.51*	107.14*	57.29*
36	CMS 302 A x 6D-1	-2.49	4.34*	22.95*	4.43*	53.09*	-10.00	-5.60*	-1.62	5.21*	3.30*	78.73*	50.54*	50.68*	31.25*
37	CMS 302 A x RHA 271	-8.36	-1.94	36.07*	19.62*	55.43*	-12.63	-3.91*	0.15	1.24	3.80*	54.58*	33.51*	63.17*	24.60*
38	CMS 302 A x HRHA 4-2	-23.84	-18.50	12.16*	20.26*	89.11*	0.54	-2.98*	1.11	2.86*	5.47*	63.55*	48.89*	38.99*	29.59*
39	CMS 302 A x HRHA 5-3	-13.67	-7.62	56.30*	36.71*	73.50*	-4.20	-0.61	-1.47	12.05*	5.98*	30.02*	-2.21	65.67*	24.00*
40	CMS 302 A x RHA 297	-11.98	-5.81	53.91*	15.83*	55.78*	7.90*	-2.98*	-1.80	2.87*	5.48*	48.28*	11.54*	68.75*	20.49*
41	CMS 607 A x 6D-1	-13.60	-9.09	18.75*	8.238	70.99*	0.54	-2.56*	-0.21	6.22*	0.05	25.24*	5.49*	39.24*	25.14*
42	CMS 607 A x RHA 271	-12.45	-9.62	24.31*	13.29*	59.18*	-10.52	-2.19*	0.17	2.79*	-3.17*	23.41*	6.59*	45.80*	31.03*
43	CMS 607 A x HRHA 4-2	-22.35	-19.84	1.53*	8.87*	60.77*	-11.57	-3.15*	-0.81	11.94*	5.45*	44.24*	31.32*	33.86*	24.80*
44	CMS 607 A x HRHA 5-3	5.54*	8.95*	47.92*	34.81*	59.20*	-12.10	-3.51*	-4.35*	12.50*	5.98*	56.43*	17.57*	31.68*	18.34*
45	CMS 607 A x RHA 297	-12.87	-8.62	13.19*	3.17*	30.70*	-9.47	-4.24*	-3.07*	13.66*	7.07*	93.28*	42.29*	48.08*	33.09*
46	CMS 852 A x 6D -1	-20.23	-7.82	22.21*	3.80*	14.84*	-15.25	-2.01*	0.11	9.61*	7.62*	31.73*	17.03*	39.83*	21.80*
47	CMS 852 A x RHA 271	-15.61	-2.47	40.39*	23.42*	31.24*	-3.16	-2.03*	0.09	2.63*	5.98*	51.52*	34.61*	82.02*	38.99*
48	CMS 852 A x HRHA 4-2	-16.07	-3.01	-18.54	-12.66	14.84*	-15.25	-1.68	0.45	2.08	8.74*	47.25*	34.05*	26.76*	18.18*
49	CMS 852A x HRHA 5-3	-21.10	-8.82	-10.27	-21.51	2.00*	-24.73	2.56*	1.67	12.05*	5.98*	24.92*	10.98*	55.50*	16.38*
50	CMS 852 A x RHA 297	-13.53	-0.07	108.19*	33.558	1.28*	-25.26	0.64	1.87	2.77*	6.21*	11.32*	-1.10	64.80*	17.17*
51	ARG 2A x 6D-1	-4.58	0.40	4.99*	14.56*	79.95*	5.80*	-3.33*	1.14	7.39*	5.45*	33.82*	31.32*	33.52*	29.84*
52	ARG 2A x RHA 271	-7.54	-12.69	22.39*	33.55*	48.88*	-16.31	-4.70*	1.45	2.63*	5.98*	33.82*	31.32*	28.42*	24.89*
53	ARG 2A x HRHA 4-2	30.02*	-2.67	-11.25	-3.16	89.56*	-12.10	-6.00*	1.21	1.18	7.07*	36.06*	33.51*	26.76*	23.27*
54	ARG 2A x HRHA 5-3	12.67*	-3.41	-24.59	-17.72	40.13*	-22.63	2.17*	1.28	13.82*	7.65*	41.10*	38.45*	28.66*	25.12*

Sr. No	Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
55	ARG 2A x RHA 297	-9.17	-4.74	-27.49	-20.89	11.70*	-22.63	1.35	2.59*	5.19*	8.71*	14.22*	12.08*	45.10*	41.11*
56	ARG 3A x 6D -1	-7.12	-2.27	8.53*	1.90*	29.81*	-23.69	0.85	5.50*	8.50*	6.53*	31.77*	10.98*	49.79*	30.48*
57	ARG 3A x RHA 271	-12.07	-16.97	26.73*	18.99*	53.56*	-13.67	-0.79	5.61*	2.63*	5.98*	43.13*	23.62*	49.63*	28.14*
58	ARG 3A x HRHA 4-2	16.57*	-5.74	10.39*	18.36*	54.57*	-13.67	-4.19*	5.50*	-1.53	4.89*	12.25*	2.19*	50.25*	40.08*
59	ARG 3A x HRHA 5-3	-0.35	-14.56	22.01*	14.56*	83.79*	2.64*	6.78*	5.85*	10.42*	4.43*	64.47*	23.62*	52.58*	30.67*
60	ARG 3A x RHA 297	-13.06	-8.82	14.59*	7.60*	41.34*	-2.10	4.15*	5.41*	-1.75	1.54	69.09*	21.43*	56.97*	34.43*
61	ARG 6A x 6D-1	-10.65	-3.61	46.80*	24.68*	44.25*	1.06*	4.62*	5.65*	1.91	0.07	58.51*	33.51*	60.33*	39.65*
62	ARG 6A x RHA 271	-23.34	-17.30	56.23*	37.35*	23.97*	-13.15	16.55*	17.70*	-0.53	2.72*	76.21*	52.18*	72.89*	32.02*
63	ARG 6A x HRHA 4-2	-3.90	3.67*	-6.73	0.00	24.72*	-12.63	5.55*	6.59*	-2.55*	3.80*	43.63*	30.76*	25.59*	17.09*
64	ARG 6A x HRHA 5-3	-13.31	-6.48	21.56*	6.33*	22.46*	-14.21	8.53*	7.59*	9.75*	3.80*	8.03*	-14.29	60.16*	19.878
65	ARG 6 A x RHA 297	-21.55	-15.36	89.44*	21.52*	42.75*	0.00	6.54*	7.59*	2.14	5.56*	25.35*	-0.56	72.53*	22.67*
66	DV 10 x 6D -1	-17.98	-13.69	11.55*	15.19*	76.37*	3.69*	-1.33	0.20	7.93*	5.98*	46.12*	23.08*	29.54*	23.76*
67	DV 10 x RHA 271	12.55*	6.28*	1.13	4.43*	49.81*	-15.79	-1.37	0.17	3.35*	6.73*	39.95*	20.87*	30.06*	24.27*
68	DV 10 x HRHA 4-2	19.40*	4.61*	-12.63	-6.32	48.08*	-16.83	-1.37	0.16	-1.53	4.89*	0.18	-8.80	19.76*	14.42*
69	DV 10 x HRHA 5-3	4.76*	-8.22	-5.61	-2.53	38.71*	-22.11	0.26	-0.61	12.05*	5.98*	11.84*	-15.94	33.36*	27.41*
70	DV -10 x RHA 297	-18.85	-14.90	9.71*	13.29*	11.70*	-22.63	4.38*	5.65*	4.52*	8.01*	14.77*	-17.59	59.38*	52.28*
71	CMS 207 A x 6D -1	-16.62	-6.15	50.52*	27.86*	18.35*	-16.83	9.76*	14.83*	9.04*	7.07*	20.03*	1.09	69.47*	47.62*
72	CMS 207 A x RHA 271	-26.17	-16.90	49.75*	31.65*	53.56*	7.90*	0.04	6.50*	3.68*	7.07*	73.03*	49.45*	82.47*	39.34*
73	CMS 207 A x HRHA 4-2	-18.58	-8.35	19.24*	27.86*	48.31*	4.22*	-5.38*	4.18*	0.15	3.80*	48.46*	35.16*	53.86*	43.45*
74	CMS 207 A x HRHA 5-3	-11.45	-0.33	93.20*	68.99*	58.80*	11.59*	17.05*	16.03*	8.50*	2.62*	99.56*	49.99*	102.07*	51.24*
75	CMS 207 A x RHA 297	-7.77	3.81*	127.92*	46.21*	99.25*	40.01*	6.67*	7.97*	-2.16	1.12	86.69*	34.05*	108.00*	47.89*
	SE	1.56	1.25	0.93	0.90	0.40	0.35	1.00	1.02	1.21	1.14	0.74	0.66	2.36	2.16
	CDat5%	3.12	2.50	1.85	1.80	0.79	0.70	2.01	2.04	2.42	2.28	1.47	1.32	4.72	4.32

Table 4.36.2. Estimation of heterotic effects for oil content, hull content and seed germination in E₁

Sr. No	Hybrids	OC (%)		HC (%)		% SF		GERM. (%)		EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)		VIAB. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
1	CMS 11 A x 6D-1	11.39*	15.67*	25.82*	23.47*	51.99*	43.57*	13.36*	43.44*	-38.89*	-33.03*	25.78*	50.03*
2	CMS 11 A x RHA 271	34.59*	18.16*	43.52*	29.35*	35.44*	39.26*	-5.86	25.13*	-60.65*	-56.93*	10.35*	49.40*
3	CMS 11 A x HRHA 4-2	-0.25	18.16*	17.65*	28.11*	33.01*	37.69*	6.35*	34.55*	-51.85*	-47.18*	16.41*	38.86*
4	CMS 11 A x HRHA 5-3	24.16*	14.63*	39.51*	28.01*	52.18*	45.08*	11.80*	41.45*	-25.00*	-17.81*	17.15*	39.74*
5	CMS 11 A x RHA 297	32.56*	19.40*	28.86*	13.15*	55.39*	46.78*	11.95*	41.65*	-48.92*	-3.65*	16.44*	38.88*
6	CMS 17-A x 6D-1	16.68*	21.16*	26.43*	30.47*	40.46*	52.35*	14.65*	45.08*	-41.01*	-35.01*	25.61*	49.82*
7	CMS 17-A x RHA 271	30.19*	19.09*	30.94*	35.13*	39.17*	50.96*	7.30*	42.62*	-28.11*	-20.85*	9.13*	47.75*
8	CMS 17 -A x HRHA 4-2	5.10*	24.48*	24.35*	35.41*	39.82*	51.66*	12.33*	41.59*	-28.11*	-20.85*	23.92*	47.80*
9	CMS 17 -A x HRHA 5-3	30.45*	20.44*	30.27*	34.44*	39.39*	51.19*	15.73*	45.88*	8.76*	19.79*	26.67*	49.04*
10	CMS 17 A x RHA 297	31.66*	20.44*	27.19*	31.26*	33.87*	45.21*	11.72*	40.82*	-46.51*	0.91*	25.90*	46.18*
11	CMS 44 A x 6D-1	12.39*	16.70*	38.28*	35.70*	125.50*	46.41*	14.33*	44.67*	-18.72*	-16.29*	13.31*	38.80*
12	CMS 44 A x RHA 271	37.17*	21.16*	50.12*	35.30*	44.66*	48.74*	8.15*	43.75*	6.90*	10.05*	10.78*	49.98*
13	CMS 44 A x HRHA 4-2	3.08*	22.10*	-1.20	7.59	43.38*	48.42*	13.40*	40.64*	0.99*	3.96*	20.81*	47.99*
14	CMS 44 A x HRHA 5-3	27.64*	17.84*	21.96*	11.90*	45.59*	38.80*	14.63*	42.16*	-2.46*	0.46*	17.94*	44.47*
15	CMS 44 A x RHA 297	31.06*	18.05*	60.33*	23.62*	106.03*	49.11*	14.64*	42.17*	-62.37*	-28.92*	20.83*	48.02*
16	CMS 148 A x 6D-1	13.06*	19.29*	-9.03	5.66	48.85*	49.91*	2.84	40.49*	-56.70*	-50.84*	12.46*	48.11*
17	CMS 148 A x RHA 271	13.74*	20.02*	0.73	17.00*	46.51*	50.65*	5.27	43.81*	-72.32*	-68.49*	11.33*	50.73*
18	CMS 148 A x HRHA 4-2	1.42	20.13*	19.94*	39.31*	48.27*	53.48*	4.40	42.63*	-51.34*	-44.75*	12.23*	47.81*
19	CMS 148 A x HRHA 5-3	9.52*	15.56*	21.08*	40.63*	48.19*	49.25*	1.90	39.21*	-32.59*	-23.44*	9.92*	44.77*
20	CMS 148 A x RHA 297	11.19*	17.32*	3.76*	20.52*	45.81*	46.85*	1.25	38.32*	-58.60*	-21.92*	8.35*	42.70*
21	CMSH 91 A x 6D-1	15.08*	19.50*	20.738	18.48*	43.32*	39.06*	4.74	35.71*	-1.71*	-12.79*	21.16*	44.51*
22	CMSH 91 A x RHA 271	29.16*	16.70*	20.83*	8.90	37.82*	41.71*	3.62	37.72*	5.71*	-6.09*	1.33	37.18*
23	CMSH 91 A x HRHA 4-2	-1.03	17.22*	15.80*	26.10*	28.45*	32.96*	-7.94	19.29*	43.43*	27.40*	8.23*	29.08*
24	CMSH 91 A x HRHA 5-3	32.25*	22.10*	33.15*	22.17*	49.26*	44.82*	7.90*	39.81*	33.71*	18.72*	13.49*	33.54*
25	CMSH 91 A x RHA 297	32.61*	19.81*	62.93*	29.79*	54.51*	49.91*	9.71*	42.15*	-47.85*	-1.52*	23.02*	44.12*
26	CMS 103 A x 6D-1	8.99*	13.18*	45.02*	42.31*	63.40*	40.39*	8.07*	41.69*	20.98*	25.88*	13.05*	46.38*
27	CMS 103 A x RHA 271	24.56*	20.54*	64.90*	48.62*	30.12*	33.79*	9.17*	45.09*	21.95*	26.79*	10.10*	49.07*

Sr. No	Hybrids	OC (%)		HC (%)		% SF		GERMN. (%)		EC ($\mu\text{Scm}^1\text{g}^1$)		VIAB. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
28	CMS 103 A x HRHA 4-2	-1.91	16.18*	18.48*	29.02*	34.06*	38.77*	10.66*	45.08*	8.29*	12.63*	17.23*	51.79*
29	CMS 103 A x HRHA 5-3	21.77*	17.84*	30.24*	19.50*	50.47*	43.45*	6.12*	39.13*	1.95*	6.09*	13.42*	46.85*
30	CMS 103 A x RHA 297	24.34*	20.33*	64.16*	27.18*	61.49*	38.75*	9.65*	43.76*	-37.63*	17.66*	11.50*	44.37*
31	CMS 234 A x 6D-1	14.29*	18.67*	48.03*	45.27*	46.60*	39.86*	12.33*	42.14*	-26.45*	15.68*	12.54*	34.23*
32	CMS 234A x RHA 271	33.43*	17.01*	43.73*	29.54*	39.78*	43.72*	9.98*	46.17*	-32.58*	6.09*	5.02	42.19*
33	CMS 234 A x HRHA 4-2	-0.60	17.74*	16.73*	27.11*	43.40*	48.45*	16.89*	42.98*	-38.06*	-2.59*	24.48*	48.47*
34	CMS 234 A x HRHA 5-3	27.19*	17.43*	46.37*	34.30*	49.07*	42.22*	13.55*	38.56*	-34.52*	3.04*	22.40*	44.01*
35	CMS 234 A x RHA 297	29.68*	16.81*	34.67*	15.95*	48.87*	42.03*	66.53*	36.04*	-62.37*	-28.92*	78.56*	39.53*
36	CMS 302 A x 6D-1	14.29*	18.67*	38.42*	35.83*	106.49*	43.81*	2.32	39.23*	-29.33*	-19.33*	12.92*	45.61*
37	CMS 302 A x RHA 271	29.79*	18.78*	44.56*	30.29*	28.98*	32.61*	3.31	40.58*	-22.67*	-11.72*	9.09*	47.69*
38	CMS 302 A x HRHA 4-2	-1.03	17.22*	37.60*	49.84*	35.48*	40.24*	-1.65	33.84*	-16.44*	-4.57*	18.77*	53.15*
39	CMS 302 A x HRHA 5-3	28.65*	18.78*	52.02*	39.48*	59.34*	51.91*	5.33	43.32*	-8.89*	3.96*	17.26*	51.20*
40	CMS 302 A x RHA 297	30.70*	19.61*	79.90*	38.71*	111.30*	52.92*	1.97	38.75*	-43.28*	7.00*	10.86*	42.94*
41	CMS 607 A x 6D-1	-0.88	17.22*	42.69*	40.02*	131.16*	50.08*	8.03*	36.71*	-8.76*	16.13*	20.20*	43.37*
42	CMS 607 A x RHA 271	1.14	19.61*	49.20*	40.55*	37.94*	41.83*	8.04*	43.59*	4.38*	32.88*	9.08*	47.69*
43	CMS 607 A x HRHA 4-2	2.38	21.27*	30.25*	41.83*	34.70*	39.44*	18.84*	45.36*	-13.15*	10.65*	21.32*	44.71*
44	CMS 607 A x HRHA 5-3	0.09	18.36*	58.07*	48.91*	50.36*	43.35*	18.08*	44.09*	-35.86*	-18.26*	27.68*	50.23*
45	CMS 607 A x RHA 297	-1.58	16.39*	35.03*	27.20*	85.06*	33.93*	27.68*	40.29*	-45.70*	2.44*	46.44*	46.38*
46	CMS 852 A x 6D -1	13.09*	17.43*	-2.64	-4.46	112.95*	38.26*	12.27*	42.07*	10.08*	32.88*	25.03*	49.12*
47	CMS 852 A x RHA 271	34.14*	17.64*	23.85*	11.62*	31.76*	35.47*	1.16	34.45*	14.29*	38.05*	4.49	41.47*
48	CMS 852 A x HRHA 4-2	1.24	19.92*	31.97*	43.71*	40.52*	45.46*	16.77*	42.82*	0.00	20.70*	22.54*	46.16*
49	CMS 852A x HRHA 5-3	29.668	19.71*	59.27*	46.13*	45.60*	38.81*	13.12*	38.04*	-13.45*	4.57*	19.65*	40.78*
50	CMS 852 A x RHA 297	29.33*	16.49*	90.10*	46.57*	78.00*	28.83*	16.37*	26.02*	-51.88*	-9.13*	15.90*	17.69*
51	ARG 2A x 6D-1	-2.33	15.67*	38.35*	37.12*	91.25*	44.92*	13.06*	43.07*	-19.63*	-10.65*	23.08*	46.80*
52	ARG 2A x RHA 271	0.65	19.19*	29.83*	28.68*	29.57*	33.22*	5.57	40.32*	-1.83*	9.13*	8.23*	46.53*
53	ARG 2A x HRHA 4-2	4.75*	24.07*	26.74*	38.01*	35.76*	40.54*	13.33*	38.63*	5.02*	16.74*	21.50*	44.91*
54	ARG 2A x HRHA 5-3	0.39	18.88*	27.25*	26.13*	42.44*	35.80*	13.68*	38.72*	6.85*	18.72*	22.86*	44.56*

Sr. No	Hybrids	OC (%)		HC (%)		% SF		GERMN. (%)		EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)		VIAB. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
55	ARG 2A x RHA 297	3.28*	22.30*	27.84*	26.71*	82.96*	38.64*	20.30*	44.97*	-32.80*	26.79*	27.48*	40.41*
56	ARG 3A x 6D -1	13.39*	17.74*	16.87*	14.69*	113.88*	38.86*	1.45	28.54*	21.15*	27.85*	21.61*	45.05*
57	ARG 3A x RHA 271	19.38*	14.84*	31.47*	18.51*	36.67*	40.52*	2.95	36.83*	-3.85*	1.52*	1.90	37.96*
58	ARG 3A x HRHA 4-2	3.08*	22.10*	-2.00	6.72	51.16*	56.48*	7.80*	36.59*	-37.50*	-34.09*	11.08*	32.49*
59	ARG 3A x HRHA 5-3	28.22*	23.34*	15.63*	6.09	64.96*	57.27*	6.35*	34.76*	-8.65*	-3.65*	13.31*	35.15*
60	ARG 3A x RHA 297	21.54*	16.91*	21.92*	9.91*	119.54*	58.89*	9.20*	38.36*	-44.09*	5.48*	16.59*	39.05*
61	ARG 6A x 6D-1	15.68*	20.13*	46.15*	43.42*	129.59*	49.06*	-0.25	38.20*	-25.94*	-10.20*	-4.56	29.22*
62	ARG 6A x RHA 271	31.03*	16.60*	66.428	49.99*	48.79*	52.99*	2.18	41.57*	-17.99*	-0.61*	-1.28	33.65*
63	ARG 6A x HRHA 4-2	3.08*	22.10*	25.14*	36.27*	35.72*	40.49*	2.00	41.33*	1.26*	22.83*	6.75*	44.53*
64	ARG 6A x HRHA 5-3	35.17*	24.79*	36.05*	24.83*	54.27*	47.07*	2.60	42.15*	-0.84*	20.24*	9.94*	48.84*
65	ARG 6 A x RHA 297	37.74*	24.07*	69.10*	30.39*	114.15*	54.99*	1.88	41.16*	-39.78*	13.70*	9.02*	47.60*
66	DV 10 x 6D -1	14.99*	19.40*	12.89*	28.50*	0.42	-10.84	-21.89	4.70	25.34*	40.49*	-18.20*	3.75
67	DV 10 x RHA 271	15.79*	17.53*	32.308	50.59*	28.95*	32.59*	-6.34	25.53*	-33.03*	-24.96*	-2.52	31.98*
68	DV 10 x HRHA 4-2	-0.60	17.74*	31.238	49.38*	17.19*	21.31*	-6.32	25.56*	-27.60*	-18.87*	1.91	29.25*
69	DV 10 x HRHA 5-3	17.02*	18.78*	30.67*	48.73*	30.47*	24.38*	-7.86	23.50*	-14.48*	-4.11*	-0.63	26.03*
70	DV -10 x RHA 297	14.46*	16.18*	30.32*	48.34*	75.618	55.93*	4.94	40.66*	-48.39*	-2.59*	16.96*	48.34*
71	CMS 207 A x 6D -1	15.88*	20.33*	2.39	0.48	64.82*	50.80*	17.46*	48.63*	-17.41*	3.50*	22.63*	46.26*
72	CMS 207 A x RHA 271	42.54*	25.00*	23.538	16.38*	49.62*	53.84*	5.43	40.13*	-1.21*	23.74*	8.38*	46.74*
73	CMS 207 A x HRHA 4-2	4.31*	23.55*	20.73*	31.46*	47.76*	52.96*	16.83*	42.90*	0.00	25.27*	16.40*	38.83*
74	CMS 207 A x HRHA 5-3	30.79*	20.75*	45.81*	37.37*	56.03*	48.75*	20.45*	47.31*	2.43*	28.31*	20.84*	42.19*
75	CMS 207 A x RHA 297	41.31*	27.28*	26.03*	18.73*	50.51*	37.71*	12.92*	38.10*	-34.68*	23.29*	25.73*	44.59*
	SE	1.42	1.33	4.73	4.85	3.65	3.74	2.87	2.74	0.09	0.08	2.59	2.36
	CDat5%	2.84	2.66	9.45	9.69	7.29	7.47	5.73	5.47	0.18	0.16	5.17	4.72

Table 4.36.3 Estimation of Heterotic effects of hybrids for linoleic acid, oleic acid and seedling vigour in E₁

Sr. No	Hybrids	VG I		VG II		PALM. (%)		STER. (%)		OLEIC (%)		LINO. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
1	CMS 11 A x 6D-1	27.00	18.25	77.52*	9.99	9.20*	2.02*	40.66*	39.07*	-16.43*	67.12*	21.96*	74.41*
2	CMS 11 A x RHA 271	34.56	23.48	68.31*	8.00	10.65*	-8.08*	-12.03*	-13.01*	-33.96*	60.82*	10.54*	58.08*
3	CMS 11 A x HRHA 4-2	30.39	19.50	32.41*	-17.96*	5.65*	17.55*	-3.90*	13.31*	-36.79*	35.83*	11.88*	59.99*
4	CMS 11 A x HRHA 5-3	48.77*	29.69	44.15*	-10.69	47.01*	2.47*	-39.87*	8.22*	-34.70*	41.70*	13.28*	61.99*
5	CMS 11 A x RHA 297	37.70	17.97	69.51*	5.03	13.28*	12.72*	24.91*	23.50*	-56.92*	4.87*	14.94*	66.80*
6	CMS 17-A x 6D-1	29.66	20.90	90.48*	14.01*	0.22	-6.38*	-3.68*	31.63*	-41.06*	33.79*	17.90*	63.87*
7	CMS 17-A x RHA 271	28.58	26.58	11.17*	-28.67*	26.80*	5.34*	-4.82*	30.08*	-43.79*	36.90*	16.87*	62.44*
8	CMS 17 -A x HRHA 4-2	35.12	20.43	82.18*	9.04	-1.63*	9.45*	-47.18*	-27.81*	15.10*	161.27*	-10.95*	23.76*
9	CMS 17 -A x HRHA 5-3	7.82	6.89	90.88*	14.24*	11.02*	-11.40*	-34.68*	17.56*	-56.12*	-0.41	26.73*	76.14*
10	CMS 17 A x RHA 297	27.57	18.34	81.46*	8.61	-6.21*	-6.68*	-13.31*	18.47*	-42.92*	38.97*	11.90*	62.39*
11	CMS 44 A x 6D-1	26.48	12.29	39.09*	-9.97	26.09*	17.79*	38.19*	34.97*	-60.09*	-15.91*	31.39*	73.58*
12	CMS 44 A x RHA 271	18.97	17.48	81.02*	17.17*	-5.99*	-21.91*	9.13*	6.58*	-59.09*	-0.38	33.26*	76.05*
13	CMS 44 A x HRHA 4-2	48.96*	24.76	99.70*	29.26*	-6.87*	3.62*	3.78*	22.36*	-37.69*	33.90*	23.98*	63.80*
14	CMS 44 A x HRHA 5-3	58.64*	34.96	36.31*	-11.77*	45.22*	-1.55*	-37.91*	11.74*	-50.60*	7.20*	29.60*	71.21*
15	CMS 44 A x RHA 297	57.82*	12.10	41.79*	-8.23	-13.13*	-13.57*	-10.87*	-12.95*	-13.91*	109.61*	-1.29	43.25*
16	CMS 148 A x 6D-1	-0.10	-9.98	60.70*	24.67*	-5.00*	-11.25*	-32.51*	-20.96*	0.25	122.70*	7.97*	41.12*
17	CMS 148 A x RHA 271	-2.21	-10.96	32.62*	2.88	9.26*	-9.24*	-26.22*	-13.59*	13.03*	175.27*	-8.04*	17.27*
18	CMS 148 A x HRHA 4-2	1.33	0.69	48.74*	15.39*	-2.39*	8.59*	-23.59*	-9.92*	-66.63*	-25.87*	45.47*	85.51*
19	CMS 148 A x HRHA 5-3	20.08	7.07	31.88*	2.31	29.54*	1.16*	-40.90*	6.37*	-35.27*	43.79*	23.55*	57.57*
20	CMS 148 A x RHA 297	5.32	-2.43	11.51*	-13.49*	-7.93*	-8.3*	3.75*	21.51*	-60.29*	-3.33*	18.37*	71.77*
21	CMSH 91 A x 6D-1	20.33	5.85	40.13*	-5.03	3.39*	-3.41*	-3.69*	-11.25*	-40.83*	18.33*	18.00*	67.20*
22	CMSH 91 A x RHA 271	4.48	6.28	23.13*	-16.55*	6.05*	-3.11*	30.38*	19.68*	-64.78*	-14.22*	26.48*	79.21*
23	CMSH 91 A x HRHA 4-2	24.98	3.15	71.14*	15.99*	-15.99*	-6.53*	-3.30*	14.01*	-56.06*	-5.58*	29.93*	84.11*
24	CMSH 91 A x HRHA 5-3	12.32	-5.23	98.74*	34.70*	6.00*	-3.17*	-38.38*	10.89*	-58.31*	-9.54*	24.08*	75.81*
25	CMSH 91 A x RHA 297	14.51	12.18	117.55*	47.44*	1.62*	1.12*	10.82*	8.00*	-51.20*	18.81*	14.48*	66.13*
26	CMS 103 A x 6D-1	67.85*	39.27*	93.27*	47.91*	0.43	-5.58*	8.94*	9.49*	-48.98*	2.02	26.18*	81.20*
27	CMS 103 A x RHA 271	24.94	22.78	127.91*	74.42*	20.31*	13.12*	28.87*	29.51*	-63.49*	-11.08*	19.31*	71.34*

Sr. No	Hybrids	VG I		VG II		PALM. (%)		STER. (%)		OLEIC (%)		LINO. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
28	CMS 103 A x HRHA 4-2	45.08*	18.51	89.46*	44.99*	-5.10*	5.58*	14.05*	34.46*	-51.18*	4.90*	21.18*	74.02*
29	CMS 103 A x HRHA 5-3	26.44	13.05	32.18*	1.16	19.78*	12.62*	-37.91*	11.74*	-49.36*	9.89*	16.22*	66.90*
30	CMS 103 A x RHA 297	39.94	20.80	6.52	-18.48*	26.21*	25.58*	40.35*	41.04*	6.96*	160.41*	-23.76*	10.64*
31	CMS 234 A x 6D-1	35.15	14.99	48.92*	-14.49*	26.43*	22.12*	19.95*	31.49*	11.25*	122.47*	0.97	31.98*
32	CMS 234A x RHA 271	12.88	16.42	96.21*	25.90*	30.65*	26.19*	-1.03*	8.49*	-39.30*	47.84*	22.39*	50.16*
33	CMS 234 A x HRHA 4-2	52.05*	19.29	157.40*	25.82*	-7.86*	2.52*	-12.12*	3.61*	10.69*	137.85*	17.96*	2.22
34	CMS 234 A x HRHA 5-3	21.42	7.19	116.08*	23.19*	21.33*	17.19*	-32.28*	21.87*	-29.45*	53.09*	-5.20*	17.34*
35	CMS 234 A x RHA 297	31.35	6.15	174.20*	31.70*	5.56*	5.04*	85.86*	103.76*	-2.46	137.47*	11.34*	61.57*
36	CMS 302 A x 6D-1	18.17	14.25	82.14*	35.94*	1.93*	13.93*	11.93*	48.05*	-33.33*	44.46*	31.46*	71.83*
37	CMS 302 Ax RHA 271	34.37	43.76*	53.29*	14.41*	-0.76	10.92*	52.54*	101.76*	3.51*	152.09*	-12.26*	7.64*
38	CMS 302 A x HRHA 4-2	88.62*	51.53*	14.23*	-14.74*	-0.13	11.61*	8.88*	44.01*	-29.33*	53.12*	89.70*	60.13*
39	CMS 302 A x HRHA 5-3	42.46*	34.16	70.81*	27.49*	5.49*	17.90*	-16.63*	50.04*	-33.13*	45.10*	40.21*	73.54*
40	CMS 302 A x RHA 297	72.30*	36.50	35.69*	1.27	7.24*	19.86*	-43.61*	-25.41*	-49.62*	22.66*	21.26*	75.97*
41	CMS 607 A x 6D-1	26.93	14.11	29.47*	-25.66*	4.07*	15.59*	105.52*	100.28*	-56.50*	-13.00*	35.88*	77.61*
42	CMS 607 A x RHA 271	21.22	16.13	66.29*	6.71	-17.15*	-7.99*	24.40*	21.23*	-63.93*	-12.15*	34.70*	73.59*
43	CMS 607 A x HRHA 4-2	34.78	5.07	86.02*	-9.07	31.62*	46.43*	44.30*	70.13*	11.29*	139.14*	-32.75*	-13.33*
44	CMS 607 A x HRHA 5-3	7.78	0.44	25.67*	-28.35*	-38.14*	-31.30*	-33.86*	19.04*	-25.85*	60.91*	21.82*	57.00*
45	CMS 607 A x RHA 297	41.65*	13.84	146.83*	-1.82	-3.30*	7.39*	64.42*	60.23*	10.41*	168.81*	-23.97*	10.33*
46	CMS 852 A x 6D -1	14.88	8.60	97.52*	13.42*	-0.05	-0.15	4.63*	28.03*	-52.68*	-5.37*	31.15*	71.42*
47	CMS 852 A x RHA 271	19.82	16.62	58.53*	1.73	1.36*	1.27*	12.90*	38.15*	-49.40*	23.23*	30.29*	61.37*
48	CMS 852 A x HRHA 4-2	19.15	6.07	106.59*	8.46	-17.71*	-8.44*	-20.42*	-2.61*	-55.38*	-4.12*	40.14*	73.57*
49	CMS 852A x HRHA 5-3	25.60	8.05	63.08*	-7.03	0.96*	0.86*	-31.69*	22.93*	12.91*	145.01*	-2.00	21.37*
50	CMS 852 A x RHA 297	19.55	14.24	71.84*	-9.79	-42.56*	-42.61*	29.27*	58.17*	-54.628	10.49*	16.16*	68.57*
51	ARG 2A x 6D-1	37.63	16.40	17.93*	-27.31*	-3.59*	2.67*	-3.06*	27.81*	17.538	146.88*	-35.77*	-3.52
52	ARG 2A x RHA 271	6.16	7.59	21.99*	-21.73*	-8.21*	-2.26*	56.79*	106.73*	-49.90*	22.02*	6.64*	60.18*
53	ARG 2A x HRHA 4-2	39.47	14.25	50.31*	-7.35	0.32	11.61*	-17.28*	9.07*	41.37*	203.78*	-31.64*	2.68
54	ARG 2A x HRHA 5-3	22.15	8.64	66.09*	2.37	-8.97*	-3.06*	-21.59*	41.13*	-56.32*	-5.21*	12.52*	69.03*

Sr. No	Hybrids	VG I		VG II		PALM. (%)		STER. (%)		OLEIC (%)		LINO. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
55	ARG 2A x RHA 297	28.95	10.77	67.01*	2.94	-8.87*	-2.95*	85.94*	145.16*	-13.30*	111.08*	-22.15*	16.94*
56	ARG 3A x 6D -1	21.06	4.09	31.32*	-1.71	-19.94*	-9.80*	60.65*	84.65*	-34.23*	32.40*	-15.18*	21.42*
57	ARG 3A x RHA 271	-1.06	-4.05	10.62	-17.21*	19.00*	34.07*	-10.90*	2.40*	-34.03*	60.65*	-17.48*	18.13*
58	ARG 3A x HRHA 4-2	17.20	1.13	-8.12	-31.24*	24.09*	39.80*	38.60*	63.42*	7.71*	131.46*	-20.23*	14.20*
59	ARG 3A x HRHA 5-3	34.55	17.50	12.20*	-16.03*	-30.298	-21.45*	57.02*	182.59*	-41.97*	25.91*	1.79	45.71*
60	ARG 3A x RHA 297	50.69*	18.94	19.69*	-10.42	-29.13*	-20.14*	111.95*	143.59*	-48.03*	26.53*	13.24*	64.32*
61	ARG 6A x 6D-1	23.59	16.96	25.17*	-15.32*	-21.07*	-22.46*	81.80*	155.90*	-55.15*	1.31	9.07*	57.67*
62	ARG 6A x RHA 271	11.32	12.05	22.20*	-17.33*	12.58*	10.61*	89.04*	166.09*	-33.66*	61.55*	-10.74*	29.03*
63	ARG 6A x HRHA 4-2	17.79	9.95	27.30*	-13.88*	-49.01*	-43.27*	-16.89*	16.99*	-48.04*	17.38*	17.06*	69.21*
64	ARG 6A x HRHA 5-3	9.01	-1.41	115.19*	45.57*	-26.80*	-28.09*	-18.25*	47.13*	-50.67*	11.43*	-0.69	43.56*
65	ARG 6 A x RHA 297	-7.82	-0.81	106.74*	39.85*	7.63*	7.09*	-4.47*	34.46*	-37.86*	51.28*	3.41	50.06*
66	DV 10 x 6D -1	29.91	17.57	73.88*	-0.16	-7.97*	1.51*	-15.39*	-0.42	-31.17*	37.64*	21.73*	59.11*
67	DV 10 x RHA 271	13.55	9.22	40.81*	-9.65	16.77*	28.80*	-11.18*	4.52*	21.20*	195.17*	-18.49*	0.00
68	DV 10 x HRHA 4-2	13.07	0.97	104.36*	11.14*	11.52*	24.08*	35.47*	59.72*	-49.11*	9.34*	41.97*	68.84*
69	DV 10 x HRHA 5-3	0.52	-2.31	56.15*	-10.98*	-6.47*	3.17*	-3.15*	74.31*	-58.89*	-10.79*	38.47*	71.39*
70	DV -10 x RHA 297	14.91	6.53	60.70*	-12.61*	-4.87*	4.93*	15.75*	36.24*	-39.85*	46.43*	5.25*	52.74*
71	CMS 207 A x 6D -1	22.87	2.72	26.94*	-15.79*	-4.28*	-8.89*	-36.97*	8.85*	-58.44*	-16.88*	37.11*	79.22*
72	CMS 207 A x RHA 271	-2.78	0.53	10.52	-26.68*	28.72*	22.52*	-40.37*	2.97*	-65.87*	-16.88*	34.07*	73.86*
73	CMS 207 A x HRHA 4-2	36.56	13.89	59.67*	5.93	-5.87*	4.73*	-33.20*	15.358	-51.44*	4.35*	29.04*	67.34*
74	CMS 207 A x HRHA 5-3	27.29	17.70	109.25*	38.82*	15.10*	9.56*	-40.46*	7.15*	-47.62*	13.67*	26.99*	64.69*
75	CMS 207 A x RHA 297	39.35	12.38	71.46*	13.76*	48.69*	47.94*	-17.83*	41.89*	-51.20*	18.81*	4.84*	52.15*
	SE	18.00	17.00	5.66	5.36	0.41	0.39	0.36	0.33	1.37	1.34	2.19	2.10
	CDat5%	41.40	36.63	11.31	10.71	0.81	0.78	0.72	0.66	2.74	2.68	4.38	4.20

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI -I -Vigour index I, VI -II – Vigour index II,PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

Table 4.37.1. Estimation of heterotic effects of hybrids for morphological traits and seed yield in E₂

Sr. No	Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
1	CMS 11 A x 6D-1	-0.01	12.16*	12.96*	-8.79*	31.25*	24.83*	-2.18*	-0.59	1.89*	0.64	28.23*	-19.99*	55.83*	13.33*
2	CMS 11 A x RHA 271	14.82*	13.68*	15.69*	-6.59*	52.32*	26.90*	-2.69*	0.96	3.77*	2.75*	92.12*	14.15*	53.31*	12.99*
3	CMS 11 A x HRHA 4-2	15.99*	5.79*	-2.81*	-9.89*	55.63*	29.67*	-5.85*	-2.31*	4.40*	3.38*	33.38*	0.00	30.53*	16.85*
4	CMS 11 A x HRHA 5-3	19.08*	8.61*	11.79*	-4.95*	94.54*	62.07*	2.63*	-1.79	6.21*	1.73	52.90*	-3.41*	41.71*	20.35*
5	CMS 11 A x RHA 297	-4.04*	4.85*	-6.77*	-24.73*	-5.74*	-4.82*	-0.47	1.68	2.57*	1.57	31.72*	-15.12*	78.90*	30.10*
6	CMS 17-A x 6D-1	3.54*	16.14*	37.65*	3.85*	62.18*	62.07*	-1.50	0.10	1.89*	0.64	75.14*	9.28*	60.70*	25.64*
7	CMS 17-A x RHA 271	4.62*	4.49*	35.47*	2.20*	21.46*	21.39*	-4.99*	2.05*	-4.39*	-0.77	123.52*	12.21*	54.65*	20.91*
8	CMS 17 -A x HRHA 4-2	1.14	1.01	-1.04	-8.24*	20.77*	20.69*	-4.75*	1.73	-3.59*	0.06	38.58*	3.91*	13.46*	1.56
9	CMS 17 -A x HRHA 5-3	-10.09*	-10.20*	71.24*	45.61*	84.96*	84.83*	3.80*	-0.67	6.97*	2.46*	43.63*	-9.26*	31.74*	11.88*
10	CMS 17 A x RHA 297	5.43*	15.20*	15.08*	-13.19*	22.27*	23.46*	-4.59*	-2.53*	-1.11	2.64*	10.52*	-28.77*	42.64*	11.51*
11	CMS 44 A x 6D-1	-2.72	9.12*	56.20*	23.63*	86.37*	77.26*	-1.38	0.22	8.15*	4.44*	109.54*	30.73*	64.40*	24.77*
12	CMS 44 A x RHA 271	3.20*	2.17	18.01*	-6.59*	51.23*	22.76*	-1.09	4.90*	9.63*	5.87*	102.70*	2.44*	52.33*	15.60*
13	CMS 44 A x HRHA 4-2	9.95*	5.43*	7.85*	0.00	61.15*	24.15*	-1.37	4.60*	5.23*	1.62	51.59*	13.67*	31.69*	17.88*
14	CMS 44 A x HRHA 5-3	-2.58	-6.58*	29.24*	9.89*	53.98*	18.62*	3.54*	-0.92	7.16*	2.64*	35.14*	-14.63*	17.04*	-0.60
15	CMS 44 A x RHA 297	0.73	10.06*	22.18*	-3.30*	22.95*	24.15*	2.27*	4.49*	7.55*	3.86*	64.27*	5.85*	54.72*	17.42*
16	CMS 148 A x 6D-1	-17.23*	-7.16*	-7.42*	-19.78*	5.15*	0.00	-2.09*	-0.50	6.10*	4.79*	57.94*	-1.46*	36.31*	12.80*
17	CMS 148 A x RHA 271	-8.56*	-8.10*	15.41*	0.00	43.20*	24.15*	-5.19*	1.84*	0.90	4.87*	89.49*	7.32*	46.65*	21.36*
18	CMS 148 A x HRHA 4-2	1.38	1.88	33.33*	23.63*	94.11*	68.28*	-6.33*	0.04	-0.91	5.44*	30.12*	-2.43*	18.96*	6.49*
19	CMS 148 A x HRHA 5-3	-13.67*	-13.24*	-13.76*	-25.27*	11.38*	-3.43*	3.67*	-0.80	4.77*	0.35	86.10*	17.56*	42.91*	21.36*
20	CMS 148 A x RHA 297	-15.70*	-7.89*	4.63*	-9.34*	18.85*	20.01*	-1.99*	0.13	-2.83*	1.32	62.00*	4.39*	39.88*	15.76*
21	CMSH 91 A x 6D-1	-17.68*	-7.67*	-11.70*	-18.13*	29.08*	22.76*	1.45	3.10*	6.10*	4.79*	55.32*	-0.97	22.33*	11.97*
22	CMSH 91 A x RHA 271	1.08	0.07	14.37*	6.05*	44.18*	28.97*	-5.35*	1.66	1.57	3.36*	83.63*	17.08*	37.39*	25.76*
23	CMSH 91 A x HRHA 4-2	30.62*	2.10	3.11*	-4.39*	37.24*	22.76*	-3.86*	2.69*	1.71	3.50*	53.55*	15.13*	23.99*	13.49*
24	CMSH 91 A x HRHA 5-3	16.45*	3.91*	1.33	-6.04*	42.64*	27.60*	6.54*	1.95*	8.38*	3.81*	60.67*	2.44*	29.33*	18.38*
25	CMSH 91 A x RHA 297	-7.55*	1.01	1.93*	-5.49*	25.00*	26.22*	1.03	3.22*	3.19*	5.01*	90.01*	22.45*	31.67*	20.51*
26	CMS 103 A x 6D-1	-8.39*	2.75	23.91*	-2.19*	30.53*	24.15*	13.69*	15.54*	6.39*	5.08*	103.96*	30.73*	65.74*	25.33*
27	CMS 103 A x RHA 271	25.64*	24.39*	-8.11*	-27.47*	38.63*	13.12*	15.24*	18.30*	0.63	4.59*	62.10*	3.91*	50.07*	13.49*

Sr. No	Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
28	CMS 103 A x HRHA 4-2	33.59*	16.64*	-8.74*	-15.38*	42.86*	16.55*	12.51*	15.50*	-3.20*	1.46	34.03*	0.50	35.60*	21.38*
29	CMS 103 A x HRHA 5-3	16.77*	4.20*	-6.95*	-20.88*	42.86*	16.55*	23.28*	17.97*	14.49*	9.67*	71.99*	10.24*	37.22*	16.53*
30	CMS 103 A x RHA 297	4.11*	13.75*	5.12*	-17.03*	-5.05*	-4.14*	11.86*	14.28*	2.71*	7.10*	67.30*	7.82*	58.12*	19.58*
31	CMS 234 A x 6D-1	8.90*	22.14*	4.41*	-11.54*	33.43*	26.90*	-1.09	0.10	9.92*	3.97*	36.76*	-9.26*	56.38*	16.20*
32	CMS 234A x RHA 271	-6.74*	-7.67*	-5.32*	-19.78*	48.68*	20.69*	-0.91	0.28	11.10*	5.08*	56.62*	3.91*	52.96*	13.65*
33	CMS 234 A x HRHA 4-2	4.64*	-7.89*	3.70*	-3.84*	68.57*	22.0*	2.56*	3.80*	12.61*	6.51*	45.74*	9.28*	34.80*	20.67*
34	CMS 234 A x HRHA 5-3	28.69*	14.83*	35.70*	15.39*	128.92*	70.35*	19.46*	14.32*	20.19*	13.68*	94.85*	29.27*	27.44*	8.23*
35	CMS 234 A x RHA 297	3.25*	12.81*	-3.37*	-18.13*	22.95*	24.15*	2.48*	3.72*	10.89*	4.88*	41.91*	-5.85*	51.28*	12.41*
36	CMS 302 A x 6D-1	-21.75*	-12.23*	57.84*	-14.84*	31.25*	24.83*	-1.34	0.26	6.12*	4.81*	64.48*	3.91*	99.08*	21.08*
37	CMS 302 A x RHA 271	-12.69*	-3.33*	20.43*	-15.93*	34.04*	21.39*	-2.69*	0.58	-1.28	1.43	62.16*	2.44*	59.91*	17.85*
38	CMS 302 A x HRHA 4-2	3.26*	14.33*	30.37*	20.89*	66.79*	51.04*	-2.14*	1.14	-1.43	1.27	60.70*	20.49*	44.36*	29.23*
39	CMS 302 A x HRHA 5-3	10.12*	21.92*	10.50*	-6.04*	42.42*	28.97*	20.83*	15.63*	22.60*	17.44*	69.11*	6.83*	37.13*	16.45*
40	CMS 302 A x RHA 297	14.30*	26.56*	53.85*	-14.28*	24.32*	25.53*	0.68	2.86*	-1.29	1.41	41.56*	-8.78*	100.50*	15.26*
41	CMS 607 A x 6D-1	0.70	12.95*	21.49*	2.20*	33.43*	26.90*	17.09*	18.99*	13.54*	11.82*	74.51*	12.21*	66.95*	19.85*
42	CMS 607 A x RHA 271	23.44*	22.87*	33.90*	12.64*	82.67*	48.29*	-2.13*	-0.10	5.13*	3.54*	87.41*	20.49*	63.14*	20.23*
43	CMS 607 A x HRHA 4-2	7.38*	6.87*	3.11*	-4.39*	44.96*	2.07*	-3.91*	-1.91	7.06*	5.44*	43.14*	7.32*	38.90*	24.33*
44	CMS 607 A x HRHA 5-3	22.21*	21.64*	2.10*	-13.19*	57.55*	17.26*	3.04*	-1.40	10.38*	5.73*	20.64*	-22.44*	16.57*	-1.00
45	CMS 607 A x RHA 297	-4.77*	4.05*	18.22*	-0.54	25.00*	26.22*	-2.80*	-0.78	7.13*	5.51*	51.40*	-2.43*	69.52*	21.70*
46	CMS 852 A x 6D -1	-5.28*	15.49*	40.52*	-21.97*	11.76*	17.94*	-1.97*	-0.38	6.80*	5.48*	61.85*	0.98	95.96*	19.18*
47	CMS 852 A x RHA 271	-18.99*	-1.23	62.14*	13.19*	33.33*	40.70*	-3.29*	-0.38	0.46	4.41*	116.82*	13.17*	76.34*	29.95*
48	CMS 852 A x HRHA 4-2	2.55	25.04*	-8.15*	-14.84*	16.99*	23.46*	-2.49*	0.44	-1.52	4.79*	61.35*	20.99*	29.94*	16.32*
49	CMS 852A x HRHA 5-3	-12.17*	7.09*	19.55*	1.65	19.61*	26.22*	22.70*	17.41*	11.41*	6.71*	28.96*	-18.53*	32.76*	12.74*
50	CMS 852 A x RHA 297	-6.65*	13.82*	51.87*	-15.38*	17.65*	24.15*	1.52	3.72*	-0.26	4.01*	40.05*	-9.75*	112.92*	15.59*
51	ARG 2A x 6D-1	-9.75*	1.23	-14.44*	-20.88*	22.55*	16.55*	0.19	1.82	7.13*	5.81*	40.61*	-8.28*	34.77*	17.58*
52	ARG 2A x RHA 271	21.62*	20.41*	6.95*	-1.10	56.33*	26.90*	7.79*	15.78*	1.59	5.59*	73.52*	13.17*	17.47*	2.49
53	ARG 2A x HRHA 4-2	46.21*	10.78*	0.15	-7.14*	54.46*	20.69*	12.34*	19.98*	4.05*	9.68*	46.39*	9.76*	34.63*	20.51*
54	ARG 2A x HRHA 5-3	18.72*	5.93*	2.20*	-5.49*	59.75*	24.83*	10.34*	5.58*	9.40*	4.79*	63.05*	6.35*	35.06*	17.83*

Sr. No	Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
55	ARG 2A x RHA 297	-11.92*	-3.76*	-3.15*	-10.43*	27.05*	28.28*	3.05*	5.28*	1.37	5.71*	59.31*	3.91*	28.27*	11.91*
56	ARG 3A x 6D -1	-11.30*	-0.51	-1.25	-13.19*	31.98*	25.53*	3.83*	5.52*	5.27*	3.97*	48.84*	0.50	30.04*	16.41*
57	ARG 3A x RHA 271	1.23	0.22	1.87*	-10.43*	54.63*	25.53*	-0.43	5.70*	-0.16	3.77*	48.84*	0.50	27.84*	14.44*
58	ARG 3A x HRHA 4-2	31.48*	11.36*	-6.96*	-13.73*	72.71*	24.83*	-0.59	5.53*	-1.33	4.99*	4.10*	-21.95*	28.47*	15.00*
59	ARG 3A x HRHA 5-3	14.42*	2.10	33.12*	17.04*	61.26*	20.01*	10.40*	5.64*	6.26*	1.78*	16.33*	-21.45*	44.84*	29.65*
60	ARG 3A x RHA 297	1.19	10.57*	-15.63*	-25.82*	4.51*	5.52*	3.22*	5.45*	0.19	4.47*	45.95*	-1.46*	35.39*	21.20*
61	ARG 6A x 6D-1	-17.04*	-6.66*	88.39*	1.65	33.24*	31.04*	4.43*	5.28*	5.12*	3.83*	75.92*	9.76*	108.87*	27.03*
62	ARG 6A x RHA 271	-24.95*	-15.56*	18.06*	-17.58*	23.42*	21.39*	3.02*	3.86*	0.97	4.94*	91.45*	-3.89*	55.35*	14.49*
63	ARG 6A x HRHA 4-2	-8.10*	3.40*	-4.00*	-10.99*	26.93*	24.83*	15.13*	16.07*	0.82	6.19*	22.32*	-8.28*	31.25*	17.49*
64	ARG 6A x HRHA 5-3	-6.62*	5.07*	-1.13	-15.93*	24.828	22.76*	11.39*	6.59*	8.06*	3.50*	51.35*	-4.39*	35.90*	15.41*
65	ARG 6 A x RHA 297	-12.35*	-1.37	38.07*	-23.08*	18.17*	19.33*	2.84*	3.69*	0.56	4.85*	89.25*	21.95*	95.07*	17.42*
66	DV 10 x 6D -1	-16.52*	-6.37*	5.16*	-13.19*	34.16*	27.60*	2.30*	3.96*	4.59*	3.30*	83.51*	15.13*	51.42*	14.18*
67	DV 10 x RHA 271	-0.96	-1.95*	10.48*	-8.79*	51.09*	24.83*	3.50*	5.27*	-1.34	2.54*	57.08*	-1.46*	54.45*	16.47*
68	DV 10 x HRHA 4-2	20.32*	7.96*	-1.04	-8.24*	53.59*	26.90*	16.13*	18.11*	-1.06	3.88*	34.68*	0.98	25.86*	12.67*
69	DV 10 x HRHA 5-3	3.39*	-7.24*	-12.76*	-25.82*	49.42*	23.46*	10.42*	5.66*	9.66*	5.04*	49.03*	-5.85*	27.76*	8.50*
70	DV -10 x RHA 297	-18.28*	-10.71*	-6.16*	-22.53*	26.37*	27.60*	13.78*	15.73*	1.39	5.73*	52.91*	-1.46*	53.65*	15.86*
71	CMS 207 A x 6D -1	-16.08*	-5.57*	55.80*	-15.93*	26.74*	25.53*	3.84*	5.53*	7.48*	6.16*	63.41*	1.96*	83.46*	17.64*
72	CMS 207 A x RHA 271	-17.94*	-7.67*	29.87*	-9.34*	23.96*	22.76*	3.33*	10.66*	3.30*	4.80*	117.69*	9.28*	56.93*	15.65*
73	CMS 207 A x HRHA 4-2	0.77	13.39*	14.37*	6.05*	72.70*	71.05*	-1.22	5.50*	3.29*	4.79*	24.27*	-6.82*	31.80*	17.99*
74	CMS 207 A x HRHA 5-3	-11.19*	-0.07	15.02*	-2.19*	33.01*	31.74*	14.95*	10.00*	6.12*	1.65	54.44*	-2.43*	48.37*	26.00*
75	CMS 207 A x RHA 297	0.77	13.39*	93.69*	7.91*	27.05*	28.28*	1.56	3.76*	1.37	2.84*	46.86*	-5.36*	87.71*	20.36*
	SE	1.58	1.62	0.93	0.90	0.43	0.43	0.92	0.85	0.90	0.87	0.69	0.66	1.30	1.25
	CDat5%	3.16	3.24	1.86	1.80	0.85	0.86	1.84	1.70	1.80	1.74	1.38	1.32	2.60	2.50

