“Study of heterosis and combining ability in cucumber (*Cucumis sativus* L.) using half diallel analysis”

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In

Genetics and Plant Breeding

By

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DECLARATION

I, hereby declared that the presented work in the thesis entitled **"Study of heterosis and combining ability in cucumber (*Cucumis sativus* L.) using half diallel analysis"** fulfillment of degree of **Doctor of Philosophy (Ph.D)** is outcome of research work carried out by me under the supervision **Dr. Harmeet Singh Janeja**, working as Professor, Department of Genetics and Plant Breeding School of Agriculture Lovely Professional University, Punjab, India. In keeping with general practice of reporting scientific observations, due acknowledgements have been made whenever work described here has been based on findings of other investigator. This work has not been submitted in part or full to any other University or Institute for the award of any degree.

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CERTIFICATE-I

This is to certify that the work reported in the Ph.D thesis entitled **"Study of heterosis and combining ability in cucumber (*Cucumis sativus* L.) using half diallel analysis"** submitted in fulfillment of the requirement for the reward of degree of **Doctor of Philosophy (Ph.D.) in the Department of Genetics and Plant Breeding,** is a research work carried out by **Khedkar Prasad Dhanraj (Registration No. 11815966),** is bonafide record of his original work carried out under my supervision and that no part of thesis has been submitted for any other degree, diploma or equivalent course.

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CERTIFICATE-II

This is to certify that the thesis entitled **"Study of heterosis and combining ability in cucumber (*Cucumis sativus* L.) using half diallel analysis"** submitted by **Khedkar Prasad Dhanraj (Registration No. 11815966) to Lovely Professional University, Phagwara** in the partial fulfillment of the requirement of **Doctor of Philosophy (Ph.D.) in the Department of Genetics and Plant Breeding** has been approved by Advisory Committee after oral examination of the student in collaboration with an external examiner.

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"Study of heterosis and combining ability in cucumber (*Cucumis Sativus* L.) using half diallel analysis"

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ABSTRACT

The present study of heterosis and combining ability in cucumber (*Cucumis sativus* L.) using half diallel analysis was carried out at Agriculture Farms, Department of Genetics and Plant Breeding, SAGR, LPU Jalandhar (Punjab) during *spring* 2021 and 2022. The experimental material consists of twelve diverse parents and thereof sixty six F_1 hybrids developed through half diallel mating design along with check varieties. These were evaluated in replicated and randomized complete block design for two consecutive years. The objectives of the investigation were to study heterosis, combining ability and gene effects for different characters in cucumber. The parent PLK was identified as a good general combiner for fruit yield and nine other important traits (*viz.*, Days to first male flower, days to first female flower, days to first harvest, days to last harvest, number ofprimary braches per vine, internodal length, vine length, number of fruit per vine and fruit girth. Parent KOP- 1 was good combiner for days to first male flower, days to first female flower, number of fruit per vine, fruit length and fruit weight. J-2, Poona Khira and MLKP were average combiners for nine, seven and seven characters respectively. The promising hybrids *viz.*, MLKP x J-4, MLKP x KDWD-1 and MLKP x Sheetal showed higher estimates of *per-se* performance, GCA, SCA and heterosis for fruit yield. Among sixty six hybrids developed for this study, thirteen hybrids have significant estimates of SCA effect for fruit yield per vine. These parents and selected hybrids could be exploited in future cucumber breeding programme by adopting appropriate breeding procedures. The present research suggested both additive and non-additive types of gene actions with higher proportion of non-additive gene action for fruit yield and other contributing traits.

Keywords: Cucumber, Heterosis, GCA, SCA, Additive gene action, Sustainability.

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LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviations	
°Brix	Degree Brix
°C	Degree Celsius
CD	Critical difference
cm	Centimeter
CV	Co-efficient of variation
df	Degrees of freedom
et al.	And others
F_1	First filial generation
g	Gram
GCA	General Combining Ability
kg	Kilo gram
Max.	Maximum
Min.	Minimum
ml	Milli litre
RCBD	Randomized Complete Block Design
SE	Standard error of difference
SE_m	Standard error of mean
SCA	Specific Combining Ability
viz.	Namely
vs.	Versus
SH	Standard Heterosis
HB	Heterobeltiosis
BP	Better Parent
σ2 gca	General Combining ability variance
σ2 Sca	Specific Combining ability variance
DFMF	Days to first male flower
DFFF	Days to first female flower
FFBN	First fruit bearing node
DFH	Days to first harvest
DLH	Days to last harvest
NPBPV	Number of primary branches per vine
IL	Internodal length (cm)