Table 4.37.2 Estimation of heterotic effects for oil content, hull content and viability in E₂

Sr. No	Hybrids	OC (%)		HC (%)		% SF		GERM. (%)		EC (µScm ¹ g ¹)		VIAB. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
1	CMS 11 A x 6D-1	35.17*	-4.15*	-10.25*	-16.38*	63.77*	48.53*	19.36*	43.11*	-20.17*	-22.52*	27.31*	70.32*
2	CMS 11 A x RHA 271	39.53*	-1.06	-7.28*	-0.85	55.56*	45.03*	9.57*	43.68*	-22.27*	-24.48*	13.13*	72.52*
3	CMS 11 A x HRHA 4-2	21.31*	0.73	9.57*	2.08	51.69*	42.15*	19.12*	42.83*	-34.45*	-36.35*	26.51*	69.43*
4	CMS 11 A x HRHA 5-3	28.28*	-9.03*	-53.71*	-50.05*	51.28*	37.20*	19.23*	42.96*	-60.92*	-62.06*	28.79*	72.30*
5	CMS 11 A x RHA 297	34.04*	-1.79	32.74*	23.66*	61.40*	46.37*	21.61*	45.82*	-57.10*	-34.76*	30.51*	74.60*
6	CMS 17-A x 6D-1	46.18*	-0.82	24.32*	38.62*	21.84*	26.47*	22.34*	42.96*	-28.38*	-35.13*	30.36*	70.61*
7	CMS 17-A x RHA 271	43.67*	-3.26*	-8.92*	1.56	44.32*	49.80*	9.19*	43.17*	-24.32*	-31.46*	5.66*	61.13*
8	CMS 17 -A x HRHA 4-2	14.06*	-5.29*	-32.18*	-24.38*	41.39*	46.76*	28.18*	47.02*	-31.53*	-37.94*	20.45*	61.31*
9	CMS 17 -A x HRHA 5-3	33.37*	-6.51*	-18.41*	-9.03*	36.87*	42.07*	25.31*	42.66*	-27.48*	-34.27*	20.43*	57.61*
10	CMS 17 A x RHA 297	25.88*	-7.81*	-33.43*	-25.77*	32.28*	37.31*	26.56*	43.41*	-67.83*	-51.04*	32.14*	72.94*
11	CMS 44 A x 6D-1	35.87*	-7.81*	49.84*	31.52*	159.10*	48.06*	23.09*	43.84*	-21.84*	-34.27*	22.62*	69.17*
12	CMS 44 A x RHA 271	40.04*	-5.70*	-1.15	5.71	40.56*	31.04*	7.41*	40.84*	-5.83*	-20.81*	13.21*	72.64*
13	CMS 44 A x HRHA 4-2	11.91*	-7.08*	46.14*	30.58*	48.51*	39.17*	25.39*	43.82*	-12.62*	-26.56*	21.76*	67.99*
14	CMS 44 A x HRHA 5-3	30.70*	-8.38*	-3.04	4.62	59.32*	40.12*	25.81*	43.24*	-27.67*	-39.17*	21.71*	67.93*
15	CMS 44 A x RHA 297	36.04*	-0.33	26.85*	3.75	120.91*	46.49*	29.51*	42.86*	-54.96*	-31.46*	23.47*	70.35*
16	CMS 148 A x 6D-1	20.05*	-8.06*	-26.08*	-14.08*	38.69*	42.64*	13.17*	43.68*	-50.00*	-48.59*	20.21*	73.66*
17	CMS 148 A x RHA 271	20.05*	-8.06*	-28.09*	-16.42*	42.42*	46.48*	11.09*	45.66*	-24.21*	-22.03*	12.54*	71.61*
18	CMS 148 A x HRHA 4-2	10.73*	-8.06*	37.95*	60.34*	42.47*	46.53*	9.04*	38.43*	-9.92*	-7.34*	10.54*	59.69*
19	CMS 148 A x HRHA 5-3	20.26*	-7.89*	7.29*	24.70*	40.35*	44.35*	10.54*	40.33*	-33.33*	-31.46*	21.75*	75.898
20	CMS 148 A x RHA 297	22.28*	-6.35*	10.37*	28.28*	45.51*	49.66*	15.59*	46.75*	-52.82*	-28.15*	22.56*	77.06*
21	CMSH 91 A x 6D-1	13.49*	-4.39*	69.64*	48.90*	105.94*	42.31*	15.55*	43.02*	-4.30*	-27.42*	17.30*	54.91*
22	CMSH 91 A x RHA 271	11.76*	-5.86*	13.58*	21.46*	55.39*	44.87*	8.91*	42.81*	14.52*	-13.10*	6.62*	62.59*
23	CMSH 91 A x HRHA 4-2	9.34*	-7.89*	55.12*	38.59*	55.41*	45.64*	15.34*	42.76*	0.00	-24.11*	27.95*	71.36*
24	CMSH 91 A x HRHA 5-3	9.44*	-7.81*	26.68*	36.68*	70.03*	49.54*	18.40*	46.55*	-38.17*	-53.12*	20.20*	58.75*
25	CMSH 91 A x RHA 297	7.70*	-9.28*	68.06*	33.34*	112.03*	46.52*	13.82*	40.88*	-62.20*	-42.47*	24.67*	64.64*
26	CMS 103 A x 6D-1	43.90*	-2.36*	51.10*	32.62*	86.68*	50.02*	16.95*	46.76*	23.90*	3.67*	7.92*	57.44*
27	CMS 103 A x RHA 271	46.49*	-0.98	18.89*	27.14*	57.24*	46.60*	10.58*	45.00*	13.66*	-4.90*	12.65*	71.78*

Sr. No	Hybrids	OC (%)		HC (%)		% SF		GERM. (%)		EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)		VIAB. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP8	Check	BP	Check
28	CMS 103 A x HRHA 4-2	17.59*	-2.36*	64.10*	46.62*	53.66*	44.00*	9.34*	37.20*	9.27*	-8.57*	7.59*	56.96*
29	CMS 103 A x HRHA 5-3	33.37*	-6.51*	6.76*	15.19*	71.93*	51.21*	13.36*	42.25*	23.41*	3.18*	11.94*	63.30*
30	CMS 103 A x RHA 297	25.15*	-8.30*	17.20*	-0.34	82.30*	46.51*	13.64*	42.60*	-27.35*	10.53*	16.31*	69.68*
31	CMS 234 A x 6D-1	15.57*	-7.16*	62.15*	42.32*	74.01*	49.80*	11.80*	30.64*	-24.38*	0.00	18.75*	54.71*
32	CMS 234A x RHA 271	15.77*	-7.00*	34.27*	43.59*	57.70*	47.03*	11.95*	46.79*	-36.42*	-15.91*	13.08*	72.44*
33	CMS 234 A x HRHA 4-2	10.73*	-8.06*	45.41*	29.92*	56.12*	46.31*	21.42*	39.27*	-31.48*	-9.42*	17.09*	56.81*
34	CMS 234 A x HRHA 5-3	18.51*	-4.80*	18.46*	27.82*	59.48*	40.26*	23.65*	40.77*	-29.63*	-6.98*	24.58*	56.88*
35	CMS 234 A x RHA 297	14.35*	-8.14*	61.00*	34.46*	54.95*	33.38*	91.88*	45.60*	-54.42*	-30.60*	102.67*	75.50*
36	CMS 302 A x 6D-1	34.31*	-8.14*	63.66*	43.65*	123.45*	49.26*	8.92*	45.91*	-37.90*	-44.55*	18.98*	71.85*
37	CMS 302 A x RHA 271	43.47*	-1.87	35.78*	45.20*	62.07*	51.10*	8.92*	45.91*	-22.83*	-31.09*	3.11	57.23*
38	CMS 302 A x HRHA 4-2	17.20*	-2.69*	66.96*	49.17*	53.33*	43.69*	2.24	36.96*	2.28*	-8.57*	7.59*	55.39*
39	CMS 302 A x HRHA 5-3	31.40*	-7.89*	28.08*	38.20*	68.13*	47.87*	4.28	39.70*	17.35*	4.90*	10.24*	59.22*
40	CMS 302 A x RHA 297	25.37*	-8.14*	104.53*	56.76*	116.86*	44.86*	5.10	40.79*	-32.44*	2.82*	10.30*	59.31*
41	CMS 607 A x 6D-1	16.18*	-7.32*	44.97*	47.66*	129.44*	43.38*	22.00*	42.55*	-13.57*	-9.06*	21.90*	58.81*
42	CMS 607 A x RHA 271	18.52*	-5.45*	57.66*	68.61*	60.29*	49.44*	11.85*	46.66*	-46.90*	-44.06*	11.63*	70.23*
43	CMS 607 A x HRHA 4-2	8.87*	-9.60*	40.31*	42.92*	55.36*	45.59*	26.53*	45.13*	-19.38*	-15.18*	29.37*	73.26*
44	CMS 607 A x HRHA 5-3	15.06*	-8.22*	44.51*	55.93*	68.16*	47.90*	21.00*	37.76*	-51.94*	-49.45*	24.79*	57.14*
45	CMS 607 A x RHA 297	19.65*	-4.56*	49.43*	52.19*	120.95*	46.52*	39.81*	43.98*	-76.68*	-64.50*	48.21*	67.20*
46	CMS 852 A x 6D -1	34.79*	-8.54*	61.05*	50.03*	131.18*	34.31*	24.73*	45.75*	-38.76*	-35.50*	24.45*	62.13*
47	CMS 852 A x RHA 271	34.85*	-9.20*	49.49*	59.86*	60.36*	49.51*	9.53*	43.61*	-37.21*	-33.90*	6.33*	62.15*
48	CMS 852 A x HRHA 4-2	13.77*	-5.53*	57.81*	47.01*	58.45*	48.49*	22.66*	40.69*	-12.02*	-7.34*	18.29*	58.42*
49	CMS 852A x HRHA 5-3	30.24*	-8.71*	25.31*	35.20*	68.22*	47.95*	24.06*	41.25*	-2.33*	2.82*	32.20*	66.47*
50	CMS 852 A x RHA 297	34.59*	-1.38	56.88*	46.14*	123.29*	48.07*	30.92*	45.94*	-40.48*	-9.42*	39.71*	61.00*
51	ARG 2A x 6D-1	16.82*	-8.54*	48.60*	49.48*	106.29*	51.10*	21.35*	41.80*	-10.39*	-15.54*	33.82*	74.34*
52	ARG 2A x RHA 271	23.88*	-3.01*	36.98*	46.48*	46.37*	36.46*	3.52	35.74*	-46.32*	-49.45*	0.44	53.17*
53	ARG 2A x HRHA 4-2	12.49*	-6.59*	17.32*	18.02*	59.43*	49.40*	24.29*	42.56*	7.79*	1.59*	22.44*	63.97*
54	ARG 2A x HRHA 5-3	24.51*	-2.52*	41.89*	53.10*	69.20*	48.80*	22.51*	39.47*	-31.60*	-35.50*	28.76*	62.14*

Sr. No	Hybrids	OC (%)		HC (%)		% SF		GERM. (%)		EC ($\mu\text{Scm}^1\text{g}^1$)		VIAB. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
55	ARG 2A x RHA 297	20.35*	-5.78*	30.77*	31.54*	103.78*	49.26*	23.04*	38.21*	-49.33*	-22.89*	24.42*	55.03*
56	ARG 3A x 6D -1	21.14*	-3.26*	32.66*	16.44*	109.96*	45.25*	19.66*	44.86*	18.97*	12.61*	16.58*	55.39*
57	ARG 3A x RHA 271	18.39*	-5.45*	42.28*	52.16*	57.83*	47.14*	10.45*	44.83*	-13.36*	-17.99*	6.78*	62.83*
58	ARG 3A x HRHA 4-2	14.45*	-4.96*	38.13*	23.42*	59.60*	49.57*	13.31*	37.17*	-24.57*	-28.64*	20.56*	61.46*
59	ARG 3A x HRHA 5-3	14.21*	-8.79*	25.44*	35.35*	64.76*	44.91*	20.73*	46.16*	-32.76*	-36.35*	19.43*	59.19*
60	ARG 3A x RHA 297	15.33*	-7.89*	40.90*	23.53*	118.53*	51.18*	16.38*	40.89*	-54.96*	-31.46*	17.74*	56.94*
61	ARG 6A x 6D-1	49.17*	1.38	42.65*	25.20*	156.21*	46.41*	10.66*	41.05*	-21.07*	-22.03*	4.11*	58.76*
62	ARG 6A x RHA 271	37.56*	-6.51*	6.92*	14.34*	59.57*	48.77*	8.83*	42.71*	-26.86*	-27.78*	5.66*	61.13*
63	ARG 6A x HRHA 4-2	16.81*	-3.01*	47.56*	31.84*	38.52*	29.82*	2.61	30.79*	-28.10*	-29.01*	0.72	53.59*
64	ARG 6A x HRHA 5-3	30.24*	-8.71*	-0.23	7.65*	63.60*	43.88*	15.84*	47.65*	-15.70*	-16.77*	1.67	55.04*
65	ARG 6 A x RHA 297	28.26*	-6.02*	78.55*	36.84*	127.77*	51.04*	14.21*	45.58*	-63.27*	-44.06*	12.72*	71.88*
66	DV 10 x 6D -1	44.62*	-1.87	72.58*	56.09*	68.24*	40.38*	14.74*	46.39*	-52.00*	-55.94*	6.88*	53.05*
67	DV 10 x RHA 271	47.37*	-0.24	7.11*	14.54*	59.55*	48.75*	8.82*	42.69*	-26.22*	-32.31*	-2.83	48.18*
68	DV 10 x HRHA 4-2	15.53*	-4.07*	76.01*	59.19*	56.09*	46.28*	15.10*	46.85*	-39.11*	-44.06*	22.29*	75.12*
69	DV 10 x HRHA 5-3	32.79*	-6.92*	28.29*	38.42*	70.71*	50.14*	-16.51*	6.52*	41.78*	30.11*	-18.52*	16.68*
70	DV -10 x RHA 297	28.26*	-6.02*	16.32*	5.21	79.11*	49.45*	7.03*	36.54*	-39.68*	-8.20*	1.15	44.84*
71	CMS 207 A x 6D -1	36.83*	-4.39*	26.76*	19.34*	72.72*	47.40*	22.08*	42.66*	-42.64*	-39.66*	18.49*	55.04*
72	CMS 207 A x RHA 271	31.83*	-7.89*	41.45*	51.26*	57.04*	46.41*	-25.88*	-2.81	22.87*	29.38*	-23.68*	16.38*
73	CMS 207 A x HRHA 4-2	10.44*	-8.30*	7.11*	0.84	38.12*	29.44*	-5.23	10.178	-20.93*	-16.77*	-2.21	30.96*
74	CMS 207 A x HRHA 5-3	39.18*	-2.44*	25.26*	35.16*	71.48*	50.81*	16.53*	35.45*	-31.01*	-27.42*	21.44*	58.89*
75	CMS 207 A x RHA 297	38.03 *	1.14	63.95*	54.36*	75.25*	49.56*	12.83*	31.16*	-30.56*	5.63*	20.05*	57.08*
	SE	1.35	1.11	3.09	3.14	1.96	1.86	2.83	2.74	0.03	0.03	1.56	1.48
	CDat5%	2.70	2.22	6.17	6.27	3.92	3.72	5.65	5.47	0.05	0.05	3.12	2.96

Table 4.37.3 Estimation of heterotic effects of hybrids for seedling vigour and fatty acids in E₂

Sr. No	Hybrids	VG I		VG II		PALM. (%)		STER. (%)		OLEIC (%)		LINO. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
1	CMS 11 A x 6D-1	74.38*	74.00*	113.17*	-17.95	7.95*	29.78*	-24.54*	-27.88*	-28.37*	54.20*	23.75*	55.96*
2	CMS 11 A x RHA 271	44.09*	43.81*	101.33*	-9.85	6.84*	72.04*	-32.39*	-25.63*	-38.63*	32.12*	22.26*	54.08*
3	CMS 11 A x HRHA 4-2	48.26*	50.36*	95.26*	-32.16	2.85*	23.65*	5.42*	0.73*	-45.47*	17.38*	27.23*	60.34*
4	CMS 11 A x HRHA 5-3	67.21*	66.85*	45.03*	-44.31	-9.94*	24.37*	14.96*	14.69*	-27.39*	70.87*	9.44*	37.92*
5	CMS 11 A x RHA 297	64.05*	63.70*	48.58*	-48.38	-0.25	17.95*	-2.41*	3.54*	-46.23*	33.80*	22.57*	54.47*
6	CMS 17-A x 6D-1	58.30*	46.49*	74.10*	-30.66	5.53*	26.84*	-6.99*	10.31*	20.50*	178.17*	-13.07*	10.43*
7	CMS 17-A x RHA 271	47.16*	46.87*	106.42*	-7.57	-26.07*	19.05*	-54.75*	-46.34*	27.22*	193.69*	-12.61*	11.01*
8	CMS 17 -A x HRHA 4-2	34.98	36.90	160.20*	3.64	11.41*	33.94*	-44.48*	-34.17*	-42.76*	32.14*	-4.24	21.65*
9	CMS 17 -A x HRHA 5-3	47.55*	39.34*	106.92*	-17.59	8.88*	50.36*	-22.24*	-7.78*	-46.91*	24.93*	20.89*	53.58*
10	CMS 17 A x RHA 297	47.42*	36.42	104.78*	-18.44	6.17*	25.53*	-6.47*	10.91*	-56.06*	9.32*	23.99*	57.51*
11	CMS 44 A x 6D-1	42.05*	38.13	111.60*	-18.55	-13.60*	3.85*	21.02*	3.11*	-23.21*	53.54*	11.11*	39.39*
12	CMS 44 A x RHA 271	17.83	17.60	70.04*	-23.86	-23.35*	23.43*	6.48*	17.12*	-38.59*	30.49*	27.46*	59.91*
13	CMS 44 A x HRHA 4-2	42.66*	44.69*	62.57*	-41.39	0.18	20.43*	-2.04*	-15.27*	-39.32*	16.79*	-4.58	19.71*
14	CMS 44 A x HRHA 5-3	52.17*	47.97*	56.75*	-39.81	6.92*	47.65*	-5.86*	-6.08*	-37.11*	48.00*	16.87*	46.62*
15	CMS 44 A x RHA 297	57.39*	53.05*	78.62*	-35.60	-14.20*	1.45*	14.41*	21.38*	-29.04*	76.56*	38.33*	73.54*
16	CMS 148 A x 6D-1	28.27	32.67	149.73*	17.17	0.30	22.68*	11.76*	35.99*	22.22*	144.36*	-1.42	30.62*
17	CMS 148 A x RHA 271	41.08*	45.91*	113.28*	0.07	-30.01*	12.70*	-44.94*	-33.00*	-59.73*	-14.44*	-20.08*	5.89*
18	CMS 148 A x HRHA 4-2	31.64	36.16	41.89*	-33.43	1.91*	24.66*	-19.47*	-2.01*	-39.68*	16.11*	-26.93*	-3.18
19	CMS 148 A x HRHA 5-3	33.62	38.20	25.26*	-41.23	19.66*	65.25*	-15.62*	2.69*	-17.80*	93.44*	-13.33*	14.83*
20	CMS 148 A x RHA 297	42.88*	47.78*	3.12	-51.62	-2.51*	19.27*	-14.71*	3.78*	-16.58*	107.57*	7.42*	42.33*
21	CMSH 91 A x 6D-1	53.16*	53.71*	29.04*	-45.94	37.10*	64.81*	1.97*	0.80*	11.49*	122.92*	26.24*	68.81*
22	CMSH 91 A x RHA 271	41.98*	42.50*	2.25	-54.22	-8.34*	47.58*	-23.70*	-16.08*	22.17*	159.61*	7.89*	44.28*
23	CMSH 91 A x HRHA 4-2	45.89*	47.96*	112.08*	-11.15	35.40*	62.75*	-1.48*	-2.61*	-31.75*	31.36*	-29.34*	-5.51*
24	CMSH 91 A x HRHA 5-3	46.60*	47.13*	136.28*	-1.02	37.47*	89.84*	18.44*	18.16*	7.51*	152.98*	16.46*	55.74*
25	CMSH 91 A x RHA 297	32.89	33.37	152.73*	5.88	20.68*	42.70*	-22.85*	-18.14*	-13.01*	116.44*	-0.34	33.27*
26	CMS 103 A x 6D-1	54.58*	44.70*	166.77*	15.34	15.66*	45.02*	-30.77*	-32.45*	27.26*	167.65*	-16.63*	14.83*
27	CMS 103 A x RHA 271	59.03*	58.73*	142.55*	8.60	-15.41*	36.19*	-0.33	9.63*	-1.58	109.14*	-6.53*	28.73*

Sr. No	Hybrids	VG I		VG II		PALM. (%)		STER. (%)		OLEIC (%)		LINO. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
28	CMS 103 A x HRHA 4-2	43.67*	45.71*	133.67*	1.03	30.68*	63.85*	-16.04*	-18.09*	-30.76*	45.61*	-21.55*	8.06*
29	CMS 103 A x HRHA 5-3	51.86*	43.41*	123.85*	-3.22	-3.59*	33.13*	-6.96*	-7.18*	-40.70*	39.54*	-26.17*	1.69
30	CMS 103 A x RHA 297	46.71*	37.33	129.65*	-0.71	29.22*	62.03*	12.74*	19.62*	-56.87*	7.32*	-35.97*	-11.82*
31	CMS 234 A x 6D-1	47.51*	35.90	181.50*	8.36	-8.88*	44.58*	22.32*	2.14*	-69.41*	-29.27*	-31.94*	-16.39*
32	CMS 234A x RHA 271	40.30*	40.03*	121.13*	-0.99	-2.99*	56.19*	-18.00*	-9.79*	-23.62*	76.56*	4.81*	23.80*
33	CMS 234 A x HRHA 4-2	31.22	33.08	185.82*	-18.16	-16.24*	32.91*	134.37*	102.69*	-36.45*	46.91*	13.56*	41.62*
34	CMS 234 A x HRHA 5-3	45.16*	37.09	124.36*	-13.84	6.35*	68.75*	-38.52*	-38.66*	-4.74*	124.16*	32.55*	57.63*
35	CMS 234 A x RHA 297	32.69	22.24	236.12*	-5.88	-16.19*	32.98*	73.94*	84.54*	4.73*	160.58*	36.93*	66.72*
36	CMS 302 A x 6D-1	34.08	37.13	7.06*	-49.28	-0.98*	62.19*	42.87*	69.69*	-15.61*	90.95*	14.80*	49.00*
37	CMS 302 A x RHA 271	45.39*	48.69*	6.89*	-49.35	12.34*	83.99*	72.82*	105.24*	1.53	129.72*	-3.05	25.84*
38	CMS 302 A x HRHA 4-2	46.76*	50.10*	60.18*	-24.11	-16.31*	37.07*	-15.18*	0.73*	-8.63*	106.75*	-21.34*	2.10
39	CMS 302 A x HRHA 5-3	53.83*	57.32*	8.04*	-48.81	-12.39*	43.49*	-28.41*	-14.98*	-44.84*	29.81*	-26.75*	-4.93*
40	CMS 302 A x RHA 297	60.12*	63.75*	44.34*	-31.61	-12.75*	42.92*	-43.33*	-32.71*	-43.97*	39.41*	-4.17	24.38*
41	CMS 607 A x 6D-1	52.05*	34.05	102.71*	-21.97	20.22*	44.51*	81.91*	81.25*	-50.11*	-0.26	18.42*	51.16*
42	CMS 607 A x RHA 271	31.39	31.14	74.54*	-21.85	14.96*	85.09*	2.05*	12.24*	-46.13	14.49*	4.73*	33.69*
43	CMS 607 A x HRHA 4-2	21.70	23.43	91.27*	-45.23	70.61*	105.10*	6.66*	6.29*	3.63*	99.46*	-4.62*	21.75*
44	CMS 607 A x HRHA 5-3	39.47	31.71	41.13*	-45.80	6.03*	46.42*	-36.20*	-36.36*	13.68*	167.52*	-14.68*	8.92*
45	CMS 607 A x RHA 297	62.15*	33.64	213.37*	-17.99	40.74*	66.41*	-19.92*	-15.04*	-22.92*	91.79*	-30.46*	-11.22*
46	CMS 852 A x 6D -1	27.76	34.22	140.97*	-7.24	23.07*	47.95*	25.53*	4.82*	-46.58*	14.53*	-24.48*	-7.23*
47	CMS 852 A x RHA 271	27.45	33.89	129.84*	2.91	3.76*	67.07*	-22.87*	-15.17*	14.19*	144.82*	-0.71	19.33*
48	CMS 852 A x HRHA 4-2	31.76	38.43	256.41*	10.73	-10.99*	7.01*	-23.87*	-34.17*	-13.90*	84.59*	3.25	28.77*
49	CMS 852A x HRHA 5-3	8.96	14.47	95.19*	-25.04	-18.66*	12.33*	33.33*	33.02*	-15.16*	99.64*	23.62*	48.58*
50	CMS 852 A x RHA 297	22.99	29.21	231.60*	3.02	55.74*	84.15*	-2.76*	3.18*	13.51*	182.44*	25.74*	53.10*
51	ARG 2A x 6D-1	46.13*	29.52	76.70*	-28.36	18.42*	46.86*	134.82*	140.69*	26.03*	151.99*	17.86*	62.17*
52	ARG 2A x RHA 271	15.98	15.76	3.93*	-53.46	-1.81*	58.09*	59.58*	75.53*	-9.87*	91.53*	1.51	39.68*
53	ARG 2A x HRHA 4-2	42.89*	44.91*	34.40*	-45.51	8.36*	34.38*	-2.91*	-0.48	11.84*	115.27*	4.91*	44.36*
54	ARG 2A x HRHA 5-3	48.49*	40.23*	26.05*	-48.89	33.88*	84.87*	-17.47*	-15.40*	-31.57*	61.04*	19.48*	64.39*

Sr. No	Hybrids	VG I		VG II		PALM.(%)		STER. (%)		OLEIC (%)		LINO. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
55	ARG 2A x RHA 297	55.35*	37.69	18.17*	-52.09	80.58*	123.93*	41.33*	49.95*	-41.42*	45.77*	24.93*	71.90*
56	ARG 3A x 6D -1	20.04	27.96	41.92*	-27.38	-17.60*	12.39*	-22.86*	-34.22*	-55.79*	15.45*	4.33	28.18*
57	ARG 3A x RHA 271	34.32	43.18*	52.80*	-21.81	8.20*	74.23*	139.15*	163.05*	-61.64*	0.18	-7.22*	11.16*
58	ARG 3A x HRHA 4-2	22.70	30.79	99.49*	2.08	32.69*	81.02*	31.97*	14.14*	-50.10*	30.31*	-15.06*	5.93*
59	ARG 3A x HRHA 5-3	37.20	46.25*	119.17*	12.15	15.38*	59.34*	13.06*	12.79*	-29.75*	83.45*	18.61*	42.11*
60	ARG 3A x RHA 297	29.01	37.52	117.30*	11.19	20.01*	63.72*	-3.04*	2.87*	5.84*	176.38*	33.18*	62.16*
61	ARG 6A x 6D-1	15.54	19.92	141.39*	11.44	-36.03*	-12.42*	-60.55*	-60.17*	6.86*	113.67*	25.90*	55.41*
62	ARG 6A x RHA 271	9.35	13.50	137.81*	9.79	-13.24*	39.70*	-8.47*	0.68*	5.38*	123.93*	27.61*	57.51*
63	ARG 6A x HRHA 4-2	33.49	38.55	110.04*	-3.03	33.90*	83.34*	-13.63*	-12.79*	52.30*	193.13*	22.82*	53.18*
64	ARG 6A x HRHA 5-3	45.90*	51.43*	156.58*	18.46	77.91*	145.68*	48.43*	49.88*	-18.61*	91.53*	2.64	26.70*
65	ARG 6 A x RHA 297	32.96	38.00	141.39*	11.44	-10.13*	23.06*	-20.55*	-15.71*	-34.85*	62.10*	7.72*	32.96*
66	DV 10 x 6D -1	58.67*	39.89*	175.35*	5.99	34.73*	61.97*	3.15*	-12.11*	-7.97*	84.01*	14.65*	44.37*
67	DV 10 x RHA 271	38.14	37.87	97.83*	-11.42	3.67*	66.91*	-13.68*	-5.04*	-37.79*	32.19*	12.71*	41.93*
68	DV 10 x HRHA 4-2	32.36	34.24	100.43*	-27.63	69.16*	103.35*	54.01*	33.20*	-31.21*	32.40*	26.99*	59.91*
69	DV 10 x HRHA 5-3	9.65	3.55	94.47*	-25.32	19.87*	65.54*	38.52*	38.19*	-54.60*	6.83*	30.04*	63.74*
70	DV -10 x RHA 297	57.73*	30.00	115.12*	-22.32	57.78*	86.56*	4.94*	11.33*	-53.34*	16.09*	34.54*	69.41*
71	CMS 207 A x 6D -1	60.14*	41.18*	38.47*	-40.22	37.69*	83.21*	-32.10*	-8.15*	-53.64*	22.89*	22.56*	50.56*
72	CMS 207 A x RHA 271	4.22	4.02	54.93*	-30.63	-0.18	60.72*	-49.66*	-31.90*	-36.39*	68.61*	11.75*	33.85*
73	CMS 207 A x HRHA 4-2	4.13	5.60	101.64*	-12.95	-5.54*	25.68*	-52.14*	-35.26*	-24.44*	100.30*	13.94*	42.10*
74	CMS 207 A x HRHA 5-3	39.34	31.58	163.17*	13.61	-4.39*	32.03*	-40.61*	-19.66*	-21.97*	106.83*	35.52*	62.32*
75	CMS 207 A x RHA 297	44.38*	25.07	100.84*	-13.29	117.99*	190.06*	-9.68*	22.18*	-33.32*	76.748*	40.66*	71.27*
	SE	24.30	16.00	1.66	1.56	0.47	0.39	0.29	0.27	1.74	1.66	2.26	2.18
	CDat5%	40.54	38.99	3.32	3.12	0.95	0.78	0.59	0.54	3.48	3.32	4.52	4.36

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

Table 4.38.1. Estimation of heterotic effects of hybrids for morphological traits and seed yield in E₃.

Sr. No	Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
1	CMS 11 A x 6D-1	35.53*	28.32*z	5.92*	4.18*	65.28*	16.54*	-3.78*	-3.67*	-5.00*	0.76	50.94*	34.67*	43.58*	4.88*
2	CMS 11 A x RHA 271	30.81*	21.58*	14.34*	12.47*	30.10*	6.26*	-4.56*	-4.45*	-4.64*	1.14	27.64*	13.87*	32.39*	10.16*
3	CMS 11 A x HRHA 4-2	23.52*	16.67*	13.89*	12.03*	99.55*	29.76*	-1.79	-1.67	-3.15*	4.92*	38.73*	23.76*	72.17*	25.77*
4	CMS 11 A x HRHA 5-3	33.77*	24.34*	28.07*	25.99*	34.44*	18.51*	2.41	0.80	0.72	5.68*	22.64*	9.42*	88.61*	37.78*
5	CMS 11 A x RHA 297	39.59*	29.74*	6.36*	4.62*	96.09*	37.61*	2.25	2.37	-2.78*	6.06*	29.86*	15.85*	46.03*	6.68*
6	CMS 17-A x 6D-1	29.01*	28.27*	42.98*	11.16*	71.53*	20.95*	-0.28	2.11	3.93*	10.23*	34.00*	-0.49	70.60*	15.60*
7	CMS 17-A x RHA 271	20.30*	19.62*	53.63*	19.45*	49.88*	22.42*	5.57*	7.31*	2.14*	8.33*	54.17*	28.22*	58.68*	32.04*
8	CMS 17 -A x HRHA 4-2	32.57*	31.81*	42.98*	11.16*	92.25*	21.45*	3.52*	5.99*	-0.35	7.20*	49.33*	10.90*	74.74*	18.41*
9	CMS 17 -A x HRHA 5-3	35.14*	34.37*	22.79*	-4.53*	44.44*	27.32*	-2.35	-3.88*	-3.61*	1.14	42.67*	5.94*	53.91*	4.29*
10	CMS 17 A x RHA 297	18.97*	18.29*	56.99*	22.06*	73.06*	21.45*	-2.56	-0.23	-7.39*	-0.38	11.33*	-17.32*	96.32*	33.03*
11	CMS 44 A x 6D-1	16.67*	16.57*	52.51*	10.72*	80.67*	32.70*	-6.11*	-5.61*	-5.02*	0.38	70.67*	26.73*	133.14*	27.35*
12	CMS 44 A x RHA 271	19.13*	19.03*	39.90*	1.57	37.29*	12.13*	-5.61*	-5.10*	-2.87*	2.65*	46.43*	21.79*	22.59*	2.01
13	CMS 44 A x HRHA 4-2	9.64	9.54	83.13*	32.96*	51.33*	11.16*	-3.89*	-3.37*	0.00	5.68*	50.71*	4.46*	154.60*	39.07*
14	CMS 44 A x HRHA 5-3	22.87*	22.76*	71.12*	24.24*	81.67*	60.13*	3.64*	2.01	-0.36	4.55*	72.00*	27.73*	78.95*	14.38*
15	CMS 44 A x RHA 297	18.79*	18.68*	79.53*	30.34*	99.33*	46.42*	0.67	1.21	-1.08	4.55*	70.00*	26.24*	111.81*	42.96*
16	CMS 148 A x 6D-1	23.28*	16.72*	65.39*	22.06*	113.89*	50.83*	-3.91*	-1.03	0.71	6.82*	41.95*	22.28*	69.63*	11.36*
17	CMS 148 A x RHA 271	32.66*	22.86*	58.30*	16.83*	66.67*	36.14*	-5.40*	-3.84*	-5.00*	0.76	43.10*	23.27*	36.09*	13.24*
18	CMS 148 A x HRHA 4-2	31.17*	23.89*	68.93*	24.68*	127.20*	39.08*	-7.56*	-3.60*	-2.45*	5.68*	45.98*	25.75*	101.59*	32.33*
19	CMS 148 A x HRHA 5-3	23.43*	14.16*	81.33*	33.83*	57.78*	39.08*	3.76	2.14	2.89*	7.95*	48.28*	27.73*	108.76*	37.04*
20	CMS 148 A x RHA 297	26.62*	17.11*	87.83*	38.63*	114.93*	50.83*	-1.41	1.58	-7.29*	1.14	43.10*	23.27*	114.82*	44.99*
21	CMSH 91 A x 6D-1	23.59*	17.01*	70.75*	57.80*	84.62*	41.03*	-2.04	-0.23	-1.44	3.79*	38.95*	30.70*	83.88*	51.55*
22	CMSH 91 A x RHA 271	34.52*	24.58*	31.13*	21.19*	105.64*	67.96*	-4.04*	-2.46	1.44	6.82*	26.32*	18.82*	36.19	13.32*
23	CMSH 91 A x HRHA 4-2	28.98*	21.83*	22.64*	13.34*	78.85*	36.62*	-6.21*	-4.48*	-4.68*	0.38	32.11*	24.27*	31.94*	8.74*
24	CMSH 91 A x HRHA 5-3	43.15*	20.85*	28.77*	19.01*	32.78*	17.04*	-3.39	-4.90*	1.81	6.82*	37.89*	29.70*	37.33*	13.19*
25	CMSH 91 A x RHA 297	30.90*	11.55	35.38*	25.11*	60.90*	22.92*	-7.30*	-5.59*	-5.04*	0.00	31.05*	23.27*	48.55*	22.43*
26	CMS 103 A x 6D-1	37.04*	29.74*	58.24*	15.96*	104.08*	46.91*	-7.41*	-6.05*	0.71	6.82*	77.33*	31.69*	124.26*	21.52*
27	CMS 103 A x RHA 271	25.23*	15.98*	63.59*	19.88*	51.08*	23.40*	-7.41*	-6.05*	-7.14*	-1.51	59.52*	32.67*	36.14*	13.29*

Sr. No	Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
28	CMS 103 A x HRHA 4-2	21.85*	15.09*	74.30*	27.73*	110.88*	51.80*	-6.17*	-4.79*	-1.40	6.82*	62.67*	20.79*	159.22*	32.63*
29	CMS 103 A x HRHA 5-3	49.35*	29.01*	71.33*	25.55*	63.33*	43.97*	-2.38	-3.91*	-2.53*	2.27*	82.00*	35.16*	79.37*	14.65*
30	CMS 103 A x RHA 297	42.01*	22.66*	63.00*	19.45*	89.80*	36.62*	-3.60*	-2.19	-0.35	8.71*	78.00*	32.18*	72.77*	16.61*
31	CMS 234 A x 6D-1	36.83*	29.55*	88.26*	41.24*	95.83*	38.09*	-1.67	-2.13	3.21*	9.47*	48.67*	10.40*	154.34*	39.16*
32	CMS 234A x RHA 271	25.69*	18.73*	62.12*	21.62*	87.05*	52.78*	8.30*	7.80*	4.29*	10.61*	32.74*	10.40*	40.16*	16.63*
33	CMS 234 A x HRHA 4-2	8.41	2.41	40.03*	5.06*	97.63*	39.08*	11.49*	10.98*	2.86*	9.09*	46.00*	8.42*	95.67*	7.06*
34	CMS 234 A x HRHA 5-3	24.03*	17.16*	34.81*	1.14	35.00*	19.00*	-0.42	-1.98	1.81	6.82*	51.33*	12.39*	64.15*	4.92*
35	CMS 234 A x RHA 297	28.56*	21.44*	73.16*	29.91*	62.14*	14.10*	-2.29	-2.74	2.86*	9.09*	-0.67	-26.23*	67.51*	13.06*
36	CMS 302 A x 6D-1	34.49*	27.34*	46.63*	25.99*	69.23*	50.83*	-6.99*	-4.99*	2.86*	9.09*	13.33*	-15.83*	117.03*	17.60*
37	CMS 302 A x RHA 271	57.08*	45.48*	49.67*	28.60*	54.40*	37.61*	-3.48*	-1.89	2.86*	9.09*	32.14*	9.91*	66.00*	38.13*
38	CMS 302 A x HRHA 4-2	28.57*	21.44*	34.96*	15.96*	53.85*	37.11*	-0.23	1.92	0.00	8.33*	25.33*	-6.92*	110.97*	9.49*
39	CMS 302 A x HRHA 5-3	41.11*	25.37*	35.97*	16.83*	51.65*	35.15*	5.29*	3.64*	3.25*	8.33*	43.33*	6.45*	74.70*	11.66*
40	CMS 302 A x RHA 297	53.34*	36.23*	40.54*	20.75*	42.86*	27.32*	4.18*	6.42*	-1.39	7.58*	67.33*	24.27*	72.66*	16.53*
41	CMS 607 A x 6D-1	28.54*	27.14*	41.72*	12.91*	54.06*	36.62*	7.98*	5.00*	3.96*	9.47*	37.10*	26.24*	32.56*	13.14*
42	CMS 607 A x RHA 271	37.00*	35.50*	55.40*	23.80*	32.52*	17.53*	7.44*	4.48*	1.44	6.82*	26.34*	16.34*	38.54*	18.24*
43	CMS 607 A x HRHA 4-2	28.54*	27.14*	55.40*	23.80*	43.57*	27.32*	1.93	-0.88	1.44	6.82*	13.44*	4.46*	42.89*	21.95*
44	CMS 607 A x HRHA 5-3	37.49*	35.99*	34.06*	6.80*	54.61*	37.11*	13.31*	10.19*	2.53*	7.58*	18.82*	9.42*	24.84*	6.55*
45	CMS 607 A x RHA 297	20.89*	19.57*	36.25*	8.55*	35.84*	20.46*	12.74*	9.63*	2.88*	8.33*	1.08	-6.92*	28.65*	9.80*
46	CMS 852 A x 6D -1	29.25*	22.37*	64.98*	34.70*	70.14*	19.98*	1.34	-0.93	0.71	6.82*	3.32*	7.93*	47.78*	30.17*
47	CMS 852 A x RHA 271	25.29*	16.03*	44.69*	18.14*	73.26*	41.52*	-0.59	-2.81	0.71	6.82*	14.22*	19.31*	30.03*	14.53*
48	CMS 852 A x HRHA 4-2	27.78*	20.70*	45.22*	18.57*	124.80*	37.61*	-0.94	-3.15	-1.40	6.82*	9.95*	14.85*	34.18*	18.19*
49	CMS 852A x HRHA 5-3	18.25*	9.14	44.69*	18.14*	48.33*	30.75*	-1.81	-4.00*	1.81	6.82*	19.43*	24.76*	34.11*	18.13*
50	CMS 852 A x RHA 297	21.18*	11.85*	35.08*	10.29*	91.91*	34.67*	15.74*	13.15*	-1.40	6.82*	19.91*	25.25*	28.05*	12.79*
51	ARG 2A x 6D-1	29.61*	22.71*	102.12*	36.88*	47.02*	20.95*	-2.18	-3.29*	0.71	6.82*	-2.52*	14.85*	56.52*	34.68*
52	ARG 2A x RHA 271	41.90*	31.42*	80.61*	18.57*	64.88*	35.64*	1.80	0.64	0.71	6.82*	0.00	17.82*	42.09*	22.26*
53	ARG 2A x HRHA 4-2	27.68*	20.60*	72.71*	24.68*	56.55*	28.79*	1.89	0.73	-5.59*	2.27*	-14.71*	0.50	48.69*	27.95*
54	ARG 2A x HRHA 5-3	46.44*	25.32*	67.71*	17.26*	51.67*	33.69*	-1.92	-3.46*	-2.89*	1.89*	11.34*	31.19*	52.22*	30.98*

Sr. No	Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
55	ARG 2A x RHA 297	50.23*	28.56*	101.62*	19.45*	63.10*	34.17*	4.17*	2.98	0.70	9.09*	15.97*	36.64*	55.55*	33.85*
56	ARG 3A x 6D -1	22.39*	15.88*	54.85*	8.98*	56.14*	30.75*	-3.57*	-0.67	1.43	7.58*	50.00*	36.64*	66.65*	20.51*
57	ARG 3A x RHA 271	33.89*	23.99*	61.66*	13.78*	43.86*	20.46*	2.24	3.93*	0.71	6.82*	53.26*	39.61*	39.80*	16.33*
58	ARG 3A x HRHA 4-2	18.88*	12.29*	47.34*	6.37*	52.05*	27.32*	-1.01	3.23*	-1.75	6.44*	38.04*	25.75*	48.66*	7.50*
59	ARG 3A x HRHA 5-3	34.41*	13.47*	54.23*	8.55*	42.22*	25.36*	8.38*	6.68*	1.81	6.82*	28.26*	16.84*	51.60*	9.62*
60	ARG 3A x RHA 297	30.55*	11.26	60.42*	12.91*	52.05*	27.32*	2.89	6.01*	-1.74	7.20*	45.11*	32.18*	71.04*	23.68*
61	ARG 6A x 6D-1	16.68*	10.47	69.30*	14.65*	39.88*	18.51*	-8.94*	-6.21*	1.07	7.20*	74.00*	29.21*	56.40*	27.37*
62	ARG 6A x RHA 271	25.07*	15.83*	83.93*	20.75*	38.73*	17.53*	3.66*	5.37*	0.36	6.44*	33.33*	10.90*	49.70*	24.57*
63	ARG 6A x HRHA 4-2	21.33*	14.60*	53.38*	10.72*	67.63*	42.02*	-5.64*	-1.61	-1.40	6.82*	76.71*	27.73*	39.65*	13.72*
64	ARG 6A x HRHA 5-3	42.62*	21.78*	58.98*	11.16*	48.89*	31.23*	4.17*	2.54	1.81	6.82*	60.67*	19.31*	47.83*	20.39*
65	ARG 6 A x RHA 297	39.28*	18.93*	81.94*	16.39*	57.23*	33.20*	1.34	4.42*	-2.08*	6.82*	71.33*	27.24*	64.00*	33.55*
66	DV 10 x 6D -1	42.02*	34.46*	59.03*	8.11*	49.69*	18.01*	3.62*	5.95*	3.57*	9.8*	59.33*	18.33*	65.96*	8.94*
67	DV 10 x RHA 271	25.39*	16.13*	52.61*	3.75*	44.48*	18.01*	12.45*	14.31*	3.57*	9.85*	57.14*	30.70*	29.39*	7.67*
68	DV 10 x HRHA 4-2	28.04*	20.94*	50.97*	8.98*	47.20*	16.06*	10.70*	13.19*	-1.40	6.82*	5.80*	-27.71*	60.23*	5.18*
69	DV 10 x HRHA 5-3	37.39*	17.35*	45.89*	2.01	33.89*	18.01*	9.59*	7.87*	1.81	6.82*	46.00*	8.42*	69.93*	11.55*
70	DV -10 x RHA 297	41.83*	21.14*	57.74*	7.24*	50.93*	19.00*	-3.75*	-1.59	-2.43*	6.44*	70.00*	26.24*	56.23*	5.45*
71	CMS 207 A x 6D -1	23.02*	16.47*	17.20*	-4.97*	78.47*	25.86*	-4.40*	-1.52	1.43	7.58*	0.59	-15.34*	35.79*	4.42*
72	CMS 207 A x RHA 271	27.30*	17.90*	26.34*	2.45*	36.09*	11.16*	0.43	2.09	2.14*	8.33*	11.76*	-5.94*	26.20*	5.01*
73	CMS 207 A x HRHA 4-2	20.76*	14.06*	37.10*	11.16*	66.17*	10.18*	6.94*	11.52*	-1.05	7.20*	-12.94*	-26.73*	42.96*	9.93*
74	CMS 207 A x HRHA 5-3	34.55*	14.75*	50.00*	21.62*	54.44*	36.14*	6.12*	4.46*	3.25*	8.33*	2.94*	-13.37*	57.51*	21.12*
75	CMS 207 A x RHA 297	34.09*	14.36*	74.73*	41.68*	114.24*	50.33*	7.78*	11.05*	1.04	10.23*	57.06*	32.18*	68.53*	29.60*
	SE	6.36	5.68	1.29	1.15	0.57	0.55	1.67	1.60	1.04	0.89	0.68	0.66	2.11	2.04
	CDat5%	12.71	11.35	2.58	2.30	1.15	1.10	3.34	3.20	2.08	1.78	1.36	1.32	4.22	4.08

Table 4.38.2. Estimation of heterotic effects of hybrids for oil content, hull content and viability in E₃

Sr. No	Hybrids	OC (%)		HC (%)		% SF		GERM. (%)		EC (µScm ¹ g ¹)		VIAB. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
1	CMS 11 A x 6D-1	-15.84*	-1.92	17.31*	-9.86*	41.40*	28.70*	1.50	26.95*	-72.09*	-62.09*	4.91*	66.18*
2	CMS 11 A x RHA 271	-16.58*	2.97*	31.84*	9.07*	45.30*	32.25*	0.65	28.57*	-64.34*	-51.50*	3.06	66.28*
3	CMS 11 A x HRHA 4-2	-26.05*	-1.48	9.88*	-12.61*	57.79*	43.62*	-27.73*	-10.92*	74.81*	137.44*	-26.71*	16.09*
4	CMS 11 A x HRHA 5-3	-6.84*	4.55*	6.23*	-9.16*	6.84*	-2.75	2.54	24.57*	-56.98*	-41.55*	3.37	63.74*
5	CMS 11 A x RHA 297	-22.18*	2.10	35.14*	8.76*	58.36*	44.13*	6.13	20.93*	-66.17*	-28.44*	-4.69	50.97*
6	CMS 17-A x 6D-1	-18.73*	2.36*	-12.41*	-14.63*	4.23	30.11*	-1.07	23.74*	-46.72*	-31.60*	0.79	57.82*
7	CMS 17-A x RHA 271	-21.29*	-0.87	-5.73*	-8.12*	13.38*	41.52*	-55.09*	-42.64*	42.62*	83.25*	-56.07*	-29.12*
8	CMS 17 -A x HRHA 4-2	-25.79*	-1.14	-16.01*	-18.14*	-48.76*	-36.04*	-13.02*	7.22*	-36.07*	-17.85*	-9.01*	39.31*
9	CMS 17 -A x HRHA 5-3	-19.98*	0.79	-26.60*	-28.46*	-5.03	18.54*	-16.94*	0.90	-52.46*	-38.86*	-13.35*	30.47*
10	CMS 17 A x RHA 297	-25.44*	-2.18	-8.80*	-11.12*	-9.35*	13.15*	-8.33*	9.72*	-73.13*	-43.13*	-5.43*	42.40*
11	CMS 44 A x 6D-1	-25.50*	-0.96	78.33*	-1.09	69.45*	22.20*	-2.46	26.38*	-51.03*	-37.28*	5.91*	65.83*
12	CMS 44 A x RHA 271	-22.08*	3.58*	0.83	-16.59*	104.23*	44.13*	-6.82*	20.74*	-59.67*	-48.34*	-5.44*	52.57*
13	CMS 44 A x HRHA 4-2	-24.87*	0.09	15.83*	-7.88*	58.86*	30.05*	-7.90*	19.33*	-30.04*	-10.43*	-1.47	50.86*
14	CMS 44 A x HRHA 5-3	-19.58*	6.91*	-10.85*	-23.77*	18.40*	3.15	-6.55*	21.08*	-49.79*	-35.70*	4.47	57.31*
15	CMS 44 A x RHA 297	-26.55*	-2.36*	7.36*	-13.60*	86.45*	51.97*	-46.22*	-30.32*	8.46*	129.54*	-40.17*	-10.62*
16	CMS 148 A x 6D-1	-21.80*	3.32*	3.60	0.28	-21.00*	-19.80*	-2.48	25.48*	-46.30*	-27.33*	4.15	64.91*
17	CMS 148 A x RHA 271	-19.89*	5.86*	5.19	1.82	39.91*	42.04*	-26.49*	-5.41	-49.81*	-32.07*	-23.80*	22.94*
18	CMS 148 A x HRHA 4-2	-25.20*	-0.35	-1.45	-4.60	7.22*	8.86*	0.29	29.05*	-61.87*	-48.34*	3.10	63.25*
19	CMS 148 A x HRHA 5-3	-18.23*	8.04*	-13.36*	-16.13*	30.67*	32.66*	-19.26*	3.89	-18.29*	10.58*	-16.51*	32.19*
20	CMS 148 A x RHA 297	-17.70*	8.74*	-9.91*	-12.79*	13.68*	15.41*	-57.84*	-45.75*	22.89*	160.19*	-57.71*	-33.04*
21	CMSH 91 A x 6D-1	-8.56*	6.56*	14.19*	-6.20	-43.08*	-36.99*	-8.92*	13.93*	-41.47*	-33.18*	-14.31*	35.14*
22	CMSH 91 A x RHA 271	-15.59*	4.20*	22.07*	0.99	16.33*	28.79*	-21.55*	0.21	-57.14*	-51.03*	-22.02*	25.81*
23	CMSH 91 A x HRHA 4-2	-21.33*	4.81*	22.35*	0.51	4.83	16.06*	-1.47	21.46*	-39.63*	-30.96*	1.16	59.54*
24	CMSH 91 A x HRHA 5-3	-12.43*	1.05	21.62*	4.00	26.02*	39.52*	-3.39	18.36*	-65.44*	-60.51*	-3.54	52.13*
25	CMSH 91 A x RHA 297	-25.58*	-2.36*	18.83*	-2.38	24.15*	37.44*	-18.73*	-0.44	-41.79*	23.22*	-19.20*	27.44*
26	CMS 103 A x 6D-1	-25.92*	-1.57	32.89*	-1.20	2.70	14.77*	1.51	26.98*	-50.00*	-46.76*	5.54*	65.25*
27	CMS 103 A x RHA 271	-20.79*	5.24*	40.58*	16.31*	19.19*	33.20*	-2.39	24.68*	-33.66*	-29.38*	1.15	63.19*

Sr. No	Hybrids	OC (%)		HC (%)		% SF		GERM. (%)		EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)		VIAB. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
28	CMS 103 A x HRHA 4-2	-26.12*	-1.57	25.98*	0.20	26.65*	41.54*	-0.39	22.79*	-29.21*	-24.64*	2.47	58.00*
29	CMS 103 A x HRHA 5-3	-24.61*	0.18	22.23*	4.53	25.70*	40.48*	-60.85*	-52.04*	107.69*	127.49*	-59.15*	-37.02*
30	CMS 103 A x RHA 297	-23.29*	1.92	11.95*	-9.91*	-50.76*	-44.97*	-11.78*	8.09*	-60.45*	-16.27*	-7.78*	42.21*
31	CMS 234 A x 6D-1	-14.18*	0.00	43.92*	2.89	24.43*	24.81*	-47.62*	-34.48*	39.14*	139.65*	-45.89*	-15.27*
32	CMS 234A x RHA 271	-19.49*	-0.61	17.68*	-2.64	-26.69*	-26.46*	-8.06*	17.45*	-55.96*	-24.17*	-5.05*	53.20*
33	CMS 234 A x HRHA 4-2	-26.32*	-1.84	51.06*	20.14*	34.35*	34.76*	0.64	24.06*	-57.49*	-26.86*	3.48	58.44*
34	CMS 234 A x HRHA 5-3	-15.54*	-1.57	15.92*	-0.88	41.09*	41.52*	-4.98	15.44*	-48.01*	-10.43*	10.81*	66.86*
35	CMS 234 A x RHA 297	-25.44*	-2.18	7.75*	-13.28*	33.64*	34.05*	54.41*	20.62*	-58.96*	-13.11*	70.80*	47.91*
36	CMS 302 A x 6D-1	-27.75*	-0.17	78.72*	12.53*	67.95*	39.57*	-9.10*	13.70*	-32.38*	-25.28*	-5.30*	49.43*
37	CMS 302 A x RHA 271	-24.21*	4.72*	43.54*	18.75*	57.17*	30.62*	-10.30*	14.58*	-30.48*	-23.06*	-7.02*	50.01*
38	CMS 302 A x HRHA 4-2	-26.30*	1.84	21.42*	-3.43	57.85*	31.19*	-57.86*	-48.06*	122.38*	145.97*	-58.89*	-35.13*
39	CMS 302 A x HRHA 5-3	-24.46*	4.37*	10.06*	-5.88*	-31.88*	-40.65*	2.28	24.25*	-61.43*	-57.35*	4.15	64.34*
40	CMS 302 A x RHA 297	-24.02*	4.98*	28.05*	3.05	69.67*	41.00*	4.63	27.06*	-61.44*	-18.33*	4.57	65.01*
41	CMS 607 A x 6D-1	-17.33*	3.58*	13.40*	-1.59	44.20*	44.23*	-46.05*	-32.52*	27.03*	130.17*	-45.08*	-14.00*
42	CMS 607 A x RHA 271	-14.47*	7.17*	4.28	-9.50*	-23.40*	-23.39*	-1.75	25.50*	-70.93*	-47.39*	1.84	64.32*
43	CMS 607 A x HRHA 4-2	-19.36*	7.43*	13.75*	-1.29	35.49*	35.52*	0.10	23.40*	-81.10*	-65.72*	6.34*	62.81*
44	CMS 607 A x HRHA 5-3	-19.70*	0.61	3.32	-10.34*	23.98*	24.01*	-14.88*	3.41	-53.20*	-15.17*	-10.58*	34.65*
45	CMS 607 A x RHA 297	-24.31*	-0.70	-11.80*	-23.46*	16.72*	16.74*	-52.08*	-50.79*	-7.21*	96.37*	-48.24*	-37.77*
46	CMS 852 A x 6D -1	-23.85*	2.62*	41.33*	3.24	-25.15*	-42.26*	1.40	26.83*	-61.11*	-11.53*	7.76*	68.73*
47	CMS 852 A x RHA 271	-22.88*	3.93*	7.59*	-10.99*	84.59*	42.38*	-6.54*	19.38*	-69.68*	-30.96*	-4.05	54.81*
48	CMS 852 A x HRHA 4-2	-26.90*	-1.48	8.48*	-13.72*	62.68*	33.18*	2.14	25.92*	-70.60*	-33.18*	6.78*	63.49*
49	CMS 852A x HRHA 5-3	-22.29*	4.72*	37.83*	17.86*	66.00*	44.62*	1.90	23.79*	-72.22*	-36.81*	7.65*	62.09*
50	CMS 852 A x RHA 297	-21.39*	5.94*	23.58*	-0.55	67.19*	36.27*	34.49*	28.60*	-62.27*	-14.22*	31.80*	65.68*
51	ARG 2A x 6D-1	-20.82*	-0.26	23.35*	-0.46	61.38*	44.13*	-1.30	23.46*	-36.84*	-17.85*	0.82	57.87*
52	ARG 2A x RHA 271	-23.53*	-3.67*	21.63*	0.63	60.27*	43.13*	-47.09*	-32.42*	57.09*	104.27*	-44.33*	-10.17*
53	ARG 2A x HRHA 4-2	-24.74*	0.26	32.12*	6.62*	-13.76*	-22.98*	3.00	26.97*	-55.47*	-42.02*	7.71*	64.92*
54	ARG 2A x HRHA 5-3	-19.51*	1.40	12.43*	-3.85	49.11*	33.17*	-17.22*	0.56	-35.63*	-16.27*	-12.45*	31.84*

Sr. No	Hybrids	OC (%)		HC (%)		% SF		GERM. (%)		EC ($\mu\text{Scm}^1\text{g}^1$)		VIAB. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
55	ARG 2A x RHA 297	-19.51*	5.60*	37.03*	10.58*	31.32*	17.28*	15.85*	25.24*	-68.66*	-33.65*	16.03*	53.43*
56	ARG 3A x 6D -1	-15.22*	1.75	65.28*	-0.56	97.83*	42.66*	-0.74	24.16*	-52.79*	-42.02*	-0.23	56.21*
57	ARG 3A x RHA 271	-14.32*	5.77*	17.53*	-2.77	104.50*	44.32*	-23.05*	-1.70	-30.04*	-14.22*	-22.95*	24.31*
58	ARG 3A x HRHA 4-2	-23.63*	1.75	16.44*	-7.39	37.83*	12.84*	-4.98	17.13*	-51.93*	-41.07*	-1.60	50.66*
59	ARG 3A x HRHA 5-3	-13.61*	3.67*	15.19*	-1.50	48.71*	29.56*	-2.15	18.87*	-57.08*	-47.39*	0.43	53.72*
60	ARG 3A x RHA 297	-24.71*	-1.22	28.68*	3.56	67.37*	36.41*	-2.87	14.55*	-77.61*	-52.61*	-6.99*	42.36*
61	ARG 6A x 6D-1	-27.48*	-0.96	108.14*	15.44*	84.04*	32.72*	-22.21*	0.08	-48.26*	-29.38*	-18.27*	31.84*
62	ARG 6A x RHA 271	-25.88*	1.22	33.58*	10.52*	66.24*	17.32*	-3.37	24.31*	-63.71*	-50.55*	-4.56	53.99*
63	ARG 6A x HRHA 4-2	-23.70*	4.20*	46.87*	16.81*	75.24*	43.47*	-3.09	24.67*	-65.25*	-52.61*	-5.45*	52.51*
64	ARG 6A x HRHA 5-3	-23.25*	4.81*	21.53*	3.92	63.65*	42.58*	0.71	29.56*	-56.37*	-40.44*	5.26*	69.79*
65	ARG 6 A x RHA 297	-27.93*	-1.57	32.80*	6.87*	73.36*	41.29*	-2.73	25.13*	-63.93*	-23.70*	-4.36	54.28*
66	DV 10 x 6D -1	-13.35*	6.12*	31.22*	4.24	28.14*	31.16*	-7.03*	16.29*	-42.51*	-25.28*	-2.54	52.60*
67	DV 10 x RHA 271	-20.20*	-1.48	26.91*	5.00	30.66*	33.73*	-11.73*	12.76*	-40.89*	-23.06*	-8.12*	48.23*
68	DV 10 x HRHA 4-2	-25.27*	-0.44	47.79*	17.54*	25.96*	28.93*	0.07	23.36*	-54.25*	-40.44*	-4.20	48.81*
69	DV 10 x HRHA 5-3	-19.42*	-1.31	24.21*	6.21*	40.69*	44.00*	4.40	26.83*	-44.13*	-27.33*	2.47	59.17*
70	DV -10 x RHA 297	-19.25*	5.94*	43.73*	15.67*	43.89*	47.28*	-24.28*	-8.69*	-16.92*	75.83*	-23.01*	19.60*
71	CMS 207 A x 6D -1	-6.23*	9.27*	-11.14*	-32.01*	3.11	4.46	-3.58	20.60*	-39.07*	-10.43*	-5.07*	48.63*
72	CMS 207 A x RHA 271	-17.01*	2.45*	15.97*	-4.06	38.35*	40.16*	-9.64*	15.43*	-40.86*	-13.11*	-8.58*	47.50*
73	CMS 207 A x HRHA 4-2	-24.35*	0.79	28.24*	1.99	31.70*	33.43*	-6.37*	15.42*	-59.86*	-41.07*	-1.18	51.30*
74	CMS 207 A x HRHA 5-3	-10.69*	3.15*	29.64*	10.86*	30.77*	32.49*	2.93	25.04*	-34.41*	-3.63*	1.46	52.77*
75	CMS 207 A x RHA 297	-24.51*	-0.96	8.17*	-12.95*	47.00*	48.93*	16.38*	27.06*	-56.97*	-8.85*	22.54*	66.22*
	SE	1.29	1.18	2.72	2.66	2.55	2.56	3.14	3.05	0.04	0.03	2.43	2.44
	CDat5%	2.58	2.36	5.43	5.31	5.09	5.11	6.27	6.09	0.08	0.06	4.86	4.88

Table 4.38.3 Estimation of heterotic effects for seedling vigour and linoleic acid in E₃

Sr. No	Hybrids	VG I		VG II		PALM. (%)		STER. (%)		OLEIC (%)		LINO. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
1	CMS 11 A x 6D-1	5.68	20.79	63.82*	-2.94	-22.37*	3.00*	3.83*	61.41*	23.99*	45.01*	-3.76*	10.66*
2	CMS 11 A x RHA 271	3.63	24.12	68.83*	0.03	-15.86*	11.64*	-21.63*	17.85*	1.97	20.88*	12.99*	29.92*
3	CMS 11 A x HRHA 4-2	-9.59	-10.15	14.13*	-32.38*	-17.32*	9.70*	27.34*	108.13*	-1.65	10.28*	23.79*	42.33*
4	CMS 11 A x HRHA 5-3	-2.19	20.07	50.57*	-10.79*	-15.02*	12.75*	-32.11*	49.64*	13.04*	23.49*	6.78*	22.77*
5	CMS 11 A x RHA 297	7.23	15.17	23.26*	-26.97*	-31.10*	-8.59*	-26.52*	10.52*	13.89*	24.82*	9.63*	26.04*
6	CMS 17-A x 6D-1	18.41	35.34	28.76*	-24.89*	-18.30*	3.93*	-9.36*	40.90*	14.17*	33.52*	23.64*	14.65*
7	CMS 17-A x RHA 271	-22.42	-7.08	-26.73*	-57.27*	-3.77*	6.65*	-14.17*	33.42*	-0.58	17.86*	58.30*	46.79*
8	CMS 17 -A x HRHA 4-2	-15.02	-15.56	16.60*	-31.99*	-11.56*	-1.99*	71.88*	180.93*	8.60*	21.77*	18.72*	11.18*
9	CMS 17 -A x HRHA 5-3	-15.02	4.32	65.00*	-3.75*	3.02*	14.16*	-46.01*	18.99*	42.15*	44.02*	52.22*	46.82*
10	CMS 17 A x RHA 297	-1.89	5.37	42.35*	-16.97*	-15.18*	-5.70*	14.82*	78.50*	16.16*	27.32*	63.06*	51.20*
11	CMS 44 A x 6D-1	-1.06	13.09	86.93*	1.59	-14.93*	8.24*	4.07*	61.79*	27.68*	53.96*	-43.03*	-27.36*
12	CMS 44 A x RHA 271	-16.66	-0.18	70.62*	-7.27*	-9.31*	8.82*	16.41*	53.55*	1.23	22.06*	1.94*	29.98*
13	CMS 44 A x HRHA 4-2	5.59	4.93	33.09*	-27.67*	-12.79*	4.64*	-1.86*	60.39*	11.43*	34.36*	-12.62*	11.41*
14	CMS 44 A x HRHA 5-3	-3.77	18.14	32.79*	-27.83*	-24.06*	-8.87*	-21.14*	73.83*	15.34*	39.08*	17.56*	49.90*
15	CMS 44 A x RHA 297	-27.14	-21.74	15.65*	-37.15*	-17.49*	-1.01	22.21*	53.93*	-2.11	18.04*	1.95*	29.99*
16	CMS 148 A x 6D-1	-3.11	18.85	67.40*	-1.74	-12.57*	11.23*	-22.06*	23.43*	-8.96*	6.48*	24.56*	46.83*
17	CMS 148 A x RHA 271	-32.07	-16.67	10.49*	-35.15*	-5.37*	17.99*	7.99*	71.02*	6.47*	26.22*	-2.39*	15.07*
18	CMS 148 A x HRHA 4-2	-10.79	9.44	75.82*	3.20	-24.38*	-5.70*	-23.39*	25.22*	-9.43*	5.49*	32.60*	56.31*
19	CMS 148 A x HRHA 5-3	-26.71	-10.03	29.00*	-24.28*	-22.63*	-3.53*	-3.22*	113.33*	-9.46*	5.46*	30.15*	53.43*
20	CMS 148 A x RHA 297	-59.27*	-50.04*	-21.81*	-54.11*	-9.29*	13.10*	-14.39*	35.59*	10.27*	28.43*	-3.84*	13.36*
21	CMSH 91 A x 6D-1	-23.17	-12.18	18.99*	-22.87*	-12.81*	19.28*	82.25*	183.33*	5.85*	23.79*	-12.03*	7.38*
22	CMSH 91 A x RHA 271	-24.42	-9.48	46.49*	-5.05*	-19.34*	10.35*	38.20*	82.30*	-8.95*	7.94*	14.89*	40.24*
23	CMSH 91 A x HRHA 4-2	-1.08	5.37	15.12*	-25.39*	-16.80*	13.81*	30.91*	113.94*	44.27*	67.44*	-70.07*	-63.47*
24	CMSH 91 A x HRHA 5-3	-6.17	15.18	77.24*	14.88*	-6.15*	28.40*	-31.94*	50.02*	-9.38*	5.17*	22.52*	49.55*
25	CMSH 91 A x RHA 297	-19.38	-13.41	43.08*	-7.27*	-18.78*	11.11*	40.93*	60.39*	2.91	19.44*	5.78*	29.12*
26	CMS 103 A x 6D-1	-10.62	6.75	70.49*	39.04*	-0.18	26.98*	62.54*	152.68*	-14.07*	0.50	37.67*	42.47*
27	CMS 103 A x RHA 271	-14.78	2.07	21.47*	-0.93	-1.73*	9.93*	6.81*	40.90*	-1.07	17.28*	28.86*	33.36*

Sr. No	Hybrids	VG I		VG II		PALM. (%)		STER. (%)		OLEIC (%)		LINO. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
28	CMS 103 A x HRHA 4-2	-8.61	9.15	19.58*	-2.47	-0.63	11.16*	32.53*	116.60*	-4.95*	6.57*	35.11*	39.82*
29	CMS 103 A x HRHA 5-3	-20.41	-2.30	24.42*	1.47	21.65*	36.10*	-11.26*	95.59*	9.59*	11.04*	35.75*	40.48*
30	CMS 103 A x RHA 297	-28.27	-14.34	23.87*	1.02	13.98*	27.51*	81.37*	127.99*	14.62*	25.63*	9.76*	13.59*
31	CMS 234 A x 6D-1	48.51*	41.15*	23.20*	-39.97*	-27.31*	-7.53*	56.27*	142.95*	0.65	17.72*	10.90*	29.97*
32	CMS 234A x RHA 271	-5.92	12.67	129.09*	16.95*	12.30*	20.76*	15.23*	76.22*	3.95*	23.23*	4.65*	22.64*
33	CMS 234 A x HRHA 4-2	5.42	4.76	138.15*	-2.93	23.89*	33.21*	-37.65*	1.90*	38.54*	55.35*	17.01*	37.12*
34	CMS 234 A x HRHA 5-3	-27.49	-10.99	51.69*	-34.96*	21.82*	30.99*	-32.45*	48.88*	20.85*	35.39*	21.85*	42.80*
35	CMS 234 A x RHA 297	3.08	10.72	56.49*	-37.90*	25.28*	39.28*	6.46*	62.82*	12.92*	26.50*	-5.70*	10.51*
36	CMS 302 A x 6D-1	-5.87	7.58	33.37*	-24.91*	-8.04*	26.33*	-8.90*	77.48*	8.20*	26.54*	29.64*	46.57*
37	CMS 302 A x RHA 271	-8.76	9.28	26.20*	-28.95*	-1.16	35.80*	-42.43*	12.15*	-0.82	17.57*	20.95*	36.75*
38	CMS 302 A x HRHA 4-2	-14.76	-9.49	4.57*	-41.13*	-3.21*	32.98*	-32.75*	31.03*	19.30*	33.78*	20.81*	36.58*
39	CMS 302 A x HRHA 5-3	-13.31	6.42	65.17*	-7.01*	-25.46*	2.42*	-46.87*	17.09*	19.70*	24.42*	39.37*	57.57*
40	CMS 302 A x RHA 297	7.92	15.91	59.13*	-10.41*	-4.36*	31.39*	-39.31*	18.23*	40.37*	53.85*	29.22*	46.09*
41	CMS 607 A x 6D-1	-15.14	6.60	-29.59*	-65.70*	-0.83	26.16*	-30.21*	8.51*	12.59*	40.34*	-6.44*	-5.81*
42	CMS 607 A x RHA 271	-9.65	13.49	43.94*	-26.52*	12.42*	31.39*	-0.69	46.33*	-3.87*	19.82*	24.73*	25.57*
43	CMS 607 A x HRHA 4-2	-9.72	13.41	83.71*	-25.12*	2.97*	20.34*	30.05*	112.57*	7.78*	34.34*	27.12*	27.97*
44	CMS 607 A x HRHA 5-3	-29.34	-11.24	66.11*	-28.78*	23.99*	44.92*	-33.03*	47.63*	-4.91*	18.52*	21.09*	21.90*
45	CMS 607 A x RHA 297	-17.33	3.85	15.84*	-55.95*	13.08*	32.15*	58.16*	133.08*	5.15*	31.07*	6.91*	7.63*
46	CMS 852 A x 6D -1	3.89	18.74	62.91*	-20.63*	-1.17	29.45*	62.90*	153.44*	0.68	17.75*	0.85	15.06*
47	CMS 852 A x RHA 271	-17.85	-1.61	49.24*	-23.81*	30.66*	71.13*	-6.59*	45.35*	21.65*	44.22*	25.218	42.86*
48	CMS 852 A x HRHA 4-2	11.34	10.64	115.04*	2.01	7.68*	41.04*	-3.25*	58.11*	20.96*	38.95*	4.08*	18.74*
49	CMS 852A x HRHA 5-3	-12.15	7.84	116.86*	2.87	14.36*	49.79*	-23.03*	69.65*	29.63*	48.92*	21.94*	39.12*
50	CMS 852 A x RHA 297	12.69	21.03	83.79*	-12.82*	-2.06*	28.27*	19.12*	85.34*	2.69	17.97*	9.29*	24.69*
51	ARG 2A x 6D-1	13.83	30.10	47.90*	-21.00*	0.46	27.81*	-26.52*	23.81*	22.71*	55.11*	45.67*	50.33*
52	ARG 2A x RHA 271	-4.47	14.41	-1.73	-47.51*	12.58*	39.38*	30.80*	120.39*	14.63*	44.89*	42.21*	46.76*
53	ARG 2A x HRHA 4-2	13.92	13.21	85.51*	-0.91	3.09*	27.64*	-24.27*	27.61*	-5.42*	19.55*	25.23*	29.24*
54	ARG 2A x HRHA 5-3	-37.89	-23.75	-21.11*	-57.86*	3.61*	28.27*	-45.09*	21.04*	17.04*	47.94*	49.40*	54.18*

Sr. No	Hybrids	VG I		VG II		PALM. (%)		STER. (%)		OLEIC (%)		LINO. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
55	ARG 2A x RHA 297	15.00	23.51	42.85*	-23.70*	20.80*	49.56*	-26.97*	23.05*	34.06*	69.45*	41.19*	45.72*
56	ARG 3A x 6D -1	12.90	32.44	27.99*	-12.81*	20.92*	65.49*	-29.11*	38.74*	22.35*	52.11*	-19.28*	3.53*
57	ARG 3A x RHA 271	-9.23	8.72	14.05*	-22.31*	11.43*	52.50*	-37.65*	22.03*	25.11*	55.55*	6.74*	36.91*
58	ARG 3A x HRHA 4-2	1.66	19.26	-13.78*	-41.27*	-2.36*	33.63*	-17.53*	61.41*	18.75*	47.63*	-10.85*	14.35*
59	ARG 3A x HRHA 5-3	7.40	31.85	-11.92*	-40.00*	0.30	37.27*	-42.22*	27.35*	11.31*	38.39*	5.51*	35.33*
60	ARG 3A x RHA 297	-9.88	5.71	-17.60*	-43.87*	17.10*	60.26*	-4.01*	87.88*	16.38*	44.69*	11.15*	42.57*
61	ARG 6A x 6D-1	-18.79	-2.47	26.71*	3.27	32.11*	76.31*	-44.89*	15.95*	22.54*	49.76*	16.83*	36.83*
62	ARG 6A x RHA 271	-1.11	18.75	-20.39*	-35.128	50.62*	101.01*	-55.78*	-6.95*	17.77*	43.93*	-5.11*	11.14*
63	ARG 6A x HRHA 4-2	-0.39	19.62	-6.09*	-23.47*	4.23*	39.10*	-36.28*	34.07*	10.36*	34.87*	-13.81*	0.94
64	ARG 6A x HRHA 5-3	1.78	24.94	-6.09*	-23.47*	12.56*	50.218	-42.79*	26.09*	19.53*	46.08*	-5.40*	10.80*
65	ARG 6 A x RHA 297	2.51	23.10	-8.06*	-25.07*	-10.48*	19.45*	-41.88*	22.29*	8.64*	32.78*	28.43*	50.42*
66	DV 10 x 6D -1	-2.80	11.09	9.72*	-37.30*	-8.69*	16.17*	2.44*	59.25*	16.18*	35.88*	5.43*	39.42*
67	DV 10 x RHA 271	-2.59	16.67	8.05*	-38.25*	39.91*	65.91*	-1.54*	29.89*	12.69*	33.59*	0.77	33.26*
68	DV 10 x HRHA 4-2	8.85	21.14	62.29*	-7.26*	11.06*	31.69*	-14.72*	39.38*	12.35*	25.98*	-10.90*	17.83*
69	DV 10 x HRHA 5-3	-2.28	19.96	10.21*	-37.02*	8.38*	28.52*	-51.58*	6.72*	30.46*	41.28*	-16.03*	11.04*
70	DV -10 x RHA 297	-12.04	-2.11	-25.86*	-57.63*	14.23*	35.45*	-26.77*	-8.58*	35.12*	48.10*	16.43*	53.96*
71	CMS 207 A x 6D -1	0.06	14.37	56.44*	-20.45*	32.72*	68.84*	-59.72*	27.50*	5.98*	23.94*	11.54*	9.21*
72	CMS 207 A x RHA 271	-14.73	2.13	170.50*	38.09*	21.12*	49.03*	-69.32*	-2.89*	16.59*	38.22*	2.26*	0.12
73	CMS 207 A x HRHA 4-2	11.30	12.84	39.79*	-28.91*	151.74*	209.75*	-71.64*	-10.25*	38.29*	55.07*	7.83*	5.57*
74	CMS 207 A x HRHA 5-3	5.65	29.69	91.06*	-2.84	-19.78*	-1.29*	-56.76*	36.84*	26.20*	41.15*	21.37*	18.83*
75	CMS 207 A x RHA 297	36.71	46.83*	96.27*	-0.19	-11.04*	9.47*	-69.44*	-3.27*	36.59*	52.77*	24.93*	22.31*
	SE	21.56	18.85	2.05	1.85	0.61	0.55	0.31	0.32	1.86	1.74	0.52	0.55
	CDat5%	43.08	37.66	4.10	3.70	1.22	1.10	0.61	0.64	3.72	3.48	1.04	1.10

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI - I -Vigour index I, VI - I – Vigour index II,PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

Table 4.39.1. Estimation of heterotic effects of hybrids for morphological traits and seed yield in E₄

Sr. No	Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
1	CMS 11 A x 6D-1	41.94*	33.40*	38.05*	31.44*	95.64*	0.39	7.83*	13.31*	2.45*	-1.03	28.38*	46.76*	51.04*	-8.15*
2	CMS 11 A x RHA 271	51.27*	41.37*	34.36*	27.92*	42.86*	-11.58*	8.35*	13.86*	1.38	0.01	13.31*	29.54*	34.91*	12.29*
3	CMS 11 A x HRHA 4-2	55.80*	46.42*	33.65*	27.24*	67.05*	-15.82*	10.07*	15.67*	6.62*	5.17*	27.34*	45.58*	85.23*	12.64*
4	CMS 11 A x HRHA 5-3	66.61*	53.89*	48.44*	41.33*	57.19*	4.63*	12.67*	13.89*	7.22*	0.04	32.02*	50.93*	85.74*	12.95*
5	CMS 11 A x RHA 297	47.27*	36.02*	48.96*	41.82*	104.60*	3.09*	17.76*	20.31*	5.58*	4.14*	37.73*	57.45*	89.92*	22.73*
6	CMS 17-A x 6D-1	54.16*	55.90*	69.14*	45.32*	88.11*	-3.48*	11.01*	13.36*	7.81*	4.14*	58.99*	45.58*	97.32*	27.69*
7	CMS 17-A x RHA 271	46.93*	48.59*	62.16*	39.33*	59.70*	-1.16	14.71*	17.14*	3.90*	1.72	65.48*	51.52*	51.90*	26.43*
8	CMS 17 -A x HRHA 4-2	46.28*	47.93*	59.84*	37.33*	98.39*	-4.63*	10.13*	12.45*	2.85*	0.69	63.53*	49.73*	96.00*	26.83*
9	CMS 17 -A x HRHA 5-3	46.38*	48.03*	55.77*	33.84*	53.13*	1.93*	12.22*	13.44*	9.44*	2.07	51.90*	49.73*	87.44*	21.29*
10	CMS 17 A x RHA 297	38.40*	39.96*	59.84*	37.33*	100.80*	-3.48**	11.54*	13.90*	4.25*	2.07	39.52*	27.75*	44.58*	-6.44*
11	CMS 44 A x 6D-1	42.41*	40.46*	41.91*	22.34*	61.78*	-16.98*	7.33*	12.33*	9.86*	2.76*	80.21*	51.52*	114.63*	7.30*
12	CMS 44 A x RHA 271	45.12*	43.14*	48.86*	28.34*	33.50*	-17.38*	6.52*	11.48*	7.28*	0.34	50.47*	34.28*	-0.88	-17.51*
13	CMS 44 A x HRHA 4-2	40.37*	38.45*	2.17	-11.91*	49.63*	-30.50*	8.82*	13.90*	11.71*	4.48*	66.91*	37.84*	162.64*	28.54*
14	CMS 44 A x HRHA 5-3	57.96*	55.80*	56.39*	34.83*	61.25*	7.34*	8.06*	9.23*	6.49*	-0.69	50.69*	48.54*	118.15*	25.77*
15	CMS 44 A x RHA 297	55.10*	52.98*	55.81*	34.33*	125.44*	8.11*	5.50*	7.78*	6.54*	-0.35	57.97*	36.67*	44.80*	-6.43*
16	CMS 148 A x 6D-1	54.66*	45.36*	17.38*	1.87	70.81*	-12.35*	3.70	10.27*	4.95*	1.38	44.40*	35.47*	91.57*	16.24*
17	CMS 148 A x RHA 271	54.51*	44.40*	53.57*	33.28*	75.30*	8.50*	7.50*	12.97*	2.08	1.38	34.26*	25.97*	36.49*	13.61*
18	CMS 148 A x HRHA 4-2	64.81*	54.89*	50.75*	30.84*	94.51*	-9.65*	0.36	8.54*	2.56*	1.38	55.16*	45.58*	96.71*	19.36*
19	CMS 148 A x HRHA 5-3	56.63*	45.86*	57.08*	36.33*	51.97*	1.16	19.67*	20.96*	9.81*	2.41*	39.84*	37.84*	110.25*	27.58*
20	CMS 148 A x RHA 297	52.08*	41.62*	57.65*	36.83*	98.87*	-4.63*	6.04*	8.34*	-0.01	-0.69	65.93*	55.67*	98.78*	28.45*
21	CMSH 91 A x 6D-1	66.10*	56.11*	45.48*	42.32*	102.82*	5.41*	6.60*	11.98*	6.91*	2.07	42.70*	50.93*	78.20*	27.67*
22	CMSH 91 A x RHA 271	58.56*	48.18*	36.80*	33.84*	50.97*	-6.56*	10.56*	16.14*	10.88*	5.86*	28.09*	35.47*	36.78*	13.84*
23	CMSH 91 A x HRHA 4-2	65.08*	55.15*	43.95*	40.82*	100.59*	4.25*	11.95*	17.61*	9.08*	4.14*	24.16*	31.32*	56.82*	12.34*
24	CMSH 91 A x HRHA 5-3	70.45*	46.06*	46.50*	43.32*	60.67*	6.95*	15.13*	16.37*	7.22*	0.08	14.04*	20.62*	107.51*	48.66*
25	CMSH 91 A x RHA 297	49.01*	29.26*	38.34*	35.33*	84.99*	-3.86*	7.84*	10.17*	3.30*	-1.38	20.22*	27.15*	86.65*	33.72*
26	CMS 103 A x 6D-1	40.28*	31.84*	56.95*	33.84*	112.19*	8.88*	8.16*	11.66*	3.17*	-0.35	61.84*	36.06*	129.63*	19.06*
27	CMS 103 A x RHA 271	42.14*	32.85*	71.01*	45.82*	74.05*	7.73*	9.83*	13.38*	0.010	-0.35	25.83*	12.30*	44.55*	20.31*

Sr. No	Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
28	CMS 103 A x HRHA 4-2	46.19*	37.39*	51.10*	28.84*	61.97*	-20.07*	5.26*	8.66*	-0.23	-1.38	89.49*	52.10*	96.88*	2.08
29	CMS 103 A x HRHA 5-3	66.51*	42.68*	39.39*	18.85*	16.59*	-22.39*	6.68*	7.83*	5.38*	-1.72	32.01*	30.12*	121.35*	27.61*
30	CMS 103 A x RHA 297	51.68*	31.58*	-0.44	-15.11*	44.76*	-28.56*	2.70	4.91*	3.56*	3.10*	61.40*	39.63*	58.08*	2.15
31	CMS 234 A x 6D-1	44.43*	36.23*	28.92*	26.34*	67.04*	-14.28*	7.89*	11.57*	5.67*	2.07	51.24*	27.15*	116.72*	8.35*
32	CMS 234A x RHA 271	53.68*	44.95*	45.22*	42.32*	78.42*	10.43*	8.71*	12.42*	1.50	-1.38	55.13*	38.45*	28.10*	6.62*
33	CMS 234 A x HRHA 4-2	37.85*	30.02*	19.24*	16.85*	79.88*	-8.87*	-0.21	3.19	6.11*	3.10*	73.85*	43.80*	114.77*	6.87*
34	CMS 234 A x HRHA 5-3	47.00*	38.65*	-10.60*	-12.38*	12.53*	-25.09*	0.25	1.34	7.22*	0.16	39.24*	37.25*	83.43 *	5.75*
35	CMS 234 A x RHA 297	41.38*	33.35*	30.45*	27.84*	65.40*	-16.22*	-0.92	1.23	3.63*	0.69	62.77*	40.82*	62.26*	4.85*
36	CMS 302 A x 6D-1	34.32*	26.24*	55.53*	31.33*	30.99*	-9.27*	-2.56	0.77	4.24*	0.69	-1.04	-15.03*	107.30*	3.64*
37	CMS 302 A x RHA 271	53.59*	43.54*	59.08*	34.33*	50.50*	4.25*	0.01	3.42	-1.85	-4.48*	61.12*	43.80*	30.45*	8.57*
38	CMS 302 A x HRHA 4-2	47.53*	38.65*	55.53*	31.33*	27.65*	-11.58*	0.35	3.78	-1.14	-3.79*	7.27*	-7.90*	139.03*	7.69*
39	CMS 302 A x HRHA 5-3	67.44*	52.07*	59.67*	34.83*	47.16*	1.93*	8.16*	9.33*	5.75*	-1.38	40.45*	38.45*	85.14*	6.74*
40	CMS 302 A x RHA 297	53.67*	39.56*	62.63*	37.33*	42.14*	-1.54	12.66*	15.09*	2.05	-0.69	53.85*	33.10*	93.77*	25.21*
41	CMS 607 A x 6D-1	32.77*	33.25*	57.61*	44.82*	68.02*	11.98*	13.87*	14.07*	5.49*	-0.69	35.82*	27.75*	67.65*	29.18*
42	CMS 607 A x RHA 271	46.90*	47.43*	65.22*	51.81*	65.12*	10.04*	9.12*	9.31*	6.96*	0.69	39.61*	31.32*	33.73*	11.31*
43	CMS 607 A x HRHA 4-2	53.73*	54.29*	50.54*	38.33*	49.48*	-0.38	8.12*	8.31*	7.69*	1.38	72.46*	62.21*	42.23*	9.59*
44	CMS 607 A x HRHA 5-3	55.04*	55.60*	36.96*	25.84*	34.99*	-10.03*	7.36*	7.55*	13.14*	5.52*	1.87*	0.41	52.93*	17.84*
45	CMS 607 A x RHA 297	32.72*	33.20*	8.97*	0.13	34.99*	-10.03*	5.08*	5.26*	0.00	-5.86*	72.46*	62.21*	37.16*	5.68*
46	CMS 852 A x 6D -1	41.46*	32.95*	36.79*	17.36*	41.46*	-27.41*	9.17*	7.54*	10.66*	6.90*	22.10*	40.82*	27.37*	-1.09
47	CMS 852 A x RHA 271	54.58*	45.01*	36.79*	17.36*	21.02*	-25.09*	1.04	-0.48	-6.17*	-7.93*	8.71*	25.37*	34.70*	12.12*
48	CMS 852 A x HRHA 4-2	47.64*	38.75*	59.49*	36.83*	134.41*	8.88*	2.38	0.84	7.18*	5.17*	25.19*	44.39*	30.44*	1.29
49	CMS 852A x HRHA 5-3	54.31*	44.75*	-3.03*	-16.80*	42.11*	-5.40*	2.94	1.40	10.18*	2.76*	14.37*	31.91*	33.49*	3.66*
50	CMS 852 A x RHA 297	50.87*	41.52*	50.76*	29.34*	81.96*	-12.74*	2.64	1.10	-5.12*	-6.90*	-11.90*	1.60*	33.77*	3.88*
51	ARG 2A x 6D-1	47.58*	38.70*	71.14*	36.83*	79.08*	5.79*	2.19	4.49*	5.31*	1.72	21.77*	28.93*	13.72*	-10.72*
52	ARG 2A x RHA 271	47.97*	38.29*	71.02*	36.73*	69.68*	5.03*	3.51	5.83*	-3.81*	-5.86*	29.07*	36.67*	31.68*	9.60*
53	ARG 2A x HRHA 4-2	41.46*	32.95*	63.02*	30.34*	61.44*	-4.63*	4.85*	7.20*	2.89*	0.69	31.31*	39.04*	37.37*	7.85*
54	ARG 2A x HRHA 5-3	50.01*	31.74*	61.15*	28.84*	40.37*	-6.56*	13.27*	14.49*	0.94	-5.86*	39.73*	47.95*	32.60*	4.10*

Sr. No	Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
55	ARG 2A x RHA 297	59.95*	40.46*	44.28*	15.36*	29.41*	-23.558	7.13*	9.45*	-3.45*	-5.52*	-11.34*	-6.11*	50.33*	18.02*
56	ARG 3A x 6D -1	37.91*	29.62*	76.16*	48.31*	74.28*	4.63*	8.72*	14.45*	3.17*	-0.35	26.56*	26.56*	81.42*	22.01*
57	ARG 3A x RHA 271	39.82*	30.68*	61.33*	35.83*	52.21*	-5.79*	10.93*	16.57*	0.69	0.34	54.49*	54.49*	24.45*	3.58*
58	ARG 3A x HRHA 4-2	39.26*	30.88*	43.53*	20.85*	24.76*	-25.09*	8.87*	14.61*	2.21*	1.03	24.18*	24.19*	45.71*	-2.01
59	ARG 3A x HRHA 5-3	59.44*	36.63*	46.50*	23.35*	29.35*	-13.90*	13.04*	14.26*	6.49*	-0.69	22.40*	22.41*	62.51*	9.29*
60	ARG 3A x RHA 297	70.70*	48.08*	59.55*	34.33*	56.91*	-5.79*	5.89*	8.18*	1.14	0.69	47.95*	47.95*	62.48*	9.27*
61	ARG 6A x 6D-1	47.95*	39.05*	58.60*	26.84*	30.88*	-16.22*	3.35	5.47*	4.95*	1.38	77.42*	50.32*	52.22*	14.12*
62	ARG 6A x RHA 271	64.44*	53.68*	74.84*	39.83*	55.61*	-0.38	4.41*	6.55*	3.81*	3.45*	35.82*	21.21*	20.04*	-0.09
63	ARG 6A x HRHA 4-2	43.93*	35.27*	60.47*	28.34*	44.15*	-7.71*	6.08*	8.26*	5.00*	3.79*	57.08*	33.10*	43.68*	7.72*
64	ARG 6A x HRHA 5-3	50.03*	32.75*	66.09*	32.83*	36.31*	-9.27*	13.99*	15.22*	12.03*	4.48*	25.38*	23.58*	34.88*	1.13
65	ARG 6 A x RHA 297	53.85*	36.13*	53.61*	22.85*	55.01*	-0.76	9.22*	11.46*	4.25*	3.79*	33.24*	15.28*	64.74*	23.52*
66	DV 10 x 6D -1	62.39*	52.62*	90.72*	50.81*	115.25*	11.20*	8.67*	7.44*	7.81*	4.14*	44.88*	21.80*	60.49*	7.37*
67	DV 10 x RHA 271	55.69*	45.51*	76.19*	39.33*	59.70*	-1.16	5.90*	4.69*	3.96*	2.41*	70.44*	52.10*	34.97*	12.33*
68	DV 10 x HRHA 4-2	48.87*	39.91*	62.30*	28.34*	83.86*	-5.02*	10.59*	9.33*	3.96*	2.41*	63.81*	30.71*	53.47*	2.67
69	DV 10 x HRHA 5-3	69.28*	47.28*	67.98*	32.83*	35.73*	-9.65*	9.70*	8.45*	9.44*	2.07	25.98*	24.19*	67.44*	12.02*
70	DV -10 x RHA 297	48.28*	29.01*	66.72*	31.84*	68.16*	-13.12*	7.36*	6.13*	5.01*	3.45*	71.02*	47.95*	53.99*	3.01
71	CMS 207 A x 6D -1	57.24*	47.78*	47.28*	24.85*	60.27*	-17.76*	6.83*	13.60*	6.38*	2.76*	36.54*	43.19*	63.51*	15.95*
72	CMS 207 A x RHA 271	57.37*	47.07*	53.76*	30.34*	44.10*	-10.81*	4.95*	10.28*	6.39*	3.10*	19.55*	25.37*	37.00*	14.02*
73	CMS 207 A x HRHA 4-2	55.42*	46.06*	57.88*	33.84*	84.21*	-8.11*	-0.47	7.65*	7.11*	3.79*	54.67*	62.21*	42.308	0.91
74	CMS 207 A x HRHA 5-3	61.49*	39.96*	44.33*	22.34*	15.43*	-23.17*	2.56	3.67	9.81*	2.41*	28.61*	34.88*	119.85*	55.91*
75	CMS 207 A x RHA 297	42.20*	23.36*	44.92*	22.85*	42.41*	-28.96*	-0.93	1.21	3.55*	0.34	18.98*	24.78*	74.54*	23.77*
	SE	2.23	2.11	1.34	1.08	0.82	0.74	2.14	2.06	1.08	1.15	0.70	0.66	1.56	1.74
	CDat5%	4.46	4.22	2.68	2.16	1.64	1.48	4.28	4.12	2.16	2.30	1.40	1.32	3.12	3.48

Table 4.39.2 Estimation of heterotic effects of hybrids for oil content, hull content and viability in E₄

Sr. No	Hybrids	OC (%)		HC (%)		% SF		GERM. (%)		EC (µScm ¹ g ¹)		VIAB. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
1	CMS 11 A x 6D-1	-15.88*	-4.71*	31.31*	16.45*	23.92*	72.27*	-13.27*	20.82*	-48.57*	-67.62*	-12.94*	12.55*
2	CMS 11 A x RHA 271	-16.13*	-2.95*	21.08*	12.52*	40.50*	95.32*	-5.07	38.03*	-60.41*	-75.10*	-2.90	30.90*
3	CMS 11 A x HRHA 4-2	-22.72*	-2.86*	30.03*	15.31*	42.97*	98.75*	3.81	42.98*	-81.22*	-88.20*	-7.25*	19.90*
4	CMS 11 A x HRHA 5-3	-6.51*	-2.53*	37.09*	24.38*	62.22*	125.51*	9.33*	48.23*	-66.53*	-78.95*	8.45*	40.20*
5	CMS 11 A x RHA 297	-22.68*	-2.10	40.47*	24.57*	44.43*	100.78*	3.34	38.84*	-88.54*	-88.67*	-2.34	26.25*
6	CMS 17-A x 6D-1	-13.91*	1.52	23.24*	30.51*	16.53*	107.65*	6.12	47.83*	-80.59*	-88.20*	11.89*	42.36*
7	CMS 17-A x RHA 271	-20.27*	-5.98*	-24.17*	-19.69*	-41.53*	4.19	-50.38*	-27.85*	100.84*	22.36*	-49.51*	-31.93*
8	CMS 17 -A x HRHA 4-2	-20.98*	-0.67	11.62*	18.20*	-14.40*	52.52*	-21.63*	7.94*	34.60*	-18.04*	-14.77*	2.65*
9	CMS 17 -A x HRHA 5-3	-17.70*	-2.95*	21.12*	28.26*	22.98*	119.14*	9.10*	49.82*	-89.03*	-93.29*	11.95*	38.47*
10	CMS 17 A x RHA 297	-22.95*	-2.44*	31.74*	39.51*	21.25*	116.05*	7.24*	47.26*	-82.81*	-83.04*	14.74*	36.02*
11	CMS 44 A x 6D-1	-17.59*	1.26	73.20*	0.47	97.40*	109.39*	3.39	44.03*	-90.39*	-94.37*	7.23*	36.43*
12	CMS 44 A x RHA 271	-18.07*	0.67	16.51*	8.26*	98.32*	109.05*	-1.53	43.18*	-89.08*	-93.60*	-1.81	32.37*
13	CMS 44 A x HRHA 4-2	-23.85*	-4.29*	0.44	-14.81*	89.23*	118.98*	9.13*	50.31*	-66.38*	-80.19*	12.30*	41.17*
14	CMS 44 A x HRHA 5-3	-20.05*	-1.77	6.88*	-3.03	43.87*	79.33*	-8.06*	26.40*	-82.10*	-89.44*	-1.80	23.44*
15	CMS 44 A x RHA 297	-24.21*	-4.04*	29.76*	14.59*	66.59*	99.65*	-2.78	33.66*	-81.25*	-81.50*	5.60*	32.74*
16	CMS 148 A x 6D-1	-22.95*	-2.69*	-0.22	10.31*	49.93*	123.76*	0.51	48.25*	-34.66*	-57.83*	4.39*	40.02*
17	CMS 148 A x RHA 271	-26.21*	-6.82*	3.77	14.73*	3.33	54.21*	-26.74*	8.06*	-76.10*	-84.58*	-26.29*	-0.64
18	CMS 148 A x HRHA 4-2	-23.35*	-3.20*	11.34*	23.10*	50.64*	124.82*	2.61	51.35*	-78.09*	-85.89*	2.36	37.29*
19	CMS 148 A x HRHA 5-3	-26.68*	-7.41*	-53.63*	-48.73*	16.07*	73.24*	-17.07*	22.32*	-38.25*	-60.14*	-16.42*	12.11*
20	CMS 148 A x RHA 297	-25.87*	-6.14*	-20.39*	-11.98*	-37.91*	-7.33*	-57.09*	-36.71*	-61.98*	-62.45*	-53.67*	-37.86*
21	CMSH 91 A x 6D-1	-11.05*	0.76	-40.03*	-44.66*	33.94*	123.24*	7.91*	50.32*	-35.24*	-65.07*	12.56*	43.22*
22	CMSH 91 A x RHA 271	-12.85*	0.84	29.59*	20.42*	2.88	71.47*	-19.52*	17.01*	-44.29*	-69.93*	-16.67*	12.34*
23	CMSH 91 A x HRHA 4-2	-22.58*	-2.69*	32.95*	22.67*	28.94*	114.91*	6.28	46.37*	-39.52*	-67.39*	14.12*	37.45*
24	CMSH 91 A x HRHA 5-3	-15.31*	-5.89*	6.89*	-1.37	18.48*	97.46*	-2.76	32.02*	-59.52*	-78.18*	0.04	23.74*
25	CMSH 91 A x RHA 297	-25.67*	-5.89*	4.32	-3.75	-8.51*	52.49*	-17.79*	11.61*	-16.93*	-18.04*	-8.96*	6.16*
26	CMS 103 A x 6D-1	-25.99*	-7.07*	29.86*	0.86	14.06*	72.88*	-17.92*	17.13*	-73.96*	-87.12*	6.90*	41.54*
27	CMS 103 A x RHA 271	-24.44*	-5.13*	10.76*	2.92	28.71*	95.08*	-2.33	42.01*	-43.75*	-72.24*	-2.62	31.27*

Sr. No	Hybrids	OC (%)		HC (%)		% SF		GERMN. (%)		EC ($\mu\text{Scm}^1\text{g}^1$)		VIAB. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
28	CMS 103 A x HRHA 4-2	-21.58*	-1.43	27.02*	7.73*	29.76*	96.67*	-5.28	35.16*	-76.56*	-88.43*	-3.81	27.36*
29	CMS 103 A x HRHA 5-3	-22.90*	-3.20*	13.48*	2.96	-46.78*	-19.34*	-61.93*	-45.68*	83.85*	-9.25*	-60.02*	-47.06*
30	CMS 103 A x RHA 297	-24.01*	-3.79*	29.37*	14.24*	14.71*	73.86*	-17.27*	18.06*	-81.51*	-81.73*	-14.34*	13.42*
31	CMS 234 A x 6D-1	-12.91*	-1.35	34.00*	4.39	-20.38*	19.93*	-40.32*	-16.86*	21.15*	-2.85*	-37.57*	-20.56*
32	CMS 234A x RHA 271	-18.02*	-5.13*	33.92*	24.45*	21.23*	82.59*	-14.58*	24.20*	-72.44*	-77.87*	-11.89*	18.77*
33	CMS 234 A x HRHA 4-2	-20.71*	-0.34	40.07*	18.80*	37.12*	106.53*	1.66	40.01*	-62.18*	-69.70*	7.90*	29.95*
34	CMS 234 A x HRHA 5-3	-15.19*	-4.80*	35.20*	22.67*	42.16*	114.12*	5.45	42.97*	-59.62*	-67.62*	5.73*	30.77*
35	CMS 234 A x RHA 297	-19.96*	1.35	47.78*	30.50*	28.28*	93.22*	51.26*	33.14*	-86.20*	-86.35*	83.27*	28.86*
36	CMS 302 A x 6D-1	-23.16*	0.51	55.98*	2.80	67.47*	100.53*	-3.87	36.91*	-65.38*	-81.50*	1.65	29.33*
37	CMS 302 A x RHA 271	-25.92*	-3.11*	32.66*	23.28*	30.02*	55.69*	-27.17*	5.90	64.42*	-12.10*	-27.47*	-2.23
38	CMS 302 A x HRHA 4-2	-23.35*	0.25	56.29*	32.56*	-26.49*	-11.98*	-57.82*	-39.93*	-62.98*	-80.19*	-48.51*	-34.81*
39	CMS 302 A x HRHA 5-3	-24.44*	-1.18	37.96*	25.17*	38.69*	72.88*	-14.35*	21.98*	-62.02*	-79.72*	-13.50*	9.52*
40	CMS 302 A x RHA 297	-24.12*	-0.76	46.01*	28.94*	68.07*	101.43*	-5.18	35.05*	-78.39*	-78.64*	2.08	29.25*
41	CMS 607 A x 6D-1	-18.98*	-4.55*	14.17*	5.24	-8.34*	7.39*	-46.05*	-24.84*	15.03*	-3.62*	-46.00*	-31.29*
42	CMS 607 A x RHA 271	-18.63*	-4.12*	27.45*	18.44*	50.26*	76.05*	-13.95*	25.11*	-60.12*	-66.62*	-11.66*	19.09*
43	CMS 607 A x HRHA 4-2	-25.33*	-6.14*	12.75*	3.93	86.81*	118.88*	6.84*	47.15*	-79.75*	-83.04*	15.84*	39.51*
44	CMS 607 A x HRHA 5-3	-14.41*	0.84	24.80*	15.04*	-11.56*	10.24*	-39.42*	-17.87*	15.95*	-2.85*	-36.67*	-21.67*
45	CMS 607 A x RHA 297	-21.69*	-0.84	20.96*	11.50*	-30.99*	-17.29*	-52.52*	-41.99*	-9.90*	-11.10*	-44.01*	-45.84*
46	CMS 852 A x 6D -1	-19.36*	-3.11*	35.68*	3.78	105.59*	118.08*	7.15*	49.27*	-81.28*	-80.49*	2.83	30.84*
47	CMS 852 A x RHA 271	-21.32*	-5.47*	26.06*	17.14*	103.51*	114.518	-1.60	43.08*	-74.88*	-73.79*	1.21	36.44*
48	CMS 852 A x HRHA 4-2	-23.45*	-3.79*	53.11*	29.86*	63.79*	89.53*	-7.52*	27.37*	-79.06*	-78.18*	-4.53	14.98*
49	CMS 852A x HRHA 5-3	-19.71*	-3.54*	21.96*	10.65*	29.16*	60.99*	-18.15*	10.97*	-17.98*	-14.42*	-16.34*	3.47
50	CMS 852 A x RHA 297	-21.55*	-0.67	24.08*	9.57*	27.23*	52.48*	-1.41	7.18*	-15.76*	-12.10*	-2.39	1.60
51	ARG 2A x 6D-1	-19.74*	-3.96*	38.90*	28.29*	60.10*	122.84*	7.91*	50.32*	-79.18*	-86.89*	11.25*	41.55*
52	ARG 2A x RHA 271	-14.75*	2.02	48.74*	38.22*	-19.56*	11.96*	-48.38*	-24.95*	57.96*	-0.54*	-46.20*	-27.47*
53	ARG 2A x HRHA 4-2	-19.30*	1.43	53.28*	41.56*	10.28*	53.50*	-25.13*	3.11	27.35*	-19.81*	-18.59*	-1.96
54	ARG 2A x HRHA 5-3	-18.06*	-1.94	50.53*	39.02*	34.69*	87.48*	-3.69	30.57*	-82.45*	-88.97*	1.49	25.53*

Sr. No	Hybrids	OC (%)		HC (%)		% SF		GERM. (%)		EC ($\mu\text{Scm}^1\text{g}^1$)		VIAB.(%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
55	ARG 2A x RHA 297	-21.09*	-0.08	39.62*	28.95*	32.76*	84.79*	1.32	27.87*	-88.02*	-88.20*	11.46*	19.58*
56	ARG 3A x 6D -1	-15.14*	-3.87*	53.50*	3.72	98.25*	118.26*	4.97	46.28*	-78.92*	-87.90*	3.28	31.40*
57	ARG 3A x RHA 271	-13.36*	0.25	18.31*	9.94*	46.94*	61.77*	-24.54*	9.72*	73.99*	-0.31	-21.50*	5.82*
58	ARG 3A x HRHA 4-2	-23.65*	-4.04*	54.18*	30.77*	56.15*	80.69*	-12.20*	22.36*	-68.61*	-82.04*	-12.95*	8.78*
59	ARG 3A x HRHA 5-3	-14.14*	-4.80*	49.86*	35.96*	70.78*	112.87*	2.76*	43.20*	-67.71*	-81.50*	8.37*	35.44*
60	ARG 3A x RHA 297	-23.88*	-3.62*	27.79*	12.85*	69.72*	103.41*	-3.08	35.06*	-79.43*	-79.72*	1.84	27.27*
61	ARG 6A x 6D-1	-28.71*	-4.88*	120.81*	28.08*	53.87*	63.21*	-22.92*	12.77*	-68.92*	-79.95*	-21.77*	2.76
62	ARG 6A x RHA 271	-27.70*	-3.54*	48.97*	38.43*	92.06*	102.45*	-1.57	44.01*	-56.97*	-72.24*	-3.89	29.56*
63	ARG 6A x HRHA 4-2	-24.93*	0.17	12.33*	-4.73	45.66*	68.56*	-20.90*	15.73*	-65.74*	-77.87*	-19.27*	6.04*
64	ARG 6A x HRHA 5-3	-25.49*	-0.59	25.72*	14.06*	60.45*	99.99*	-6.55*	36.73*	-63.35*	-76.33*	0.34	31.80*
65	ARG 6 A x RHA 297	-29.28*	-5.64*	46.86*	29.69*	82.62*	118.88*	0.29	46.73*	-78.39*	-78.64*	-2.12	28.57*
66	DV 10 x 6D -1	-17.19*	-5.13*	53.56*	34.84*	28.62*	91.36*	-9.75*	29.59*	-64.81*	-78.95*	-9.94*	22.16*
67	DV 10 x RHA 271	-16.20*	-3.03*	43.50*	33.35*	30.84*	94.66*	-8.06*	33.68*	-69.53*	-81.73*	-6.82*	26.38*
68	DV 10 x HRHA 4-2	-21.18*	-0.93	34.04*	17.70*	16.16*	72.81*	-18.56*	16.94*	-67.81*	-80.72*	-20.30*	8.11*
69	DV 10 x HRHA 5-3	-12.56*	0.17	40.77*	27.72*	35.46*	101.53*	-6.29*	34.55*	-66.52*	-79.95*	-6.78*	26.45*
70	DV -10 x RHA 297	-18.83*	2.78*	28.90*	13.83*	4.02	54.76*	-27.84*	3.62	5.73*	4.32*	-25.91*	0.50
71	CMS 207 A x 6D -1	-7.85*	4.38*	15.45*	-2.19	10.87*	74.87*	-14.51*	19.09*	-45.45*	-62.99*	-12.44*	11.41*
72	CMS 207 A x RHA 271	-13.73*	-0.17	24.96*	16.12*	23.34*	94.54*	-9.61*	31.42*	-54.92*	-69.39*	-8.52*	23.32*
73	CMS 207 A x HRHA 4-2	-19.23*	1.52	58.10*	34.09*	27.52*	101.13*	-0.77	36.66*	-39.39*	-58.91*	7.04*	28.91*
74	CMS 207 A x HRHA 5-3	-11.39*	-2.02	30.29*	18.21*	38.00*	117.66*	7.88*	46.27*	-67.80*	-78.18*	13.33*	40.17*
75	CMS 207 A x RHA 297	-19.09*	2.44*	38.80*	22.57*	39.24*	119.61*	15.61*	50.30*	-42.97*	-43.72*	28.41*	44.87*
	SE	1.16	1.06	3.03	2.87	2.48	2.40	3.13	3.04	0.06	0.05	2.39	2.42
	CDat5%	2.32	2.12	6.05	5.73	4.96	4.80	6.25	6.07	0.11	0.10	4.78	4.84

Table 4.39.3 Estimation of heterotic effects for seedling vigour and linoleic acid in E₄

Sr. No	Hybrids	VG I		VG II		PALM.(%)		STER. (%)		OLEIC (%)		LINO. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
1	CMS 11 A x 6D-1	10.74	13.36	23.92*	85.07*	-28.81*	-45.45*	-13.01*	39.92*	10.74*	38.12*	-22.10*	-11.00*
2	CMS 11 A x RHA 271	17.05	25.45	8.93*	62.68*	-12.96*	-36.76*	-24.50*	21.43*	2.20	34.33*	12.87*	28.95*
3	CMS 11 A x HRHA 4-2	20.21	34.75	54.94*	131.40*	-13.90*	-37.45*	34.05*	118.22*	-3.71*	17.94*	25.58*	43.47*
4	CMS 11 A x HRHA 5-3	42.87*	46.26*	53.60*	129.40*	-16.14*	-39.07*	-21.09*	61.51*	14.39*	33.84*	7.49*	22.80*
5	CMS 11 A x RHA 297	57.08	60.80*	87.81*	180.49*	-26.81*	-46.83*	-14.94*	36.82*	15.69*	35.36*	10.81*	26.59*
6	CMS 17-A x 6D-1	19.44	21.82	40.32*	95.95*	-21.75*	-40.04*	17.49*	94.46*	8.92*	35.84*	111.26*	15.76*
7	CMS 17-A x RHA 271	-16.84	-10.86	57.39*	119.79*	2.00*	-35.50*	-12.72*	44.46*	-6.55*	22.82*	91.62*	46.50*
8	CMS 17 -A x HRHA 4-2	1.83	14.15	-9.22*	26.77*	10.59*	-29.90*	75.33*	190.19*	9.89*	34.60*	30.13*	11.57*
9	CMS 17 -A x HRHA 5-3	26.20	28.71	-12.87*	21.67*	5.68*	-30.23*	-38.32*	26.24*	9.82*	17.64*	57.32*	48.15*
10	CMS 17 A x RHA 297	47.00*	50.33*	106.62*	188.53*	-3.70*	-33.26*	22.09*	102.05*	-2.73	12.94*	129.69*	51.34*
11	CMS 44 A x 6D-1	45.30*	47.01*	96.59*	152.29*	-10.26*	-31.24*	27.04*	99.11*	30.93*	63.30*	-42.59*	-27.63*
12	CMS 44 A x RHA 271	23.17	32.01	25.67*	61.27*	7.03*	-31.39*	11.01*	57.64*	0.18	31.67*	3.28*	30.19*
13	CMS 44 A x HRHA 4-2	20.88	35.50	30.13*	67.00*	8.95*	-30.16*	-5.71*	53.49*	12.16*	39.50*	-11.21*	11.92*
14	CMS 44 A x HRHA 5-3	28.91	17.68	54.49*	98.26*	-7.05*	-38.64*	-11.68*	80.74*	-7.68*	14.83*	18.93*	49.92*
15	CMS 44 A x RHA 297	13.65	16.22	21.29*	55.65*	7.44*	-25.54*	13.83*	61.63*	2.46	27.44*	2.51*	29.22*
16	CMS 148 A x 6D-1	36.17	54.76*	81.18*	149.65*	-6.78*	-28.57*	-14.43*	34.11*	-4.74*	18.81*	32.44*	47.43*
17	CMS 148 A x RHA 271	-7.04	5.65	24.78*	71.93*	-0.39	-25.62*	14.86*	79.73*	2.73*	35.03*	3.53*	15.25*
18	CMS 148 A x HRHA 4-2	21.09	37.62*	-2.14*	34.85*	-14.88*	-36.44*	-19.52*	31.01*	-4.15*	19.01*	40.96*	56.92*
19	CMS 148 A x HRHA 5-3	-0.51	13.07	38.42*	90.73*	-10.19*	-32.93*	7.70*	120.43*	-9.40*	12.49*	38.22*	53.86*
20	CMS 148 A x RHA 297	-21.11	-10.34	-5.52*	30.18*	-5.65*	-29.55*	-0.33	55.93*	17.44*	45.83*	2.92*	14.58*
21	CMSH 91 A x 6D-1	36.15	41.97*	-46.59*	-14.25*	-13.02*	-29.15*	87.80*	194.30*	8.26*	35.03*	-4.65*	7.10*
22	CMSH 91 A x RHA 271	-0.61	6.53	15.93*	86.12*	-16.83*	-32.25*	67.29*	109.42*	-7.37*	21.75*	24.78*	40.16*
23	CMSH 91 A x HRHA 4-2	-7.15	4.08	14.53*	83.87*	-17.36*	-32.68*	34.05*	118.22*	54.12*	88.78*	-66.97*	-62.89*
24	CMSH 91 A x HRHA 5-3	42.83*	48.94*	14.71*	84.16*	-11.60*	-28.00*	-20.77*	62.13*	33.59*	62.26*	33.42*	49.87*
25	CMSH 91 A x RHA 297	3.90	8.34	-7.71*	48.16*	-9.65*	-26.41*	25.48*	59.03*	8.56*	31.86*	14.06*	28.12*
26	CMS 103 A x 6D-1	26.83	28.31	-21.71*	44.48*	2.35*	-21.57*	65.70*	159.69*	8.28*	35.04*	47.01*	43.15*
27	CMS 103 A x RHA 271	28.24	37.45	3.23	90.50*	5.25*	-26.22*	25.70*	57.36*	-0.91	30.24*	37.21*	33.60*

Sr. No	Hybrids	VG I		VG II		PALM. (%)		STER. (%)		OLEIC (%)		LINO. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
28	CMS 103 A x HRHA 4-2	-5.24	6.22	-25.99*	36.59*	0.21	-29.76*	36.51*	122.21*	15.08*	40.97*	45.05*	41.24*
29	CMS 103 A x HRHA 5-3	16.09	9.45	-16.07*	54.89*	18.48*	-16.96*	-3.22*	98.06*	30.34*	39.61*	43.59*	39.82*
30	CMS 103 A x RHA 297	5.66	8.06	-52.33*	-12.04*	15.39*	-19.12*	71.76*	117.71*	14.10*	32.48*	17.18*	14.10*
31	CMS 234 A x 6D-1	24.76	26.22	33.95*	49.33*	-18.93*	-37.88*	60.29*	156.59*	4.44*	30.26*	19.61*	28.93*
32	CMS 234A x RHA 271	3.30	10.71	-30.20*	-14.35*	-0.75	-28.25*	4.52*	67.33*	2.10	34.20*	14.28*	23.18*
33	CMS 234 A x HRHA 4-2	31.43	47.32*	111.62*	94.51*	44.76*	4.65*	-33.73*	7.87*	37.59*	68.54*	27.13*	37.04*
34	CMS 234 A x HRHA 5-3	33.17	20.77	42.07*	49.42*	12.67*	-18.54*	-24.49*	54.53*	26.15*	47.36*	32.99*	43.35*
35	CMS 234 A x RHA 297	46.85*	50.19*	121.16*	107.04*	26.70*	-8.41*	6.05*	69.77*	18.31*	38.19*	3.69*	11.77*
36	CMS 302 A x 6D-1	16.56	17.92	17.07*	48.87*	-9.66*	-26.11*	-14.55*	66.94*	31.94*	64.56*	36.85*	46.99*
37	CMS 302 A x RHA 271	43.76*	54.08*	50.24*	91.05*	11.51*	-8.80*	-21.16*	53.99*	-7.20*	21.97*	27.22*	36.65*
38	CMS 302 A x HRHA 4-2	-12.42	-1.82	-7.60*	17.50*	4.94*	-14.18*	-13.29*	69.38*	-2.03	20.00*	26.94*	36.35*
39	CMS 302 A x HRHA 5-3	-3.33	-6.51	-26.38*	-6.39*	-25.45*	-39.04*	-22.54*	58.53*	0.35	13.26*	47.41*	58.34*
40	CMS 302 A x RHA 297	16.14	18.77	3.08	31.08*	1.81*	-16.74*	-21.23*	53.88*	38.32*	60.60*	36.33*	46.44*
41	CMS 607 A x 6D-1	36.67	54.38*	49.84*	67.04*	34.46*	3.03*	15.17*	80.50*	6.03*	46.12*	-0.47	-6.33*
42	CMS 607 A x RHA 271	-5.79	6.42	-34.69*	-19.85*	18.69*	-17.75*	19.76*	79.34*	-5.74*	29.91*	33.90*	26.00*
43	CMS 607 A x HRHA 4-2	11.10	25.50	43.09*	37.48*	5.41*	-26.95*	34.84*	119.50*	-11.43*	22.06*	37.47*	29.36*
44	CMS 607 A x HRHA 5-3	29.56	46.35*	80.51*	89.85*	40.86*	-2.38*	-11.05*	82.05*	-8.91*	25.54*	29.60*	22.05*
45	CMS 607 A x RHA 297	-20.10	-9.75	11.77*	7.39*	17.18*	-18.80*	60.22*	139.92*	-0.76	36.76*	15.05*	8.27*
46	CMS 852 A x 6D -1	32.05	33.60	-39.48*	-29.79*	2.25*	-18.04*	68.28*	174.81*	-0.79	24.98*	9.41*	16.07*
47	CMS 852 A x RHA 271	-2.25	4.77	4.14*	27.80*	30.06*	4.25*	16.46*	90.19*	-17.56*	8.35*	34.91*	43.12*
48	CMS 852 A x HRHA 4-2	7.53	20.54	49.44*	73.37*	27.81*	2.46*	37.10*	123.91*	-1.01	24.70*	12.61*	19.47*
49	CMS 852A x HRHA 5-3	36.43	28.78	79.38*	108.10*	17.37*	-5.92*	0.13	104.92*	-10.88*	12.26*	32.86*	40.94*
50	CMS 852 A x RHA 297	-1.76	0.47	1.20	17.40*	2.66*	-17.72*	41.46*	131.01*	-3.18*	21.97*	18.67*	25.89*
51	ARG 2A x 6D-1	-11.77	-1.27	-40.57*	-15.74*	-0.94	-19.81*	-14.34*	45.08*	-18.94*	12.36*	54.54*	50.50*
52	ARG 2A x RHA 271	3.74	16.09	-10.89*	26.33*	8.11*	-12.48*	32.95*	125.19*	-4.88*	31.86*	51.50*	47.54*
53	ARG 2A x HRHA 4-2	-7.09	4.15	-43.05*	-19.26*	-4.50*	-22.69*	2.29*	73.26*	-8.41*	26.97*	33.48*	29.99*
54	ARG 2A x HRHA 5-3	7.96	20.80	-36.13*	-9.46*	-0.62	-19.56*	-21.28*	61.12*	-20.89*	9.67*	58.54*	54.40*

Sr. No	Hybrids	VG I		VG II		PALM. (%)		STER. (%)		OLEIC (%)		LINO. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
55	ARG 2A x RHA 297	17.28	31.23	-11.44*	25.54*	12.12*	-9.23*	4.12*	76.36*	-19.28*	11.90*	50.48*	46.55*
56	ARG 3A x 6D -1	16.14	17.50	-48.20*	-8.88*	28.91*	3.28*	9.56*	104.26*	8.85*	36.66*	-11.87*	3.90*
57	ARG 3A x RHA 271	-10.81	-4.40	-15.62*	48.43*	19.72*	-4.08*	-6.38*	74.53*	-10.75*	17.30*	16.16*	36.94*
58	ARG 3A x HRHA 4-2	5.67	18.45	-53.34*	-17.92*	4.55*	-16.23*	14.41*	113.29*	6.37*	33.55*	-2.81*	14.58*
59	ARG 3A x HRHA 5-3	41.30*	28.15	-53.26*	-17.79*	5.63*	-15.37*	-14.02*	75.97*	-4.75*	19.58*	15.47*	36.12*
60	ARG 3A x RHA 297	19.97	22.69	-40.47*	4.72*	23.37*	-1.16*	35.41*	152.44*	-15.74*	5.79*	22.19*	44.05*
61	ARG 6A x 6D-1	1.19	10.25	-43.77*	-8.35*	42.30*	14.07*	-13.30*	76.86*	-15.53*	12.69*	21.64*	36.82*
62	ARG 6A x RHA 271	25.68	36.92	-23.15*	25.25*	54.14*	23.56*	-41.93*	18.49*	-4.75	27.06*	-1.33	10.99*
63	ARG 6A x HRHA 4-2	19.49	33.94	4.00*	69.50*	29.48*	3.79*	-30.08*	42.64*	3.82*	38.50*	-9.29*	2.02*
64	ARG 6A x HRHA 5-3	5.26	14.67	-10.39*	46.06*	41.99*	13.82*	-38.95*	24.92*	-0.87	32.25*	-0.67	11.72*
65	ARG 6 A x RHA 297	-12.81	-5.01	-8.42*	49.27*	-8.06*	-26.30*	-47.12*	7.87*	-15.30*	13.00*	34.13*	50.86*
66	DV 10 x 6D -1	-5.61	9.78	6.20*	38.04*	12.85*	-13.53*	-9.238	42.25*	-6.40*	16.74*	11.28*	40.08*
67	DV 10 x RHA 271	-10.41	4.20	-19.12*	5.12*	59.99*	14.69*	4.00*	34.38*	-12.11*	15.52*	5.72*	33.08*
68	DV 10 x HRHA 4-2	0.73	17.14	13.46*	47.48*	14.59*	-17.86*	-12.22*	42.91*	9.14*	33.69*	-6.21*	18.07*
69	DV 10 x HRHA 5-3	8.52	26.20	18.21*	53.65*	11.42*	-20.13*	-46.15*	10.19*	29.91*	48.91*	-11.17*	11.82*
70	DV -10 x RHA 297	-14.92	-1.06	22.24*	58.88*	17.06*	-16.09*	-29.00*	-8.26*	-2.64	13.05*	23.37*	55.30*
71	CMS 207 A x 6D -1	1.61	2.80	11.14*	36.26*	33.99*	2.67*	-60.94*	24.81*	3.84*	29.51*	16.83*	9.18*
72	CMS 207 A x RHA 271	8.96	16.79	33.10*	63.33*	30.04*	-5.84*	-68.26*	1.43*	10.56*	45.31*	7.80*	0.75
73	CMS 207 A x HRHA 4-2	10.71	24.11	49.96*	83.85*	158.74*	87.34*	-74.08*	-17.17*	-2.49	19.44*	11.73*	4.42*
74	CMS 207 A x HRHA 5-3	39.74	26.73	10.00*	34.87*	6.58*	-22.84*	-55.80*	41.20*	11.86*	33.84*	26.50*	19.13*
75	CMS 207 A x RHA 297	18.29	20.98	20.15*	47.30*	-0.60	-28.03*	-68.66*	0.12	13.96*	36.36*	30.67*	22.12*
	SE	25.00	18.20	1.68	1.52	0.43	0.37	0.49	0.45	1.38	1.33	0.69	0.61
	CDat5%	40.92	37.55	3.36	3.04	0.87	0.74	0.97	0.90	2.76	2.66	1.38	1.22

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II, PALM. - Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

Table 4.40.1. Estimation of heterotic effects of hybrids for morphological characters and seed yield over the environments

Sr. No	Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP*	Check
1	CMS 11 A x 6D-1	16.82*	17.14*	19.54*	11.25*	60.49*	5.86*	-1.76*	1.80*	1.36*	1.15*	39.24*	15.41*	48.71*	5.97*
2	CMS 11 A x RHA 271	27.00*	20.06*	18.42*	10.20*	43.40*	-0.90	-1.19	2.39*	-1.12	0.96*	44.18*	19.51*	42.17*	13.97*
3	CMS 11 A x HRHA 4-2	28.17*	18.36*	21.16*	12.75*	66.97*	3.74*	-1.45	2.12*	1.11*	3.24*	42.42*	18.05*	67.348	19.25*
4	CMS 11 A x HRHA 5-3	33.75*	23.51*	34.03*	24.73*	63.84*	16.01*	4.17*	2.71*	5.21*	2.06*	45.61*	20.69*	76.46*	25.75*
5	CMS 11 A x RHA 297	25.89*	19.27*	18.53*	10.31*	56.74*	7.12*	3.47*	5.71*	0.93	3.05*	38.60*	14.88*	73.37*	23.55*
6	CMS 17-A x 6D-1	26.47*	27.34*	67.13*	28.37*	64.92*	12.25*	-0.36	3.52*	4.03*	3.81*	50.34*	13.70*	77.52*	25.23*
7	CMS 17-A x RHA 271	19.17*	19.99*	59.86*	22.79*	64.61*	13.76*	1.63*	6.78*	-0.75	2.38*	75.69*	34.16*	61.85*	29.74*
8	CMS 17 -A x HRHA 4-2	22.34*	23.18*	32.50*	13.43*	56.08*	6.24*	-1.16	4.71*	-1.56	2.04*	74.85*	24.13*	71.29*	20.83*
9	CMS 17 -A x HRHA 5-3	19.36*	20.17*	75.97*	37.99*	73.92*	23.16*	3.28*	1.84*	4.57*	1.43*	49.60*	15.01*	66.91*	17.74*
10	CMS 17 A x RHA 297	16.15*	16.94*	53.43*	17.85*	74.15*	19.02*	0.46	2.64*	-1.41	2.20*	39.15*	2.61*	72.03*	21.35*
11	CMS 44 A x 6D-1	19.25*	19.58*	49.33*	23.56*	71.89*	13.38*	-1.71*	2.11*	5.21*	2.83*	73.39*	31.12*	94.69*	21.91*
12	CMS 44 A x RHA 271	15.98*	13.26*	33.63*	10.57*	44.85*	0.10	-1.67*	2.59*	4.47*	2.11*	49.75*	14.35*	31.17*	5.15*
13	CMS 44 A x HRHA 4-2	14.72*	12.02*	31.05*	12.18*	55.83*	-6.66*	-0.51	3.80*	5.33*	2.94*	72.06*	22.14*	108.34*	30.45*
14	CMS 44 A x HRHA 5-3	23.15*	20.26*	55.45*	28.63*	66.84*	18.14*	3.35*	1.90*	4.57*	1.43*	61.28*	23.99*	76.85*	20.10*
15	CMS 44 A x RHA 297	23.51*	20.61*	47.92*	22.39*	80.93*	23.66*	1.14	3.33*	4.65*	2.28*	69.95*	25.31*	91.26*	23.81*
16	CMS 148 A x 6D-1	13.01*	13.31*	23.30*	7.58*	62.20*	6.99*	-1.73*	2.10*	3.86*	3.64*	44.16*	16.60*	57.83*	15.50*
17	CMS 148 A x RHA 271	18.92*	13.59*	36.68*	19.26*	65.52*	14.39*	-2.67*	2.26*	-0.43	2.71*	47.10*	18.98*	46.99*	17.83*
18	CMS 148 A x HRHA 4-2	26.78*	21.10*	50.10*	30.97*	106.55*	16.14*	-6.11*	0.55	-0.59	4.30*	53.63*	24.26*	70.57*	24.82*
19	CMS 148 A x HRHA 5-3	18.37*	13.07*	32.08*	15.25*	63.66*	15.89*	7.60*	6.09*	6.20*	3.02*	58.86*	28.48*	81.39*	32.74*
20	CMS 148 A x RHA 297	22.61*	17.11*	36.70*	19.28*	68.65*	15.26*	0.77	2.96*	-2.88*	0.97	52.98*	23.73*	79.26*	31.19*
21	CMSH 91 A x 6D-1	20.69*	21.02*	30.44*	26.94*	66.15*	14.64*	-0.59	3.28*	3.54*	3.33*	42.00*	19.11*	63.64*	31.89*
22	CMSH 91 A x RHA 271	25.16*	18.32*	20.29*	17.07*	70.41*	17.77*	-1.16	3.85*	4.78*	5.90*	41.06*	18.32*	45.85*	17.56*
23	CMSH 91 A x HRHA 4-2	43.27*	21.62*	28.57*	25.12*	73.60*	19.77*	-2.30*	4.23*	2.32*	3.41*	46.25*	22.68*	42.71*	15.02*
24	CMSH 91 A x HRHA 5-3	40.72*	21.07*	19.76*	16.55*	60.12*	13.38*	6.63*	5.13*	7.57*	4.34*	44.21*	20.96*	63.07*	31.43*
25	CMSH 91 A x RHA 297	16.64*	10.52*	23.90*	20.58*	65.97*	14.51*	0.59	2.77*	1.24*	2.32*	43.26*	20.16*	56.62*	26.23*
26	CMS 103 A x 6D-1	17.56*	17.88*	42.22*	15.12*	75.12*	15.51*	5.83*	8.56*	4.52*	4.30*	72.87*	30.73*	96.47*	22.52*
27	CMS 103 A x RHA 271	24.87*	18.04*	37.40*	11.22*	56.09*	7.87*	4.44*	7.14*	-2.08*	1.01	50.10*	14.62*	47.89*	18.55*

Sr. No	Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
28	CMS 103 A x HRHA 4-2	39.53*	20.13*	38.88*	18.89*	73.15*	8.12*	3.35*	6.01*	-2.71*	2.08*	67.72*	22.28*	91.52*	19.43*
29	CMS 103 A x HRHA 5-3	42.07*	22.32*	34.83*	9.14*	45.26*	2.86*	10.71*	9.16*	5.98*	2.80*	67.98*	29.14*	77.43*	20.50*
30	CMS 103 A x RHA 297	23.36*	16.88*	21.19*	-1.90*	41.70*	-3.15*	1.54*	3.74*	1.48*	5.50*	68.70*	24.39*	74.61*	13.03*
31	CMS 234 A x 6D-1	23.48*	23.81*	41.95*	19.41*	60.30*	5.74*	0.24	1.55*	5.33*	4.07*	51.39*	14.48*	100.28*	21.63*
32	CMS 234A x RHA 271	27.11*	20.16*	34.85*	13.43*	76.21*	21.77*	4.01*	5.37*	5.63*	4.36*	49.40*	14.09*	42.76*	14.44*
33	CMS 234 A x HRHA 4-2	14.33*	4.95*	24.16*	6.29*	75.06*	7.62*	2.90*	4.25*	6.89*	5.61*	64.25*	16.60*	83.90*	11.68*
34	CMS 234 A x HRHA 5-3	27.78*	17.29*	29.05*	8.55*	53.57*	8.75*	4.33*	2.86*	9.01*	5.74*	58.88*	22.14*	61.63*	9.77*
35	CMS 234 A x RHA 297	24.11*	17.59*	36.39*	14.73*	54.90*	5.87*	-0.88	0.42	5.66*	4.39*	47.21*	8.54*	82.89*	18.39*
36	CMS 302 A x 6D-1	13.79*	14.10*	49.74*	13.30*	50.75*	12.13*	-4.56*	-1.45*	4.59*	4.38*	39.69*	5.64*	93.51*	16.33*
37	CMS 302 A x RHA 271	27.73*	24.84*	55.58*	17.72*	50.41*	11.88*	-2.63*	0.54	-0.56	2.30*	58.57*	21.09*	52.75*	22.45*
38	CMS 302 A x HRHA 4-2	18.98*	16.29*	42.52*	22.01*	54.79*	15.14*	-1.21	2.00*	-0.20	2.67*	53.50*	13.69*	111.18*	16.33*
39	CMS 302 A x HRHA 5-3	28.09*	25.19*	53.27*	20.19*	53.11*	13.88*	8.29*	6.77*	10.82*	7.50*	45.14*	11.58*	66.77*	13.26*
40	CMS 302 A x RHA 297	29.04*	26.12*	53.00*	15.77*	51.93*	13.01*	3.53*	5.77*	0.46	3.34*	54.22*	14.23*	85.01*	19.76*
41	CMS 607 A x 6D-1	17.73*	18.19*	36.48*	17.72*	68.48*	18.27*	9.02*	9.45*	7.31*	5.06*	46.21*	17.79*	50.28*	21.68*
42	CMS 607 A x RHA 271	26.11*	26.60*	46.42*	26.29*	62.41*	14.01*	3.14*	3.55*	4.09*	1.90*	47.03*	18.45*	46.66*	18.75*
43	CMS 607 A x HRHA 4-2	20.21*	20.68*	36.63*	17.85*	48.85*	4.49*	0.80	1.20	6.95*	4.71*	54.56*	24.52*	46.98*	19.01*
44	CMS 607 A x HRHA 5-3	32.36*	32.88*	30.75*	12.78*	50.39*	6.49*	4.69*	3.22*	9.46*	6.17*	25.06*	0.75	36.89*	10.84*
45	CMS 607 A x RHA 297	13.81*	14.26*	19.53*	3.10*	48.85*	4.49*	2.54*	2.95*	5.81*	3.60*	50.79*	21.49*	42.03*	15.00*
46	CMS 852 A x 6D -1	13.26*	17.48*	55.02*	10.44*	45.30*	-4.15*	1.30	1.59*	6.93*	6.70*	29.86*	15.54*	58.40*	16.66*
47	CMS 852 A x RHA 271	12.69*	16.88*	61.03*	17.85*	57.90*	9.12*	-1.21	-0.93	-0.98	2.15*	37.87*	22.67*	51.13*	21.15*
48	CMS 852 A x HRHA 4-2	17.25*	21.61*	27.34*	9.01*	73.09*	13.14*	-0.69	-0.41	1.37*	6.36*	43.51*	27.69*	52.73*	12.48*
49	CMS 852A x HRHA 5-3	10.94*	15.07*	23.71*	-2.99*	48.27*	4.99*	5.42*	3.94*	8.78*	5.52*	25.11*	11.32*	52.36*	12.20*
50	CMS 852 A x RHA 297	13.95*	18.19*	59.95*	13.95*	50.87*	3.11*	4.82*	5.11*	-1.52*	2.37*	17.10*	4.19*	51.12*	11.30*
51	ARG 2A x 6D-1	17.84*	18.16*	43.40*	18.63*	69.23*	11.63*	-2.81*	0.97	5.11*	4.89*	20.25*	15.68*	35.20*	16.17*
52	ARG 2A x RHA 271	28.65*	21.61*	47.13*	21.72*	61.71*	11.75*	1.72*	5.83*	-0.16	2.98*	28.89*	23.99*	33.80*	14.97*
53	ARG 2A x HRHA 4-2	37.97*	17.13*	31.90*	12.91*	63.09*	6.74*	3.00*	7.17*	0.66	4.92*	24.23*	19.51*	38.86*	19.32*
54	ARG 2A x HRHA 5-3	36.04*	17.04*	30.20*	7.71*	49.15*	5.62*	5.89*	4.40*	5.18*	2.03*	35.07*	29.94*	38.38*	18.90*

Sr. No	Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
55	ARG 2A x RHA 297	24.83*	18.27*	24.55*	3.04*	47.57*	0.85*	2.85*	5.08*	0.35	4.32*	16.82*	12.38*	46.63*	25.99*
56	ARG 3A x 6D -1	12.30*	12.60*	35.65*	12.52*	60.96*	8.37*	2.15*	6.12*	4.56*	4.34*	50.03*	18.45*	59.71*	22.02*
57	ARG 3A x RHA 271	18.75*	12.26*	38.47*	14.86*	51.56*	4.74*	2.74*	7.95*	0.96	4.15*	62.74*	28.49*	42.31*	14.08*
58	ARG 3A x HRHA 4-2	33.74*	13.53*	25.98*	7.84*	48.68*	0.11	0.32	7.20*	-0.61	4.28*	35.31*	6.83*	46.39*	11.85*
59	ARG 3A x HRHA 5-3	29.90*	11.76*	39.41*	15.64*	50.04*	6.24*	9.68*	8.14*	6.18*	3.00*	38.48*	9.34*	53.34*	17.15*
60	ARG 3A x RHA 297	23.85*	17.35*	30.48*	8.23*	54.54*	5.62*	4.02*	6.28*	-0.53	3.40*	57.05*	23.99*	57.85*	20.60*
61	ARG 6A x 6D-1	11.89*	12.20*	71.60*	16.81*	36.86*	5.36*	-0.33	2.37*	3.27*	3.05*	71.47*	29.67*	70.82*	25.35*
62	ARG 6A x RHA 271	17.21*	13.23*	64.05*	20.06*	36.53*	5.12*	5.39*	8.25*	1.16*	4.35*	55.97*	19.11*	44.95*	16.20*
63	ARG 6A x HRHA 4-2	20.01*	15.92*	26.13*	7.97*	42.55*	9.75*	4.32*	7.15*	0.19	5.12*	68.90*	19.90*	54.20*	13.15*
64	ARG 6A x HRHA 5-3	19.51*	15.45*	39.52*	9.40*	37.35*	5.74*	9.46*	7.93*	7.86*	4.62*	37.58*	5.77*	54.33*	13.25*
65	ARG 6 A x RHA 297	16.31*	12.36*	67.76*	9.79*	45.16*	11.76*	4.51*	6.77*	1.22*	5.22*	57.95*	16.47*	70.80*	25.33*
66	DV 10 x 6D -1	20.72*	21.04*	41.79*	15.64*	73.03*	14.14*	3.33*	4.46*	5.97*	5.75*	57.85*	19.38*	52.90*	12.14*
67	DV 10 x RHA 271	25.68*	18.81*	35.10*	10.18*	51.92*	4.98*	5.14*	6.30*	2.07*	5.29*	62.89*	24.39*	42.01*	13.84*
68	DV 10 x HRHA 4-2	37.88*	20.25*	24.76*	6.80*	58.26*	3.36*	9.10*	10.30*	-0.45	4.45*	37.46*	-2.42*	46.56*	7.49*
69	DV 10 x HRHA 5-3	32.41*	15.48*	25.70*	2.52*	41.90*	0.48	6.95*	5.45*	8.16*	4.92*	32.94*	2.21*	55.45*	14.01*
70	DV -10 x RHA 297	15.25*	9.20*	32.23*	7.84*	46.65*	0.23	5.16*	6.31*	1.84*	5.87*	53.30*	13.03*	57.05*	15.18*
71	CMS 207 A x 6D -1	15.83*	16.14*	50.48*	6.93*	49.53*	1.48*	3.87*	7.92*	6.05*	5.83*	40.56*	6.30*	67.16*	18.45*
72	CMS 207 A x RHA 271	17.04*	13.60*	54.28*	12.91*	52.47*	5.36*	2.12*	7.30*	2.53*	5.76*	55.11*	18.45*	44.88*	16.14*
73	CMS 207 A x HRHA 4-2	21.84*	18.26*	39.33*	19.28*	67.81*	13.88*	-0.10	7.32*	1.64*	4.86*	58.30*	13.30*	61.88*	14.71*
74	CMS 207 A x HRHA 5-3	19.25*	15.75*	60.56*	25.90*	55.70*	10.25*	9.92*	8.38*	6.89*	3.68*	50.29*	15.54*	95.53*	38.55*
75	CMS 207 A x RHA 297	17.92*	14.46*	82.56*	29.72*	72.87*	18.14*	3.81*	6.06*	0.34	3.52*	63.86*	20.83*	82.52*	29.33*
	SE	1.77	1.55	0.57	0.48	0.29	0.27	0.76	0.66	0.53	0.48	0.35	0.32	0.94	0.74
	CDat5%	3.54	3.10	1.14	0.96	0.58	0.54	1.52	1.32	1.06	0.96	0.70	0.64	1.88	1.48

Table 4.40.2 Effects of heterosis for oil content and viability over the environments

Sr. No	Hybrids	OC (%)		HC (%)		% SF		GERM. (%)		EC ($\mu\text{Scm}^1\text{g}^1$)		VIAB. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
1	CMS 11 A x 6D-1	0.74	0.49	20.46*	3.35*	45.30*	46.07*	5.32*	33.51*	-45.66*	-49.09*	10.11*	48.15*
2	CMS 11 A x RHA 271	5.07*	3.56*	22.38*	12.65*	48.32*	49.11*	-0.26	33.63*	-52.04*	-55.05*	5.72*	53.55*
3	CMS 11 A x HRHA 4-2	-10.07*	2.94*	19.33*	7.08*	50.83*	51.63*	1.34	26.00*	-20.90*	-25.88*	0.51	35.23*
4	CMS 11 A x HRHA 5-3	7.09*	1.15*	7.40*	-0.23	43.52*	44.29*	12.55*	38.75*	-53.19*	-56.14*	13.66*	52.92*
5	CMS 11 A x RHA 297	-1.78*	3.62*	36.28*	16.92*	54.90*	55.72*	10.56*	36.29*	-65.38*	-48.12*	8.79*	46.38*
6	CMS 17-A x 6D-1	5.55*	5.28*	14.04*	18.43*	19.88*	49.00*	9.90*	39.32*	-49.67*	-54.67*	16.28*	54.38*
7	CMS 17-A x RHA 271	1.67*	1.39*	-2.82	0.93	12.29*	39.56*	-23.35*	2.70	24.78*	12.43*	-23.73*	10.77*
8	CMS 17 -A x HRHA 4-2	-9.74*	3.31*	-1.37	2.42	1.63	26.31*	0.97	25.54*	-14.89*	-23.33*	4.25*	36.46*
9	CMS 17 -A x HRHA 5-3	2.29*	2.01*	0.92	4.80*	22.26*	51.96*	7.89*	33.60*	-41.41*	-47.18*	11.44*	43.70*
10	CMS 17 A x RHA 297	-4.23*	1.04	4.78*	8.82*	18.28*	47.01*	8.52*	34.38*	-67.80*	-51.73*	15.84*	48.58*
11	CMS 44 A x 6D-1	-0.98	1.53*	57.64*	14.55*	110.07*	51.62*	9.86*	39.27*	-46.99*	-54.26*	13.65*	51.42*
12	CMS 44 A x RHA 271	1.48*	4.04*	15.67*	6.47*	67.27*	53.44*	1.92	36.55*	-39.39*	-47.71*	3.90*	50.90*
13	CMS 44 A x HRHA 4-2	-11.17*	1.68*	13.45*	1.81	58.27*	53.56*	9.92*	37.80*	-28.26*	-38.10*	13.59*	51.34*
14	CMS 44 A x HRHA 5-3	0.27	2.81*	3.02	-4.30*	41.93*	36.70*	6.02*	32.91*	-42.11*	-50.03*	10.37*	47.05*
15	CMS 44 A x RHA 297	-3.22*	2.10*	30.86*	5.89*	93.57*	58.32*	-4.01*	20.33*	-46.70*	-20.09*	1.38	35.07*
16	CMS 148 A x 6D-1	-7.09*	2.06*	-7.03*	1.18	28.77*	42.07*	3.21	38.94*	-46.65*	-48.59*	9.96*	55.65*
17	CMS 148 A x RHA 271	-7.35*	1.77*	-3.57*	4.95*	33.92*	47.76*	-9.16*	22.29*	-55.08*	-56.70*	-7.18*	34.81*
18	CMS 148 A x HRHA 4-2	-11.61*	1.17*	15.84*	26.07*	37.93*	52.18*	3.92*	39.90*	-50.30*	-52.12*	6.86*	51.26*
19	CMS 148 A x HRHA 5-3	-7.81*	1.26*	-10.87*	-2.99	33.84*	47.66*	-6.57*	25.77*	-30.49*	-33.02*	-1.16	39.90*
20	CMS 148 A x RHA 297	-6.63*	2.56*	-4.83*	3.58*	17.08*	29.17*	-26.03*	-0.42	-36.64*	-4.99*	-21.92*	10.52*
21	CMSH 91 A x 6D-1	4.32*	4.82*	20.67*	0.89	27.19*	34.30*	5.68*	34.91*	-22.21*	-40.01*	8.70*	44.31*
22	CMSH 91 A x RHA 271	2.76*	3.25*	21.73*	12.04*	36.79*	44.43*	-7.63*	23.75*	-22.84*	-40.45*	-8.11*	33.45*
23	CMSH 91 A x HRHA 4-2	-10.86*	2.03*	33.71*	19.99*	38.95*	46.71*	3.37	31.96*	-11.80*	-31.93*	13.19*	48.17*
24	CMSH 91 A x HRHA 5-3	0.82	1.30*	22.21*	13.53*	46.06*	54.22*	4.74*	33.71*	-35.41*	-50.18*	8.47*	40.96*
25	CMSH 91 A x RHA 297	-5.63*	-0.44	34.03*	12.07*	38.27*	46.00*	-3.71*	22.92*	-42.00*	-13.04*	3.44*	34.42*
26	CMS 103 A x 6D-1	-5.33*	-0.09	48.97*	16.38*	37.30*	41.92*	2.33	33.11*	-18.78*	-36.02*	8.71*	52.01*
27	CMS 103 A x RHA 271	-1.37*	4.09*	33.18*	22.58*	43.49*	48.32*	3.54	38.71*	-9.83*	-29.00*	5.12*	52.67*

Sr. No	Hybrids	OC (%)		HC (%)		% SF		GERM. (%)		EC ($\mu\text{Scm}^1\text{g}^1$)		VIAB. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
28	CMS 103 A x HRHA 4-2	-10.86*	2.03*	31.90*	18.36*	46.56*	51.49*	3.54	34.68*	-21.14*	-37.90*	5.63*	47.72*
29	CMS 103 A x HRHA 5-3	-4.07*	1.24*	18.18*	9.79*	29.09*	33.43*	-27.09*	-5.16*	55.10*	22.12*	-24.90*	5.01*
30	CMS 103 A x RHA 297	-3.75*	1.57*	32.13*	6.92*	20.20*	24.25*	-1.90	27.60*	-52.12*	-28.23*	0.91	41.11*
31	CMS 234 A x 6D-1	1.93*	1.68*	53.42*	21.21*	29.52*	34.89*	-17.68*	4.35*	2.59*	27.91*	-15.52*	12.16*
32	CMS 234A x RHA 271	1.09	0.22	31.80*	21.31*	27.11*	32.38*	-0.55	33.24*	-49.33*	-36.81*	0.00	45.23*
33	CMS 234 A x HRHA 4-2	-11.73*	1.04	37.54*	23.42*	48.45*	54.61*	9.51*	36.16*	-47.29*	-34.31*	12.78*	47.63*
34	CMS 234 A x HRHA 5-3	1.62*	0.75	28.39*	19.27*	48.35*	54.50*	8.69*	33.75*	-42.89*	-28.79*	15.30*	48.69*
35	CMS 234 A x RHA 297	-4.10*	1.17*	41.63*	14.61*	40.85*	46.69*	65.21*	33.44*	-65.51*	-48.27*	83.65*	46.75*
36	CMS 302 A x 6D-1	-5.11*	1.86*	67.64*	21.81*	89.21*	54.45*	0.20	33.27*	-40.95*	-50.18*	6.76*	48.00*
37	CMS 302 A x RHA 271	-3.24*	3.87*	39.09*	28.02*	54.18*	41.42*	-5.53*	26.57*	-3.60*	-18.63*	-5.88*	36.69*
38	CMS 302 A x HRHA 4-2	-9.61*	3.47*	43.79*	29.04*	33.22*	29.25*	-28.80*	-5.30*	10.90*	-6.35*	-21.60*	8.68*
39	CMS 302 A x HRHA 5-3	-4.37*	2.65*	31.03*	21.72*	34.04*	29.11*	-0.63	32.17*	-27.84*	-39.10*	4.36*	44.67*
40	CMS 302 A x RHA 297	-4.02*	3.03*	59.46*	29.04*	90.95*	56.17*	1.61	35.15*	-54.21*	-31.35*	6.84*	48.11*
41	CMS 607 A x 6D-1	-7.38*	1.39*	28.98*	19.94*	72.118	38.86*	-17.49*	4.59*	7.21*	23.77*	-15.00*	12.84*
42	CMS 607 A x RHA 271	-5.52*	3.43*	34.81*	25.36*	44.14*	32.22*	0.78	35.01*	-46.65*	-38.43*	2.51*	48.88*
43	CMS 607 A x HRHA 4-2	-10.73*	2.19*	28.13*	19.14*	59.21*	54.48*	12.33*	39.66*	-52.76*	-45.45*	17.68*	54.04*
44	CMS 607 A x HRHA 5-3	-6.77*	2.06*	32.89*	23.57*	38.40*	33.30*	-5.10*	16.79*	-30.11*	-19.30*	-0.45	28.38*
45	CMS 607 A x RHA 297	-6.95*	1.86*	21.36*	12.86*	50.93*	23.45*	-11.31*	-3.25*	-34.16*	-1.32*	-0.79	5.93*
46	CMS 852 A x 6D -1	0.81	1.24*	44.46*	11.18*	78.56*	29.46*	10.79*	40.45*	-50.22*	-34.99*	14.25*	51.68*
47	CMS 852 A x RHA 271	0.39	0.82	26.08*	16.06*	69.66*	55.63*	0.43	34.55*	-50.00*	-34.67*	1.86	47.93*
48	CMS 852 A x HRHA 4-2	-11.44*	1.37*	37.44*	23.34*	55.55*	50.92*	7.78*	34.01*	-49.25*	-33.73*	10.36*	44.47*
49	CMS 852A x HRHA 5-3	1.67*	2.10*	35.77*	26.12*	52.61*	46.99*	4.46*	28.54*	-31.71*	-10.78*	9.65*	41.40*
50	CMS 852 A x RHA 297	-0.98	4.46*	51.50*	22.59*	71.85*	40.55*	20.36*	27.17*	-40.82*	-11.28*	21.05*	34.43*
51	ARG 2A x 6D-1	-8.97*	-0.09	36.79*	25.94*	77.84*	60.55*	9.69*	39.05*	-37.37*	-42.22*	16.17*	54.23*
52	ARG 2A x RHA 271	-6.27*	2.87*	37.14*	26.26*	45.00*	33.01*	-22.51*	3.82*	18.26*	9.08*	-21.27*	14.34*
53	ARG 2A x HRHA 4-2	-9.34*	3.78*	36.08*	25.28*	31.82*	27.89*	2.98	28.04*	-4.35*	-11.75*	7.78*	41.09*
54	ARG 2A x HRHA 5-3	-5.99*	3.18*	35.49*	25.87*	53.75*	48.08*	2.77	26.46*	-36.94*	-41.83*	8.82*	40.33*

Sr. No	Hybrids	OC (%)		HC (%)		% SF		GERM. (%)		EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)		VIAB. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
55	ARG 2A x RHA 297	-4.72*	4.58*	34.00*	23.37*	59.61*	44.10*	14.98*	33.86*	-60.09*	-40.19*	19.71*	41.08*
56	ARG 3A x 6D -1	0.68	2.32*	44.04*	7.57*	107.40*	56.08*	6.87*	35.47*	-23.55*	-32.90*	10.19*	46.28*
57	ARG 3A x RHA 271	1.55*	3.20*	26.80*	16.72*	60.55*	47.27*	-9.10*	21.79*	6.25*	-6.79*	-9.41*	31.56*
58	ARG 3A x HRHA 4-2	-10.24*	2.74*	24.88*	12.06*	51.43*	46.92*	1.71	28.02*	-45.65*	-52.35*	3.68*	36.84*
59	ARG 3A x HRHA 5-3	0.61	2.25*	26.48*	17.49*	62.23*	56.26*	7.36*	35.13*	-42.19*	-49.29*	9.91*	45.07*
60	ARG 3A x RHA 297	-5.03*	0.20	37.82*	11.53*	93.92*	58.61*	4.57*	31.63*	-64.40*	-46.65*	6.57*	40.66*
61	ARG 6A x 6D-1	-3.58*	3.14*	75.08*	27.21*	102.81*	46.38*	-9.28*	22.41*	-41.47*	-43.18*	-10.39*	29.28*
62	ARG 6A x RHA 271	-5.44*	1.15*	38.73*	27.69*	64.56*	50.95*	2.02	37.65*	-41.98*	-43.71*	-1.15	43.57*
63	ARG 6A x HRHA 4-2	-8.27*	4.99*	32.44*	18.85*	47.80*	43.40*	-5.02*	28.16*	-40.26*	-42.01*	-4.42*	37.90*
64	ARG 6A x HRHA 5-3	-2.80*	3.98*	20.75*	12.17*	60.44*	54.53*	2.83	38.75*	-34.81*	-36.72*	4.32*	50.51*
65	ARG 6 A x RHA 297	-5.01*	1.61*	53.70*	24.38*	97.69*	61.69*	3.10*	39.12*	-61.53*	-42.30*	3.60*	49.47*
66	DV 10 x 6D -1	2.74*	3.828*	39.80*	28.41*	31.10*	33.58*	-5.41*	23.91*	-34.23*	-40.39*	-5.84*	31.53*
67	DV 10 x RHA 271	1.43*	2.50*	35.67*	24.88*	45.92*	48.68*	-4.38*	28.10*	-42.66*	-48.00*	-5.01*	37.96*
68	DV 10 x HRHA 4-2	-10.61*	2.32*	45.36*	33.52*	37.14*	39.73*	-2.19	28.12*	-47.62*	-52.50*	-0.87	38.48*
69	DV 10 x HRHA 5-3	0.78	1.83*	38.06*	28.26*	48.17*	50.98*	-6.20*	22.87*	-21.81*	-29.11*	-5.62*	31.84*
70	DV -10 x RHA 297	-1.38*	4.04*	31.35*	20.65*	48.71*	51.52*	-10.41*	17.35*	-24.43*	13.28*	-8.64*	27.62*
71	CMS 207 A x 6D -1	6.90*	6.63*	8.58*	-6.23*	35.40*	41.46*	4.53*	32.51*	-36.45*	-34.78*	4.88*	39.24*
72	CMS 207 A x RHA 271	5.27*	3.76*	27.37*	17.24*	48.72*	55.37*	-9.84*	20.79*	-19.37*	-17.24*	-8.02*	33.59*
73	CMS 207 A x HRHA 4-2	-9.70	3.36*	30.28*	16.90*	43.31*	49.72*	1.23	25.86*	-31.01*	-29.23*	4.86*	37.26*
74	CMS 207 A x HRHA 5-3	8.67*	4.02*	33.37*	23.90*	50.61*	57.34*	12.16*	38.02*	-33.30*	-31.58*	14.71*	47.93*
75	CMS 207 A x RHA 297	0.97	6.52*	35.92*	17.39*	52.15*	58.96*	14.46*	36.22*	-41.61*	-12.46*	24.20*	52.61*
	SE	0.65	0.56	1.74	1.66	1.37	1.28	1.50	1.45	0.03	0.03	1.14	1.05
	CDat5%	1.31	1.12	3.48	3.32	2.74	2.56	3.00	2.90	0.06	0.06	2.28	2.10

Table 4.40.3. Estimation of heterosis effects for seedling vigour and linoleic acid over the environments

Sr. No	Hybrids	VG I		VG II		PALM.(%)		STER. (%)		OLEIC (%)		LINO. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
1	CMS 11 A x 6D-1	31.17	30.39*	68.57*	5.90*	-9.26*	-9.71*	2.00*	19.23*	5.05*	46.22*	10.08*	39.29*
2	CMS 11 A x RHA 271	22.02	28.80	69.20*	6.29*	8.77*	0.07	-19.97*	-6.45*	-11.48*	31.86*	15.02*	45.54*
3	CMS 11 A x HRHA 4-2	16.71	22.87	44.82*	-9.02*	2.77*	-2.55*	16.87*	42.63*	-14.88*	16.96*	21.20*	53.36*
4	CMS 11 A x HRHA 5-3	42.67*	39.99*	51.70*	-4.70*	2.00*	-6.17*	-22.14*	26.53*	1.69*	34.81*	9.90*	39.06*
5	CMS 11 A x RHA 297	41.71*	38.78*	57.24*	-1.22	-7.07*	-12.06*	-0.41*	16.42*	-11.56*	27.25*	16.18*	47.01*
6	CMS 17-A x 6D-1	25.90	30.71*	55.30*	-2.91	-9.79*	-10.24*	-1.53*	36.17*	8.30*	50.75*	17.83*	28.08*
7	CMS 17-A x RHA 271	5.04	12.88	39.51*	-12.79*	7.32*	-6.43*	-23.42*	5.90*	-4.78*	41.85*	29.01*	40.23*
8	CMS 17 -A x HRHA 4-2	10.60	13.31	54.33*	-3.52*	2.64*	-2.68*	2.80*	42.16*	5.14*	44.47*	8.76*	18.22*
9	CMS 17 -A x HRHA 5-3	13.30	19.29	58.47*	-0.93	13.50*	-1.71*	-32.16*	10.25*	-4.26*	26.91*	42.13*	57.83*
10	CMS 17 A x RHA 297	22.88	27.41	81.61*	13.53*	-5.14*	-10.24*	1.28*	40.06*	-15.58*	21.47*	43.97*	56.49*
11	CMS 44 A x 6D-1	38.24	27.38	84.88*	10.57*	-3.59*	-4.08*	25.52*	38.98*	6.94*	48.86*	-3.78*	23.11*
12	CMS 44 A x RHA 271	8.55	16.72	66.79*	1.40	2.47*	-10.66*	20.30*	26.92*	-16.90*	23.79*	19.52*	52.91*
13	CMS 44 A x HRHA 4-2	20.63	26.99	55.17*	-7.20*	0.01	-5.17*	-1.10*	20.70*	-2.34*	34.18*	1.25	29.54*
14	CMS 44 A x HRHA 5-3	39.87	29.14	46.07*	-12.65*	6.63*	-7.66*	-21.49*	27.59*	-7.26*	27.43*	21.28*	55.17*
15	CMS 44 A x RHA 297	26.32	13.82	36.21*	-18.54*	-7.47*	-12.45*	15.16*	23.19*	-3.30*	39.14*	15.12*	47.29*
16	CMS 148 A x 6D-1	17.27	23.93	87.27*	29.05*	-6.09*	-6.56*	-12.30*	16.11*	0.27	40.60*	13.10*	40.23*
17	CMS 148 A x RHA 271	-0.65	4.87	42.70*	-1.66	-0.03	-5.29*	-17.20*	9.62*	-4.11*	42.84*	-8.93*	12.90*
18	CMS 148 A x HRHA 4-2	11.89	20.60	42.16*	-2.04	-2.59*	-7.64*	-20.11*	5.76*	-23.11*	7.81*	18.21*	46.56*
19	CMS 148 A x HRHA 5-3	5.81	11.34	31.22*	-9.57*	4.80*	-0.71*	-12.34*	42.47*	-12.57*	22.59*	15.13*	42.74*
20	CMS 148 A x RHA 297	-10.81	-5.25	-3.44	-33.46*	-1.17*	-6.37*	-6.80*	23.38*	-2.80*	39.86*	12.79*	39.84*
21	CMSH 91 A x 6D-1	28.71	21.50	7.49	-25.14*	1.97*	4.34*	45.19*	60.76*	-0.56	38.42*	11.19*	44.06*
22	CMSH 91 A x RHA 271	2.11	10.57	25.26*	-12.76*	-3.87*	-1.63*	26.16*	32.72*	-14.45*	27.43*	18.07*	52.98*
23	CMSH 91 A x HRHA 4-2	9.85	14.21	46.89*	2.30	-1.53*	0.75*	16.89*	42.65*	18.11*	62.28*	-24.21*	-1.81*
24	CMSH 91 A x HRHA 5-3	34.33	26.01	76.30*	22.78*	8.65*	11.17*	-20.77*	28.75*	6.24*	40.83*	22.94*	59.28*
25	CMSH 91 A x RHA 297	11.00	9.45	67.55*	16.69*	-1.47*	0.82*	8.64*	16.22*	-6.29*	34.84*	8.93*	41.13*
26	CMS 103 A x 6D-1	40.98*	29.31	66.85*	34.06*	5.21*	4.68*	30.27*	44.24*	-5.08*	32.13*	16.57*	45.44*
27	CMS 103 A x RHA 271	20.56	29.46	63.16*	31.09*	8.03*	2.54*	19.60*	29.06*	-13.44*	28.95*	14.76*	43.17*

Sr. No	Hybrids	VG I		VG II		PALM.(%)		STER. (%)		OLEIC (%)		LINO. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
28	CMS 103 A x HRHA 4-2	15.91	19.14	42.67*	14.63*	10.07*	4.48*	18.43*	44.53*	-10.28*	23.27*	12.47*	40.32*
29	CMS 103 A x HRHA 5-3	22.67	15.11	32.36*	6.35*	16.77*	10.84*	-17.65*	33.82*	-6.08*	24.50*	9.08*	36.09*
30	CMS 103 A x RHA 297	19.81	12.24	17.31*	-5.74*	22.80*	16.56*	49.34*	61.15*	-1.08	42.34*	-15.90*	4.92*
31	CMS 234 A x 6D-1	19.38	8.22	68.33*	-7.33*	-2.81*	-1.62*	45.45*	61.08*	-6.88*	29.62*	8.99*	15.95*
32	CMS 234A x RHA 271	9.87	19.38	79.96*	9.41*	9.65*	10.99*	11.46*	23.43*	-8.55*	36.22*	23.35*	31.22*
33	CMS 234 A x HRHA 4-2	22.43	25.95	149.07*	10.72*	13.86*	15.25*	14.10*	39.25*	23.11*	69.16*	20.51*	28.21*
34	CMS 234 A x HRHA 5-3	21.05	12.86	83.36*	-4.08*	15.15*	16.56*	-32.04*	10.44*	14.60*	51.91*	26.07*	40.00*
35	CMS 234 A x RHA 297	33.31	22.39	141.29*	6.60*	11.24*	12.60*	66.35*	84.23*	10.72*	59.32*	32.04*	43.29*
36	CMS 302 A x 6D-1	24.59	18.72	36.42*	-9.53*	-4.25*	10.89*	10.22*	63.94*	7.61*	49.79*	42.47*	54.86*
37	CMS 302 A x RHA 271	26.36	38.68*	34.50*	-10.80*	5.45*	22.13*	20.80*	79.67*	-0.57	48.11*	14.77*	24.75*
38	CMS 302 A x HRHA 4-2	19.94	21.70	17.28*	-22.22*	-3.66*	11.58*	-12.15*	30.66*	1.43	39.37*	22.14*	32.77*
39	CMS 302 A x HRHA 5-3	28.02	21.80	32.04*	-12.43*	-14.64*	-1.14*	-24.49*	22.71*	-8.29*	23.48*	28.78*	43.01*
40	CMS 302 A x RHA 297	45.84*	32.85*	36.40*	-9.53*	-2.05*	13.44*	-37.64*	-7.26*	4.87*	50.90*	36.37*	48.23*
41	CMS 607 A x 6D-1	19.28	27.15	34.70*	-25.84*	19.09*	18.50*	51.05*	74.51*	-8.13*	31.40*	17.50*	36.40*
42	CMS 607 A x RHA 271	9.08	16.37	37.62*	-16.33*	18.81*	13.39*	14.32*	32.07*	-20.10*	19.01*	22.62*	42.34*
43	CMS 607 A x HRHA 4-2	12.24	16.70	79.30*	-20.30*	31.03*	25.06*	33.53*	62.96*	4.82*	49.91*	-1.69*	14.13*
44	CMS 607 A x HRHA 5-3	8.23	16.45	53.21*	-19.84*	14.29*	9.08*	-29.36*	14.80*	0.01	43.04*	10.48*	28.25*
45	CMS 607 A x RHA 297	4.95	9.70	92.45*	-23.07*	19.26*	13.82*	37.87*	59.29*	8.87*	56.65*	-11.54*	2.69*
46	CMS 852 A x 6D -1	25.01	23.53	64.72*	-9.32*	5.70*	8.36*	37.73*	65.82*	-15.79*	17.22*	6.54*	24.96*
47	CMS 852 A x RHA 271	5.32	12.81	59.90*	-2.78	25.84*	29.00*	7.26*	29.15*	-5.99*	40.04*	20.26*	41.06*
48	CMS 852 A x HRHA 4-2	14.11	18.39	122.91*	15.04*	6.19*	8.86*	-3.51*	17.76*	-3.58*	33.73*	17.80*	38.17*
49	CMS 852A x HRHA 5-3	18.75	14.82	99.14*	4.18*	8.37*	11.09*	-8.78*	48.25*	10.28*	52.96*	16.96*	37.18*
50	CMS 852 A x RHA 297	16.77	15.85	87.45*	-3.26*	1.22*	3.76*	29.13*	55.48*	-4.71*	37.11*	25.07*	46.70*
51	ARG 2A x 6D-1	16.95	18.36	22.41*	-24.26*	3.48*	7.91*	27.00*	70.15*	11.84*	61.64*	9.11*	38.16*
52	ARG 2A x RHA 271	4.84	13.41	6.02*	-34.40*	9.06*	13.72*	50.08*	101.07*	-4.22*	42.67*	17.42*	48.67*
53	ARG 2A x HRHA 4-2	14.38	18.38	30.54*	-19.22*	2.55*	6.93*	-10.73*	19.60*	7.48*	55.34*	-0.29	26.25*
54	ARG 2A x HRHA 5-3	7.73	10.67	5.35*	-34.82*	8.64*	13.29*	-25.58*	20.95*	-10.67*	29.10*	27.77*	61.78*

Sr. No	Hybrids	VG I		VG II		PALM.(%)		STER. (%)		OLEIC (%)		LINO. (%)	
		BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check
55	ARG 2A x RHA 297	21.78	25.50	28.17*	-20.70*	23.15*	28.42*	33.53*	78.90*	4.42*	50.91*	14.93*	45.52*
56	ARG 3A x 6D -1	32.15	20.31	10.72*	-14.47*	4.08*	15.06*	5.87*	37.83*	-6.40*	39.97*	-8.95*	16.54*
57	ARG 3A x RHA 271	2.70	9.95	13.45*	-12.36*	19.03*	31.60*	34.39*	74.95*	-9.05*	36.02*	-3.61*	23.37*
58	ARG 3A x HRHA 4-2	10.68	17.06	1.09	-21.91*	13.82*	25.84*	18.23*	53.92*	0.77	50.69*	-12.70*	11.73*
59	ARG 3A x HRHA 5-3	40.35*	30.52*	10.54*	-14.60*	-2.69*	7.58*	9.42*	77.81*	-9.63*	35.15*	9.89*	40.66*
60	ARG 3A x RHA 297	30.44	20.75	13.81*	-12.08*	7.37*	18.71*	42.51*	85.52*	-4.20*	43.26*	21.39*	55.37*
61	ARG 6A x 6D-1	7.63	10.90	30.77*	0.13	6.98*	13.67*	-4.83*	41.91*	-3.78*	37.67*	17.81*	48.75*
62	ARG 6A x RHA 271	11.62	20.53	18.95*	-8.92*	31.67*	39.91*	2.57*	52.96*	0.02	48.99*	3.59*	30.80*
63	ARG 6A x HRHA 4-2	20.95	25.18	26.36*	-3.25*	6.74*	13.42*	-23.81*	13.62*	6.21*	51.98*	8.92*	37.53*
64	ARG 6A x HRHA 5-3	19.13	21.62	50.17*	14.98*	26.24*	34.14*	-13.36*	40.79*	-0.75	42.01*	-0.54	25.59*
65	ARG 6 A x RHA 297	6.80	13.14	45.26*	11.23*	-5.18*	0.75*	-26.18*	10.09*	-8.85*	31.15*	14.82*	44.98*
66	DV 10 x 6D -1	14.65	18.99	62.10*	-5.24*	10.50*	9.95*	1.86*	12.78*	-3.31*	34.59*	17.42*	46.90*
67	DV 10 x RHA 271	8.95	16.39	35.75*	-17.46*	45.28*	38.53*	1.07*	10.46*	-1.72*	46.40*	0.81	26.11*
68	DV 10 x HRHA 4-2	13.88	17.95	66.07*	-2.92	30.83*	24.76*	17.99*	44.00*	-7.21*	27.49*	16.71*	46.00*
69	DV 10 x HRHA 5-3	6.26	12.13	43.62*	-16.04*	16.76*	11.34*	-14.36*	39.17*	0.98	33.86*	16.21*	45.38*
70	DV -10 x RHA 297	3.15	7.71	34.60*	-21.32*	24.17*	18.40*	2.71*	12.26*	-8.58*	31.55*	26.83*	58.67*
71	CMS 207 A x 6D -1	26.67	14.53	33.54*	-18.92*	28.45*	28.19*	-47.90*	8.67*	-13.14*	20.91*	26.07*	42.71*
72	CMS 207 A x RHA 271	-2.52	5.94	70.06*	3.40*	25.18*	24.92*	-57.18*	-10.68*	-7.65*	37.57*	17.03*	32.48*
73	CMS 207 A x HRHA 4-2	10.16	14.37	61.79*	-1.78	82.53*	82.15*	-58.03*	-12.47*	2.71*	41.12*	19.19*	34.92*
74	CMS 207 A x HRHA 5-3	34.01	26.30	92.65*	16.96*	-0.13	-0.33	-48.03*	8.40*	5.93*	42.60*	28.92*	45.93*
75	CMS 207 A x RHA 297	38.49	26.37	72.27*	4.59*	37.84*	37.56*	-42.39*	20.16*	1.06	45.42*	29.23*	46.29*
	SE	21.00	18.00	1.62	1.52	0.24	0.21	0.18	0.17	0.80	0.77	0.82	0.76
	CDat5%	40.00	30.02	3.24	3.04	0.49	0.42	0.37	0.34	1.61	1.54	1.63	1.52

PH –Plant height, HD -Head diameter, SD- Stem diameter ,DF- days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield per plant, OC- Oil content, HC- Hull content, % SF- Percent seed filling, GERM.- Germination ,EC- Electrical conductivity, VIAB. – Viability, VI I -Vigour index I, VI II – Vigour index II,PALM.- Palmitic acid, STER. – Stearic acid, OLEIC- Oleic acid, LINO. - Linolenic acid.

Over the environments (table 4.40), seventy one hybrids over better parent and seventy five hybrids over standard check had positive and significant heterosis per cent. The major hybrids over better parent were CMS 17 A x RHA 297 (43.97%), CMS 302 A x 6D-1 (42.47%) and CMS17 A x HRHA 4-2 (42.13%) and the prominent hybrids over standard check were CMSH 91 A x HRHA 5-3(59.28%), DV 10 x RHA 297 (58.67%) and CMS 17 A x HRHA 5-3 (57.83%) showed positive and significant heterosis for this trait.

Sunflower is one of the important oilseed crops of our country. Sunflower oil is considered as high quality edible oil. Due to its high content of mono and poly-unsaturated fatty acids, it has great consumer acceptance among the edible oils. It is generally recommended as safe for heart patients. Thus it is imperative to develop sunflower genotypes possessing high seed yield as well as high oil quality. The mode of reproduction in any crop determines its breeding behavior and breeding methods to be adopted for successful crop improvement programme. The breeding programme can efficiently be planned with prior knowledge of the genetic makeup of complex quantitative characters like yield and its attributes. It is therefore necessary to examine the genetic architecture of various quantitative characters in relation to breeding behavior of the genetic material available.

Since heterozygosity *per se* has to be maintained in cross pollinated crops like sunflower, exploitation of heterosis or hybrid vigour is an important globally adopted method of crop improvement in such crops. In order to exploit heterosis, choice of suitable parents is an important step. The concept of general and specific combining ability given by Sprague and Tatum (1942) helps breeder in assessing many of the lines to be used as parents in the production of hybrids and also in identifying superior hybrids having additive and non-additive gene effects.

Genetic constitution and divergence among the parents involved in hybridization govern the heterotic effects and their manifestation in the hybrids. It is therefore necessary to assess the genetic of the parents in hybrid combination through systematic studies in relation to general and specific combining abilities which are due to additive and non-additive gene effects respectively. In this regard, the line x tester analysis method of Kempthorne (1957) is very widely used for estimation of combining ability effects and variances.

5.1 Variability

Results of analysis of variance indicated that mean sum of squares due to genotypes were highly significant for all the characters thereby indicating the existence of substantial genetic variation among genotypes for all the characters studied (Table 4.1 to 4.5). Rao *et al.* (2003) also reported significant differences for all the characters studied in sunflower. For the adoption of suitable breeding programmes, the estimation of heritable and non-heritable components in the total variability observed is indispensable. The heritable component can be assessed by studying phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and predicted genetic advance. The phenotypic coefficient of variation (PCV) was found higher than that of genotypic coefficient of variation (GCV) for all

the traits studied suggesting the role of environmental factors on various characters, which confirmed earlier finding of Khan (2007). High values of GCV and PCV were observed in stearic acid, oleic acid, vigour index II, hundred seed weight, seed yield, electrical conductivity and percent seed filling. Supriya *et al.* (2017) reported high estimation of GCV and PCV for seed yield and test weight, moderate for plant height and oil content and low for days to maturity and days to 50% flowering. Similar findings were also reported by Rao *et al.* (2003), Reddy *et al.* (2006), Kalukhe *et al.* (2010), Makane *et al.* (2011). Similar findings were also reported by Sultana *et al.* (2005) for days to maturity and oil content. The results obtained for PCV and GCV showed that there is considerable possibility of further improvement in genotypes taken for present study through inter mating followed by appropriate selection for these characters. The differences between the PCV and GCV were relatively very small for which showed least influence of environment, which was supported by the findings of Teklewood *et al.* (1999) while hundred seed weight in E₂ had larger difference between PCV and GCV which showed more influence of environments.

The heritability (broad sense) estimates were high for seed yield per plant (g), oil content (%), percent seed filling, plant height (cm) and linoleic acid (%). Moderate heritability was recorded for days to 50% flowering, stem diameter (cm) and hundred seed weight (g). The characters having high heritability estimates are of immense importance as it permits selection at phenotypic level and there would be greater correspondence between phenotypic and breeding values.

The conventional breeding approach is mainly based on the phenotypic performance of the genotypes. So in this condition high heritability estimates would be helpful for breeding superior genotypes. However, Johnson *et al.* (1955) reported that heritability value with genetic advance were better approach for selecting the desirable individuals rather than heritability value alone.

High value of genetic advance *as per cent* of mean was observed for seed yield per plant (g), fatty acids (%), percent seed filling and electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$) indicating that these characters can be improved to considerably very good extent. Moderate estimation of genetic advance *as per cent* mean were shown by hundred seed weight (g), hull content (%) and viability (%), low by remaining characters. The similar findings were also reported by Sultana *et al.* (2005), Janamma *et al.* (2007), Safavi *et al.* (2011).

High heritability associated with high genetic advance was reported for seed yield per plant (g) and seed filling rate and fatty acids (%) indicating the presence of additive gene action. High heritability with moderate genetic advance were observed for oil content (%) and hull content (%) whereas moderate heritability with moderate genetic advance *as per cent* mean was observed for hundred seed weight (g). High heritability associated with low

genetic advance was reported for days to maturity. Supriya *et al.* (2017) reported that high value of heritability coupled with the high genetic advance was estimated for plant height (cm), test weight (g), seed yield per plant (g), and head diameter (cm), high heritability coupled with moderate genetic advance was recorded for days to 50 per cent flowering and oil content (%) which indicated additive gene action. These observations are in agreement with the earlier reports of Reddy *et al.* (2006), Janamma *et al.* (2007), Arshad *et al.* (2010) for seed yield, Sutar *et al.* (2010) for days to maturity and seed yield, Kalukhe *et al.* (2010) for hull content and days to maturity.

5.2 Genetic divergence

Genetic diversity existing within and between groups of germplasm is important and particularly useful in proper choice of parents for realizing higher heterosis and obtaining useful recombinants. D^2 statistic is a useful tool for estimating the genetic divergence in plant breeding experiments. Based on the Euclidean minimum variance, 96 sunflower genotypes involved in the present study were grouped into 6 distinct clusters. The clustering pattern revealed the presence of considerable amount of genetic diversity in the material. In general intracluster distances were relatively lower than intercluster distances showing that genotypes included within a cluster were genetically less diverse than the genotypes included in different clusters. Highest number of genotypes were possessed by Cluster IV 35 genotypes followed by cluster V with 32 genotypes, cluster I with 15 genotypes, cluster VI with 8 genotypes, cluster II with 5 genotypes and III having only one genotype. Genotypes from different sources were grouped in the same cluster thereby indicating that genetic divergence had little relationship with the geographic distance. Reddy *et al.* (2012) reported the similar result while analyzing the genetic diversity in germplasm accessions of *Helianthus annuus* L which also suggested that geographical divergence does not necessarily represent genetic diversity. The findings of present study were also supported by Teklewold *et al.* (2002). However, in some clusters like in cluster I and II, the genotypes related to their place of origin have shown their tendency to group together in the same cluster.

The maximum intra cluster distance was observed for cluster I followed by cluster II, V and VI which revealed the existence of maximum differences among the genotypes falling in these clusters. Cluster IV had the minimum intra cluster D^2 value indicating a minimum difference among the grouped genotypes in this cluster for various traits.

To get more heterotic F_1 's and large number of desirable transgressive segregants in further advance generation, selection of parents for hybridization should be properly based on genetic diversity rather than geographic diversity. An effective hybridization programme may be initiated by involving the genotypes belonging to diverse clusters with high mean for almost all

component characters. The cluster means for seed yield per plant and its component characters revealed considerable differences among all the clusters for most of the characters studied.

In the present study, cluster VI showed the higher mean value for hundred seed weight (g), seed yield per plant (g), plant height (cm), head diameter (cm), hull content (%) and cluster II reported higher mean value for oil content (%). Cluster V had higher mean value for percent seed filling, oleic acid (%) and linoleic acid (%). Cluster IV reported high mean for seedling vigour I and seedling vigour II. Cluster I showed higher mean value for days to 50 % flowering, days to maturity and for germination (%). The comparison indicated that overall clusters IV, V and VI, had best combination for cluster means for most of the characters. Therefore, cluster IV, V and VI might be considered better for selecting genotypes. Neelima *et al.* (2016) reported that in their studies cluster XI had high mean value for seed yield per plant (g), Cluster X had higher mean value for plant height (cm) and head diameter (cm) and cluster XII had higher test weight (g). The maximum inter cluster distance was recorded between cluster XI and XII followed by cluster X and XII and clusters V and XII. It was suggested that if the diverse accessions from these diverse groups are used in the breeding programme, it is expected to produce a wide range of genetic variability in the population. Similar results were reported by Sasikala (2000), Ravi (2001), Loganathan (2002), Subrahmanyam *et al.* (2003), Anuradha *et al.* (2004), Komuraiah *et al.* (2004), Mohan and Seetharam (2005), Loganathan *et al.* (2006), Srinivas *et al.* (2006), Arshad *et al.* (2007), Binodh *et al.* (2007), Ananda kumar *et al.* (2008), Punitha *et al.* (2010), Luciene *et al.*, (2010), Dan *et al.* (2012), Tyagi *et al.* (2013), Shamshad *et al.* (2014), and Chandirakala *et al.* (2014).

5.3 Stability

On the basis of stability analysis, analysis of variance showed that the mean sum of squares were significant for pooled analysis when tested against pooled deviation, which revealed that the hybrids had significant differences in response to pooled conditions.

Although, the test environments created by different sowing dates indicated considerable differences between the environments for all the traits studied, the variation among the limited number of hybrids selected for seed yield and its component traits obviously did not differ much amongst themselves. The estimates of stability parameters viz. mean ($\bar{X}$), regression coefficient (b_i) and deviation from regression (δ^2_{di}), of stable hybrids are presented in table 4.10 to 4.14.

According to Eberhart and Russell (1966) model, for plant height (cm), female parents CMS 852 A (119.19 cm) and the hybrid CMS 607A x HRHA 5-3 (152.70 cm) recorded the maximum height. Similar results were observed by Ahmad *et al.* (2017), as they found that the plant height ranged from 45 cm to 151.6 cm. The hybrid CMS-373 x R-346

exhibited highest (151.6 cm) value for plant height, these differences for plant height were due to variability in genetic makeup of these cultivars. Ali *et al.* (2011) also reported significant differences in plant height, and achene yield among sunflower genotypes. The hybrids CMS 148 A x RHA 271 and ARG 6A x RHA 297 were appropriate for favorable environment with predictable performance. Hybrids CMS 207 A x RHA 297 and CMS 852 A x HRHA 4-2 A were stable for poor environments. For head diameter, the parents CMS 302 A, CMS 852 A, CMS 207 A and hybrids DV-10 X RHA 297, ARG 6A x HRHA 4-2, ARG 6A x RHA 297, CMS 11 A x RHA 271 and CMS 11 A x HRHA 4-2 were stable for favorable environments. However, the parents ARG 3 A, ARG 2 A, DV 10, CMS 234 A, RHA 4-2, HRHA 5-3 and hybrids CMS 44A x HRHA 5-3, CMS 148 A x HRHA 4-2, CMS 207 A x HRHA 4-2 and CMS 852 A x RHA 271 were stable for poor environments.

Stem diameter of the parents CMS 607 A, HRHA 5-3 and hybrids CMS 207 A x RHA 271, DV-10 x RHA 297, DV-10 x HRHA 5-3, DV-10 x HRHA 4-2 and ARG 3 A x RHA 271 were stable for favorable environments. The parent ARG 3A and hybrids CMS 302 A x RHA 297, ARG 3A x HRHA 5-3, CMS 607 A x HRHA 5-3 showed stability under poor environments. For days to 50 % flowering the parent CMS 234A and hybrids CMS 44A x RHA 297, CMS 148 A x RHA 297, CMS 852 A x 6D-1 and ARG 2A x RHA 297 were stable for favorable environments while the parents CMS 148 A, RHA 297, RHA 4-2 and hybrid CMS 302 A x RHA 271 and ARG 2A x 6D-1 were stable for poor environment. For maturity the parents CMS 207 A, RHA 271 and hybrids CMS 11 A x RHA 271, CMS 44 A x RHA 297 and ARG 3 A x HRHA 4-2 were observed stable for favorable environments and the parents ARG 6A, CMS 103 A and the hybrids CMS 103 A x HRHA 4-2 and CMS 302 A x RHA 271 performed well under poor environments.

For test weight, the parents CMS 44 A, HRHA 5-3, and hybrids CMS 148 A x 6D-1, CMS 302 A x RHA 297 and ARG 3A x HRHA 4-2 were stable for favorable environments. The hybrids CMS 852A x HRHA 4-2, CMS 148 A x HRHA 5-3 and CMS 44 A x HRHA 4-2 were stable for poor environments. For seed yield per plant, the parents CMS 852 A, ARG 6 A, RHA 271, and hybrids CMS 11 A x HRHA 4-2, CMS 11 A x RHA 271, CMS 148 A x RHA 271, CMS 302 A x HRHA 5-3, CMS 234 A x RHA 271, ARG 2A x RHA 271, ARG 6 A x RHA 271 were stable for favorable environments. The female parents CMS 148 A, CMS 607 A, ARG 3 A and hybrid CMS 852 A x RHA 271, ARG 3 A x HRHA 5-3, CMS 302 A x 6D-1 were stable for poor environments.

For oil content, the parents CMS 207 A and HRHA 5-3 were stable for favorable environments while the crosses CMS 207 A x RHA 271, CMS 207 A x 6D-1, CMS 852 A x 6D-1, CMS 607 A x 6D-1, CMS 234 A x 6D-1, CMS 91 A x RHA 271, CMS 44 A x RHA 271 and CMS 17 A x RHA 271 were stable for poor environments. The hull content of

parent CMS 234 A and hybrids CMS 11 A x RHA 271 and ARG 6A x HRHA 5-3 were stable for favorable environments. The parent ARG 2 A and hybrid CMSH 91 A x HRHA 4-2 and CMS 302 A x RHA 297 were stable for poor environments. For percent seed filling, the parents CMS 11 A, CMS 234 A and crosses CMS 234 A x HRHA 4-2, CMS 234 A x RHA 297, ARG 6A x RHA 297 were stable for poor environments. For electrical conductivity, the hybrids CMS 17 A x 6D-1, CMS 44 A x 6 D-1, CMS 44 A x HRHA 4-2 , CMS 148 A x 6D-1, CMS 103 A x HRHA 4-2 , CMS 302 A x 6 D-1 , ARG 2A x 6 D-1 and ARG 6 A x 6 D-1 were stable for favorable environments. The parents CMS 17A, CMS 302 A, ARG 2 A, DV-10 and RHA 297 were stable for poor environment. For viability, the hybrids CMS 148 A x 6D-1, CMS 852 A x RHA 271 and DV 10 x RHA 271 were stable for the poor environment.

For seedling vigour index I, the hybrids CMS 11 A x RHA 297 , CMS 17 A x RHA 297 and CMS 44 A x 6D-1 were stable for favorable environments and the hybrids CMS 44A x HRHA 5-3, CMS 103 A x HRHA 4-2 and DV 10 x RHA 271 were stable for poor environment. For seedling vigour index II, the hybrids CMS 11 A x 6D-1 and CMSH 91 A x 6D-1 were stable for favorable environments and the female parent CMS 302 A and hybrid CMS 302 A x 6D-1 were stable for poor environment.

For palmitic acid, the parent ARG 6 A and the hybrids CMS 44A x RHA 271, CMS 148 A x 6D-1, CMS 148 A x RHA 297 and CMS 103 A x 6D-1 were suitable for favorable environments and the parent CMS 302 A and hybrids CMS 234 A x HRHA 5-3, CMS 607 A x RHA 297 and ARG 2 A x RHA 271 were stable for poor environments. For stearic acid, the parents and hybrids viz., DV-10 , CMS 207 A x 6D-1, CMS 103 A x RHA 271 , CMS 148 A x RHA 297, CMS 17 A x HRHA 5-3, CMS 11 A x RHA 297 were stable for favorable environment and female parent ARG 2 A and hybrids CMS 103 A x HRHA 5-3 and CMS 103 A x RHA 297 were stable for poor environments. For oleic acid, the hybrids viz., CMS 148 A x HRHA 4-2, CMS 302 A x HRHA 5-3, CMS 607 A x RHA 271 and CMS 852A x RHA 271 were stable for favorable environment. The parents CMS 607 A, ARG 3 A and hybrids CMS 17A x 6D-1, CMS 607A x RHA 297 and CMS 852A x HRHA 4-2 were stable for poor environment. For linoleic acid, the hybrid ARG 6A x HRHA 5-3 and parent CMS 207A were stable for favorable environments and the parents CMS 11A, CMS 44A and CMS 148A x 6D-1, ARG 6A x RHA 297 were stable for poor environments. Bhoite *et al.* (2010) reported that variance due to hybrids, environments and G x E interaction were found significant. The hybrids KSFH 401, 402 and 446 were found to be below average stability, whereas the hybrid KSFH 434 showed stable performance for seed yield. Binodh *et al.* (2009) reported that the hybrids viz., CSFH 6008, CSFH 6037, CSFH 6039, CSFH 6045 and CSFH 6058 were stable over environments for seed yield and oil yield. Among these hybrids, CSFH 6045 was found superior.

Similar results were obtained by Rao *et al.* (2004), Hladni *et al.* (2004), Ghafoor *et al.* (2005), Bakht *et al.* (2006), Hladni *et al.* (2006), Ahmed and Abdella (2009), Yan *et al.* (2011) Ali *et al.* (2011), Sarwar *et al.* (2013), Alem *et al.* (2016), Mousavi *et al.* (2016), Ahmed *et al.* (2017) and Dudhe *et al.* (2017).

5.4 Combining ability

From the analysis of variance for combining ability, in E_1 and E_3 (Table 4.15 & 4.17), the mean sum of square due to lines, testers and lines x testers were highly significant for all character except electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$) and in E_2 (table 4.16), the mean sum of square due to treatments were significant for all traits except stem diameter (cm) and electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$). In E_4 (table.4.18), the mean sum of square due to lines, testers and line x testers were significant except 100 Seed weight (g) and electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$). Over the environments, it is quite evident that significant differences existed among lines. Also, mean sum of squares due to testers were significant for most of characters except electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$), justifying the selection of parents for line x tester mating to generate hybrids for combining ability analysis. The crosses between these lines and testers differed significantly from each other for all the characters indicating that lines and testers complement each other for combining ability. The variance due to interaction between females and males was significant for almost all the characters suggesting significant contribution of sca effects towards variation among the crosses.

The estimates of SCA variances were high for all the characters indicating predominance of non-additive gene action for these traits, which is also evident from the studies on heterosis. The estimates of σ^2 GCA: σ^2 SCA ratio (Variance ratio) was less than one for all the characters, indicating relatively higher proportion of SCA (σ^2 D) responsible for the expression of major yield components. The magnitude of the ratio varied among the different characters. The predominance of non-additive gene action for head diameter (cm) was reported by Ashok *et al.* (2000), Kaya and Atakisi (2004). Reddy and Madhavilatha (2005) reported a predominant role of non-additive gene action for maturity. Phad *et al.* (2002), Sharma *et al.* (2003) and Sakthivel (2003) reported predominant role of non-additive gene action for traits such as days to 50 per cent flowering and seed filling per cent. Goksoy *et al.* (2000 and 2001), Haldini *et al.* (2006) reported the non-additive gene action for test weight. Non – additive gene action as a predominant factor in the inheritance of oil content (%) and seed yield (g) has also been reported by Burili and Jadhav (2001), Radhika *et al.* (2001), Laureti *et al.* (2001) and Ortis *et al.* (2005).

5.4.1 General combining ability

In E_1, E_2, E_3, E_4 and over the environments, the common parents observed were namely; CMS 148A, CMS 207, RHA 271, ARG 3A, ARG 6A, CMS 44A and 6D-1 which

exhibited negative significant *gca* effects for plant height. Muhammad *et al.* (2012) reported A-26 and HBRS-1 as good combiners for plant height. For head diameter, among female parents, CMS 17A, CMS 44A, CMSH 91A, CMS 207 A and CMS 148 A and among male parents HRHA 5-3, HRHA 4-2 were observed highly significant for *gca* effects in E₁, E₂, E₃, E₄ and over the environments. Chandra *et al.* (2011) reported that ARM 243B, CMS 17B and RHA-6D-1R, RES-834-1 and 3376R were good combiner for head diameter. For stem diameter, the lines, CMS 207, CMS 17A, CMS 148 A, CMS 302 A and CMSH 91 A and testers RHA 271 and RHA 297 were found to be good general combiner in E₁, E₂, E₃, E₄ and over the environments. Similar results were recorded by Alone *et al.* (1996) observed the male parent RHA- 296 and 297 as a good combiners for stem girth. Reddy (2001) noticed RHA- 274 and Modern as good combiners for stem girth. For days to 50 % flowering the lines CMS 11 A, CMS 17 A, CMS 44 A, CMS 148A, CMS 852A, CMS 302 A, CMS 234A and testers RHA 297, 6D-1 exhibited significant negative *gca* effects in E₁, E₂, E₃, E₄ and over the environments. Binodh *et al.* (2008) reported as CSFH-6009 was good combiner for early flowering. In E₁, E₂, E₃, E₄ and over the environments, the common parents observed were namely; CMS 11A, CMS 17A, CMS 44A, RHA 271, CMSH 91 A, CMS 148A, CMS 103 A and RHA 297 which exhibited negative significant *gca* effects for early maturity. Maximum negatively significant *gca* showed that these lines can be used for short duration hybrid progeny. These results were in accordance with the findings of Shankar *et al.* (2007). For hundred seed weight, the parents CMSH 91A, CMS 103A, CMS 17 A , CMS 148 A and RHA 271 were found to be good general combiner for the environments viz., E₁, E₂, E₃, E₄ and over the environments. Chandra *et al.* (2011) reported that ARM 243B, CMS 17B and RHA-6D-1R, RES-834-1 and 3376R were good combiner for this character. For seed yield per plant, the lines, CMS 207 A, CMS 148 A, CMSH 91 A, CMS 17A and testers RHA 271, HRHA 5-3 exhibited significant positive *gca* effects for all the environments. Chandra *et al.* (2011) reported that ARM 243B, CMS 17B and RHA-6D-1R, RES-834-1 and 3376R were good combiner for this character. Athoni *et al.* (2012) reported that IX-79 (NB) was good combiner for seed yield. In E₁, E₂, E₃, E₄ and over the environments, the lines CMS 207 A and CMS 103 A showed significant positive *gca* effects for oil content. Chandra *et al.* (2011) reported that ARM 243B, CMS 17B and RHA-6D-1R, RES-834-1 and 3376R as good combiners for this characters. For hull content, the parents namely; CMS 11A, CMS 44A, CMS 17A, CMS 148A, CMSH 91A and 6D-1 exhibited significant negative *gca* effects in E₁, E₂, E₃, E₄ and over the environments. For percent seed filling, the parents, CMS 207 A, ARG 3A, ARG 6A, RHA 297, CMS 44A and CMS 11 A exhibited significant *gca* effects in E₁, E₂, E₃, E₄ and over the environments. Similar results were reported by Muhammad *et al.* (2012). They evaluated A-26 and HBRS-1 as good combiners for this character. In E₁, E₂, E₃, E₄ and

over the environments, the parents CMS 17A, CMS 207 A, CMS 11 A ARG 3A, 6D-1, CMS 44A, and RHA 4-2 were found to be good general combiner for germination. In E₁, E₂, E₃, E₄ and over the environments, the common parents observed were namely; CMS 17A, CMS11 A, CMS 44A, HRHA 4-2, ARG 6A, CMS 148 A and HRHA 5-3 which exhibited negative significant *gca* effects for electrical conductivity. For viability, the parents namely; CMS 17 A, CMS 148 A, CMS 44 A, CMS 11A, CMS 607A, CMSH 91 A, 6D-1 and CMS 852 A were observed to have significant positive *gca* effects.

In E₁, E₂, E₃, E₄ and over the environments, the parents, CMS 103A , CMS 44A, 6D-1, CMS 11 A, CMS 103 A and HRHA 5-3 exhibited significant positive *gca* effects for seedling vigour index-I. In E₁, E₂, E₃, E₄ and over the environments, the common parents observed were namely, CMS 103 A, ARG 6A, CMS 852 A, CMSH 91 A, 6D-1, CMS 11 A and CMS 207 A which exhibited significant positive *gca* effects for seedling vigour index –II. For palmitic acid, the parents CMS 207 A, RHA 271, HRHA 5-3, ARG 6A, ARG 3A, CMS 852 A and HRHA 4-2 exhibited significant positive *gca* effects in E₁, E₂, E₃, E₄ and over the environments. For stearic acid, the parents, ARG 3A, RHA 297, 6D-1, CMS 852 A ,CMS 103 A, CMSH 91 and ARG 2A were found to be good general combiner. In E₁, E₂, E₃, E₄ and over the environments, the parents, ARG 2A, RHA 297, ARG 6A, HRHA 4-2, CMSH 91 A, CMS 234A and CMS 302 A exhibited significant positive *gca* effects for oleic acid. Similar results were reported by Rather *et al.* (1999) and Singh *et al.* (1999) for oleic acid. For linoleic acid, in E₁, E₂, E₃, E₄ and over the environments, the common parents, CMS 302 A, CMS 11 A, ARG 2A, HRHA 5-3, RHA 297, CMS 148 A and DV-10 were found to be good general combiner. Similar results were reported by Loganathan and Gopalan (2006) for linoleic acid.

5.4.2 Specific combining ability

In E₁, E₂, E₃, E₄ and over the environments, for plant height, the hybrids CMS 234 A x HRHA 4-2 , CMS 302 A x 6D-1 and CMS 607 A x RHA 297 exhibited significant *sca* effects due to low x low , high x low and high x low combination of parents indicating non additive gene action. For head diameter, the hybrids namely; CMS 17A x HRHA 5-3 and CMS 148 A x HRHA 4-2 were highly significant for *sca* effects, from high x low and low x high effects suggesting non additive gene action. These results were at par with those reported by Binodh *et al.* (2008), Chandra *et al.* (2011).

For stem diameter, the hybrids CMSH 91 A x RHA 271 and CMS 44 A x RHA 297 were significant for *sca* effects emanating from high x low and low x low effects suggesting non additive gene action. Reddy (2001) reported the best specific combination for stem girth at base.

For hundred seed weight, in E_1 , E_2 , E_3 , E_4 and over the environments, the hybrids namely, DV-10 x 6D-1, CMS 607 A x RHA 297, CMS 17 A x RHA 271 and ARG 6A x 6D-1 were highly significant for *sca* effects and showed high x low, high x low and high x low effects suggesting non additive gene action. Muhammad *et al.* (2012) reported that A-41 x A-35, A-1 x G96 12 and A-41 x HBPS-1 had significant and positive *sca* effect for this character. For Seed yield per plant, the hybrids CMS 852 A x RHA 271 and CMS 207 A x HRHA 5-3 exhibited significant positive *sca* effects from high x low and high x low interactions indicating non-additive gene action. Muhammad *et al.* (2012) and Chandra *et al.* (2011) observed similar results.

In E_1 , E_2 , E_3 , E_4 and over the environments, for oil content, the hybrids CMS 207 A x RHA 297, ARG 6A x HRHA 5-3 and CMS 103 A x RHA 271 showed positive *sca* effects. Also for hull content, the hybrids CMS 852 A x RHA 271, CMS 207 A x 6D-1, CMSH 91 A x 6D-1 and ARG 6A x HRHA 5-3 showed negative significant *sca* effects with high x low, high x low and low x high effects suggesting non additive gene action. Similar result was observed by Kaya (2005b), who reported that oil content for *sca* was positive significant. Positive values indicate a contribution toward large effects on oil while negative values indicate a contribution toward smaller effects and reverse interaction was observed between oil content and hull content.

For percent seed filling, the hybrids, CMS 607 A x 6D-1, CMS 607 A x HRHA 4-2 and ARG 2A x 6D-1 and for germination, the hybrids, CMS 607 A x RHA 271, CMS 607 A x HRHA 4-2 and CMS 103 A x RHA 271 were highly significant for *sca* effects emanating from high x low, high x low and high x low effects suggesting non additive gene action. Madrap and Makne (1993) reported similar results in cross CMS 234 A x RHA 273 for filled seed per cent.

In E_1 , E_2 , E_3 , E_4 and over the environments, for electrical conductivity, the hybrids CMS 234 A x RHA 297, CMS 607 A x HRHA 4-2 and CMS 17 A x RHA 297 showed significant negative *sca* effects and for viability the hybrids CMS 44A x HRHA 4-2, CMS 607 A x HRHA 4-2 and CMS 607 A x RHA 271 exhibited significant positive *sca* effects with high x low, high x low and high x high combining parents indicating non-additive gene action. For seedling vigour index –I, the hybrids CMS 148A X 6D-1, CMS 302 A X RHA 271 and CMS 207 A X RHA 297 showed significant positive *sca* effects and for seedling vigour index –II, the hybrids, CMS 148 A x 6D-1, CMSH 91 A x RHA 297, CMS 103 A x RHA 271 and CMS 148 A x 6D-1 were highly significant for *sca* effects involving parents with high x low, high x low, low x high and high x low effects suggesting non additive gene action.

In E₁, E₂, E₃, E₄ and over the environments, for palmitic acid, the hybrids, ARG 2 A x RHA 297, CMS 207 A x HRHA 4-2, DV 10 x RHA 271, CMS 11 A x HRHA 5-3, ARG 6A x HRHA 5-3 and CMS 207 A x RHA 297 had significant positive *sca* effects with high x low, low x high, low x low, high x low and high x low combining parents indicating non-additive gene action. For stearic acid, the hybrids, CMS 17 A x HRHA 4-2 and ARG 2 A x RHA 271 exhibited positive significant *sca* effects. For oleic acid, the hybrids, CMSH 91 A x HRHA 4-2 and CMS 234 A x HRHA 4-2 showed positive significant *sca* effects and for linoleic acid, the hybrids, CMS 607 A x RHA 271, CMSH 91 A x HRHA 5-3 and CMS 148 A x HRHA 4-2 were possessing significant *sca* effects due to high x low, high x low and high x low interaction which also illustrated the non additive gene action. The occurrence of good hybrids by the combination of one good combiner may be due to accumulation of favorable genes and partly due to dominance interaction. Similar results were reported by Radhika *et al.* (2001), Goksoy *et al.* (2005), Varaprasad *et al.* (2006), Pavani *et al.* (2006), Shankar *et al.* (2007), Tan (2010), Mohansundaram *et al.* (2010), Ghaffari *et al.* (2011), Ahmad *et al.* (2011), Waqas *et al.* (2012), Andarkhor *et al.* (2012), Meena *et al.* (2013) and Nasreen, *et al.* (2016).

5.5 Heterosis

In the present study, superiority of hybrids was estimated over better parent and standard checks for all the 19 traits. Analysis of variances for parents, hybrids, location, parent vs. female, parent vs. female x location were significant for all the characters except electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$) in E₁, E₂, E₃ and E₄. Over all the environments (table 4.35), analysis of variances for parents, hybrids, location, parent vs. female, parent vs. female x location were significant for all the characters except electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$) for male, female vs male and parents vs hybrids.

5.5.1 Plant height (cm)

In E₁, heterosis over better parent ranged from -26.17% (CMS 207 A X RHA 271) to 30.02% (ARG 2A x HRHA 4-2) and over standard check varied from -23.91% (CMS 44 A x RHA 271) to 14.96% (CMS 234A x RHA 271) while in E₂, heterosis ranged from -24.95% (ARG 6A x RHA 271) to 46.21% (ARG 2A x HRHA 4-2), and from -15.56% (ARG 6A x RHA 271) to 26.56% (CMS 302 A x RHA 297) over better parent and over standard check respectively. In E₃, heterosis over better parent ranged from 8.41% (CMS 234 A x HRHA 4-2) to 57.08% (CMS 302 A x RHA 271) and over standard check it ranged from 2.41% (CMS 234 A x HRHA 4-2) to 45.48% (CMS 302 A x RHA 271) whereas in E₄, heterosis ranged from 32.72% (CMS 607 A x RHA 297) to 70.70% (ARG 3A X RHA 297) and over standard check ranged from 23.36% (CMS 207 A x RHA 297) to 56.11% (CMSH 91 A x 6D-1). In pooled analysis, heterosis over better parent ranged from 10.94% (CMS 852 A x HRHA 5-3) to 43.27% (CMSH 91 A x HRHA 4-2) and over standard check varied from 4.95% (CMS 234

A x HRHA 4-2) to 32.88% (CMS 607 A x HRHA 5-3) for this trait. The results revealed that some experimental hybrids were taller/dwarf than standard check and these dwarf hybrids probably suit for mechanization and intercropping without much reduction in their yield levels. The results are supported by the findings of Shankara (1981), Govindaraju (1986) and Shivakumar (1989).

5.5.2 Head diameter (cm)

Head diameter being positively correlated with seed yield, heterosis in the positive direction only is desirable for this trait. Heterosis over better parent ranged from -27.49% (ARG 2A X RHA 297) to 127.92% (CMS 207 A X RHA 297) and over standard check ranged from -21.51% (CMS 852A X HRHA 5-3) to 96.21% (CMS 17 -A X HRHA 5-3) in E₁, as presented in table. In E₂, heterosis over better parent varied from -15.63% (ARG 3A X RHA 297) to 93.69% (CMS 207 A X RHA 297) and over standard check ranged from -27.47% (CMS 103 A X RHA 271) to 45.61% (CMS 17 -A X HRHA 5-3) whereas heterosis over better parent ranged from 5.92% (CMS 11 A X 6D-1) to 102.12% (ARG 2A X 6D-1) and over standard parent from -4.97% (CMS 207 A X 6D -1) to 57.80% (CMSH 91 A X 6D-1) in E₃, for this trait.

In E₄, heterosis ranged from -10.60% (CMS 234 A X HRHA 5-3) to 90.72% (DV 10 X 6D -1) and from -16.80% (CMS 852A X HRHA 5-3) to 51.81% (CMS 607 AX RHA 271) over better parent and standard parent respectively, whereas, heterosis over all the environments ranged from 10.94% (CMS 852A X HRHA 5-3) to 43.27% (CMSH 91 A X HRHA 4-2) over better parent and 4.95% (CMS 234 A X HRHA 4-2) to 32.88% (CMS 607 A X HRHA 5-3) over standard check as presented in table 4.40. Positive heterotic effects have been reported by most of the researchers for this trait. Goksoy *et al.* (2000), Radhika *et al.* (2001), Phad *et al.* (2002), Alone *et al.* (2003) and Manivannan *et al.* (2005) reported significant positive heterosis, indicated positive influence of cytoplasmic sources on heterosis for head diameter

5.5.3 Stem diameter (cm)

For stem diameter in E₁, heterosis over better parent ranged from 1.28% (CMS 852 A X RHA 297) to 127.84% (CMS 148 A X HRHA 5-3) and over standard check varied from -25.26% (CMS 852 A X RHA 297) to 43.69% (CMS 17 A X RHA 297) whereas in E₂, heterosis ranged from -5.74% (CMS 11 A X RHA 297) to 128.92% (CMS 234 A X HRHA 5-3) and from -4.82% (CMS 11 A X RHA 297) to 84.83% (CMS 17 -A X HRHA 5-3) over better parent and over standard check respectively. In E₃, (table 4.38) heterosis over better parent ranged from 30.10% (CMS 11 A X RHA 271) to 127.20% (CMS 148 AX HRHA 4-2) and over standard check it ranged from 6.26% (CMS 11 A X RHA 271) to 67.96% (CMSH 91 A X RHA 271) whereas in E₄, heterosis ranged from 12.53% (CMS 234 A X HRHA 5-3)

to 134.41% (CMS 852 A X HRHA 4-2) and over standard check ranged from -30.50% (CMS 44 A X HRHA 4-2) to 11.98% (CMS 607 A X 6D-1). In pooled analysis, heterosis over better parent ranged from 36.53% (ARG 6A X RHA 271) to 106.55% (CMS 148 AX HRHA 4-2) and over standard check ranged from -6.66% (CMS 44 A X HRHA 4-2) to 23.16% (CMS 17 -A X HRHA 5-3) as presented in table 4.40. The positive heterosis of moderate magnitude for stem girth was reported by Govindaraju *et al.* (1992) and Gangappa *et al.* (1997).

5.5.4 Days to 50 % flowering

Heterosis over better parent ranged from -10.85% (CMS 17 -A X HRHA 4-2) to 17.05% (CMS 207 A X HRHA 5-3) and over standard check varied from -4.35% (CMS 607 A X HRHA 5-3) to 17.70% (ARG 6A X RHA 271) in E_1 for days to 50% flowering. In E_2 , heterosis ranged from -6.33% (CMS 148 AX HRHA 4-2) to 23.28% (CMS 103 AX HRHA 5-3) and from -2.53% (CMS 17 A X RHA 297) to 19.98 (ARG 2A X HRHA 4-2) over better parent and over standard check respectively, whereas, in E_3 heterosis over better parent varied from -8.94% (ARG 6A X 6D-1) to 15.74% (CMS 852 A X RHA 297) and over standard check varied from -6.21% (ARG 6A X 6D-1) to 14.31% (DV 10 X RHA 271). In E_4 heterosis ranged from -2.56% (CMS 302 A X 6D-1) to 19.67% (CMS 148 AX HRHA 5-3) and over standard check -0.48% (CMS 852 A X RHA 271) to 20.96% (CMS 148 AX HRHA 5-3). whereas over all the environment the heterosis over better parent ranged from -6.11% (CMS 148 AX HRHA 4-2) to 10.71% (CMS 103 AX HRHA 5-3) and over standard check varied from 10.30% (DV 10 X HRHA 4-2) to -1.45% (CMS 302 A X 6D-1) for days to 50% flowering. The existence of both significant positive and negative heterotic effects over check suggests the presence of non-additive gene action for this trait. Giriraj *et al.* (1986), Gangappa *et al.* (1997), Radhika *et al.* (2001), Singh and Singh (2003) and Manivannan *et al.* (2005) have also reported heterosis for earliness in sunflower hybrids.

5.5.5 Days to maturity

For days to maturity in E_1 heterosis ranged from -4.98% (CMS 17 -A X HRHA 4-2) to 13.82% (ARG 2A X HRHA 5-3) and from -3.17% (CMS 607 AX RHA 271) to 8.71% (ARG 2A X RHA 297) over better parent and over standard check respectively whereas in E_2 heterosis over better parent varied from -4.39% (CMS 17-A X RHA 271) to 22.60% (CMS 302 A X HRHA 5-3) and over standard check varied from -0.77% (CMS 17-A X RHA 271) to 17.44% (CMS 302 A X HRHA 5-3). In E_3 heterosis over better parent and standard check ranged from -7.39% (CMS 17 A X RHA 297) to 10.61% (CMS 234A x RHA 271) and from -1.51% (CMS 103 AX RHA 271) to 10.61% (CMS 234A X RHA 27) respectively for maturity. In E_4 heterosis ranged from -6.17% (CMS 852 A X RHA 271) to 13.14% (CMS 607 A X HRHA 5-3), and over standard check -7.93% (CMS 852 A X RHA 271) to 6.90% (CMS 852 A X 6D -1) whereas, over all the environment the heterosis over better parent ranged from -

2.88% (CMS 148 A X RHA 297) to 10.82% (CMS 302 A X HRHA 5-3) and over standard check varied from 0.96% (CMS 11 A X RHA 271) to 7.50% (CMS 302 A X HRHA 5-3) for this trait. Phad *et al.* (2002), Bajaj *et al.* (2003) and Alone *et al.* (2003) have also reported heterosis for early maturity in hybrids.

5.5.6 Hundred seed weight (g)

For hundred seed weight, heterosis over better parent ranged from 0.18% (DV 10 X HRHA 4-2) to 99.56% (CMS 207 A X HRHA 5-3) and over standard check heterosis varied from -17.59% (DV -10 X RHA 297) to 52.18% (ARG 6A X RHA 271) in E₁ for test weight. whereas in E₂ heterosis ranged from 4.10% (ARG 3A X HRHA 4-2) to 123.52% (CMS 17-A X RHA 271) over better parent and heterosis varied from -28.77% (CMS 17 A X RHA 297) to 30.73% (CMS 103 A X 6D-1) over standard check. In E₃ heterosis over better parent ranged from -14.71% (ARG 2A X HRHA 4-2) to 82.00% (CMS 103 AX HRHA 5-3) and over standard check heterosis varied -27.71% (DV 10 X HRHA 4-2) to 39.61% (ARG 3A X RHA 271) while in E₄ heterosis ranged from -11.90% (CMS 852 A X RHA 297) to 89.49% (CMS 103 AX HRHA 4-2) and over standard check heterosis ranged from -15.03% (CMS 302 A X 6D-1) to 62.21% (CMS 207 A X HRHA 4-2). Over the environments (table 4.40) heterosis over better parent and standard check ranged from -16.82% (ARG 2A X RHA 297) to 75.69% (CMS 17-A X RHA 271) and -2.42% (DV 10 X HRHA 4-2) to 34.16% (CMS 17-A X RHA 271) respectively. Studies conducted by Sawant *et al.* (2007), Sujatha and Reedy (2009) have observed sufficient heterosis for this trait.

5.5.7 Seed yield per plant (g)

For seed yield, heterosis over better parent ranged from 19.76% (DV 10 X HRHA 4-2) to 108.00% (CMS 207 A X RHA 297) and over standard check ranged from 14.42% (DV 10 X HRHA 4-2) to 60.01% (CMS 17 A X RHA 297) in E₁ as presented in table 4.36. In E₂, heterosis over better parent varied from 13.46% (CMS 17 -A X HRHA 4-2) to 112.92% (CMS 852 A X RHA 297) and over standard check ranged from -1.00% (CMS 607 A X HRHA 5-3) to 30.10% (CMS 11 A X RHA 297) whereas heterosis over better parent ranged from 22.59% (CMS 44 A X RHA 271) to 159.22% (CMS 103 AX HRHA 4-2) and over standard parent from 2.01% (CMS 44 A X RHA 271) to 51.55% (CMSH 91 A X 6D-1) in E₃ for seed yield per plant. In E₄, heterosis ranged from -0.88% (CMS 44 A X RHA 271) to 162.64% (CMS 44 A X HRHA 4-2) and over standard check it ranged from -17.51% (CMS 44 A X RHA 271) to 55.91% (CMS 207 A X HRHA 5-3) whereas, over the environments heterosis over better parent varied from 31.17% (CMS 44 A X RHA 271) to 111.18% (CMS 302 A X HRHA 4-2) and over standard check from 5.15% (CMS 44 A X RHA 271) to 38.55% (CMS 207 A X HRHA 5-3). High degree of heterosis (more than 100 %) for seed yield was reported by Limbore *et al* (1998) and Lande *et al* (1998) in sunflower. Naware

(1999) noticed highest standard heterosis to the extent of 85.63 per cent in the hybrid 302 A x SS-56. Higher standard heterosis for seed yield per plant also have been reported by Habib *et al.* (2007) and Khan *et al.* (2008).

5.5.8 Oil content (%)

In E_1 heterosis ranged from -2.33% (ARG 2A X 6D-1) to 42.54% (CMS 207 A X RHA 271) and 13.18% (CMS 103 A X 6D-1) to 27.28% (CMS 207 A X RHA 297) over better parent and over standard check respectively whereas in E_2 heterosis over better parent varied from 7.70% (CMSH 91 A X RHA 297) to 49.17% (ARG 6A X 6D-1) and over standard check varied from -9.60% (CMS 607 AX HRHA 4-2) to 1.38% (ARG 6A X 6D-1). In E_3 heterosis over better parent and standard check ranged from -27.93% (ARG 6 A X RHA 297) to -6.23% (CMS 207 A X 6D -1) and from -3.67% (ARG 2A X RHA 271) to 9.27% (CMS 207 A X 6D -1) respectively for oil content. In E_4 , heterosis over better parent ranged from -29.28% (ARG 6 A X RHA 297) to -6.51% (CMS 11 A X HRHA 5-3) and over standard check from -7.41% (CMS 148 AX HRHA 5-3) to 4.38% (CMS 207 A X 6D -1) whereas over all the environments heterosis ranged from -11.73% (CMS 234 A X HRHA 4-2) to 8.67% (CMS 207 A X HRHA 5-3) and from -0.44% (CMSH 91 A X RHA 297) to 6.63% (CMS 207 A X 6D -1) over better parent and standard check respectively, for oil content. A varying degree of negative heterosis for oil content was noticed over better parent and over standard check. Similar results were reported by several workers viz., Gill and Punia (1996), Harini (1992), Kumar *et al.* (1999) and Alone *et al.* (2003). Higher heterosis for oil content has earlier been reported by Devi *et al.* (2005), Kaya (2005a) and Sujatha and Reddy (2009).

5.5.9 Hull content (%)

For hull content in E_1 , heterosis over better parent ranged from -9.03% (CMS 148 A X 6D-1) to 90.10% (CMS 852 A X RHA 297) and over standard check varied from -4.46% (CMS 852 A X 6D -1) to 50.59% (DV 10 X RHA 271) whereas in E_2 heterosis ranged from -53.71% (CMS 11 A X HRHA 5-3) to 104.53% (CMS 302 A X RHA 297) over better parent and heterosis ranged from -50.05% (CMS 11 A X HRHA 5-3) to 68.61% (CMS 607 AX RHA 271) over standard check. In E_3 , heterosis over better parent ranged from -26.60% (CMS 17 -A X HRHA 5-3) to 108.14 (ARG 6A X 6D-1) over standard check varied from -32.01 (CMS 207 A X 6D -1) to 20.14% (CMS 234 A X HRHA 4-2) whereas, in E_4 heterosis ranged from -53.63% (CMS 148 A X HRHA 5-3) to 120.81% (ARG 6A X 6D-1) over better parent and from -48.73% (CMS 148 A X HRHA 5-3) to 41.56% (ARG 2A X HRHA 4-2) over standard check. In pooled analysis, heterosis ranged from -10.87% (CMS 148 A X HRHA 5-3) to 75.08% (ARG 6A X 6D-1) and from -6.23% (CMS 207 A X 6D -1) to 33.52% (DV 10 X HRHA 4-2) over better parent and standard check respectively.

5.5.10 Percent seed filling

For percent seed filling in E_1 , heterosis over better parent ranged from 0.42% (DV 10 X 6D -1) to 131.16% (CMS 607 A X 6D-1) and over standard check ranged from -10.84% (DV 10 X 6D -1) to 58.89% (ARG 3A X RHA 297) whereas in E_2 heterosis ranged from 21.84% (CMS 17-A X 6D-1) to 159.10% (CMS 44 A X 6D-1) over better parent and heterosis ranged from 26.47% CMS 17-A X 6D-1 to 51.21% CMS 103 AX HRHA 5-3 over standard check. In E_3 , heterosis over better parent ranged from -50.76% (CMS 103 A X RHA 297) to 104.50% (ARG 3A X RHA 271) over standard check varied from -44.97% (CMS 103 A X RHA 297) to 51.97% (CMS 44 A X RHA 297) whereas, in E_4 heterosis ranged from -46.78% (CMS 103 AX HRHA 5-3) to 105.59% (CMS 852 A X 6D -1) over better parent and from -19.34% (CMS 103 AX HRHA 5-3) to 125.51% (CMS 11 A X HRHA 5-3). Over the environments, heterosis over better parent and standard check ranged from 1.63% (CMS 17 - A X HRHA 4-2) to 110.07% (CMS 44 A X 6D-1), 23.45% (CMS 607 A X RHA 297) to 61.69% (ARG 6 A X RHA 297) respectively. Ahire *et al.* (1994) recorded highest heterosis in cross EC 42283 x EC 75270 and EC 73260 x EC 68414 for seed filled percent. Burali and Jadhav (2001) and Dudhe (2004) also reported the comparable results with present investigation.

5.5.11 Germination (%)

In E_1 , heterosis for germination over better parent ranged from -21.89% (DV 10 X 6D -1) to 66.53% (CMS 234 A X RHA 297) and over standard check heterosis ranged from 4.70% (DV 10 X 6D -1) to 48.63% (CMS 207 A X 6D -1). In E_2 heterosis ranged from -25.88% (CMS 207 A X RHA 271) to 91.88% (CMS 234 A X RHA 297) over better parent and heterosis over standard check varied from -2.81% (CMS 207 A X RHA 271) to 47.65% (ARG 6A X HRHA 5-3) whereas in E_3 heterosis ranged from -60.85% (CMS 103 AX HRHA 5-3) to 54.41% (CMS 234 A X RHA 297) and from -52.04% (CMS 103 AX HRHA 5-3) to 29.56% (ARG 6A X HRHA 5-3) over better parent and standard check. In E_4 heterosis over better parent ranged from -61.93% (CMS 103 AX HRHA 5-3) to 51.26% (CMS 234 A X RHA 297) and over standard check varied from -45.68% (CMS 103 AX HRHA 5-3) to 51.35% (CMS 148 AX HRHA 4-2). In pooled analysis, heterosis ranged from -28.80% (CMS 302 A X HRHA 4-2) to 65.21% (CMS 234 A X RHA 297) over better parent and from -5.30% (CMS 302 A X HRHA 4-2) to 40.45% (CMS 852 A X 6D -1) over standard check for this trait.

5.5.12 Electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$)

Heterosis for electrical conductivity over better parent ranged from -72.32% (CMS 148 AX RHA 271) to 43.43% (CMSH 91 A X HRHA 4-2) and over standard check from -68.49% (CMS 148 AX RHA 271) to 40.49% (DV 10 X 6D -1) in E_1 whereas, in E_2 heterosis

ranged from -76.68% (CMS 607 A X RHA 297) to 41.78% (DV 10 X HRHA 5-3) over better parent and ranged from -64.50% (CMS 607 A X RHA 297) to 30.11% (DV 10 X HRHA 5-3) over standard check. In E₃, heterosis over better parent ranged from -81.10% (CMS 607 AX HRHA 4-2) to 122.38% (CMS 302 A X HRHA 4-2) and over standard check varied from -65.72% (CMS 607 AX HRHA 4-2) to 160.19% (CMS 148 A X RHA 297). In E₄ heterosis over better parent and over standard check ranged from -90.39% (CMS 44 A X 6D-1) to 100.84% (CMS 17-A X RHA 271) and from -94.37% (CMS 44 A X 6D-1) to 22.36% (CMS 17-A X RHA 271) respectively. Over all the environments, heterosis ranged from -67.80% (CMS 17 A X RHA 297) to 55.10% (CMS 103 A X HRHA 5-3) and from -56.70% (CMS 148 AX RHA 271) to 279% (CMS 234 A X 6D-1) over better parent and over standard check respectively.

5.5.13 Viability (%)

For viability in E₁, heterosis over better parent ranged from -18.20% (DV 10 X 6D -1) to 78.56% (CMS 234 A X RHA 297) and over standard check varied from 3.75% (DV 10 X 6D -1) to 53.15% (CMS 302 A X HRHA 4-2) whereas, in E₂ heterosis ranged from -23.68% (CMS 207 A X RHA 271) to 102.67% (CMS 234 A X RHA 297) over better parent and ranged from 16.38% (CMS 207 A X RHA 271) to 77.06% (CMS 148 A X RHA 297) over standard check. In E₃, heterosis over better parent ranged from -59.15% (CMS 103 AX HRHA 5-3) to 70.80% (CMS 234 A X RHA 297) and over standard check -37.77% (CMS 607 A X RHA 297) to 69.79% (ARG 6A X HRHA 5-3) whereas, in E₄ heterosis over better parent ranged from -60.02% (CMS 103 AX HRHA 5-3) to 83.27% (CMS 234 A X RHA 297) and over standard check from -47.06% (CMS 103 AX HRHA 5-3) to 44.87% (CMS 207 A X RHA 297). In pooled analysis, heterosis ranged from -24.90% (CMS 103 AX HRHA 5-3) to 83.65% (CMS 234 A X RHA 297) over better parent and from 5.93% (CMS 607 A X RHA 297) to 55.65% (CMS 148 A X 6D-1) over standard check.

5.5.14 Vigour index –I

In E₁, heterosis for vigour index – I ranged from -6.28% (CMS 148 AX RHA 271) to 60.26% (CMS 103 A X 6D-1) and from 10.96% (CMS 148 A X RHA 271) to 51.53% (CMS 302 A X HRHA 4-2) over better parent and over standard check respectively, however, heterosis over better parent ranged from 4.13% (CMS 207 A X HRHA 4-2) to 74.38% (CMS 11 A X 6D-1) and over standard check varied from 3.55% (DV 10 X HRHA 5-3) to 74.00% (CMS 11 A X 6D-1) in E₂. However, in E₃ and E₄ heterosis varied from -59.27% (CMS 148 A X RHA 297) to 36.71% (CMS 207 A X RHA 297), from -77.79 (ARG 3A X RHA 271) to 61.38% (CMS 234 A X HRHA 4-2) over better parent and from -50.04% (CMS 148 A X RHA 297) to 46.83% (CMS 207 A X RHA 297), from -10.86% (CMS 17-A X RHA 271) to 60.80% (CMS 11 A X RHA 297) over standard check respectively. Over the environments,

heterosis over better parent ranged from -42.39% (ARG 3A X RHA 271) to 46.87% (CMS 11 A X RHA 297) and over standard check -5.25% (CMS 148 A X RHA 297) to 39.99% (CMS 11 A X HRHA 5-3).

5.5.15 Vigour index –II

Heterosis for vigour index –II over better parent ranged from -8.12% (ARG 3A X HRHA 4-2) to 174.20% (CMS 234 A X RHA 297) and over standard check from -31.24 % (ARG 3A X HRHA 4-2) to 74.42% (CMS 103 A X RHA 271) in E_1 whereas, in E_2 heterosis ranged from 2.25% (CMSH 91 A X RHA 271) to 256.41% (CMS 852 A X HRHA 4-2) over better parent and heterosis ranged from -54.22% (CMSH 91 A X RHA 271) to 18.46% (ARG 6A X HRHA 5-3) over standard check. In E_3 , heterosis over better parent ranged from -29.59% (CMS 607 A X 6D-1) to 170.50% (CMS 207 A X RHA 271) and over standard check varied from -65.70% (CMS 607 A X 6D-1) to 39.04% (CMS 103 A X 6D-1) In E_4 heterosis over better parent and over standard check ranged from -53.34% (ARG 3A X HRHA 4-2) to 121.16% (CMS 234 A X RHA 297) and from -29.79% (CMS 852 A X 6D -1) to 188.53% (CMS 17 A X RHA 297) respectively. Over all the environments, heterosis ranged from -3.44% (CMS 148 A X RHA 297) to 149.07% (CMS 234 A X HRHA 4-2) and from -34.82% (ARG 2A X HRHA 5-3) to 34.06% (CMS 103 A X 6D-1) over better parent and over standard check respectively.

5.5.16 Palmitic acid (%)

In E_1 and E_2 heterosis for palmitic acid over better parent varied from -49.01% (ARG 6A X HRHA 4-2) to 48.69% (CMS 207 A X RHA 297) and from -36.03% (ARG 6A X 6D-1) to 117.99% (CMS 207 A X RHA 297) and heterosis over standard check varied from -43.27% (ARG 6A X HRHA 4-2) to 47.94% (CMS 207 A X RHA 297), and from -12.42% (ARG 6A X 6D-1) to 190.06% (CMS 207 A X RHA 297) respectively. In E_3 , heterosis over better parent ranged from -31.10% (CMS 11 A X RHA 297) to 151.74% (CMS 207 A X HRHA 4-2) and heterosis over standard check varied from -8.87% (CMS 44 A X HRHA 5-3) to 209.75% (CMS 207 A X HRHA 4-2) whereas, in E_4 heterosis over better parent ranged from -28.81% (CMS 11 A X 6D-1) to 158.74% (CMS 207 A X HRHA 4-2) and over standard check from -46.83% (CMS 11 A X RHA 297) to 87.34% (CMS 207 A X HRHA 4-2). In pooled analysis, heterosis ranged from -14.64 (CMS 302 A X HRHA 5-3) to 82.53% (CMS 207 A X HRHA 4-2) over better parent and -12.45% (CMS 44 A X RHA 297) to 82.15% (CMS 207 A X HRHA 4-2) over standard check. Heterosis for palmitic acid has been recorded by Lokendrakumar *et al.* (1998), Singh *et al.* (2002) and Giriraj and Nagaraj (2003).

5.5.17 Stearic acid (%)

For stearic acid heterosis over better parent and over standard check ranged from -47.18% (CMS 17 -A X HRHA 4-2) to 111.95% (ARG 3A X RHA 297) and -27.81% (CMS

17 -A X HRHA 4-2) to 182.59% (ARG 3A X HRHA 5-3) respectively, in E₁. while in E₂ and E₃ heterosis over better parent ranged -60.55% (ARG 6A X 6D-1) to 139.15% (ARG 3A X RHA 271) and from -71.64% (CMS 207 A X HRHA 4-2) to 82.25% (CMSH 91 A X 6D-1) and heterosis over standard check varied from -60.17% (ARG 6A X 6D-1) to 163.05% (ARG 3A X RHA 271) and from -10.25% (CMS 207 A X HRHA 4-2) to 183.33% (CMSH 91 A X 6D-1) respectively. In E₄ heterosis over better parent ranged from -74.08% (CMS 207 A X HRHA 4-2) to 87.80% (CMSH 91 A X 6D-1) and over standard check ranged from -58.03% (CMS 207 A X HRHA 4-2) to 101.07% (ARG 2A X RHA 271). Over all the environments, heterosis ranged -58.03% (CMS 207 A X HRHA 4-2) to 66.35% (CMS 234 A X RHA 297) over better parent and heterosis varied from -12.47% (CMS 207 A X HRHA 4-2) to 101.07% (ARG 2A X RHA 271) over standard check. The similar results were observed by Lokendrakumar *et al.* (1998) and Singh *et al.* (2002).

5.5.18 Oleic acid (%)

For oleic acid in E₁, heterosis over better parent ranged from -66.63% (CMS 148 AX HRHA 4-2) to 41.37% (ARG 2A X HRHA 4-2) and over standard check ranged from -25.87% (CMS 148 A X HRHA 4-2) to 203.78% (ARG 2A X HRHA 4-2). In E₂, heterosis ranged from -69.41% (CMS 234 A X 6D-1) to 52.30 (ARG 6A X HRHA 4-2) over better parent and heterosis ranged from -29.27% (CMS 234 A X 6D-1) to 193.13% (ARG 6A X HRHA 4-2) over standard check. In E₃, heterosis over better parent ranged from -14.07% (CMS 103 A X 6D-1) to 44.27% (CMSH 91 A X HRHA 4-2) and over standard check ranged from 0.50% (CMS 103 A X 6D-1) to 69.45% (ARG 2A X RHA 297) whereas in E₄, heterosis ranged from -20.89% (ARG 2A X HRHA 5-3) to 54.12% (CMSH 91 A X HRHA 4-2) over better parent and heterosis varied from 5.79% (ARG 3A X RHA 297) to 88.78% (CMSH 91 A X HRHA 4-2) over standard check. In pooled analysis, heterosis over better parent ranged from -23.11% (CMS 148 A X HRHA 4-2) to 23.11% (CMS 234 A X HRHA 4-2) and over standard check heterosis varied from 7.81% (CMS 148 A X HRHA 4-2) to 69.16% (CMS 234 A X HRHA 4-2). Significant heterosis for oleic acid has been reported by Skoric *et al.* (1978), Baldani *et al.* (1991), Shekar *et al.* (1998), Singh *et al.* (1999) and Giriraj and Nagaraj (2003) in various studies.

5.5.19 Linoleic acid (%)

For linoleic acid heterosis over better parent ranged from -35.77% (ARG 2A X 6D-1) to 89.70% (CMS 302 A X HRHA 4-2) and over standard check from -13.33% (CMS 607 AX HRHA 4-2) to 85.51% (CMS 148 AX HRHA 4-2) in E₁ whereas, in E₂ heterosis ranged from -35.97% (CMS 103 A X RHA 297) to 40.66% (CMS 207 A X RHA 297) over better parent and heterosis over standard check varied from -16.39% (CMS 234 A X 6D-1) to 73.54% (CMS 44 A X RHA 297). In E₃ and E₄, heterosis over better parent ranged from -70.07%

(CMSH 91 A X HRHA 4-2) to 63.06% (CMS 17 A X RHA 297) and from -66.97% (CMSH 91 A X HRHA 4-2) to 129.69% (CMS 17 A X RHA 297) while over standard check -63.47% (CMSH 91 A X HRHA 4-2) to 57.57% (CMS 302 A X HRHA 5-3), and -62.89% (CMSH 91 A X HRHA 4-2) to 58.34% (CMS 302 A X HRHA 5-3) respectively. Over the environments heterosis over better parent ranged from -24.21% (CMSH 91 A X HRHA 4-2) to 43.97% (CMS 17 A X RHA 297) and over standard check from -1.81% (CMSH 91 A X HRHA 4-2) to 61.78% (ARG 2A X HRHA 5-3).

Heterosis for this trait has been reported earlier by Lokendrakumar *et al.* (1998), Rather *et al.* (1999), Singh *et al.* (1999) and Giriraj and Nagaraj (2003).

The fatty acid biosynthesis pathway shows the formation of palmitic acid-stearic acid-oleic acid-linoleic acid in which oleic acid is the precursor of linoleic, the unsaturated fatty acid as it is formed in subsequent pathway. Correlation between oleic and linoleic acid has been found to be negative and highly significant (Singh *et al.* 2002). Due to such association among these traits, as oleic acid increases linoleic acid decreases.

Similar result were reported by Giriraj *et al.* (1986), Goksoy *et al.* (2000) Nehru *et al.* (2000), Seetharam *et al.* (2001), Gill and Sheoran (2002), Khan *et al.* (2004), Goksoy and Turan (2004), Kaya (2005a), Khan *et al.* (2008), Karasu *et al.* (2010) and Deshmukh *et al.* (2016).

5.6 Implication in future breeding programme

The ultimate objective of this investigation was to identify the better parental lines and testers and promising hybrids for the improvement of seed yield per plant (g) and its component traits and oil content (%) and its quality through further hybrid development programmes for breaking the present yield ceiling in sunflower.

From the table (5.1): the seed parents (CMS 207 A, CMS 148 A, CMSH 91 A and CMS 17A) and pollen parents (RHA 271 and HRHA 5-3) were found to be better performing and good general combiner for both seed yield and oil content in different environments and over all the environments.

On the basis of specific combining ability, heterosis and stability, the common hybrids namely CMS 207 A x HRHA 5-3, CMS 852 A x RHA 271, CMS 207 A x RHA 297, CMS 234 A x 6D-1 and CMS 207 A x 6D-1 can be selected for future breeding program as they had good *per se performance*, *gca* and *sca*, better heterosis and stability over all the environments and in E₁, E₂, E₃, E₄. The hybrids with good heterotic value, good *gca*, good *sca*, and better value of stability could be directly used for heterosis breeding because of their dominant nature. The use of genotypes identified in present study in hybridization from these results is likely to produce more heterotic combinations in future sunflower hybrid breeding programs and/or better populations for high yielding composites.

The present study can be regarded as holistic as all important aspects of breeding including parameters of variability, heritability and genetic advance, genetic divergence, combining ability and heterosis have been studied over different environments reflecting growing environments in different agro-ecological regions of Haryana and/or elsewhere. The high yielding stable hybrids revealing high heterosis over standard check may be included in station yield trials for their comparative performance. Likewise heterotic hybrids involving high general combining ability parents may be used for developing improved population by exploiting complementary gene action causing heterosis for development of improved composites or developing better inbred lines. The present studies, therefore, can be regarded as stepping stone for academic and material gains.

Table 5.1: Summary of superior hybrids and parents and promising selected hybrids on the basis of GCA, SCA, heterosis and stability

Superior hybrids and parental lines for the seed yield and its contributing traits and oil content over the env. and different environments (E_1 , E_2 , E_3 , E_4) in sunflower	
GCA	CMS 207 A, CMS 148 A, CMSH 91 A, CMS 17A, HRHA 5-3, RHA 271
SCA	CMS 207 A x HRHA 5-3, CMS 207 A x RHA 297, CMS 852 A x RHA 271, ARG 6A x HRHA 5-3, CMS 103 A x RHA 27
HETROSIS	CMS 44A x HRHA 4-2, CMS 234 A x 6D-1, CMS 103 A x HRHA 4-2, CMS 17 A x RHA 297, CMS 207A x 6D-1, CMS 207 A x RHA 297, CMS 207 A x HRHA 5-3, ARG 6A x RHA 297
STABILITY	CMS 207 A x RHA 271, CMS 852 A x RHA 271, CMS 207 A x 6D-1, CMS 207 A x HRHA 5-3.

CHAPTER-VI

SUMMARY AND CONCLUSION

The present investigation entitled “**Studies on genetic divergence, stability, heterosis and combining ability in sunflower (*Helianthus annuus* L.)**” was undertaken to estimate genetic divergence, heterosis, combining ability and $G \times E$ interactions using parents and hybrids.

The crosses were made during the *spring* (February) season of the year 2014. Hybrids and parents were evaluated during *summer* (September) 2014. All the seventy five hybrids and standard check (HSFH 848) along with twenty parents were grown in randomized block design with two row plot of 4.0 m length in three replications under four environment *i.e.*, Summer 2014 *i.e.* last week of August (E_1) and First week of September (E_2) and during 2015, *i.e.*, first week of February (E_3) and Last week of August (E_4). The recommended cultural package of practices was followed to raise a healthy crop.

Data on five randomly selected plants from each replication on each genotype were recorded on different quantitative characters *viz.*, days to 50% flowering, days to maturity, plant height (cm), head diameter (cm), stem diameter (cm), 100 seed weight (g), seed yield per plant (g), oil content (%), hull content (%), percent seed filling, germination (%), electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$), viability (%), seedling vigour index I, seedling vigour index II, palmitic acid (%), stearic acid (%), oleic acid (%) and linoleic acid (%) in all the four test environments.

- ❖ The analysis of variance for all the morphological and quality characters revealed that the mean sum of squares due to genotypes were highly significant for nineteen parameters in all the four test environments indicating the existence of sufficient variability among the genotypes for all the traits studied.
- ❖ For seed yield per plant, high GCV (%) were observed in E_3 (22.01%) and E_4 (23.17%) and moderate estimate in E_1 (17.66%) and E_2 (17.57%), whereas high PCV (%) recorded in E_3 (22.97%) and E_4 (23.72%). High estimate of heritability observed in E_3 (91.79%) and E_4 (95.39%) with high expected genetic advance *as per cent* mean in these environments.
- ❖ For oil content, high GCV were observed in E_2 (10.67 %) and E_3 (9.71%), along with high estimate of PCV in E_2 (11.57%) and E_3 (10.46%). High estimate of heritability in E_4 (86.98%) and high estimate of expected genetic advance *as per cent* mean in E_2 (20.27%).
- ❖ Using Mahalanobis D^2 statistics, all the 96 genotypes were grouped into six clusters with cluster IV having the highest number of genotypes (35), whereas, clusters III and II

comprised of less number of genotypes (1 and 5) respectively. The results indicated that the distribution pattern of genotypes in different clusters was random.

- ❖ The intra-cluster distance was recorded highest for cluster I which indicates the existence of maximum variability within this cluster. Lowest intra-cluster distance on the other hand was recorded for cluster IV. Inter-cluster distance was maximum between clusters III and V which indicates that the genotypes included in these clusters are genetically diverse. The minimum inter-cluster distance was observed between clusters IV and V. So, it is desirable to select genotypes from these clusters having high inter-cluster distance for exploitation of heterosis.
- ❖ The cluster means for all the nineteen characters studied in sunflower genotypes revealed considerable differences among all the clusters.
- ❖ Overall comparison indicated that cluster IV, V and VI, had better cluster means for respective characters viz., 100 seed weight (g), head diameter (cm), stem diameter (cm), palmitic acid (%), stearic acid (%), vigour index II, oleic and linoleic acid (%). Therefore, cluster IV, V and VI could be considered while selecting genotypes for further sunflower breeding.
- ❖ Diversity analysis indicates a lot of diversity between these hybrids, which can be exploited in hybrids breeding program
- ❖ On the basis of stability analysis, analysis of variance showed that the mean sum of squares were significant for pooled analysis when tested against pooled deviation, which revealed that the hybrids had significant differences in response to pooled conditions.
- ❖ For seed yield and oil content, among parents CMS 148A, ARG 2A and CMS 607A and among hybrids CMS 207 A x HRHA 5-3, CMS 207 A x RHA 271, CMS 207 A x 6D-1 were found stable having higher mean value with significant regression coefficient and non significant regression from deviation line. Hybrids CMS 11A x RHA 271, CMS 148 A x RHA 271, CMS 302 A x HRHA 5-3, CMS 234A x RHA 271 and parents CMS 207 A , HRHA 5-3 with lower mean value, above average stability to environment ($b < 1$) with non significant deviation from regression line. Therefore, these observed the stable performance in favorable environments, whereas, the parents RHA 4-2, CMS 607 A, CMS 148 A and hybrids, CMS 852A x RHA 271, CMS 852 A x 6D-1, ARG 3A x HRHA 5-3, CMS 302 A x 6D-1, CMS 44A x RHA 271 had maximum mean, below standard stability to environments ($b > 1$) and non-significant deviation from regression line, thus, these genotypes were more stable in poor environments.
- ❖ The mean sum of square due to partitioning of components of treatments viz., parents, hybrids, lines, testers and line x testers were found highly significant for all the traits

studied except electrical conductivity individually as well as jointly. This indicates that selected experimental material had sufficient genetic variation for all seed yield and its components characters.

- ❖ Parents CMS 207 A, CMS 148 A, CMSH 91 A and CMS 17A (female) and pollen parents RHA 271 and HRHA 5-3 observed highest GCA effect for seed yield and its component traits. These results indicated that good general combiner parents could be efficiently used for exploiting seed yield in future breeding program.
- ❖ On the basis of SCA effects over all the environment and in E_1 , E_2 , E_3 , E_4 , the top performing crosses were namely, CMS 852 A x RHA 271, CMS 207A x HRHA 5-3, CMS 103A x RHA 271, CMS 207A x RHA 297, ARG 6 A x HRHA 5-3 and which have high heterotic effect for seed yield and its related traits which indicates that high significant heterosis is mainly due to non additive gene action.
- ❖ The ratio of σ^2 GCA/ σ^2 SCA was less than unit, for all the characters indicating that these traits were mainly under the control of non-additive gene action. So, one can go for hybrid breeding for exploitation of heterosis.
- ❖ Further, the parents involved in the crosses containing low value of SCA can be used as inbred line in the development of synthetic varieties.
- ❖ On the basis of heterosis, the mean sums of square due to replications were found significant for four different environments which emphasis presence of variations in the environment. The mean sum of square due to partitioning component-parents, males, females, hybrids, location, hybrid x location, (parent vs. hybrid) x location were found significant for seed yield and its component characters except female vs. male for electrical conductivity.
- ❖ Approximately, all the hybrids were found significant for all traits studied, though some of the hybrids showed higher and positive heterosis for seed yield and oil content. The cross combinations, viz., CMS 44A x HRHA 4-2, CMS 207A x HRHA 5-3, CMS 207A x RHA 297, CMS 207 A x RHA 271, CMS 302A x HRHA 4-2, CMS 234A x 6D-1, CMS 17A x RHA 297 and ARG 6A x RHA 297 were significant and exhibited higher heterosis over all the environments and in E_1 , E_2 , E_3 , E_4 that can be used for further breeding programs.
- ❖ On the basis of specific combining ability, heterosis and stability, the common hybrids namely CMS 207 A x HRHA 5-3, CMS 852 A x RHA 271, CMS 207 A x RHA 297, CMS 234 A x 6D-1 and CMS 207 A x 6D-1 could be selected for future breeding program because they had good *gca* and *sca*, better heterosis and stability over the test environment and spring season.

- ❖ The hybrids with good heterotic value, good GCA, SCA, and better value of stability could be directly used for heterosis breeding because of their dominant nature.
- ❖ The use of genotypes in hybridization from these results is likely to produce more heterotic combination in future sunflower breeding program.

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APPENDIX –I

Mean performance of parents and hybrids for morphological traits and seed yield in E₁

Sr.No.	Parents/ Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
1	CMS 11 A	92.37	10.20	3.73	57.67	94.00	4.44	17.90	28.21	36.05	57.73
2	CMS 17 A	102.35	6.90	4.83	60.01	97.35	3.57	16.34	29.39	42.37	66.29
3	CMS 44 A	94.72	10.24	3.76	58.00	88.08	4.36	18.19	28.38	26.72	33.56
4	CMS 148 A	98.02	11.38	3.35	58.68	100.00	5.48	20.64	33.91	47.68	61.55
5	CMSH 91 A	78.01	11.49	4.35	60.33	94.01	4.55	17.23	29.03	32.70	59.30
6	CMS 103 A	86.03	9.37	3.51	56.15	96.38	4.52	18.13	31.10	31.81	52.51
7	CMS 234 A	88.10	8.32	3.69	55.13	90.03	3.50	16.02	27.74	35.35	58.31
8	CMS 302 A	106.79	7.93	3.37	56.80	94.33	4.56	15.06	29.41	27.38	42.56
9	CMS 607 A	103.02	9.60	3.48	55.82	86.66	4.47	18.96	38.00	38.67	33.45
10	CMS 852 A	115.33	5.88	4.67	55.68	98.33	5.39	13.82	26.36	28.05	38.06
11	ARG 2-A	74.71	11.49	2.94	58.68	97.35	5.95	20.52	38.05	40.69	46.31
12	ARG 3-A	80.70	9.89	3.54	60.02	100.00	3.57	18.07	30.91	37.01	38.32
13	ARG 6-A	107.67	6.61	4.44	55.04	98.35	4.81	14.89	28.59	29.20	33.49
14	DV -10	87.44	10.88	3.56	55.35	99.11	3.81	20.16	32.62	46.73	54.27
15	CMS 207 A	112.33	6.29	4.45	60.00	95.36	3.55	14.23	27.93	38.68	55.92
16	6D-1	105.01	8.95	3.72	57.02	90.33	5.11	18.38	33.37	40.29	39.68
17	RHA 271	94.24	9.26	3.56	58.02	95.00	5.24	16.11	28.18	37.00	62.84
18	RHA 4-2	70.26	11.29	2.89	60.37	98.00	5.52	19.67	38.06	44.70	63.27
19	HRHA 5-3	85.56	9.21	3.50	54.03	87.02	4.56	15.79	29.67	37.67	58.27
20	RHA 297	104.67	6.76	4.39	55.16	95.08	4.36	15.00	28.94	31.65	44.23
21	CMS 11 A x 6D-1	84.87	12.53	5.53	53.50	96.00	6.37	26.31	37.17	50.69	87.74
22	CMS 11 A x RHA 271	95.47	10.93	5.37	54.13	92.00	7.43	26.25	37.97	53.10	85.11
23	CMS 11 A x HRHA 4-2	94.93	12.80	5.23	52.63	91.50	6.47	25.76	37.97	52.59	84.15
24	CMS 11 A x HRHA 5-3	95.73	14.33	5.93	53.23	93.00	8.03	28.07	36.83	52.55	88.67
25	CMS 11 A x RHA 297	96.00	12.53	5.63	53.50	92.50	6.57	31.01	38.37	46.45	89.71
26	CMS 17-A x 6D-1	98.40	16.87	5.47	53.53	92.50	6.37	28.90	38.93	53.56	93.11

Sr.No.	Parents/ Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
27	CMS 17-A x RHA 271	96.73	13.73	7.53	54.57	92.50	7.09	29.70	38.27	55.47	92.26
28	CMS 17 -A x HRHA 4-2	98.93	11.73	5.93	53.50	92.50	8.37	28.40	40.00	55.59	92.69
29	CMS 17 -A x HRHA 5-3	91.87	20.67	6.37	53.69	92.00	7.30	29.68	38.70	55.19	92.40
30	CMS 17 A x RHA 297	86.07	12.93	9.10	54.09	96.00	5.67	33.76	38.70	53.89	88.75
31	CMS 44 A x 6D-1	105.47	15.13	5.40	55.50	95.33	7.13	28.49	37.50	55.71	89.48
32	CMS 44 A x RHA 271	75.93	12.73	5.93	54.16	91.67	6.13	29.33	38.93	55.54	90.90
33	CMS 44 A x HRHA 4-2	86.33	13.33	5.27	54.67	92.04	6.98	27.88	39.23	44.17	90.71
34	CMS 44 A x HRHA 5-3	94.40	15.67	5.53	52.83	91.50	5.98	29.88	37.87	45.94	84.83
35	CMS 44 A x RHA 297	89.93	13.20	7.60	54.41	93.18	6.00	31.72	37.93	50.75	91.13
36	CMS 148 A x 6D-1	85.00	13.20	5.80	54.28	93.67	6.87	26.19	38.33	43.38	91.62
37	CMS 148 A x RHA 271	80.07	13.40	5.80	53.51	95.50	7.33	27.29	38.57	48.03	92.07
38	CMS 148 A x HRHA 4-2	90.13	15.67	5.50	53.00	96.50	7.04	29.66	38.60	57.19	93.80
39	CMS 148 A x HRHA 5-3	92.27	11.40	7.97	55.50	93.50	8.07	30.85	37.13	57.73	91.22
40	CMS 148 A x RHA 297	107.53	10.73	6.37	55.43	94.01	7.07	27.10	37.70	49.48	89.75
41	CMSH 91 A x 6D-1	106.27	12.07	5.87	53.50	94.50	6.03	26.67	38.40	48.64	84.99
42	CMSH 91 A x RHA 271	86.93	10.80	5.60	54.56	99.02	6.27	25.88	37.50	44.71	86.61
43	CMSH 91 A x HRHA 4-2	94.80	16.47	7.63	55.23	97.00	7.37	27.85	37.67	51.77	81.26
44	CMSH 91 A x HRHA 5-3	103.93	11.07	6.80	58.68	98.50	8.03	30.86	39.23	50.15	88.51
45	CMSH 91 A x RHA 297	92.87	13.20	7.70	56.57	97.26	6.53	26.51	38.50	53.28	91.62
46	CMS 103 A x6D-1	97.07	11.60	5.33	62.33	97.50	7.57	26.86	36.37	58.42	85.80
47	CMS 103 A x RHA 271	95.20	10.47	5.53	56.56	93.11	6.60	27.38	38.73	61.01	81.77
48	CMS 103 A x HRHA 4-2	107.13	14.00	5.90	57.51	93.65	7.33	26.38	37.33	52.97	84.81
49	CMS 103 A x HRHA 5-3	102.80	11.33	5.23	63.24	93.02	8.67	25.79	37.87	49.06	87.67
50	CMS 103 A x RHA 297	92.27	10.67	5.67	53.58	95.04	7.30	25.10	38.67	52.21	84.80
51	CMS 234 A x 6D-1	100.93	12.07	5.20	52.63	93.03	8.13	25.41	38.13	59.64	85.48
52	CMS 234A x RHA 271	114.73	10.87	6.63	54.73	95.41	6.50	26.40	37.60	53.18	87.84
53	CMS 234 A x HRHA 4-2	86.87	11.20	5.40	53.61	95.69	6.60	25.01	37.83	52.18	90.73
54	CMS 234 A x HRHA 5-3	91.27	14.53	6.13	53.50	94.50	6.73	26.72	37.73	55.13	86.92

Sr.No.	Parents/ Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
55	CMS 234 A x RHA 297	95.73	12.00	7.17	54.34	95.04	8.10	33.18	37.53	47.60	86.80
56	CMS 302 A x 6D-1	104.13	11.00	5.70	53.62	95.04	9.13	27.69	38.13	55.76	87.89
57	CMS 302 A x RHA 271	97.87	12.60	5.53	54.58	95.50	8.10	26.29	38.17	53.49	81.05
58	CMS 302 A x HRHA 4-2	81.33	12.67	6.37	55.11	97.03	7.54	27.34	37.67	61.51	85.71
59	CMS 302 A x HRHA 5-3	92.20	14.40	6.07	53.70	97.50	5.93	26.16	38.17	57.26	92.84
60	CMS 302 A x RHA 297	94.00	12.20	6.83	53.52	97.04	6.77	25.42	38.43	56.94	93.46
61	CMS 607 A x 6D-1	90.73	11.40	6.37	54.39	92.05	6.40	26.40	37.67	57.48	91.72
62	CMS 607 A x RHA 271	90.20	11.93	5.67	54.59	89.08	6.47	27.64	38.43	57.70	86.68
63	CMS 607 A x HRHA 4-2	80.00	11.47	5.60	54.06	97.01	7.97	26.33	38.97	58.23	85.22
64	CMS 607 A x HRHA 5-3	108.73	14.20	5.57	52.13	97.50	7.13	24.97	38.03	61.13	87.61
65	CMS 607 A x RHA 297	91.20	10.87	5.73	52.83	98.50	5.76	28.08	37.40	52.22	81.86
66	CMS 852 A x 6D -1	92.00	10.93	5.37	54.56	99.01	7.10	25.70	37.73	39.22	84.50
67	CMS 852 A x RHA 271	97.33	13.00	6.13	54.55	97.50	6.55	29.32	37.80	45.82	82.80
68	CMS 852 A x HRHA 4-2	96.80	9.20	5.37	54.75	100.04	8.13	24.93	38.53	59.00	88.90
69	CMS 852A x HRHA 5-3	91.00	8.27	4.77	55.41	97.50	6.73	24.55	38.47	59.99	84.84
70	CMS 852 A x RHA 297	99.73	14.07	4.73	55.52	97.71	6.00	24.72	37.43	60.17	78.74
71	ARG 2A x 6D-1	100.20	12.07	6.70	55.12	97.01	6.98	27.39	37.17	56.29	88.57
72	ARG 2A x RHA 271	87.13	14.07	5.30	55.29	97.50	7.97	26.35	38.30	52.83	81.42
73	ARG 2A x HRHA 4-2	97.13	10.20	5.57	55.16	98.50	6.87	26.01	39.87	56.66	85.89
74	ARG 2A x HRHA 5-3	96.40	8.67	4.90	55.20	99.04	6.40	26.40	38.20	51.78	83.00
75	ARG 2A x RHA 297	95.07	8.33	4.90	55.91	100.01	6.80	29.77	39.30	52.02	84.73
76	ARG 3A x 6D -1	97.53	10.73	4.83	57.50	98.01	6.73	27.53	37.83	47.08	84.87
77	ARG 3A x RHA 271	82.87	12.53	5.47	57.56	97.50	7.50	27.03	36.90	48.65	85.88
78	ARG 3A x HRHA 4-2	94.07	12.47	5.47	57.50	96.50	6.20	29.55	39.23	43.81	95.63
79	ARG 3A x HRHA 5-3	85.27	12.07	6.50	57.69	96.08	7.50	27.57	39.63	43.55	96.12
80	ARG 3A x RHA 297	91.00	11.33	6.20	57.45	93.42	7.37	28.36	37.57	45.12	97.11
81	ARG 6A x 6D-1	96.20	13.13	6.40	57.58	92.06	6.19	29.46	38.60	58.88	91.10
82	ARG 6A x RHA 271	82.53	14.47	5.50	64.15	94.50	5.34	27.85	37.47	61.58	93.50

Sr.No.	Parents/ Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
83	ARG 6A x HRHA 4-2	103.47	10.53	5.53	58.09	95.50	7.93	24.70	39.23	55.94	85.86
84	ARG 6A x HRHA 5-3	93.33	11.20	5.43	58.64	95.50	5.20	25.29	40.10	51.25	89.89
85	ARG 6 A x RHA 297	84.47	12.80	6.33	58.64	97.11	6.03	25.88	39.87	53.53	94.73
86	DV 10 x 6D -1	86.13	12.13	6.57	54.61	97.50	5.47	26.11	38.37	52.75	54.49
87	DV 10 x RHA 271	106.07	11.00	5.33	54.59	98.19	7.33	26.22	37.77	61.82	81.03
88	DV 10 x HRHA 4-2	104.40	9.87	5.27	54.59	96.50	5.53	24.14	37.83	61.32	74.14
89	DV 10 x HRHA 5-3	91.60	10.27	4.93	54.17	97.50	5.10	26.88	38.17	61.06	76.02
90	DV -10 x RHA 297	84.93	11.93	4.90	57.58	99.37	5.00	32.13	37.33	60.90	95.30
91	CMS 207 A x 6D -1	93.67	13.47	5.27	62.58	98.50	6.13	31.14	38.67	41.25	92.17
92	CMS 207 A x RHA 271	82.93	13.87	6.83	58.04	98.50	7.03	29.40	40.17	47.78	94.02
93	CMS 207 A x HRHA 4-2	91.47	13.47	6.60	56.78	95.50	7.00	30.26	39.70	53.97	93.48
94	CMS 207 A x HRHA 5-3	99.47	17.80	7.07	63.24	94.41	8.01	31.91	38.80	56.39	90.91
95	CMS 207 A x RHA 297	103.60	15.40	8.87	58.84	93.03	7.13	31.20	40.90	48.74	84.17
96	HSFH 848	99.80	10.53	6.33	54.50	92.00	6.07	21.10	32.13	41.05	61.12
	Mean	94.17	11.77	5.52	55.96	95.33	6.39	25.44	36.69	49.58	79.42
	Range	70.26	5.88	2.89	52.13	86.66	3.50	13.82	26.36	26.72	33.45
		115.33	20.67	9.10	64.15	100.04	9.13	33.76	40.90	61.82	97.11
	SE	1.56	0.93	0.40	1.00	1.21	0.74	2.35	1.42	4.71	3.63
	CDat5%	3.11	1.85	0.79	2.00	2.42	1.47	4.70	2.83	9.40	7.26

Mean performance of parents and hybrids for germination, vigour and fatty acids in E₁

Sr.No.	Parents/ Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
1	CMS 11 A	84.01	0.72	74.00	20034.00	21.07	4.62	4.66	8.62	60.43
2	CMS 17 A	83.70	0.72	72.04	19213.00	20.35	5.29	6.44	31.82	58.74
3	CMS 44 A	82.35	0.68	76.00	20316.67	22.01	4.48	4.60	29.54	55.83
4	CMS 148 A	90.71	0.75	81.71	20014.33	26.38	5.18	5.52	31.15	53.89
5	CMSH 91 A	86.04	0.58	72.68	21078.67	23.04	6.06	4.32	20.14	59.88
6	CMS 103 A	87.05	0.68	80.33	19569.00	26.02	6.24	4.73	23.74	60.69
7	CMS 234 A	47.50	1.03	41.64	18079.00	16.33	6.41	5.16	16.96	36.62
8	CMS 302 A	90.35	0.75	80.00	22344.00	25.38	7.41	6.23	30.38	35.67
9	CMS 607 A	72.95	0.84	62.02	21892.33	12.42	7.37	4.59	25.44	54.46
10	CMS 852 A	71.90	0.79	63.00	19677.33	17.85	6.63	5.76	26.01	52.34
11	ARG 2-A	80.02	0.73	68.33	20768.33	20.96	7.06	6.21	29.45	63.48
12	ARG 3-A	84.13	0.69	74.00	22989.00	25.45	7.47	5.41	28.22	60.50
13	ARG 6-A	92.00	0.80	84.00	18680.00	23.00	6.52	6.63	31.67	61.09
14	DV -10	89.00	0.74	78.69	20588.67	18.49	7.32	5.54	25.30	50.26
15	CMS 207 A	81.21	0.82	71.35	18125.00	22.56	6.31	8.13	18.71	54.80
16	6D-1	84.02	0.27	74.00	20423.00	19.52	6.20	4.34	28.04	55.24
17	RHA 271	88.25	0.39	84.00	22328.67	21.82	5.51	3.58	34.14	51.85
18	RHA 4-2	81.22	0.44	74.00	18106.33	16.62	7.38	5.55	30.13	32.53
19	HRHA 5-3	81.03	0.54	73.00	21767.33	19.38	4.50	8.48	30.42	52.31
20	RHA 297	54.24	1.24	48.48	19358.67	13.52	6.60	4.59	34.13	61.33
21	CMS 11 A x 6D-1	95.25	0.44	93.08	27790.00	37.40	6.77	6.55	23.43	73.71
22	CMS 11 A x RHA 271	83.08	0.28	92.69	29021.33	36.72	6.10	4.10	22.55	66.80
23	CMS 11 A x HRHA 4-2	89.34	0.35	86.15	28086.00	27.89	7.80	5.34	19.04	67.61
24	CMS 11 A x HRHA 5-3	93.92	0.54	86.70	30479.33	30.37	6.80	5.10	19.87	68.46
25	CMS 11 A x RHA 297	94.05	0.63	86.17	27724.33	35.71	7.48	5.82	14.70	70.49

Sr.No.	Parents/ Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
26	CMS 17-A x 6D-1	96.33	0.43	92.95	28413.67	38.76	6.21	6.20	18.76	69.25
27	CMS 17-A x RHA 271	94.70	0.52	91.67	29748.67	24.25	6.99	6.13	19.19	68.65
28	CMS 17 -A x HRHA 4-2	94.01	0.52	91.70	28303.33	37.07	7.26	3.40	36.63	52.30
29	CMS 17 -A x HRHA 5-3	96.86	0.79	92.47	25122.00	38.84	5.88	5.54	13.96	74.44
30	CMS 17 A x RHA 297	93.51	0.66	90.70	27812.67	36.93	6.19	5.58	19.48	68.63
31	CMS 44 A x 6D-1	96.06	0.55	86.11	26389.33	30.61	7.81	6.36	11.79	73.36
32	CMS 44 A x RHA 271	95.45	0.72	93.05	27610.00	39.84	5.18	5.02	13.97	74.40
33	CMS 44 A x HRHA 4-2	93.38	0.68	91.82	29320.67	43.95	6.87	5.76	18.77	69.22
34	CMS 44 A x HRHA 5-3	94.40	0.66	89.63	31719.00	30.00	6.53	5.26	15.03	72.35
35	CMS 44 A x RHA 297	94.40	0.47	91.83	26345.33	31.20	5.73	4.10	29.39	60.54
36	CMS 148 A x 6D-1	93.29	0.32	91.89	21156.67	42.39	5.89	3.72	31.22	59.64
37	CMS 148 A x RHA 271	95.49	0.21	93.52	20925.67	34.98	6.02	4.07	38.59	49.56
38	CMS 148 A x HRHA 4-2	94.70	0.36	91.71	23663.67	39.23	7.20	4.24	10.39	78.40
39	CMS 148 A x HRHA 5-3	92.43	0.50	89.82	25163.00	34.79	6.71	5.01	20.16	66.59
40	CMS 148 A x RHA 297	91.85	0.51	88.53	22932.00	29.41	6.08	5.72	13.55	72.59
41	CMSH 91 A x 6D-1	90.11	0.57	89.66	24877.33	32.29	6.41	4.18	16.59	70.66
42	CMSH 91 A x RHA 271	91.45	0.62	85.11	24977.67	28.37	6.43	5.64	12.03	75.73
43	CMSH 91 A x HRHA 4-2	79.21	0.84	80.09	24243.33	39.44	6.20	5.37	13.24	77.80
44	CMSH 91 A x HRHA 5-3	92.83	0.78	82.85	22273.67	45.80	6.42	5.22	12.68	74.30
45	CMSH 91 A x RHA 297	94.39	0.65	89.42	26364.00	50.13	6.71	5.09	16.66	70.21
46	CMS 103 A x 6D-1	94.08	0.83	90.82	32730.33	50.29	6.26	5.16	14.30	76.58
47	CMS 103 A x RHA 271	96.34	0.83	92.49	28855.33	59.30	7.50	6.10	12.47	72.41
48	CMS 103 A x HRHA 4-2	96.33	0.74	94.17	27852.67	49.30	7.00	6.33	14.71	73.54
49	CMS 103 A x HRHA 5-3	92.38	0.70	91.11	26569.67	34.39	7.47	5.26	15.41	70.53
50	CMS 103 A x RHA 297	95.46	0.77	89.57	28391.33	27.72	8.33	6.64	36.51	46.76
51	CMS 234 A x 6D-1	94.38	0.76	83.28	27025.67	29.07	8.10	6.19	31.19	55.77

Sr.No.	Parents/ Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
52	CMS 234A x RHA 271	97.06	0.70	88.22	27360.00	42.81	8.37	5.11	20.73	63.46
53	CMS 234 A x HRHA 4-2	94.94	0.64	92.11	28035.67	42.78	6.80	4.88	33.35	43.20
54	CMS 234 A x HRHA 5-3	92.00	0.68	89.35	25192.33	41.88	7.77	5.74	21.46	49.59
55	CMS 234 A x RHA 297	90.33	0.47	86.57	24947.33	44.78	6.97	9.60	33.29	68.28
56	CMS 302 A x 6D-1	92.45	0.53	90.34	26851.33	46.22	7.56	6.97	20.25	72.62
57	CMS 302 A x RHA 271	93.35	0.58	91.63	33785.33	38.90	7.36	9.50	35.34	45.49
58	CMS 302 A x HRHA 4-2	88.87	0.63	95.02	35612.00	28.99	7.40	6.78	21.47	67.67
59	CMS 302 A x HRHA 5-3	95.17	0.68	93.81	31531.00	43.35	7.82	7.07	20.34	73.34
60	CMS 302 A x RHA 297	92.13	0.70	88.69	32081.00	34.43	7.95	3.51	17.20	74.37
61	CMS 607 A x 6D-1	90.77	0.76	88.95	26817.00	25.28	7.67	9.43	12.20	75.06
62	CMS 607 Ax RHA 271	95.35	0.87	91.63	27293.67	36.28	6.10	5.71	12.32	73.36
63	CMS 607 A x HRHA 4-2	96.52	0.73	89.78	24694.67	30.92	9.71	8.01	33.53	36.63
64	CMS 607 A x HRHA 5-3	95.67	0.54	93.21	23604.33	24.36	4.56	5.61	22.56	66.35
65	CMS 607 A x RHA 297	93.15	0.67	90.82	26754.33	33.38	7.12	7.55	37.69	46.63
66	CMS 852 A x 6D -1	94.33	0.87	92.52	25524.00	38.56	6.62	6.03	13.27	72.44
67	CMS 852 A x RHA 271	89.27	0.91	87.77	27407.67	34.59	6.72	6.51	17.28	68.19
68	CMS 852 A x HRHA 4-2	94.83	0.79	90.68	24927.67	36.88	6.07	4.59	13.44	73.35
69	CMS 852A x HRHA 5-3	91.66	0.69	87.35	25393.67	31.61	6.69	5.79	34.35	51.29
70	CMS 852A x RHA 297	83.68	0.60	73.02	26848.00	30.67	3.81	7.45	15.49	71.24
71	ARG 2A x 6D-1	95.00	0.59	91.08	27356.67	24.71	6.81	6.02	34.61	40.77
72	ARG 2A x RHA 271	93.17	0.72	90.91	25286.67	26.61	6.48	9.74	17.11	67.69
73	ARG 2A x HRHA 4-2	92.05	0.77	89.91	26851.33	31.50	7.40	5.14	42.59	43.39
74	ARG 2A x HRHA 5-3	92.11	0.78	89.69	25531.67	34.81	6.43	6.65	13.29	71.43
75	ARG 2A x RHA 297	96.26	0.83	87.11	26032.00	35.00	6.44	11.55	29.59	49.42
76	ARG 3A x 6D -1	85.35	0.84	89.99	24462.67	33.42	5.98	8.70	18.56	51.31
77	ARG 3A x RHA 271	90.85	0.67	85.59	22551.00	28.15	8.89	4.82	22.52	49.92

Sr.No.	Parents/ Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
78	ARG 3A x HRHA 4-2	90.69	0.43	82.20	23767.33	23.38	9.27	7.70	32.45	48.26
79	ARG 3A x HRHA 5-3	89.48	0.63	83.85	27614.33	28.55	5.21	13.31	17.65	61.58
80	ARG 3A x RHA 297	91.87	0.69	86.27	27954.00	30.46	5.30	11.47	17.74	69.44
81	ARG 6A x 6D-1	91.77	0.59	80.17	27489.00	28.79	5.14	12.05	14.20	66.63
82	ARG 6A x RHA 271	94.00	0.65	82.92	26333.00	28.11	7.34	12.53	22.65	54.53
83	ARG 6A x HRHA 4-2	93.84	0.81	89.67	25840.00	29.28	3.76	5.51	16.46	71.51
84	ARG 6A x HRHA 5-3	94.39	0.79	92.35	23171.33	49.49	4.77	6.93	15.62	60.67
85	ARG 6 A x RHA 297	93.73	0.75	91.58	23312.33	47.55	7.10	6.33	21.21	63.42
86	DV 10 x 6D -1	69.52	0.92	64.37	27632.00	33.95	6.73	4.69	19.30	67.24
87	DV 10 x RHA 271	83.35	0.49	81.89	25669.67	30.72	8.54	4.92	41.38	42.26
88	DV 10 x HRHA 4-2	83.37	0.53	80.19	23729.33	37.79	8.23	7.52	15.33	71.35
89	DV 10 xHRHA 5-3	82.01	0.63	78.19	22958.67	30.27	6.84	8.21	12.51	72.43
90	DV -10 x RHA 297	93.40	0.64	92.03	25036.00	29.71	6.96	6.42	20.53	64.55
91	CMS 207 A x 6D -1	98.69	0.68	90.74	24140.33	28.63	6.04	5.13	11.65	75.74
92	CMS 207 A x RHA 271	93.04	0.81	91.04	23626.00	24.93	8.13	4.85	11.65	73.47
93	CMS 207 A x HRHA 4-2	94.89	0.82	86.13	26765.33	36.02	6.95	5.43	14.63	70.72
94	CMS 207 A x HRHA 5-3	97.82	0.84	88.22	27662.33	47.20	7.27	5.05	15.94	69.60
95	CMS 207 A x RHA 297	91.70	0.81	89.71	26412.33	38.68	9.81	6.68	16.66	64.30
96	HSFH 848	66.40	0.66	62.04	23502.00	34.00	6.63	4.71	14.02	42.26
	Mean	89.60	0.67	84.72	25235.31	32.26	6.71	6.17	21.93	62.18
	Range	47.50	0.21	41.64	18079.00	12.42	3.76	3.40	10.39	32.53
		98.69	1.24	95.02	35612.00	59.30	9.81	13.31	42.59	78.40
	SE	2.87	0.09	2.58	1788.75	5.64	0.41	0.36	1.37	2.18
	CDat5%	5.73	0.18	5.16	3573.92	11.27	0.82	0.72	2.74	4.35

Mean performance of parents and hybrids for morphological traits and seed yield component in E₂

Sr.No.	Parents /Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
1	CMS 11 A	84.03	9.80	4.03	57.67	92.13	4.06	16.00	29.05	33.70	58.95
2	CMS 17 A	92.01	9.15	4.83	60.94	96.57	3.23	17.20	26.31	40.33	67.47
3	CMS 44 A	88.34	9.60	3.72	58.94	89.85	3.45	16.70	26.92	29.59	27.76
4	CMS 148 A	92.59	10.51	4.19	59.83	100.04	3.87	18.21	31.38	42.04	66.85
5	CMSH 91 A	72.01	11.25	4.32	60.94	94.68	4.36	20.14	34.51	28.70	44.92
6	CMS 103 A	80.45	9.58	3.94	57.06	97.52	4.38	16.64	27.69	30.76	52.24
7	CMS 234 A	81.10	10.28	3.50	56.25	88.00	4.53	16.35	32.91	30.21	55.95
8	CMS 302 A	102.01	6.48	4.38	57.44	95.59	4.32	12.65	28.02	27.72	43.42
9	CMS 607 A	91.70	10.21	3.40	56.73	91.63	4.39	15.79	32.68	36.84	40.62
10	CMS 852 A	112.33	6.74	5.10	57.25	99.67	3.57	11.24	26.14	33.70	37.76
11	ARG 2-A	69.81	11.22	3.78	60.02	98.07	4.46	19.19	32.07	36.39	47.61
12	ARG 3-A	78.03	10.67	3.49	59.00	100.67	4.61	19.69	32.72	31.71	44.97
13	ARG 6-A	103.67	6.51	4.75	56.03	98.00	3.09	13.24	27.84	27.72	36.10
14	DV -10	82.67	10.02	3.99	56.53	97.68	4.29	16.59	27.73	32.72	54.24
15	CMS 207 A	103.67	6.45	4.79	59.52	94.39	2.96	14.11	28.62	34.06	55.47
16	6D-1	103.34	6.55	4.60	56.48	91.89	4.26	13.38	27.80	31.75	37.14
17	RHA 271	91.21	8.47	3.92	59.70	96.70	3.43	16.21	27.59	38.68	60.60
18	RHA 4-2	67.70	11.25	3.16	59.36	99.00	5.12	19.69	34.02	32.32	60.91
19	HRHA 5-3	82.21	10.32	3.60	53.18	89.12	4.32	18.68	28.72	39.03	57.17
20	RHA 29	100.67	6.76	4.88	56.78	97.02	4.40	11.94	30.02	27.71	43.10
21	CMS 11 A x 6D-1	103.33	11.07	6.03	55.25	93.63	5.47	24.93	39.27	30.25	96.54
22	CMS 11 A x RHA 271	104.73	11.33	6.13	56.11	95.60	7.80	24.86	40.53	35.87	94.27
23	CMS 11 A x HRHA 4-2	97.47	10.93	6.27	54.29	96.19	6.83	25.71	41.27	36.93	92.40
24	CMS 11 A x HRHA 5-3	100.07	11.53	7.83	54.58	94.65	6.60	26.48	37.27	18.07	89.18
25	CMS 11 A x RHA 297	96.60	9.13	4.60	56.51	94.50	5.80	28.62	40.23	44.73	95.14

Sr.No.	Parents /Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
26	CMS 17-A x 6D-1	107.00	12.60	7.83	55.63	93.63	7.47	27.64	40.63	50.14	82.20
27	CMS 17-A x RHA 271	96.27	12.40	5.87	56.72	92.33	7.67	26.60	39.63	36.74	97.37
28	CMS 17 -A x HRHA 4-2	93.07	11.13	5.83	56.54	93.10	7.10	22.34	38.80	27.35	95.39
29	CMS 17 –A x HRHA 5-3	82.73	17.67	8.93	55.21	95.33	6.20	24.61	38.30	32.91	92.35
30	CMS 17 A x RHA 297	106.13	10.53	5.97	54.17	95.50	4.87	24.53	37.77	26.85	89.25
31	CMS 44 A x 6D-1	100.53	15.00	8.57	55.70	97.17	6.05	27.45	37.77	47.57	96.24
32	CMS 44 A x RHA 271	94.13	11.33	5.93	58.30	98.50	7.00	25.43	38.63	38.24	85.18
33	CMS 44 A x HRHA 4-2	97.13	12.13	6.00	58.13	94.55	7.77	25.93	38.07	47.23	90.46
34	CMS 44 A x HRHA 5-3	86.07	13.33	5.73	55.07	95.50	5.83	21.87	37.53	37.84	91.08
35	CMS 44 A x RHA 297	101.40	11.73	6.00	58.07	96.63	7.23	25.83	40.83	37.53	95.22
36	CMS 148 A x 6D-1	85.53	9.73	4.83	55.30	97.50	6.73	24.82	37.67	31.08	92.72
37	CMS 148 A x RHA 271	84.67	12.13	6.00	56.60	97.57	7.33	26.70	37.67	30.23	95.21
38	CMS 148 A x HRHA 4-2	93.87	15.00	8.13	55.60	98.10	6.67	23.43	37.67	58.00	95.24
39	CMS 148 A x HRHA 5-3	79.93	9.07	4.67	55.13	93.37	8.03	26.70	37.73	45.11	93.83
40	CMS 148 A x RHA 297	84.87	11.00	5.80	55.65	94.27	7.13	25.47	38.37	46.40	97.28
41	CMSH 91 A x 6D-1	85.07	9.93	5.93	57.30	97.50	6.77	24.63	39.17	53.86	92.50
42	CMSH 91 A x RHA 271	92.20	12.87	6.23	56.50	96.17	8.00	27.67	38.57	43.94	94.17
43	CMSH 91 A x HRHA 4-2	94.07	11.60	5.93	57.07	96.30	7.87	24.97	37.73	50.13	94.67
44	CMSH 91 A x HRHA 5-3	95.73	11.40	6.17	56.66	96.59	7.00	26.04	37.77	49.44	97.20
45	CMSH 91 A x RHA 297	93.07	11.47	6.10	57.37	97.70	6.09	26.51	37.17	48.23	95.24
46	CMS 103 A x 6D-1	94.67	11.87	6.00	64.21	97.77	6.43	27.57	40.00	47.97	97.51
47	CMS 103 A x RHA 271	114.60	8.80	5.47	65.75	97.31	7.10	24.97	40.57	45.99	95.29
48	CMS 103 A x HRHA 4-2	107.47	10.27	5.63	64.19	94.40	6.87	26.70	40.00	53.04	93.60
49	CMS 103 A x HRHA 5-3	96.00	9.60	5.63	65.56	102.04	7.53	25.64	38.30	41.67	98.29
50	CMS 103 A x RHA 297	104.80	10.07	4.63	63.51	99.65	7.37	26.31	37.57	36.05	95.23
51	CMS 234 A x 6D-1	112.53	10.73	6.13	55.63	96.73	6.20	25.56	38.03	51.48	97.37

Sr.No.	Parents /Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
52	CMS 234A x RHA 271	85.07	9.73	5.83	55.73	97.77	7.10	25.00	38.10	51.94	95.57
53	CMS 234 A x HRHA 4-2	84.87	11.67	5.90	57.69	99.10	7.47	26.55	37.67	47.00	95.10
54	CMS 234 A x HRHA 5-3	105.80	14.00	8.23	63.53	105.77	6.00	23.81	39.00	46.24	91.17
55	CMS 234 A x RHA 297	103.93	9.93	6.00	57.64	97.58	6.43	24.73	37.63	48.64	86.70
56	CMS 302 A x 6D-1	80.87	10.33	6.03	55.72	97.51	7.10	26.64	37.63	51.96	97.02
57	CMS 302 A x RHA 271	89.07	10.20	5.87	55.90	94.37	7.00	25.93	40.20	52.52	98.21
58	CMS 302 A x HRHA 4-2	105.33	14.67	7.30	56.21	94.22	8.00	28.43	39.87	53.96	93.40
59	CMS 302 A x HRHA 5-3	112.33	11.40	6.23	64.26	109.26	7.30	25.62	37.73	49.99	96.11
60	CMS 302 A x RHA 297	116.60	10.40	6.07	57.17	94.35	6.23	25.36	37.63	56.70	94.16
61	CMS 607 A x 6D-1	104.07	12.40	6.13	66.13	104.04	7.67	26.37	37.97	53.41	93.20
62	CMS 607 A x RHA 271	113.20	13.67	7.17	55.52	96.33	8.23	26.45	38.73	60.99	97.13
63	CMS 607 A x HRHA 4-2	98.47	11.60	4.93	54.51	98.10	7.33	27.35	37.03	51.70	94.63
64	CMS 607 A x HRHA 5-3	112.07	10.53	5.67	54.80	98.37	5.30	21.78	37.60	56.40	96.13
65	CMS 607 A x RHA 297	95.87	12.07	6.10	55.14	98.17	6.67	26.77	39.10	55.05	95.24
66	CMS 852 A x 6D -1	106.40	9.47	5.70	55.37	98.14	6.90	26.22	37.47	54.27	87.30
67	CMS 852 A x RHA 271	91.00	13.73	6.80	55.37	97.14	7.73	28.59	37.20	57.83	97.18
68	CMS 852 A x HRHA 4-2	115.20	10.33	5.97	55.82	97.50	6.21	25.59	38.70	53.18	96.52
69	CMS 852A x HRHA 5-3	98.67	12.33	6.10	65.25	99.29	5.57	24.80	37.40	48.91	96.17
70	CMS 852 A x RHA 297	104.87	10.27	6.00	57.64	96.77	6.17	25.43	40.40	52.86	96.25
71	ARG 2A x 6D-1	93.27	9.60	5.63	56.59	98.44	6.27	25.87	37.47	54.07	98.22
72	ARG 2A x RHA 271	110.93	12.00	6.13	64.35	98.24	7.73	22.55	39.73	52.99	88.70
73	ARG 2A x HRHA 4-2	102.07	11.27	5.83	66.68	102.05	7.50	26.51	38.27	42.69	97.11
74	ARG 2A x HRHA 5-3	97.60	11.47	6.03	58.68	97.50	7.27	25.92	39.93	55.38	96.72
75	ARG 2A x RHA 297	88.67	10.87	6.20	58.51	98.35	7.10	24.62	38.60	47.58	97.02
76	ARG 3A x 6D -1	91.67	10.53	6.07	58.64	96.73	6.87	25.61	39.63	42.12	94.41
77	ARG 3A x RHA 271	92.33	10.87	6.07	58.75	96.55	6.87	25.18	38.73	55.04	95.64

Sr.No.	Parents /Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
78	ARG 3A x HRHA 4-2	102.60	10.47	6.03	58.65	97.68	5.33	25.30	38.93	44.64	97.22
79	ARG 3A x HRHA 5-3	94.07	14.20	5.80	58.71	94.70	5.37	28.52	37.37	48.96	94.19
80	ARG 3A x RHA 297	101.87	9.00	5.10	58.61	97.20	6.73	26.66	37.73	44.68	98.27
81	ARG 6A x 6D-1	86.00	12.33	6.33	58.51	96.60	7.50	27.95	41.53	45.29	95.17
82	ARG 6A x RHA 271	77.80	10.00	5.87	57.72	97.63	6.57	25.19	38.30	41.36	96.70
83	ARG 6A x HRHA 4-2	95.27	10.80	6.03	64.51	98.80	6.27	25.85	39.73	47.69	84.38
84	ARG 6A x HRHA 5-3	96.80	10.20	5.93	59.24	96.30	6.53	25.39	37.40	38.94	93.52
85	ARG 6 A x RHA 297	90.87	9.33	5.77	57.63	97.56	5.67	25.83	38.50	49.50	98.18
86	DV 10 x 6D -1	86.27	10.53	6.17	57.78	96.11	7.87	25.12	40.20	56.46	91.25
87	DV 10 x RHA 271	90.33	11.07	6.03	58.51	95.40	6.73	25.62	40.87	41.43	96.69
88	DV 10 x HRHA 4-2	99.47	11.13	6.13	65.64	96.65	6.90	24.79	39.30	57.58	95.08
89	DV 10 x HRHA 5-3	85.47	9.00	5.97	58.72	97.73	6.43	23.87	38.13	50.07	97.59
90	DV -10 x RHA 297	82.27	9.40	6.17	64.32	98.37	6.73	25.49	38.50	38.06	97.14
91	CMS 207 A x 6D -1	87.00	10.20	6.07	58.65	98.77	6.97	25.88	39.17	43.17	95.81
92	CMS 207 A x RHA 271	85.07	11.00	5.93	61.50	97.51	7.47	25.44	37.73	54.72	95.17
93	CMS 207 A x HRHA 4-2	104.47	12.87	8.27	58.63	97.50	6.37	25.96	37.57	36.48	84.13
94	CMS 207 A x HRHA 5-3	92.07	11.87	6.37	61.13	94.58	6.67	27.72	39.97	48.89	98.03
95	CMS 207 A x RHA 297	104.47	13.09	6.20	57.67	95.68	6.47	26.48	41.43	55.84	97.21
96	HSFH 848	92.13	12.13	4.83	55.58	93.04	6.83	22.00	40.97	36.17	65.00
	Mean	95.00	10.87	5.71	58.28	96.74	6.24	23.72	36.83	43.54	84.76
	Range	67.70	6.45	3.16	53.18	88.00	2.96	11.24	26.14	18.07	27.76
		116.60	17.67	8.93	66.68	109.26	8.23	28.62	41.53	60.99	98.29
	SE	1.58	0.93	0.42	0.92	0.90	0.69	1.31	1.35	3.10	1.97
	CDat5%	3.16	1.85	0.85	1.83	1.79	1.38	2.61	2.69	6.20	3.94

Mean performance of parents and hybrids for morphological traits and seed yield component in E₂

Sr.No.	Parents / Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
1	CMS 11 A	79.15	0.79	71.94	21004.00	16.32	5.16	5.23	28.24	56.10
2	CMS 17 A	74.80	0.74	70.38	19479.67	18.70	4.82	6.49	30.28	56.55
3	CMS 44 A	72.81	0.69	74.19	20468.33	16.93	4.44	4.66	21.09	55.85
4	CMS 148 A	83.80	0.84	77.68	21771.33	22.03	5.59	6.66	24.77	58.98
5	CMSH 91 A	81.70	0.62	71.02	21126.00	19.67	5.37	5.41	23.00	59.53
6	CMS 103 A	82.83	0.68	78.45	19704.33	20.30	5.73	5.34	27.59	61.31
7	CMS 234 A	46.03	1.08	40.43	19391.33	13.15	7.25	3.73	30.32	52.24
8	CMS 302 A	88.43	0.73	77.67	21527.00	22.25	7.48	6.50	29.68	57.78
9	CMS 607 A	67.98	0.86	60.66	16900.67	11.04	4.52	5.45	24.16	56.83
10	CMS 852 A	73.58	0.86	61.97	22114.00	14.59	5.31	4.46	28.12	53.50
11	ARG 2-A	74.15	0.77	67.00	18656.33	19.04	5.66	5.61	20.73	61.25
12	ARG 3-A	79.91	0.77	71.68	22437.67	24.03	6.23	4.67	34.25	53.34
13	ARG 6-A	84.14	0.81	82.00	21847.33	21.68	6.25	5.53	20.99	54.95
14	DV -10	84.22	0.75	77.00	17118.00	16.96	4.23	4.66	18.96	56.06
15	CMS 207 A	76.73	0.86	70.36	18233.67	20.27	6.08	7.40	34.77	53.32
16	6D-1	77.13	0.27	70.06	18557.67	18.08	5.49	4.57	26.23	54.69
17	RHA 271	86.55	0.40	82.00	21008.67	21.03	7.35	6.02	27.87	52.58
18	RHA 4-2	75.71	0.46	72.01	21347.67	13.45	5.49	4.73	25.25	55.52
19	HRHA 5-3	75.15	0.56	67.71	19878.00	18.03	6.31	5.46	30.87	52.94
20	RHA 297	50.09	1.24	46.56	17348.33	12.29	5.40	5.81	32.64	54.20
21	CMS 11 A x 6D-1	94.47	0.63	91.59	36626.67	38.53	5.93	3.95	20.23	69.43
22	CMS 11 A x RHA 271	94.84	0.62	92.77	30270.67	42.33	7.86	4.07	17.33	68.59
23	CMS 11 A x HRHA 4-2	94.28	0.52	91.11	31650.67	31.86	5.65	5.51	15.40	71.38
24	CMS 11 A x HRHA 5-3	94.37	0.31	92.65	35121.00	26.15	5.68	6.28	22.41	61.40
25	CMS 11 A x RHA 297	96.26	0.53	93.89	34457.33	24.24	5.39	5.67	17.55	68.77

Sr.No.	Parents / Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
26	CMS 17-A x 6D-1	94.37	0.53	91.74	30836.00	32.56	5.79	6.04	36.49	49.16
27	CMS 17-A x RHA 271	94.51	0.56	86.64	30916.00	43.40	5.44	2.94	38.52	49.42
28	CMS 17 -A x HRHA 4-2	97.05	0.51	86.74	28815.67	48.67	6.12	3.60	17.33	54.16
29	CMS 17 -A x HRHA 5-3	94.17	0.54	84.75	29330.67	38.70	6.87	5.05	16.39	68.37
30	CMS 17 A x RHA 297	94.67	0.40	93.00	28716.33	38.30	5.73	6.07	14.34	70.12
31	CMS 44 A x 6D-1	94.95	0.54	90.97	29076.00	38.25	4.74	5.64	20.14	62.05
32	CMS 44 A x RHA 271	92.97	0.65	92.83	24754.00	35.75	5.64	6.41	17.12	71.19
33	CMS 44 A x HRHA 4-2	94.93	0.60	90.33	30455.33	27.52	5.50	4.64	15.32	53.29
34	CMS 44 A x HRHA 5-3	94.55	0.50	90.30	31145.67	28.27	6.74	5.14	19.41	65.27
35	CMS 44 A x RHA 297	94.30	0.56	91.60	32216.00	30.24	4.63	6.64	23.16	77.26
36	CMS 148 A x 6D-1	94.84	0.42	93.38	27926.00	55.02	5.60	7.44	32.05	58.15
37	CMS 148 A x RHA 271	96.15	0.64	92.28	30714.00	46.99	5.15	3.67	11.22	47.14
38	CMS 148 A x HRHA 4-2	91.38	0.76	85.87	28660.67	31.26	5.69	5.36	15.23	43.10
39	CMS 148 A x HRHA 5-3	92.63	0.56	94.58	29090.67	27.60	7.55	5.62	25.37	51.12
40	CMS 148 A x RHA 297	96.87	0.59	95.21	31107.33	22.72	5.45	5.68	27.23	63.36
41	CMSH 91 A x 6D-1	94.41	0.59	83.30	32355.67	25.39	7.53	5.52	29.24	75.15
42	CMSH 91 A x RHA 271	94.27	0.71	87.43	29995.67	21.50	6.74	4.59	34.05	64.23
43	CMSH 91 A x HRHA 4-2	94.23	0.62	92.14	31144.33	41.72	7.43	5.33	17.23	42.06
44	CMSH 91 A x HRHA 5-3	96.74	0.38	85.36	30970.00	46.48	8.67	6.47	33.18	69.33
45	CMSH 91 A x RHA 297	93.00	0.47	88.53	28074.33	49.72	6.52	4.48	28.39	59.33
46	CMS 103 A x 6D-1	96.88	0.85	84.66	30458.00	54.16	6.62	3.70	35.11	51.12
47	CMS 103 A x RHA 271	95.71	0.78	92.37	33410.67	51.00	6.22	6.00	27.43	57.31
48	CMS 103 A x HRHA 4-2	90.57	0.75	84.40	30670.67	47.44	7.48	4.48	19.10	48.10
49	CMS 103 A x HRHA 5-3	93.90	0.84	87.81	30186.00	45.45	6.08	5.08	18.30	45.27
50	CMS 103 A x RHA 297	94.13	0.90	91.24	28907.67	46.63	7.40	6.55	14.08	39.26
51	CMS 234 A x 6D-1	86.23	0.82	83.19	28605.00	50.89	6.60	5.59	9.28	37.22

Sr.No.	Parents / Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
52	CMS 234A x RHA 271	96.90	0.69	92.73	29476.00	46.50	7.13	4.94	23.16	55.11
53	CMS 234 A x HRHA 4-2	91.93	0.74	84.32	28013.33	38.43	6.07	11.09	19.27	63.05
54	CMS 234 A x HRHA 5-3	92.92	0.76	84.36	28855.67	40.46	7.71	3.36	29.40	70.17
55	CMS 234 A x RHA 297	96.11	0.57	94.37	25730.67	44.20	6.07	10.10	34.18	74.22
56	CMS 302 A x 6D-1	96.31	0.45	92.41	28864.33	23.82	7.41	9.29	25.05	66.33
57	CMS 302 A x RHA 271	96.31	0.56	84.55	31298.33	23.78	8.40	11.23	30.13	56.02
58	CMS 302 A x HRHA 4-2	90.41	0.75	83.56	31594.00	35.64	6.26	5.51	27.12	45.45
59	CMS 302 A x HRHA 5-3	92.21	0.86	85.62	33115.00	24.04	6.55	4.65	17.03	42.32
60	CMS 302 A x RHA 297	92.93	0.84	85.67	34468.67	32.12	6.53	3.68	18.29	55.37
61	CMS 607 A x 6D-1	94.10	0.74	85.40	28217.67	36.64	6.60	9.92	13.08	67.29
62	CMS 607 A x RHA 271	96.81	0.46	91.54	27604.33	36.70	8.45	6.14	15.02	59.51
63	CMS 607 A x HRHA 4-2	95.80	0.69	93.17	25980.67	25.72	9.37	5.82	26.16	54.20
64	CMS 607 A x HRHA 5-3	90.93	0.41	84.50	27724.00	25.45	6.69	3.48	35.09	48.49
65	CMS 607 A x RHA 297	95.04	0.29	89.91	28130.67	38.51	7.60	4.65	25.16	39.52
66	CMS 852 A x 6D -1	96.21	0.53	87.18	28252.00	43.56	6.76	5.74	15.02	41.30
67	CMS 852 A x RHA 271	94.80	0.54	87.19	28183.67	48.33	7.63	4.64	32.11	53.12
68	CMS 852 A x HRHA 4-2	92.87	0.76	85.19	29138.00	52.00	4.89	3.60	24.21	57.32
69	CMS 852A x HRHA 5-3	93.24	0.84	89.52	24095.67	35.20	5.13	7.28	26.19	66.14
70	CMS 852 A x RHA 297	96.33	0.74	86.58	27198.67	48.38	8.41	5.65	37.05	68.16
71	ARG 2A x 6D-1	93.60	0.69	93.75	27263.33	33.64	6.71	13.17	33.05	72.19
72	ARG 2A x RHA 271	89.60	0.41	82.36	24366.33	21.85	7.22	9.61	25.12	62.18
73	ARG 2A x HRHA 4-2	94.11	0.83	88.17	30503.00	25.59	6.14	5.45	28.24	64.26
74	ARG 2A X HRHA 5-3	92.07	0.53	87.19	29517.33	24.00	8.44	4.63	21.12	73.18
75	ARG 2A x RHA 297	91.23	0.63	83.36	28983.33	22.50	10.23	8.21	19.12	76.52
76	ARG 3A x 6D -1	95.62	0.92	83.56	26934.00	34.10	5.13	3.60	15.14	57.06
77	ARG 3A x RHA 271	95.60	0.67	87.56	30137.67	36.72	7.96	14.40	13.14	49.48

Sr.No.	Parents / Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
78	ARG 3A x HRHA 4-2	90.54	0.58	86.82	27531.00	47.94	8.27	6.25	17.09	47.16
79	ARG 3A x HRHA 5-3	96.48	0.52	85.60	30784.67	52.67	7.28	6.17	24.06	63.26
80	ARG 3A x RHA 297	93.00	0.56	84.39	28946.67	52.22	7.48	5.63	36.25	72.19
81	ARG 6A x 6D-1	93.11	0.64	85.37	25241.67	52.33	4.00	2.18	28.03	69.18
82	ARG 6A x RHA 271	94.20	0.59	86.64	23890.67	51.56	6.38	5.51	29.37	70.12
83	ARG 6A x HRHA 4-2	86.33	0.58	82.59	29164.00	45.54	8.37	4.77	38.45	68.19
84	ARG 6A x HRHA 5-3	97.47	0.68	83.37	31874.33	55.63	11.22	8.20	25.12	56.40
85	ARG 6 A x RHA 297	96.10	0.46	92.43	29048.00	52.33	5.62	4.61	21.26	59.19
86	DV 10 x 6D -1	96.63	0.36	82.30	29446.33	49.77	7.40	4.81	24.14	64.27
87	DV 10 x RHA 271	94.19	0.55	79.68	29020.67	41.60	7.62	5.20	17.34	63.18
88	DV 10 x HRHA 4-2	96.93	0.46	94.17	28256.33	33.99	9.29	7.29	17.37	71.19
89	DV 10 x HRHA 5-3	70.31	1.06	62.74	21795.67	35.07	7.56	7.56	14.01	72.89
90	DV -10 x RHA 297	90.13	0.75	77.88	27363.67	36.48	8.52	6.09	15.23	75.42
91	CMS 207 A x 6D -1	94.17	0.49	83.37	29718.00	28.07	8.37	5.03	16.12	67.03
92	CMS 207 A x RHA 271	64.16	1.06	62.58	21895.00	32.58	7.34	3.73	22.12	59.59
93	CMS 207 A x HRHA 4-2	72.72	0.68	70.42	22228.33	40.88	5.74	3.54	26.27	63.26
94	CMS 207 A x HRHA 5-3	89.41	0.59	85.44	27697.33	53.35	6.03	4.40	27.13	72.26
95	CMS 207 A x RHA 297	86.58	0.86	84.47	26325.67	40.72	13.25	6.69	23.18	76.24
96	HSFH 848	66.01	0.82	53.77	21049.33	46.96	4.57	5.47	13.12	44.52
	Mean	89.06	0.65	83.03	27099.05	34.34	6.65	5.78	23.86	59.40
	Range	46.03	0.27	40.43	16900.67	11.04	4.00	2.18	9.28	37.22
		97.47	1.24	95.21	36626.67	55.63	13.25	14.40	38.52	77.26
	SE	2.82	0.03	1.56	535.59	1.66	0.48	0.29	1.74	2.25
	CDat5%	5.64	0.05	3.11	1070.10	3.32	0.95	0.59	3.47	4.49

Mean performance of parents and hybrids of morphological traits and its seed yield component in E₃

Sr.No.	Parents/ Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
1	CMS 11 A	126.04	15.04	4.43	60.44	96.00	6.01	26.34	37.43	41.26	58.10
2	CMS 17 A	134.83	11.89	4.30	61.81	94.67	5.00	24.43	48.03	52.34	79.67
3	CMS 44 A	135.48	11.10	5.00	60.69	93.00	4.67	19.69	50.69	19.73	27.40
4	CMS 148 A	125.41	11.29	3.79	63.34	97.33	5.80	23.67	50.39	51.98	64.80
5	CMSH 91 A	90.29	14.13	5.20	61.48	92.67	6.33	29.71	44.00	44.11	70.67
6	CMS 103 A	117.13	11.21	4.90	61.25	97.00	5.00	18.45	50.67	39.92	71.33
7	CMS 234 A	128.09	11.47	4.79	60.09	93.33	5.00	19.73	44.44	38.39	64.03
8	CMS 302 A	120.48	13.14	6.07	61.67	96.33	5.00	18.71	52.69	33.81	53.05
9	CMS 607 A	134.12	12.18	6.04	58.70	92.67	6.20	30.77	47.78	46.60	63.84
10	CMS 852 A	125.16	12.49	3.93	59.02	95.33	7.03	31.76	51.39	39.23	49.23
11	ARG 2-A	116.05	9.06	5.60	59.68	95.33	7.93	31.02	48.04	43.33	57.01
12	ARG 3-A	114.13	10.76	5.70	64.04	99.67	6.13	26.07	45.76	32.31	45.02
13	ARG 6-A	115.79	9.78	5.77	64.38	98.00	4.87	29.36	52.08	29.34	38.38
14	DV -10	115.82	10.40	5.37	61.72	96.00	4.60	23.67	46.70	42.66	65.33
15	CMS 207 A	115.65	12.40	4.51	64.07	98.00	5.67	27.72	44.04	41.09	64.67
16	6D-1	128.38	10.36	4.80	62.18	93.33	5.00	19.54	44.44	29.78	46.03
17	RHA 271	125.58	10.04	5.56	61.36	93.33	5.60	30.00	47.07	44.43	45.05
18	RHA 4-2	128.08	11.04	4.17	62.95	95.33	4.00	12.10	50.80	42.71	52.26
19	HRHA 5-3	114.47	10.69	6.00	59.42	92.33	5.00	23.04	42.79	45.92	55.61
20	RHA 297	115.56	8.10	4.78	62.20	96.00	5.00	24.33	50.03	43.22	52.02
21	CMS 11 A x 6D-1	174.00	15.93	7.93	58.15	88.67	7.02	37.81	37.40	48.40	82.15
22	CMS 11 A x RHA 271	164.87	17.20	7.23	57.68	89.00	7.67	39.72	39.27	58.57	84.42
23	CMS 11 A x HRHA 4-2	158.20	17.13	8.83	59.36	92.33	8.33	45.34	37.57	46.93	91.67
24	CMS 11 A x HRHA 5-3	168.60	19.27	8.07	60.85	93.00	7.37	49.67	39.87	48.78	62.07
25	CMS 11 A x RHA 297	175.93	16.00	9.37	61.80	93.33	7.80	38.46	38.93	58.40	92.00

Sr.No.	Parents/ Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
26	CMS 17-A x 6D-1	173.93	17.00	8.23	61.64	97.00	6.70	41.68	39.03	45.84	83.05
27	CMS 17-A x RHA 271	162.20	18.27	8.33	64.78	95.33	8.38	47.60	37.80	49.34	90.33
28	CMS 17 -A x HRHA 4-2	178.73	17.00	8.27	63.98	94.33	7.47	42.69	37.70	43.96	40.83
29	CMS 17 -A x HRHA 5-3	182.20	14.60	8.67	58.02	89.00	7.13	37.60	38.43	38.42	75.67
30	CMS 17 A x RHA 297	160.40	18.67	8.27	60.23	87.67	5.57	47.96	37.30	47.73	72.22
31	CMS 44 A x 6D-1	158.07	16.93	9.03	56.98	88.33	6.87	45.91	37.77	53.11	78.00
32	CMS 44 A x RHA 271	161.40	15.53	7.63	57.29	90.33	5.30	36.78	39.50	44.79	92.00
33	CMS 44 A x HRHA 4-2	148.53	20.33	7.57	58.33	93.00	7.03	50.14	38.17	49.47	83.01
34	CMS 44 A x HRHA 5-3	166.47	19.00	10.90	61.58	92.00	4.50	41.24	40.77	40.94	65.84
35	CMS 44 A x RHA 297	160.93	19.93	9.97	61.10	92.00	6.23	51.54	37.23	46.40	97.00
36	CMS 148 A x 6D-1	158.27	18.67	10.27	59.75	94.00	7.31	40.15	39.40	53.85	51.19
37	CMS 148 A x RHA 271	166.60	17.87	9.27	58.05	88.67	7.00	40.83	40.37	54.68	90.67
38	CMS 148 A x HRHA 4-2	168.00	19.07	9.47	58.19	93.00	5.00	47.71	38.00	51.23	69.48
39	CMS 148 A x HRHA 5-3	154.80	20.47	9.47	61.66	95.00	6.00	49.41	41.20	45.04	84.68
40	CMS 148 A x RHA 297	158.80	21.20	10.27	61.32	89.00	6.00	52.27	41.47	46.83	73.67
41	CMSH 91 A x 6D-1	158.67	24.13	9.60	60.23	91.33	5.67	54.64	40.63	50.37	40.22
42	CMSH 91 A x RHA 271	168.93	18.53	11.43	58.88	94.00	7.10	40.86	39.73	54.23	82.21
43	CMSH 91 A x HRHA 4-2	165.20	17.33	9.30	57.66	88.33	6.00	39.20	39.97	53.97	74.08
44	CMSH 91 A x HRHA 5-3	163.87	18.20	7.97	57.41	94.00	7.00	40.81	38.53	55.85	89.06
45	CMSH 91 A x RHA 297	151.27	19.13	8.37	56.99	88.00	8.00	44.14	37.23	52.42	87.73
46	CMS 103 A x 6D-1	175.93	17.73	10.00	56.71	94.00	6.00	43.81	37.53	53.05	73.26
47	CMS 103 A x RHA 271	157.27	18.33	8.40	56.71	86.67	5.00	40.84	40.13	62.46	85.02
48	CMS 103 A x HRHA 4-2	156.07	19.53	10.33	57.48	94.00	6.00	47.82	37.53	53.81	90.35
49	CMS 103 A x HRHA 5-3	174.93	19.20	9.80	58.01	90.00	7.00	41.33	38.20	56.13	89.67
50	CMS 103 A x RHA 297	166.33	18.27	9.30	59.05	95.67	6.76	42.04	38.87	48.38	35.13
51	CMS 234 A x 6D-1	175.67	21.60	9.40	59.08	96.33	7.43	50.17	38.13	55.25	79.67

Sr.No.	Parents/ Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
52	CMS 234A x RHA 271	161.00	18.60	10.40	65.08	97.33	6.32	42.05	37.90	52.28	46.94
53	CMS 234 A x HRHA 4-2	138.87	16.07	9.47	66.99	96.00	7.30	38.60	37.43	64.52	86.02
54	CMS 234 A x HRHA 5-3	158.87	15.47	8.10	59.17	94.00	6.12	37.83	37.53	53.23	90.33
55	CMS 234 A x RHA 297	164.67	19.87	7.77	58.71	96.00	4.97	40.76	37.30	46.57	85.56
56	CMS 302 A x 6D-1	172.67	19.27	10.27	57.36	96.00	5.67	42.40	38.07	60.43	89.09
57	CMS 302 A x RHA 271	197.27	19.67	9.37	59.23	96.00	7.40	49.80	39.93	63.77	83.37
58	CMS 302 A x HRHA 4-2	164.67	17.73	9.33	61.53	95.33	6.27	39.47	38.83	51.86	83.74
59	CMS 302 A x HRHA 5-3	170.00	17.87	9.20	62.56	95.33	7.17	40.26	39.80	50.54	37.88
60	CMS 302 A x RHA 297	184.73	18.47	8.67	64.24	94.67	6.11	42.01	40.03	55.34	90.00
61	CMS 607 A x 6D-1	172.40	17.27	9.30	63.39	96.33	6.21	40.79	39.50	52.85	92.06
62	CMS 607 A x RHA 271	183.73	18.93	8.00	63.07	94.00	7.83	42.63	40.87	48.60	48.90
63	CMS 607 A x HRHA 4-2	172.40	18.93	8.67	59.84	94.00	7.03	43.97	40.97	53.01	86.50
64	CMS 607 A x HRHA 5-3	184.40	16.33	9.33	66.52	94.67	7.37	38.41	38.37	48.15	79.15
65	CMS 607 A x RHA 297	162.13	16.60	8.20	66.18	95.33	6.27	39.59	37.87	41.10	74.52
66	CMS 852 A x 6D -1	165.93	20.60	8.17	59.81	94.00	7.27	46.93	39.13	55.44	36.85
67	CMS 852 A x RHA 271	157.33	18.07	9.63	58.67	94.00	8.03	41.29	39.63	47.80	90.88
68	CMS 852 A x HRHA 4-2	163.67	18.13	9.37	58.46	94.00	7.73	42.61	37.57	46.33	85.01
69	CMS 852A x HRHA 5-3	148.00	18.07	8.90	57.95	94.00	8.00	42.59	39.93	63.29	92.31
70	CMS 852 A x RHA 297	151.67	16.87	9.17	68.30	94.00	6.00	40.66	40.40	53.41	86.98
71	ARG 2A x 6D-1	166.40	20.93	8.23	58.38	94.00	7.73	48.56	38.03	53.45	92.00
72	ARG 2A x RHA 271	178.20	18.13	9.23	60.75	94.00	7.93	44.08	36.73	54.04	91.36
73	ARG 2A x HRHA 4-2	163.53	19.07	8.77	60.81	90.00	6.77	46.13	38.23	57.25	49.16
74	ARG 2A x HRHA 5-3	169.93	17.93	9.10	58.28	89.67	8.83	47.22	38.67	51.63	85.00
75	ARG 2A x RHA 297	174.33	18.27	9.13	62.17	96.00	7.00	48.26	40.27	59.38	74.86
76	ARG 3A x 6D -1	157.13	16.67	8.90	59.96	94.67	5.00	43.45	38.80	53.40	91.06
77	ARG 3A x RHA 271	168.13	17.40	8.20	62.74	94.00	6.00	41.94	40.33	52.21	92.12

Sr.No.	Parents/ Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
78	ARG 3A x HRHA 4-2	152.27	16.27	8.67	62.32	93.67	5.23	38.76	38.80	49.73	72.03
79	ARG 3A x HRHA 5-3	153.87	16.60	8.53	64.40	94.00	7.87	39.52	39.53	52.89	82.70
80	ARG 3A x RHA 297	150.87	17.27	8.67	64.00	94.33	6.76	44.59	37.67	55.61	87.07
81	ARG 6A x 6D-1	149.80	17.53	8.07	56.62	94.33	6.00	45.92	37.77	61.99	84.71
82	ARG 6A x RHA 271	157.07	18.47	8.00	63.61	93.67	7.00	44.91	38.60	59.35	74.89
83	ARG 6A x HRHA 4-2	155.40	16.93	9.67	59.40	94.00	4.00	41.00	39.73	62.73	91.58
84	ARG 6A x HRHA 5-3	165.13	17.00	8.93	61.90	94.00	6.00	43.40	39.97	55.81	91.01
85	ARG 6 A x RHA 297	161.27	17.80	9.07	63.03	94.00	5.13	48.15	37.53	57.39	90.19
86	DV 10 x 6D -1	182.33	16.53	8.03	63.96	96.67	6.43	39.28	40.47	55.98	83.72
87	DV 10 x RHA 271	157.47	15.87	8.03	69.00	96.67	6.00	38.82	37.57	56.38	85.36
88	DV 10 x HRHA 4-2	164.00	16.67	7.90	68.33	94.00	4.87	37.92	37.97	63.12	82.30
89	DV 10 x HRHA 5-3	159.13	15.60	8.03	65.12	94.00	7.30	40.22	37.63	57.04	91.92
90	DV -10 x RHA 297	164.27	16.40	8.10	59.41	93.67	6.87	38.02	40.40	62.12	94.01
91	CMS 207 A x 6D -1	157.93	14.53	8.57	59.45	94.67	5.70	37.65	41.67	36.51	66.68
92	CMS 207 A x RHA 271	159.87	15.67	7.57	61.63	95.33	6.33	37.86	39.07	51.52	89.46
93	CMS 207 A x HRHA 4-2	154.67	17.00	7.50	67.32	94.33	4.93	39.63	38.43	54.77	85.17
94	CMS 207 A x HRHA 5-3	155.60	18.60	9.27	63.06	95.33	5.83	43.67	39.33	59.53	84.57
95	CMS 207 A x RHA 297	155.07	21.67	10.23	67.04	97.00	7.02	46.72	37.77	46.75	95.06
96	HSFH 848	135.60	15.29	6.81	60.37	88.00	6.73	36.05	38.13	53.70	63.83
	Mean	155.05	16.58	8.06	61.14	93.77	6.36	39.11	40.66	50.14	74.46
	Range	90.29	8.10	3.79	56.62	86.67	4.00	12.10	36.73	19.73	27.40
		197.27	24.13	11.43	69.00	99.67	8.83	54.64	52.69	64.52	97.00
	SE	6.36	1.29	0.57	1.69	1.06	0.68	2.10	1.29	2.71	2.55
	CDat5%	12.70	2.59	1.14	3.38	2.11	1.35	4.20	2.57	5.41	5.09

Mean performance of parents and hybrids of morphological traits and its seed yield component in E₃

Sr.No.	Parents / Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
1	CMS 11 A	85.08	0.86	88.38	22455.33	26.89	7.52	3.96	51.06	32.55
2	CMS 17 A	89.37	0.81	84.02	21921.00	26.47	6.28	4.09	45.97	26.25
3	CMS 44 A	96.75	0.81	83.35	22048.33	24.66	6.80	3.32	56.36	36.10
4	CMS 148 A	96.08	0.86	88.35	29060.67	26.64	7.07	4.17	54.44	33.38
5	CMSH 91 A	91.48	0.72	88.00	25236.33	29.41	7.76	3.00	54.25	34.56
6	CMS 103 A	91.48	0.67	86.04	28293.67	37.01	6.34	3.31	46.41	29.30
7	CMS 234 A	52.17	1.09	48.23	20236.00	18.01	6.10	4.03	52.36	33.18
8	CMS 302 A	90.67	0.70	88.05	25155.33	25.55	7.79	5.13	48.58	32.01
9	CMS 607 A	76.68	1.15	67.08	29759.33	17.26	6.63	3.88	58.26	28.50
10	CMS 852 A	71.40	1.44	70.14	21610.67	21.53	7.43	4.10	53.69	32.30
11	ARG 2-A	80.72	0.82	73.78	20808.33	24.24	7.02	4.44	59.08	29.22
12	ARG 3-A	88.06	0.78	85.40	27790.33	30.91	7.76	5.15	58.11	36.32
13	ARG 6-A	96.06	0.86	90.00	28448.00	36.98	7.57	5.54	57.12	33.16
14	DV -10	90.04	0.82	86.68	26364.33	25.93	6.72	3.29	50.62	37.44
15	CMS 207 A	81.52	0.93	75.69	24018.67	23.08	6.98	8.33	52.28	27.72
16	6D-1	93.40	0.19	87.37	27077.00	22.11	7.21	4.09	54.66	20.09
17	RHA 271	95.38	0.16	90.02	28373.33	23.17	5.01	3.47	55.41	23.27
18	RHA 4-2	92.04	0.49	85.43	23542.00	18.50	6.03	4.30	52.41	26.51
19	HRHA 5-3	90.71	0.69	84.02	29081.67	19.46	5.71	5.80	47.36	27.31
20	RHA 297	58.33	1.34	48.32	25444.00	13.20	6.30	2.80	51.23	21.37
21	CMS 11 A x 6D-1	94.79	0.24	92.72	28614.67	44.05	5.84	4.25	67.78	31.33
22	CMS 11 A x RHA 271	96.00	0.31	92.78	29403.67	45.39	6.33	3.10	56.50	36.78
23	CMS 11 A x HRHA 4-2	66.52	1.50	64.77	21285.00	30.69	6.22	5.48	51.55	40.30
24	CMS 11 A x HRHA 5-3	93.01	0.37	91.36	28444.00	40.48	6.39	3.94	57.72	34.76
25	CMS 11 A x RHA 297	90.29	0.45	84.24	27283.33	33.14	5.18	2.91	58.34	35.69

Sr.No.	Parents / Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
26	CMS 17-A x 6D-1	92.39	0.43	88.06	32062.00	34.08	5.89	3.71	62.41	32.46
27	CMS 17-A x RHA 271	42.83	1.16	39.55	22012.33	19.39	6.05	3.51	55.09	41.56
28	CMS 17 -A x HRHA 4-2	80.06	0.52	77.73	20005.00	30.86	5.56	7.40	56.92	31.48
29	CMS 17 –A x HRHA 5-3	75.34	0.39	72.80	24713.33	43.68	6.47	3.13	67.32	41.57
30	CMS 17 A x RHA 297	81.92	0.36	79.46	24962.67	37.68	5.35	4.70	59.51	42.81
31	CMS 44 A x 6D-1	94.37	0.40	92.53	26790.67	46.10	6.14	4.26	71.96	20.57
32	CMS 44 A x RHA 271	90.15	0.33	85.13	23647.33	42.08	6.17	4.04	57.05	36.80
33	CMS 44 A x HRHA 4-2	89.10	0.57	84.17	24857.33	32.82	5.93	4.22	62.80	31.54
34	CMS 44 A x HRHA 5-3	90.41	0.41	87.77	27986.67	32.75	5.17	4.58	65.01	42.44
35	CMS 44 A x RHA 297	52.03	1.45	49.87	18539.00	28.52	5.61	4.05	55.17	36.80
36	CMS 148 A x 6D-1	93.69	0.46	92.01	28156.67	44.59	6.31	3.25	49.77	41.57
37	CMS 148 A x RHA 271	70.63	0.43	68.60	19741.67	29.43	6.69	4.50	59.00	32.58
38	CMS 148 A x HRHA 4-2	96.36	0.33	91.09	25925.67	46.83	5.35	3.30	49.31	44.26
39	CMS 148 A x HRHA 5-3	77.57	0.70	73.76	21315.00	34.36	5.47	5.62	49.29	43.44
40	CMS 148 A x RHA 297	40.51	1.65	37.36	11836.00	20.83	6.41	3.57	60.03	32.10
41	CMSH 91 A x 6D-1	85.07	0.42	75.40	20803.67	35.00	6.76	7.46	57.86	30.40
42	CMSH 91 A x RHA 271	74.83	0.31	70.20	21443.33	43.09	6.26	4.80	50.45	39.71
43	CMSH 91 A x HRHA 4-2	90.69	0.44	89.02	24963.33	33.86	6.45	5.63	78.26	10.34
44	CMSH 91 A x HRHA 5-3	88.37	0.25	84.88	27286.33	52.13	7.28	3.95	49.16	42.34
45	CMSH 91 A x RHA 297	74.34	0.78	71.11	20512.67	42.08	6.30	4.22	55.83	36.56
46	CMS 103 A x6D-1	94.81	0.34	92.20	25289.00	63.10	7.20	6.65	46.97	40.34
47	CMS 103 A x RHA 271	93.10	0.45	91.06	24181.00	44.96	6.23	3.71	54.82	37.76
48	CMS 103 A x HRHA 4-2	91.69	0.48	88.16	25856.67	44.26	6.30	5.70	49.81	39.59
49	CMS 103 A x HRHA 5-3	35.81	1.44	35.14	23145.67	46.05	7.72	5.15	51.90	39.77
50	CMS 103 A x RHA 297	80.71	0.53	79.35	20294.00	45.84	7.23	6.00	58.72	32.16
51	CMS 234 A x 6D-1	48.92	1.52	47.28	13941.00	27.24	5.24	6.40	55.02	36.80

Sr.No.	Parents / Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
52	CMS 234A x RHA 271	87.69	0.48	85.48	26692.33	53.07	6.85	4.64	57.60	34.72
53	CMS 234 A x HRHA 4-2	92.63	0.46	88.40	24818.00	44.05	7.55	2.68	72.61	38.82
54	CMS 234 A x HRHA 5-3	86.19	0.57	93.10	21086.67	29.51	7.43	3.92	63.28	40.43
55	CMS 234 A x RHA 297	90.06	0.55	82.53	26228.67	28.18	7.90	4.29	59.13	31.29
56	CMS 302 A x 6D-1	84.90	0.47	83.38	25486.67	34.08	7.16	4.67	59.15	41.50
57	CMS 302 A x RHA 271	85.55	0.49	83.70	25889.00	32.24	7.70	2.95	54.95	38.72
58	CMS 302 A x HRHA 4-2	38.78	1.56	36.19	21443.00	26.72	7.54	3.45	62.53	38.67
59	CMS 302 A x HRHA 5-3	92.78	0.27	91.70	25210.67	42.20	5.81	3.08	58.15	44.61
60	CMS 302 A x RHA 297	94.87	0.52	92.07	27458.67	40.66	7.45	3.11	71.91	41.36
61	CMS 607 A x 6D-1	50.38	1.46	47.98	25252.67	15.57	7.15	2.86	65.60	26.67
62	CMS 607 A x RHA 271	93.71	0.33	91.68	26886.67	33.35	7.45	3.85	56.00	35.55
63	CMS 607 A x HRHA 4-2	92.14	0.22	90.84	26866.67	33.98	6.82	5.60	62.79	36.23
64	CMS 607 A x HRHA 5-3	77.21	0.54	75.13	21027.33	32.32	8.22	3.89	55.40	34.51
65	CMS 607 A x RHA 297	36.74	1.24	34.72	24601.67	19.99	7.49	6.14	61.26	30.47
66	CMS 852 A x 6D -1	94.70	0.56	94.15	28130.67	36.02	7.34	6.67	55.04	32.58
67	CMS 852 A x RHA 271	89.14	0.44	86.38	23308.67	34.57	9.70	3.83	67.41	40.45
68	CMS 852 A x HRHA 4-2	94.02	0.42	91.22	26210.67	46.29	8.00	4.16	64.95	33.62
69	CMS 852A x HRHA 5-3	92.43	0.40	90.44	25547.67	46.68	8.49	4.47	69.60	39.39
70	CMS 852 A x RHA 297	96.02	0.54	92.44	28673.00	39.56	7.27	4.88	55.14	35.30
71	ARG 2A x 6D-1	92.18	0.52	88.09	30821.33	35.85	7.25	3.26	72.50	42.56
72	ARG 2A x RHA 271	50.46	1.29	50.12	27104.00	23.82	7.90	5.80	67.72	41.55
73	ARG 2A x HRHA 4-2	94.80	0.37	92.02	26820.00	44.97	7.24	3.36	55.88	36.59
74	ARG 2A x HRHA 5-3	75.09	0.53	73.56	18062.67	19.12	7.27	3.19	69.15	43.65
75	ARG 2A x RHA 297	93.51	0.42	85.61	29260.00	34.63	8.48	3.24	79.20	41.26
76	ARG 3A x 6D -1	92.71	0.37	87.16	31375.33	39.57	9.38	3.65	71.10	29.31
77	ARG 3A x RHA 271	73.40	0.54	69.36	25755.67	35.26	8.65	3.21	72.70	38.76

Sr.No.	Parents / Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
78	ARG 3A x HRHA 4-2	87.46	0.37	84.06	28252.00	26.65	7.58	4.25	69.00	32.38
79	ARG 3A x HRHA 5-3	88.76	0.33	85.77	31234.67	27.23	7.78	3.35	64.68	38.32
80	ARG 3A x RHA 297	85.53	0.30	79.43	25043.33	25.47	9.09	4.95	67.63	40.37
81	ARG 6A x 6D-1	74.73	0.45	73.56	23104.00	46.86	10.00	3.05	70.00	38.74
82	ARG 6A x RHA 271	92.82	0.31	85.92	28132.00	29.44	11.40	2.45	67.27	31.47
83	ARG 6A x HRHA 4-2	93.09	0.30	85.10	28338.00	34.73	7.89	3.53	63.04	28.58
84	ARG 6A x HRHA 5-3	96.74	0.38	94.74	29599.00	34.73	8.52	3.32	68.28	31.37
85	ARG 6 A x RHA 297	93.43	0.48	86.08	29163.33	34.00	6.77	3.22	62.06	42.59
86	DV 10 x 6D -1	86.83	0.47	85.15	26318.33	28.45	6.59	4.19	63.51	39.47
87	DV 10 x RHA 271	84.19	0.49	82.71	27639.33	28.02	9.41	3.42	62.44	37.73
88	DV 10 x HRHA 4-2	92.11	0.38	83.03	28698.67	42.09	7.47	3.67	58.88	33.36
89	DV 10 x HRHA 5-3	94.70	0.46	88.81	28418.33	28.58	7.29	2.81	66.03	31.44
90	DV -10 x RHA 297	68.18	1.11	66.73	23190.67	19.23	7.68	2.41	69.22	43.59
91	CMS 207 A x 6D -1	90.05	0.57	82.93	27093.67	36.10	9.57	3.36	57.93	30.92
92	CMS 207 A x RHA 271	86.19	0.55	82.30	24195.00	62.67	8.45	2.56	64.60	28.35
93	CMS 207 A x HRHA 4-2	86.18	0.37	84.42	26732.67	32.26	17.56	2.36	72.48	29.89
94	CMS 207 A x HRHA 5-3	93.36	0.61	85.24	30724.00	44.09	5.60	3.60	65.97	33.64
95	CMS 207 A x RHA 297	94.87	0.58	92.75	34783.33	45.29	6.21	2.55	71.41	34.63
96	HSFH 848	74.67	0.63	55.80	23690.00	45.38	5.67	2.63	46.74	28.31
	Mean	83.12	0.63	79.27	25379.08	33.96	7.16	4.12	59.72	34.80
	Range	35.81	0.16	34.72	11836.00	13.20	5.01	2.36	45.97	10.34
		96.75	1.65	94.74	34783.33	63.10	17.56	8.33	79.20	44.61
	SE	3.13	0.04	2.43	13.29	2.06	0.61	0.31	1.86	0.52
	CDat5%	6.25	0.08	4.85	26.55	4.11	1.22	0.61	3.71	1.04

Mean performance of parents and hybrids of morphological traits and its seed yield component in E₄

Sr.No.	Parents / Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
1	CMS 11 A	122.04	12.71	4.35	60.30	95.35	6.41	22.32	34.49	40.45	58.43
2	CMS 17 A	133.62	11.47	4.15	58.60	94.64	5.14	23.75	46.70	48.31	74.90
3	CMS 44 A	130.33	11.51	3.46	60.06	90.42	4.63	17.96	48.66	18.13	29.08
4	CMS 148 A	123.05	11.59	3.63	62.14	96.01	5.26	22.27	50.01	50.43	62.73
5	CMSH 91 A	88.75	13.06	4.49	60.28	92.29	5.93	26.29	44.00	42.09	70.06
6	CMS 103 A	112.17	11.38	4.26	59.24	97.67	4.50	19.03	49.72	35.43	63.71
7	CMS 234 A	124.63	13.08	4.37	59.34	93.93	4.64	18.26	44.45	35.54	63.31
8	CMS 302 A	120.00	11.27	5.98	59.34	94.07	4.82	16.53	51.79	30.06	50.33
9	CMS 607 A	132.61	12.27	5.75	57.48	91.00	5.28	28.28	46.66	42.05	49.25
10	CMS 852 A	123.95	11.45	3.68	56.52	94.86	6.47	28.50	47.58	34.89	43.14
11	ARG 2-A	116.04	10.67	5.10	58.67	94.60	5.94	28.81	47.39	42.13	58.51
12	ARG 3-A	107.74	11.24	5.18	60.41	97.58	5.61	24.68	43.91	30.82	46.28
13	ARG 6-A	116.91	10.68	5.53	58.56	97.45	4.75	27.51	52.84	26.20	36.54
14	DV -10	114.96	10.56	4.46	56.73	95.23	4.48	24.55	45.37	40.06	62.53
15	CMS 207 A	114.52	11.32	4.31	62.45	93.68	5.88	26.02	43.79	38.65	66.30
16	6D-1	124.18	9.08	4.43	61.02	93.38	4.72	18.35	44.86	26.46	44.59
17	RHA 271	123.49	9.78	5.34	60.30	96.33	5.01	30.54	45.82	42.39	44.31
18	RHA 4-2	124.18	10.34	4.01	62.06	95.55	3.27	12.35	49.77	38.69	48.64
19	HRHA 5-3	113.23	10.01	5.75	58.00	90.15	5.53	21.16	41.29	41.39	52.39
20	RHA 297	114.63	8.42	4.14	58.62	96.24	4.85	23.71	50.14	40.28	50.38
21	CMS 11 A x 6D-1	176.27	17.55	8.67	65.02	95.67	7.00	33.71	37.73	53.12	72.41
22	CMS 11 A x RHA 271	186.80	17.08	7.63	65.34	96.67	7.27	41.21	38.43	51.33	82.10
23	CMS 11 A x HRHA 4-2	193.47	16.99	7.27	66.37	101.67	6.00	41.34	38.47	52.60	83.54
24	CMS 11 A x HRHA 5-3	203.33	18.87	9.03	65.35	96.67	4.00	41.45	38.60	56.74	94.79
25	CMS 11 A x RHA 297	179.73	18.93	8.90	69.04	100.67	4.65	45.04	38.77	56.82	84.39
26	CMS 17-A x 6D-1	206.00	19.40	8.33	65.05	100.67	8.17	46.86	40.20	59.53	87.28

Sr.No.	Parents / Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
27	CMS 17-A x RHA 271	196.33	18.60	8.53	67.22	98.33	7.00	46.40	37.23	36.63	43.79
28	CMS 17 -A x HRHA 4-2	195.47	18.33	8.23	64.53	97.33	6.75	46.54	39.33	53.92	64.11
29	CMS 17 -A x HRHA 5-3	195.60	17.87	8.80	65.09	98.67	6.11	44.51	38.43	58.51	92.11
30	CMS 17 A x RHA 297	184.93	18.33	8.33	65.36	98.67	7.17	34.33	38.63	63.64	90.81
31	CMS 44 A x 6D-1	185.60	16.33	7.17	64.46	99.33	5.22	39.38	40.10	45.83	88.01
32	CMS 44 A x RHA 271	189.13	17.13	7.13	63.97	97.00	5.14	30.27	39.87	49.39	87.87
33	CMS 44 A x HRHA 4-2	182.93	11.76	6.00	65.36	101.00	6.12	47.17	37.90	38.86	92.04
34	CMS 44 A x HRHA 5-3	205.87	18.00	9.27	62.68	96.00	7.00	46.15	38.90	44.23	75.38
35	CMS 44 A x RHA 297	202.13	17.93	9.33	61.85	96.33	7.67	34.34	38.00	52.27	83.92
36	CMS 148 A x 6D-1	192.07	13.60	7.57	63.28	98.00	7.60	42.66	38.53	50.32	94.05
37	CMS 148 A x RHA 271	190.80	17.79	9.37	64.82	98.00	7.07	41.69	36.90	52.34	64.82
38	CMS 148 A x HRHA 4-2	204.67	17.47	7.80	62.28	98.00	6.23	43.80	38.33	56.15	94.50
39	CMS 148 A x HRHA 5-3	192.73	18.20	8.73	69.41	99.00	7.73	46.82	36.67	23.39	72.82
40	CMS 148 A x RHA 297	187.13	18.27	8.23	62.17	96.00	6.34	47.14	37.17	40.15	38.95
41	CMSH 91 A x 6D-1	206.27	19.00	9.10	64.26	98.67	6.55	46.85	39.90	25.24	93.83
42	CMSH 91 A x RHA 271	195.80	17.87	8.07	66.65	102.33	7.60	41.78	39.93	54.93	72.07
43	CMSH 91 A x HRHA 4-2	205.00	18.80	9.00	67.49	100.67	7.37	41.23	38.53	55.96	90.33
44	CMSH 91 A x HRHA 5-3	193.00	19.13	9.23	66.78	96.67	6.77	54.55	37.27	44.99	83.00
45	CMSH 91 A x RHA 297	170.80	18.07	8.30	63.22	95.33	7.13	49.07	37.27	43.91	64.10
46	CMS 103 A x 6D-1	174.20	17.87	9.40	64.07	96.33	7.63	43.69	36.80	46.01	72.67
47	CMS 103 A x RHA 271	175.53	19.47	9.30	65.06	96.33	6.30	44.15	37.57	46.95	82.00
48	CMS 103 A x HRHA 4-2	181.53	17.20	6.90	62.35	95.33	8.00	37.46	39.03	49.14	82.67
49	CMS 103 A x HRHA 5-3	188.53	15.87	6.70	61.88	95.00	7.30	46.83	38.33	46.97	33.90
50	CMS 103 A x RHA 297	173.87	11.33	6.17	60.20	99.67	6.76	37.49	38.10	52.11	73.08
51	CMS 234 A x 6D-1	180.00	16.87	7.40	64.02	98.67	7.13	39.76	39.07	47.62	50.41
52	CMS 234A x RHA 271	191.53	19.00	9.53	64.51	95.33	7.77	39.13	37.57	56.77	76.75

Sr.No.	Parents / Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
53	CMS 234 A x HRHA 4-2	171.80	15.60	7.87	59.21	99.67	4.03	39.22	39.47	54.19	86.81
54	CMS 234 A x HRHA 5-3	183.20	11.70	6.47	58.15	96.67	7.70	38.81	37.70	55.96	90.00
55	CMS 234 A x RHA 297	176.20	17.07	7.23	58.09	97.33	6.03	38.48	40.13	59.53	81.22
56	CMS 302 A x 6D-1	166.80	17.53	7.83	57.82	97.33	4.77	38.03	39.80	46.89	84.29
57	CMS 302 A x RHA 271	189.67	17.93	9.00	59.35	92.33	8.07	39.84	38.37	56.24	65.44
58	CMS 302 A x HRHA 4-2	183.20	17.53	7.63	59.55	93.00	5.17	39.52	39.70	60.47	37.00
59	CMS 302 A x HRHA 5-3	200.93	18.00	8.80	62.74	95.33	5.55	39.17	39.13	57.10	72.67
60	CMS 302 A x RHA 297	184.40	18.33	8.50	66.04	96.00	5.89	45.95	39.30	58.82	84.67
61	CMS 607 A x 6D-1	176.07	19.33	9.67	65.46	96.00	6.12	47.41	37.80	48.01	45.14
62	CMS 607 A x RHA 271	194.80	20.27	9.50	62.72	97.33	7.37	40.85	37.97	54.03	74.00
63	CMS 607 A x HRHA 4-2	203.87	18.47	8.60	62.15	98.00	5.07	40.22	37.17	47.41	92.00
64	CMS 607 A x HRHA 5-3	205.60	16.80	7.77	61.71	102.00	5.63	43.24	39.93	52.48	46.34
65	CMS 607 A x RHA 297	176.00	13.37	7.77	60.40	91.00	6.44	38.78	39.27	50.86	34.77
66	CMS 852 A x 6D -1	175.67	15.67	6.27	61.71	103.33	7.90	36.30	38.37	47.34	91.67
67	CMS 852 A x RHA 271	191.60	15.67	6.47	57.11	89.00	7.03	41.14	37.43	53.44	90.17
68	CMS 852 A x HRHA 4-2	183.33	18.27	9.40	57.87	101.67	5.00	37.17	38.10	59.24	79.67
69	CMS 852A x HRHA 5-3	191.27	11.11	8.17	58.19	99.33	4.40	38.04	38.20	50.47	67.67
70	CMS 852 A x RHA 297	187.00	17.27	7.53	58.02	90.00	5.70	38.12	39.33	49.98	64.09
71	ARG 2A x 6D-1	183.27	18.27	9.13	59.96	98.33	7.23	32.76	38.03	58.52	93.67
72	ARG 2A x RHA 271	182.73	18.25	9.07	60.73	91.00	7.67	40.22	40.40	63.05	47.06
73	ARG 2A x HRHA 4-2	175.67	17.40	8.23	61.51	97.33	7.80	39.58	40.17	64.58	64.52
74	ARG 2A x HRHA 5-3	174.07	17.20	8.07	65.70	91.00	6.15	38.20	38.83	63.42	78.80
75	ARG 2A x RHA 297	185.60	15.40	6.60	62.80	91.33	5.27	43.31	39.57	58.82	77.67
76	ARG 3A x 6D -1	171.27	19.80	9.03	65.68	96.33	7.10	44.77	38.07	47.31	91.74
77	ARG 3A x RHA 271	172.67	18.13	8.13	66.89	97.00	6.03	38.01	39.70	50.15	68.00
78	ARG 3A x HRHA 4-2	172.93	16.13	6.47	65.77	97.67	6.97	35.96	38.00	59.65	75.95

Sr.No.	Parents / Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
79	ARG 3A x HRHA 5-3	180.53	16.47	7.43	65.57	96.00	6.87	40.11	37.70	62.02	89.48
80	ARG 3A x RHA 297	195.67	17.93	8.13	62.08	97.33	5.67	40.10	38.17	51.48	85.50
81	ARG 6A x 6D-1	183.73	16.93	7.23	60.52	98.00	5.09	41.88	37.67	58.43	68.60
82	ARG 6A x RHA 271	203.07	18.67	8.60	61.14	100.00	6.80	36.66	38.20	63.15	85.10
83	ARG 6A x HRHA 4-2	178.73	17.13	7.97	62.12	100.33	7.47	39.53	39.67	43.46	70.85
84	ARG 6A x HRHA 5-3	175.40	17.73	7.83	66.12	101.00	6.93	37.11	39.37	52.03	84.06
85	ARG 6 A x RHA 297	179.87	16.40	8.57	63.96	100.33	6.47	45.33	37.37	59.16	92.00
86	DV 10 x 6D -1	201.67	20.13	9.60	61.65	100.67	6.83	39.40	37.57	61.51	80.43
87	DV 10 x RHA 271	192.27	18.60	8.53	60.08	99.00	5.34	41.22	38.40	60.83	81.82
88	DV 10 x HRHA 4-2	184.87	17.13	8.20	62.74	99.00	7.33	37.68	39.23	53.69	72.64
89	DV 10 x HRHA 5-3	194.60	17.73	7.80	62.23	98.67	6.97	41.11	39.67	58.26	84.71
90	DV -10 x RHA 297	170.47	17.60	7.50	60.90	100.00	8.30	37.80	40.70	51.93	65.05
91	CMS 207 A x 6D -1	195.27	16.67	7.10	65.19	99.33	8.03	42.55	41.33	44.62	73.50
92	CMS 207 A x RHA 271	194.33	17.40	7.70	63.28	99.67	7.03	41.84	39.53	52.97	81.77
93	CMS 207 A x HRHA 4-2	193.00	17.87	7.93	61.77	100.33	7.34	37.03	40.20	61.17	84.54
94	CMS 207 A x HRHA 5-3	184.93	16.33	6.63	59.49	99.00	7.57	57.21	38.80	53.92	91.49
95	CMS 207 A x RHA 297	163.00	16.40	6.13	58.08	97.00	7.00	45.42	40.57	55.91	92.31
96	HSFH 848	132.13	13.35	8.63	57.38	96.67	5.61	36.70	39.60	45.62	42.03
	Mean	172.20	15.96	7.36	62.18	96.90	6.30	37.45	40.32	49.26	71.34
	Range	88.75	8.42	3.46	56.52	89.00	3.27	12.35	36.67	18.13	29.08
		206.27	20.27	9.67	69.41	103.33	8.30	57.21	52.84	64.58	94.79
	SE	2.22	1.34	0.82	2.14	1.08	0.70	1.56	1.17	3.04	2.48
	CDat5%	4.43	2.68	1.64	4.27	2.16	1.40	3.11	2.33	6.07	4.95

Mean performance of parents and hybrids of morphological traits and its seed yield component in E₄

Sr.No.	Parents/ Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
1	CMS 11 A	85.22	0.82	84.03	22435.33	26.06	6.71	4.15	49.27	32.16
2	CMS 17 A	87.10	0.79	77.06	21581.00	24.36	5.84	4.27	45.05	14.16
3	CMS 44 A	87.20	0.76	81.71	23014.00	22.39	5.92	3.66	52.37	35.49
4	CMS 148 A	93.56	0.84	87.18	26879.00	24.04	6.90	4.04	52.28	31.34
5	CMSH 91 A	86.12	0.70	75.79	22461.67	28.01	7.53	3.23	51.14	31.62
6	CMS 103 A	90.51	0.64	86.06	26627.00	32.20	6.48	3.23	44.82	27.41
7	CMS 234 A	50.03	1.04	44.04	21191.67	16.04	6.68	4.13	49.18	30.35
8	CMS 302 A	90.34	0.69	82.30	25925.00	22.19	7.56	5.04	47.52	30.24
9	CMS 607 A	77.49	1.09	62.88	27674.00	16.76	6.40	3.86	58.03	26.49
10	CMS 852 A	68.95	1.35	67.66	20232.00	20.24	7.41	4.21	53.04	29.87
11	ARG 2-A	80.05	0.82	69.74	24075.00	24.73	7.48	4.37	58.37	27.42
12	ARG 3-A	88.39	0.74	81.23	102435.33	30.69	7.40	4.81	52.86	33.19
13	ARG 6-A	92.80	0.84	85.38	26674.33	28.44	7.41	5.26	56.17	31.67
14	DV -10	91.08	0.78	88.17	21580.67	22.68	6.62	3.33	48.27	35.44
15	CMS 207 A	82.47	0.88	73.33	24336.00	21.39	6.69	8.24	50.38	26.31
16	6D-1	88.36	0.17	82.70	24359.33	19.45	7.08	4.04	52.52	15.43
17	RHA 271	92.23	0.13	87.62	24269.33	21.41	4.89	3.12	55.34	21.52
18	RHA 4-2	87.36	0.45	78.28	21724.00	15.35	5.86	4.20	51.58	24.14
19	HRHA 5-3	86.00	0.64	80.40	27044.33	18.35	6.10	5.28	45.10	26.51
20	RHA 297	55.83	1.28	45.70	24814.67	16.33	6.40	3.27	48.89	18.55
21	CMS 11 A x 6D-1	76.64	0.42	73.16	26976.00	32.29	5.04	3.61	58.16	25.06
22	CMS 11 A x RHA 271	87.55	0.32	85.08	29853.00	28.38	5.84	3.13	56.56	36.30
23	CMS 11 A x HRHA 4-2	90.69	0.15	77.94	32066.00	40.37	5.78	5.63	49.66	40.39
24	CMS 11 A x HRHA 5-3	94.02	0.27	91.13	34803.00	40.02	5.63	4.17	56.36	34.57
25	CMS 11 A x RHA 297	88.07	0.15	82.06	38263.67	48.94	4.91	3.53	57.00	35.64
26	CMS 17-A x 6D-1	93.77	0.15	92.53	28988.00	34.19	5.54	5.02	57.20	32.59

Sr.No.	Parents/ Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
27	CMS 17-A x RHA 271	45.76	1.59	44.24	21210.67	38.35	5.96	3.73	51.72	41.24
28	CMS 17 -A x HRHA 4-2	68.47	1.06	66.72	27162.33	22.12	6.48	7.49	56.68	31.41
29	CMS 17 -A x HRHA 5-3	95.03	0.09	90.00	30626.67	21.23	6.45	3.26	49.53	41.71
30	CMS 17 A x RHA 297	93.41	0.22	88.41	35772.67	50.34	6.17	5.21	47.56	42.61
31	CMS 44 A x 6D-1	91.36	0.07	88.68	34981.33	44.02	6.35	5.14	68.76	20.37
32	CMS 44 A x RHA 271	90.82	0.08	86.04	31413.00	28.14	6.34	4.07	55.44	36.65
33	CMS 44 A x HRHA 4-2	95.34	0.26	91.76	32243.33	29.14	6.45	3.96	58.74	31.51
34	CMS 44 A x HRHA 5-3	80.17	0.14	80.23	28003.33	34.59	5.67	4.66	48.35	42.21
35	CMS 44 A x RHA 297	84.78	0.24	86.28	27656.67	27.16	6.88	4.17	53.66	36.38
36	CMS 148 A x 6D-1	94.03	0.55	91.01	36826.67	43.56	6.60	3.46	50.03	41.51
37	CMS 148 A x RHA 271	68.54	0.20	64.59	25141.00	30.00	6.87	4.64	56.86	32.45
38	CMS 148 A x HRHA 4-2	96.00	0.18	89.24	32748.33	23.53	5.87	3.38	50.11	44.18
39	CMS 148 A x HRHA 5-3	77.59	0.52	72.87	26907.00	33.28	6.20	5.69	47.37	43.32
40	CMS 148 A x RHA 297	40.15	0.49	40.39	21334.33	22.71	6.51	4.02	61.40	32.26
41	CMSH 91 A x 6D-1	95.35	0.45	93.09	33784.33	14.96	6.55	7.59	56.86	30.15
42	CMSH 91 A x RHA 271	74.22	0.39	73.02	25349.00	32.47	6.26	5.40	51.27	39.46
43	CMSH 91 A x HRHA 4-2	92.84	0.42	89.34	24766.33	32.08	6.22	5.63	79.49	10.45
44	CMSH 91 A x HRHA 5-3	83.74	0.28	80.43	35442.67	32.13	6.65	4.18	68.32	42.19
45	CMSH 91 A x RHA 297	70.79	1.06	69.00	25781.33	25.85	6.80	4.10	55.52	36.07
46	CMS 103 A x 6D-1	74.29	0.17	92.00	30533.33	25.21	7.25	6.70	56.86	40.30
47	CMS 103 A x RHA 271	90.08	0.36	85.33	32706.67	33.24	6.82	4.06	54.84	37.61
48	CMS 103 A x HRHA 4-2	85.73	0.15	82.79	25275.67	23.83	6.49	5.73	59.36	39.76
49	CMS 103 A x HRHA 5-3	34.45	1.18	34.41	26044.00	27.02	7.67	5.11	58.79	39.36
50	CMS 103 A x RHA 297	74.88	0.24	73.72	25713.67	15.35	7.47	5.62	55.78	32.12
51	CMS 234 A x 6D-1	52.74	1.26	51.63	30034.67	26.05	5.74	6.62	54.85	36.30
52	CMS 234A x RHA 271	78.78	0.29	77.20	26345.33	14.94	6.63	4.32	56.51	34.68

Sr.No.	Parents/ Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
53	CMS 234 A x HRHA 4-2	88.81	0.39	84.47	35057.33	33.94	9.67	2.78	70.97	38.58
54	CMS 234 A x HRHA 5-3	90.68	0.42	85.00	28738.67	26.07	7.53	3.99	62.05	40.36
55	CMS 234 A x RHA 297	84.45	0.18	83.76	35738.33	36.12	8.46	4.38	58.19	31.47
56	CMS 302 A x 6D-1	86.84	0.24	84.07	28061.33	25.97	6.83	4.31	69.29	41.38
57	CMS 302 A x RHA 271	67.17	1.14	63.55	36664.33	33.33	8.43	3.97	51.36	38.47
58	CMS 302 A x HRHA 4-2	38.10	0.26	42.37	23362.67	20.50	7.93	4.37	50.53	38.39
59	CMS 302 A x HRHA 5-3	77.37	0.26	71.19	22247.67	16.33	5.63	4.09	47.69	44.58
60	CMS 302 A x RHA 297	85.66	0.28	84.01	28263.33	22.87	7.69	3.97	67.62	41.23
61	CMS 607 A x 6D-1	47.67	1.25	44.66	36735.67	29.14	9.52	4.66	61.53	26.37
62	CMS 607 A x RHA 271	79.36	0.43	77.41	25322.67	13.98	7.60	4.63	54.70	35.47
63	CMS 607 A x HRHA 4-2	93.34	0.22	90.68	29863.33	23.99	6.75	5.66	51.40	36.42
64	CMS 607 A x HRHA 5-3	52.10	1.26	50.92	34824.67	33.12	9.02	4.70	52.86	34.36
65	CMS 607 A x RHA 297	36.79	1.15	35.20	21477.00	18.74	7.50	6.19	57.59	30.48
66	CMS 852 A x 6D -1	94.68	0.25	85.04	31791.33	12.25	7.57	7.09	52.63	32.68
67	CMS 852 A x RHA 271	90.75	0.34	88.69	24930.67	22.30	9.63	4.91	45.62	40.29
68	CMS 852 A x HRHA 4-2	80.79	0.28	74.74	28683.33	30.25	9.47	5.78	52.51	33.63
69	CMS 852A x HRHA 5-3	70.39	1.11	67.26	30644.00	36.31	8.69	5.29	47.27	39.68
70	CMS 852 A x RHA 297	67.98	1.14	66.04	23907.33	20.48	7.60	5.96	51.36	35.44
71	ARG 2A x 6D-1	95.35	0.17	92.01	23494.00	14.70	7.41	3.74	47.31	42.37
72	ARG 2A x RHA 271	47.60	1.29	47.14	27624.00	22.04	8.09	5.81	55.52	41.54
73	ARG 2A x HRHA 4-2	65.40	1.04	63.73	24783.67	14.09	7.14	4.47	53.46	36.60
74	ARG 2A x HRHA 5-3	82.82	0.14	81.60	28745.33	15.80	7.43	4.16	46.18	43.47
75	ARG 2A x RHA 297	81.11	0.15	77.73	31228.00	21.90	8.39	4.55	47.12	41.26
76	ARG 3A x 6D -1	92.78	0.16	85.41	27961.33	15.90	9.54	5.27	57.54	29.25
77	ARG 3A x RHA 271	69.59	1.29	68.78	22748.67	25.90	8.86	4.50	49.39	38.55
78	ARG 3A x HRHA 4-2	77.61	0.23	70.71	28187.33	14.32	7.74	5.50	56.23	32.26

Sr.No.	Parents/ Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
79	ARG 3A x HRHA 5-3	90.83	0.24	88.03	30493.67	14.34	7.82	4.54	50.35	38.32
80	ARG 3A x RHA 297	85.67	0.26	82.73	29195.00	18.27	9.13	6.51	44.54	40.55
81	ARG 6A x 6D-1	71.53	0.26	66.80	26234.00	15.99	10.54	4.56	47.45	38.52
82	ARG 6A x RHA 271	91.34	0.36	84.22	32581.33	21.85	11.42	3.06	53.50	31.25
83	ARG 6A x HRHA 4-2	73.41	0.29	68.92	31872.00	29.57	9.59	3.68	58.32	28.72
84	ARG 6A x HRHA 5-3	86.73	0.31	85.67	27288.00	25.48	10.52	3.22	55.69	31.45
85	ARG 6 A x RHA 297	93.07	0.28	83.57	22604.00	26.04	6.81	2.78	47.58	42.47
86	DV 10 x 6D -1	82.20	0.27	79.41	26123.00	24.08	7.99	3.67	49.16	39.44
87	DV 10 x RHA 271	84.79	0.24	82.15	24794.33	18.34	10.60	3.47	48.64	37.47
88	DV 10 x HRHA 4-2	74.17	0.25	70.27	27874.67	25.73	7.59	3.69	56.29	33.24
89	DV 10 x HRHA 5-3	85.35	0.26	82.19	30030.67	26.81	7.38	2.84	62.70	31.48
90	DV -10 x RHA 297	65.72	1.35	65.33	23544.33	27.72	7.75	2.37	47.60	43.72
91	CMS 207 A x 6D -1	75.54	0.48	72.42	24461.33	23.77	9.49	3.22	54.53	30.74
92	CMS 207 A x RHA 271	83.36	0.40	80.16	27790.67	28.50	8.70	2.62	61.19	28.36
93	CMS 207 A x HRHA 4-2	86.68	0.53	83.79	29532.33	32.08	17.31	2.14	50.29	29.40
94	CMS 207 A x HRHA 5-3	92.78	0.28	91.11	30156.67	23.53	7.13	3.64	56.36	33.54
95	CMS 207 A x RHA 297	95.34	0.73	94.17	28788.00	25.70	6.65	2.58	57.42	34.38
96	HSFH 848	63.43	1.30	65.00	23796.00	17.45	9.24	2.58	42.11	28.15
	Mean	79.67	0.54	76.02	28565.98	25.54	7.41	4.42	53.99	34.12
	Range	34.45	0.07	34.41	20232.00	12.25	4.89	2.14	42.11	10.45
		96.00	1.59	94.17	102435.33	50.34	17.31	8.24	79.49	44.58
	SE	3.13	0.06	2.41	11213.11	1.68	0.44	0.49	1.39	0.69
	CDat5%	6.26	0.11	4.81	22403.79	3.36	0.88	0.97	2.77	1.37

Mean performance of parents and hybrids of morphological traits and its seed yield component over the environments

Sr.No	Parents / Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
1	CMS 11 A	106.12	11.94	4.13	59.02	94.37	5.23	20.64	32.30	37.87	58.30
2	CMS 17 A	115.70	9.85	4.53	60.34	95.81	4.23	20.43	37.61	45.84	72.08
3	CMS 44 A	112.22	10.61	3.98	59.42	90.34	4.28	18.14	38.66	23.54	29.45
4	CMS 148 A	109.77	11.19	3.74	61.00	98.35	5.10	21.19	41.42	48.04	63.99
5	CMSH 91 A	82.27	12.48	4.59	60.76	93.41	5.29	23.34	37.89	36.90	61.24
6	CMS 103 A	98.94	10.38	4.15	58.42	97.14	4.60	18.06	39.79	34.48	59.95
7	CMS 234 A	105.48	10.79	4.09	57.70	91.32	4.42	17.59	37.39	34.87	60.40
8	CMS 302 A	112.32	9.71	4.95	58.81	95.08	4.67	15.74	40.48	29.74	47.34
9	CMS 607 A	115.36	11.06	4.67	57.18	90.49	5.08	23.45	41.28	41.04	46.79
10	CMS 852 A	119.19	9.14	4.35	57.12	97.05	5.62	21.33	37.87	33.97	42.05
11	ARG 2-A	94.15	10.61	4.35	59.26	96.34	6.07	24.89	41.39	40.64	52.36
12	ARG 3-A	95.15	10.64	4.48	60.87	99.48	4.98	22.13	38.32	32.96	43.64
13	ARG 6-A	111.01	8.40	5.12	58.50	97.95	4.38	21.25	40.34	28.11	36.13
14	DV -10	100.22	10.46	4.34	57.58	97.01	4.29	21.24	38.10	40.54	59.09
15	CMS 207 A	111.54	9.12	4.51	61.51	95.36	4.52	20.52	36.10	38.12	60.59
16	6D-1	115.23	8.73	4.39	59.17	92.23	4.77	17.41	37.61	32.07	41.86
17	RHA 271	108.63	9.39	4.60	59.84	95.34	4.82	23.22	37.17	40.63	53.20
18	RHA 4-2	97.55	10.98	3.56	61.19	96.97	4.48	15.95	43.16	39.61	56.27
19	HRHA 5-3	98.87	10.06	4.71	56.16	89.66	4.85	19.67	35.62	41.00	55.86
20	RHA 297	108.88	7.51	4.55	58.19	96.08	4.65	18.75	39.78	35.72	47.43
21	CMS 11 A x 6D-1	134.62	14.27	7.04	57.98	93.49	7.28	30.69	37.89	45.62	84.71
22	CMS 11 A x RHA 271	137.97	14.14	6.59	58.32	93.32	7.00	33.01	39.05	49.72	86.47
23	CMS 11 A x HRHA 4-2	136.02	14.46	6.90	58.16	95.42	6.22	34.54	38.82	47.26	87.94
24	CMS 11 A x HRHA 5-3	141.93	16.00	7.72	58.50	94.33	7.62	36.42	38.14	44.03	83.68
25	CMS 11 A x RHA 297	137.07	14.15	7.13	60.21	95.25	7.25	35.78	39.08	51.60	90.31
26	CMS 17-A x 6D-1	146.33	16.47	7.47	58.96	95.95	7.18	36.27	39.70	52.27	86.41

Sr.No	Parents / Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
27	CMS 17-A x RHA 271	137.88	15.75	7.57	60.82	94.62	8.00	37.58	38.23	44.55	80.94
28	CMS 17 -A x HRHA 4-2	141.55	14.55	7.07	59.64	94.32	7.13	34.99	38.96	45.21	73.26
29	CMS 17 -A x HRHA 5-3	138.10	17.70	8.19	58.00	93.75	7.26	34.10	38.47	46.26	88.13
30	CMS 17 A x RHA 297	134.38	15.12	7.92	58.46	94.46	6.48	35.15	38.10	48.03	85.26
31	CMS 44 A x 6D-1	137.42	15.85	7.54	58.16	95.04	8.12	35.31	38.28	50.56	87.93
32	CMS 44 A x RHA 271	130.15	14.18	6.66	58.43	94.38	7.22	30.45	39.23	46.99	88.99
33	CMS 44 A x HRHA 4-2	128.73	14.39	6.21	59.12	95.15	7.71	37.78	38.34	44.93	89.06
34	CMS 44 A x HRHA 5-3	138.20	16.50	7.86	58.04	93.75	6.00	34.78	38.77	42.24	79.28
35	CMS 44 A x RHA 297	138.60	15.70	8.23	58.86	94.54	7.91	35.86	38.50	46.74	91.82
36	CMS 148 A x 6D-1	130.22	13.80	7.12	58.15	95.79	7.36	33.45	38.48	44.66	82.40
37	CMS 148 A x RHA 271	130.53	15.30	7.61	58.25	94.93	7.51	34.13	38.38	46.32	85.69
38	CMS 148 A x HRHA 4-2	139.17	16.80	7.73	57.27	96.40	7.84	36.15	38.15	55.64	88.26
39	CMS 148 A x HRHA 5-3	129.93	14.78	7.71	60.43	95.22	5.00	38.44	38.18	42.82	85.64
40	CMS 148 A x RHA 297	134.58	15.30	7.67	58.64	93.32	7.81	37.99	38.68	45.72	74.91
41	CMSH 91 A x 6D-1	139.07	16.28	7.63	58.82	95.50	6.00	38.20	39.53	44.53	77.89
42	CMSH 91 A x RHA 271	135.97	15.02	7.83	59.15	97.88	7.47	34.05	38.93	49.45	83.76
43	CMSH 91 A x HRHA 4-2	139.77	16.05	7.97	59.36	95.58	6.33	33.31	38.48	52.96	85.09
44	CMSH 91 A x HRHA 5-3	139.13	14.95	7.54	59.88	96.44	7.63	38.07	38.20	50.11	89.44
45	CMSH 91 A x RHA 297	127.00	15.47	7.62	58.54	94.57	7.58	36.56	37.54	49.46	84.67
46	CMS 103 A x 6D-1	135.47	14.77	7.68	61.83	96.40	7.10	35.48	37.68	51.36	82.31
47	CMS 103 A x RHA 271	135.65	14.27	7.18	61.02	93.36	6.00	34.33	39.25	54.10	86.02
48	CMS 103 A x HRHA 4-2	138.05	15.25	7.19	60.38	94.35	7.72	34.59	38.47	52.24	87.86
49	CMS 103 A x HRHA 5-3	140.57	14.00	6.84	62.17	95.01	6.00	34.90	38.18	48.46	77.38
50	CMS 103 A x RHA 297	134.32	12.58	6.44	59.09	97.51	7.85	32.73	38.30	47.19	72.06
51	CMS 234 A x 6D-1	142.28	15.32	7.03	57.84	96.19	7.22	35.23	38.34	53.50	78.23
52	CMS 234A x RHA 271	138.08	14.55	8.10	60.01	96.46	7.20	33.14	37.79	53.54	76.77

Sr.No	Parents / Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
53	CMS 234 A x HRHA 4-2	120.60	13.63	7.16	59.38	97.61	7.36	32.34	38.10	54.47	89.66
54	CMS 234 A x HRHA 5-3	134.78	13.92	7.23	58.59	97.73	7.71	31.79	37.99	52.64	89.61
55	CMS 234 A x RHA 297	135.13	14.72	7.04	57.20	96.49	6.85	34.29	38.15	50.58	85.07
56	CMS 302 A x 6D-1	131.12	14.53	7.46	56.13	96.47	6.67	33.69	38.41	53.76	89.57
57	CMS 302 A x RHA 271	143.47	15.10	7.44	57.26	94.55	7.64	35.46	39.17	56.50	82.02
58	CMS 302 A x HRHA 4-2	133.63	15.65	7.66	58.10	94.90	7.18	33.69	39.02	56.95	74.96
59	CMS 302 A x HRHA 5-3	143.87	15.42	7.58	60.82	99.36	7.04	32.80	38.71	53.72	74.88
60	CMS 302 A x RHA 297	144.93	14.85	7.52	60.24	95.52	7.21	34.69	38.85	56.95	90.57
61	CMS 607 A x 6D-1	135.82	15.10	7.87	62.34	97.11	7.43	35.24	38.23	52.94	80.53
62	CMS 607 A x RHA 271	145.48	16.20	7.58	58.98	94.19	7.48	34.39	39.00	55.33	76.68
63	CMS 607 A x HRHA 4-2	138.68	15.12	6.95	57.64	96.78	7.86	34.47	38.53	52.59	89.59
64	CMS 607 A x HRHA 5-3	152.70	14.47	7.08	58.79	98.13	6.36	32.10	38.48	54.54	77.31
65	CMS 607 A x RHA 297	131.30	13.23	6.95	58.64	95.75	7.67	33.31	38.41	49.81	71.59
66	CMS 852 A x 6D -1	135.00	14.17	6.38	57.86	98.62	7.29	33.79	38.18	49.07	75.08
67	CMS 852 A x RHA 271	134.32	15.12	7.26	56.42	94.41	7.74	35.09	38.02	51.22	90.26
68	CMS 852 A x HRHA 4-2	139.75	13.98	7.53	56.73	98.30	6.02	32.58	38.23	54.44	87.52
69	CMS 852A x HRHA 5-3	132.23	12.44	6.98	59.20	97.53	7.03	32.50	38.50	55.67	85.25
70	CMS 852 A x RHA 297	135.82	14.62	6.86	59.87	94.62	6.58	32.23	39.39	54.11	81.51
71	ARG 2A x 6D-1	135.78	15.22	7.42	57.51	96.95	7.30	33.65	37.68	55.58	93.11
72	ARG 2A x RHA 271	139.75	15.61	7.43	60.28	95.19	7.83	33.30	38.79	55.73	77.14
73	ARG 2A x HRHA 4-2	134.60	14.48	7.10	61.04	96.97	7.54	34.56	39.13	55.29	74.17
74	ARG 2A x HRHA 5-3	134.50	13.82	7.03	59.46	94.30	5.66	34.44	38.91	55.55	85.88
75	ARG 2A x RHA 297	135.92	13.22	6.71	59.85	96.42	7.09	36.49	39.43	54.45	83.57
76	ARG 3A x 6D -1	129.40	14.43	7.21	60.45	96.44	7.48	35.34	38.58	47.48	90.52
77	ARG 3A x RHA 271	129.00	14.73	6.97	61.48	96.26	4.67	33.04	38.92	51.51	85.41
78	ARG 3A x HRHA 4-2	130.47	13.83	6.66	61.06	96.38	6.74	32.39	38.74	49.46	85.21

Sr.No	Parents / Hybrids	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
79	ARG 3A x HRHA 5-3	128.43	14.83	7.07	61.59	95.20	6.90	33.93	38.56	51.86	90.62
80	ARG 3A x RHA 297	134.85	13.88	7.03	60.53	95.57	7.83	34.93	37.78	49.22	91.99
81	ARG 6A x 6D-1	128.93	14.98	7.01	58.31	95.25	5.55	36.30	38.89	56.15	84.90
82	ARG 6A x RHA 271	130.12	15.40	6.99	61.66	96.45	7.52	33.65	38.14	56.36	87.55
83	ARG 6A x HRHA 4-2	133.22	13.85	7.30	61.03	97.16	5.89	32.77	39.59	52.46	83.17
84	ARG 6A x HRHA 5-3	132.67	14.03	7.03	61.47	96.70	6.67	32.80	39.21	49.51	89.62
85	ARG 6 A x RHA 297	129.12	14.08	7.43	60.81	97.25	7.35	36.30	38.32	54.89	93.77
86	DV 10 x 6D -1	139.10	14.83	7.59	59.50	97.74	6.22	32.48	39.15	56.68	77.47
87	DV 10 x RHA 271	136.53	14.13	6.98	60.54	97.31	7.85	32.97	38.65	55.12	86.23
88	DV 10 x HRHA 4-2	138.18	13.70	6.88	62.82	96.54	6.16	31.13	38.58	58.93	81.04
89	DV 10 x HRHA 5-3	132.70	13.15	6.68	60.06	96.98	6.45	33.02	38.40	56.61	87.56
90	DV -10 x RHA 297	125.48	13.83	6.67	60.55	97.85	7.13	33.36	39.23	53.25	87.88
91	CMS 207 A x 6D -1	133.47	13.72	6.75	61.47	97.82	6.71	34.31	40.21	41.39	82.04
92	CMS 207 A x RHA 271	130.55	14.48	7.01	61.11	97.75	7.00	33.64	39.13	51.75	90.11
93	CMS 207 A x HRHA 4-2	135.90	15.30	7.58	61.13	96.92	7.15	33.22	38.98	51.60	86.83
94	CMS 207 A x HRHA 5-3	133.02	16.15	7.33	61.73	95.83	6.03	40.13	39.23	54.68	91.25
95	CMS 207 A x RHA 297	131.53	16.64	7.86	60.41	95.68	6.34	37.46	40.17	51.81	92.19
96	HSFH 848	114.92	12.83	6.65	56.96	92.43	6.31	28.96	37.71	44.14	58.00
	Mean	129.11	13.79	6.66	59.39	95.69	6.55	31.43	38.62	48.13	77.49
	Range	82.27	7.51	3.56	56.13	89.66	4.23	15.74	35.62	23.54	29.45
		152.70	17.70	8.23	62.82	99.48	8.12	40.13	43.16	58.93	93.77
	SE	1.80	0.57	0.30	0.76	0.60	0.34	0.93	0.62	1.76	1.49
	CDat5%	3.60	1.13	0.60	1.51	1.19	0.69	1.86	1.24	3.52	2.98

Mean performance of parents and hybrids of morphological traits and its seed yield component over the environments

Sr.No.	Parents / Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
1	CMS 11 A	83.37	0.80	79.59	21482.33	22.58	6.00	4.50	34.30	45.31
2	CMS 17 A	83.74	0.77	75.87	20548.67	22.47	5.56	5.32	38.28	38.93
3	CMS 44 A	84.78	0.73	78.81	21462.00	21.50	5.41	4.06	39.84	45.82
4	CMS 148 A	91.04	0.82	83.73	24431.33	24.77	6.18	5.10	40.66	44.40
5	CMSH 91 A	86.33	0.66	76.87	22475.67	25.03	6.68	3.99	37.13	46.40
6	CMS 103 A	87.97	0.67	82.72	23548.67	28.88	6.20	4.15	35.64	44.68
7	CMS 234 A	48.93	1.06	43.58	19724.33	15.88	6.61	4.26	37.21	38.10
8	CMS 302 A	89.95	0.72	82.00	23738.00	23.84	7.56	5.73	39.04	38.93
9	CMS 607 A	73.78	0.98	63.16	24057.00	14.37	6.23	4.45	41.47	41.57
10	CMS 852 A	71.46	1.11	65.69	20908.67	18.55	6.69	4.63	40.22	42.00
11	ARG 2-A	78.73	0.79	69.71	21077.33	22.24	6.81	5.16	41.91	45.34
12	ARG 3-A	85.12	0.75	78.08	24680.33	27.77	7.22	5.01	43.36	45.84
13	ARG 6-A	91.25	0.83	85.35	23912.67	27.53	6.94	5.74	41.49	45.22
14	DV -10	88.58	0.77	82.63	21413.33	21.01	6.22	4.21	35.79	44.80
15	CMS 207 A	80.48	0.87	72.68	21178.33	21.82	6.51	8.03	39.03	40.54
16	6D-1	85.73	0.23	78.53	22604.00	19.79	6.50	4.26	40.36	36.36
17	RHA 271	90.60	0.27	85.91	23995.33	21.86	5.69	4.05	43.19	37.30
18	RHA 4-2	84.08	0.46	77.43	21179.67	15.98	6.19	4.70	39.84	34.68
19	HRHA 5-3	83.22	0.61	76.28	24443.00	18.81	5.65	6.26	38.44	39.77
20	RHA 297	54.62	1.28	47.27	21741.67	13.84	6.18	4.12	41.72	38.86
21	CMS 11 A x 6D-1	90.29	0.43	87.64	29648.67	38.07	5.89	4.59	42.40	49.88
22	CMS 11 A x RHA 271	90.37	0.38	90.83	30115.33	38.21	6.53	3.60	38.24	52.12
23	CMS 11 A x HRHA 4-2	85.21	0.63	79.99	27908.33	32.70	6.36	5.49	33.91	54.92
24	CMS 11 A x HRHA 5-3	93.83	0.37	90.46	32249.33	34.26	6.13	4.87	39.09	49.80
25	CMS 11 A x RHA 297	92.17	0.44	86.59	32031.67	35.51	5.74	4.48	36.90	52.65
26	CMS 17-A x 6D-1	94.22	0.39	91.32	30209.67	34.90	5.86	5.24	43.71	45.87

Sr.No.	Parents / Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
27	CMS 17-A x RHA 271	69.45	0.96	65.53	25924.67	31.35	6.11	4.08	41.13	50.22
28	CMS 17 -A x HRHA 4-2	84.90	0.65	80.72	26538.67	34.68	6.35	5.47	41.89	42.34
29	CMS 17 -A x HRHA 5-3	90.35	0.45	85.01	27186.33	35.61	6.42	4.24	36.80	56.52
30	CMS 17 A x RHA 297	90.88	0.41	87.89	29484.33	40.81	5.86	5.39	35.22	56.04
31	CMS 44 A x 6D-1	94.18	0.39	89.57	29279.33	39.75	6.26	5.35	43.16	44.09
32	CMS 44 A x RHA 271	92.35	0.45	89.26	26791.00	36.45	5.83	4.89	35.90	54.76
33	CMS 44 A x HRHA 4-2	93.19	0.53	89.52	28845.33	33.36	6.19	4.65	38.91	46.39
34	CMS 44 A x HRHA 5-3	89.88	0.43	86.98	29949.67	31.40	6.03	4.91	36.95	55.57
35	CMS 44 A x RHA 297	81.38	0.68	79.90	26754.67	29.28	5.71	4.74	40.34	52.74
36	CMS 148 A x 6D-1	93.96	0.44	92.07	28663.67	46.39	6.10	4.47	40.77	50.22
37	CMS 148 A x RHA 271	82.70	0.37	79.75	24519.67	35.35	6.18	4.22	41.42	40.43
38	CMS 148 A x HRHA 4-2	94.61	0.41	89.48	27348.00	35.21	6.03	4.07	31.26	52.48
39	CMS 148 A x HRHA 5-3	85.06	0.57	82.76	25863.00	32.51	6.48	5.48	35.55	51.12
40	CMS 148 A x RHA 297	67.34	0.81	65.37	21801.00	23.92	6.11	4.75	40.55	50.08
41	CMSH 91 A x 6D-1	91.24	0.51	85.36	27983.67	26.91	6.81	6.19	40.14	51.59
42	CMSH 91 A x RHA 271	83.69	0.51	78.94	25202.00	31.36	6.42	5.11	36.95	54.78
43	CMSH 91 A x HRHA 4-2	89.24	0.58	87.65	26267.00	36.78	6.58	5.49	47.06	35.16
44	CMSH 91 A x HRHA 5-3	90.42	0.42	83.38	29206.00	44.14	7.26	4.96	40.84	57.04
45	CMSH 91 A x RHA 297	83.13	0.74	79.52	24133.67	41.95	6.58	4.47	39.10	50.54
46	CMS 103 A x 6D-1	90.02	0.54	89.92	30285.33	48.19	6.83	5.55	38.31	52.08
47	CMS 103 A x RHA 271	93.81	0.60	90.31	29755.33	47.12	6.69	4.97	37.39	51.27
48	CMS 103 A x HRHA 4-2	91.08	0.53	87.38	27717.00	41.21	6.82	5.56	35.74	50.25
49	CMS 103 A x HRHA 5-3	64.14	1.04	62.12	26352.00	38.23	7.24	5.15	36.10	48.73
50	CMS 103 A x RHA 297	86.30	0.61	83.47	25738.00	33.88	7.61	6.20	41.27	37.57
51	CMS 234 A x 6D-1	70.57	1.09	66.35	25162.33	33.31	6.42	6.20	37.58	41.52
52	CMS 234A x RHA 271	90.11	0.54	85.91	27115.67	39.33	7.25	4.75	39.50	46.99

Sr.No.	Parents / Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
53	CMS 234 A x HRHA 4-2	92.08	0.56	87.33	29276.00	39.80	7.52	5.36	49.05	45.91
54	CMS 234 A x HRHA 5-3	90.45	0.61	87.95	25920.00	34.48	7.61	4.25	44.05	50.14
55	CMS 234 A x RHA 297	90.24	0.44	86.81	28233.33	38.32	7.35	7.09	46.20	51.31
56	CMS 302 A x 6D-1	90.13	0.42	87.55	26739.00	32.52	7.24	6.31	43.43	55.46
57	CMS 302 A x RHA 271	85.60	0.69	80.86	31185.67	32.06	7.97	6.92	42.95	44.67
58	CMS 302 A x HRHA 4-2	64.04	0.80	64.29	28680.33	27.96	7.28	5.03	40.41	47.55
59	CMS 302 A x HRHA 5-3	89.38	0.52	85.58	27476.33	31.48	6.45	4.72	35.80	51.21
60	CMS 302 A x RHA 297	91.40	0.58	87.61	31299.00	32.52	7.41	3.57	43.75	53.08
61	CMS 607 A x 6D-1	70.73	1.05	66.75	29142.00	26.66	7.74	6.72	38.10	48.85
62	CMS 607 A x RHA 271	91.31	0.52	88.07	26920.33	30.08	7.40	5.08	34.51	50.97
63	CMS 607 A x HRHA 4-2	94.45	0.46	91.12	27421.33	28.65	8.16	6.27	43.47	40.87
64	CMS 607 A x HRHA 5-3	78.98	0.69	75.94	26442.00	28.81	7.12	4.42	41.48	45.93
65	CMS 607 A x RHA 297	65.43	0.84	62.66	25640.33	27.66	7.43	6.13	45.42	36.78
66	CMS 852 A x 6D -1	94.98	0.55	89.72	28097.33	32.60	7.07	6.38	33.99	44.75
67	CMS 852 A x RHA 271	90.99	0.56	87.51	25992.00	34.95	8.42	4.97	40.61	50.51
68	CMS 852 A x HRHA 4-2	90.63	0.56	85.46	27287.33	41.35	7.11	4.53	38.78	49.48
69	CMS 852A x HRHA 5-3	86.93	0.76	83.64	26690.33	37.45	7.25	5.71	44.35	49.13
70	CMS 852 A x RHA 297	86.00	0.76	79.52	26244.67	34.77	6.77	5.98	39.76	52.54
71	ARG 2A x 6D-1	94.03	0.49	91.23	27540.67	27.23	7.04	6.55	46.87	49.47
72	ARG 2A x RHA 271	70.21	0.93	67.63	25874.33	23.58	7.42	7.74	41.37	53.24
73	ARG 2A x HRHA 4-2	86.59	0.75	83.46	27350.00	29.04	6.98	4.60	45.04	45.21
74	ARG 2A x HRHA 5-3	85.52	0.50	83.01	25368.67	23.43	7.39	4.66	37.43	57.93
75	ARG 2A x RHA 297	90.53	0.51	83.45	28676.33	28.51	8.38	6.89	43.76	52.11
76	ARG 3A x 6D -1	91.62	0.57	86.53	27853.00	30.75	7.51	5.31	40.59	41.73
77	ARG 3A x RHA 271	82.36	0.79	77.82	25347.00	31.51	8.59	6.73	39.44	44.18
78	ARG 3A x HRHA 4-2	86.58	0.41	80.95	26466.00	28.07	8.21	5.92	43.69	40.01

Sr.No.	Parents / Hybrids	GERM. (%)	EC ($\mu\text{Scm}^{-1}\text{g}^{-1}$)	VIAB. (%)	VI-I	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
79	ARG 3A x HRHA 5-3	91.39	0.43	85.81	30053.67	30.70	7.02	6.84	39.19	50.37
80	ARG 3A x RHA 297	89.02	0.45	83.21	27624.33	31.60	7.75	7.14	41.54	55.64
81	ARG 6A x 6D-1	82.78	0.48	76.47	25548.67	35.99	7.42	5.46	39.92	53.27
82	ARG 6A x RHA 271	93.09	0.48	84.93	27548.67	32.74	9.13	5.89	43.20	46.84
83	ARG 6A x HRHA 4-2	86.67	0.49	81.57	28923.00	34.78	7.40	4.37	44.07	49.25
84	ARG 6A x HRHA 5-3	93.83	0.54	89.03	28279.67	41.33	8.76	5.42	41.18	44.97
85	ARG 6 A x RHA 297	94.08	0.49	88.41	25353.00	39.98	6.58	4.24	38.03	51.92
86	DV 10 x 6D -1	83.80	0.51	77.81	27582.00	34.06	7.18	4.34	39.03	52.61
87	DV 10 x RHA 271	86.63	0.44	81.61	26890.00	29.67	9.04	4.25	42.45	45.16
88	DV 10 x HRHA 4-2	86.65	0.40	81.92	27396.00	34.90	8.14	5.54	36.97	52.29
89	DV 10 x HRHA 5-3	83.09	0.60	77.99	25562.67	30.18	7.27	5.36	38.81	52.06
90	DV -10 x RHA 297	79.36	0.96	75.49	24813.67	28.28	7.73	4.32	38.14	56.82
91	CMS 207 A x 6D -1	89.61	0.56	82.37	26697.67	29.14	8.37	4.18	35.06	51.11
92	CMS 207 A x RHA 271	81.69	0.70	79.02	24058.00	37.17	8.15	3.44	39.89	47.44
93	CMS 207 A x HRHA 4-2	85.12	0.60	81.19	26341.33	35.31	11.89	3.37	40.92	48.32
94	CMS 207 A x HRHA 5-3	93.34	0.58	87.50	28696.67	42.04	6.51	4.17	41.35	52.26
95	CMS 207 A x RHA 297	92.12	0.75	90.27	29329.33	37.60	8.98	4.63	42.17	52.39
96	HSFH 848	67.63	0.85	59.15	23009.33	35.95	6.53	3.85	29.00	35.81
	Mean	85.36	0.62	80.76	26369.83	31.52	6.98	5.12	39.88	47.63
	Range	48.93	0.23	43.58	19724.33	13.84	5.41	3.37	29.00	34.68
		94.98	1.28	92.07	32249.33	48.19	11.89	8.03	49.05	57.93
	SE	1.53	0.03	1.16	466.20	1.49	0.21	0.18	0.69	0.90
	CDat5%	3.06	0.06	2.31	931.47	2.98	0.41	0.37	1.37	1.79

ABSTRACT

Title of Thesis : Studies on genetic divergence, stability, heterosis and combining ability in sunflower (*Helianthus annuus* L.)

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Keywords : CMS, GCA, Genetic divergence, heterosis, SCA, stability.

The present study entitled “Studies on genetic divergence, stability, heterosis and combining ability in sunflower (*Helianthus annuus* L.)” was undertaken to estimate genetic divergence, economic heterosis, combining ability with the objective of exploring possibilities of their commercial utilization and stability analysis in four different environments. The material for the present investigation comprised of seventy five hybrids developed by making crosses between fifteen female parents (lines) and five male parents (testers) in line x testers mating design along with one standard checks (HSFH 848). The crosses were made at research area of Oilseed Section, Department of Genetics and Plant Breeding, CCS HAU, Hisar during the *spring* season of 2014. Hybrids and parents were evaluated under four different environments *i.e.* Summer 2014, last week of August (E₁) and First week of Sept. (E₂) and during spring 2015, *i.e.* first week of February (E₃) and last week of February (E₄). Data on five randomly selected plants from each genotype in each replication were recorded on different quantitative characters viz. plant height (cm), head diameter (cm), stem diameter (cm) days to 50% flowering, days to maturity, hundred seed weight (g), seed yield per plant (g), oil content (%), hull content (%), percent seed filling, germination (%), electrical conductivity ($\mu\text{Scm}^{-1}\text{g}^{-1}$), viability (%), vigour index I, vigour index II, palmitic acid (%), stearic acid (%), oleic acid (%) and linoleic acid (%) in all the test environments. Based on Euclidean minimum distance, all the genotypes were grouped into six clusters which showed the presence of enough amount of genetic diversity in the present material. The cluster IV was having highest numbers of genotypes followed by clusters V, I, VI, II, III. The intra-cluster distances were less than that of inter cluster distances which showed that there was narrow genetic variation within the clusters while there was maximum genetic variation in between the clusters. Hybrids CMS 207 A x HRHA 5-3, CMS 852 A x RHA 271, CMS 207 A x RHA 297, CMS 234 A x 6D-1 and CMS 207 A x 6D-1 were found better and superior for stability, combining ability and heterosis studies for seed yield and its contributing trait and also for oil content. The combining ability analysis revealed that non-additive variance in the expression of all the traits. Among lines CMS 207 A, CMS 148 A, CMSH 91 A, CMS 17A and testers RHA 271 and HRHA 5-3 were the good general combiners. The hybrids with good heterotic value, good GCA, SCA and better value of stability could be directly used for heterosis breeding because of their dominant nature. The use of genotypes in hybridization from these results is likely to produce more heterotic combination in future.

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Abstract- 4

- Kumari, Sachin and Sheoran R. K. 2017. Sunflower (*Helianthus annuus* L.) germination and vigour test for seed quality in different environments. Paper presented at International conference on EAEE-2017 held from Feb. 16-18, 2017 at GJU, Hisar. pp. 198.
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