VL	Vine length (cm)
NFPV	Number of fruits per vine
FL	Fruit length (cm)
FG	Fruit girth (cm)
FW	Fruit weight (g)
FYPV	Fruit yield per vine (kg)
Symbols	
=	Is equal to
%	Per cent
x	Crosses
:	Colon
( )	Bracket
;	Semi colon

CHAPTER 1

INTRODUCTION

Cucumber (*Cucumis sativus* L.) belongs to the family of Cucurbitaceae. According to Candolle (1886) cucumber is believed to originated in India. Its Sanskrit equivalent name "Urvaruka" and Ervaruka" as mentioned in the old treatises of India "Chakraka Samhita" justifies its cultivation dates back to 3000 years (Jeffrey *et. al.,* 1980). Cucumber was introduced to North China through the Silk Route and to South China from Burma and India-China border, and subsequently spread to East Asia (Lv J, *et. al*., 2012). Genome variation analysis showed cucumber core germplasms were divided into four geographic groups including India, Eurasia, East Asia, and Xishuangbanna (Qi *et. al*., 2013).

The occurrence of *Cucumis sativus* L. *var*. *hardwickii* (Royle) *Alef* was reported for the first time from Melghat Biosphere Reserve located in the southern portion of Amravati district of Maharashtra in the Satpura mountain ranges of Central India (Nilamani *et. al.,* 2014). Burma could be regarded as the secondary center of origin of this crop. The genus *Cucumis* include two subgenera *sativus* (2n= 2x=14), which in turn houses several sub species including var. *sativus*, the cultivated cucumber and *hystrix* Chakr. (2n=2x=24).

Cucumber is third largest cultivated vegetable crop after tomatoes and watermelon Cucumber grows throughout the world especially in subtropical and tropical climates. It grows well in warm environment (i.e. > 20^{o}C) but susceptible to chilling and frost.

Cucumber flower anthesis occurs in early morning hours (i.e. 5:30 a.m. to 8:30 a.m. depending on temp. (ranges between 20.5 - 21.5^{o}C), humidity(65-75%) etc. Anther dehiscence takes place between 6:30 a.m. and 7:00 a.m. Pollen fertility was good up to noon however was greatly reduced by afternoon *i.e*. 2.00 pm and negligible by the evening. The stigma become receptive twelve hours before flower opening and continues to be remains active till eight hours after that.

The commercial production of cucumber fruits is directly impacted by sexual expression, wherein variations in sex types and flowering patterns were influenced by both genetic factors and the growing environment. Gynoecious or monoecious are main sex type in cucumber.

Cucumber is the most commonly cultivated Cucurbit, with a total area of 113 million hectares (ha) and production of 1638 thousand metric tones (MT). Major cucumber producing state was West Bengal which for 20.32% followed by Madhya Pradesh accounting for 14.76% (Ministry of Agriculture and Farmers Welfare 2021-22).

Cucumbers, which share a genetic relationship with melons, are an ideal low-calorie food with just around 15 calories per 100 gm and mostly composed of water (~95%). These green-skinned vegetables are rich in nutrients, including high levels of lignin, vitamin K, triterpenoids, flavonoids (like apigenin, luteolin, quercetin, and kaempferol) antioxidants beta-carotene, vitamin C, and minerals. (Mukherjee *et. al.*, 2013).

The present study was aimed to analyse combining ability which provides note worthy information on choice of parents and helps to understand nature and magnitude of gene (s) governing traits. The principle of hybrid vigor, also known as heterosis, is a key element in the development of cross-pollinated breeding programs. Cucumbers, being monoecious in sex expression, exhibit significant cross-pollination.

The first report of heterosis in cucumber was first documented by Hays and Jones in 1916. In western world, a large number of hybrids have been developed by seed companies and used by farmers (more than 80% of total area). Cucumber mode of reproduction, floral biology and adaptation to diverse ecological environments make it possible to produce hybrid seed at commercial level.

The diallel analysis has been considered a method of choice for acquainting nature of various traits and ascertains selection of parents and hybrids by the estimation of general and specific combining abilities. Moreover, the breeding strategies adoption depends upon the type and magnitude of genetic variances. In addition, diallel analysis also provides detailed information of genetic architecture of experimental material. Griffing (1956) devised statistical analysis for diallel crosses which provides information oncombining ability of parents and hybrids and components of genetic variance. Therefore, a research effort was oriented to study genetic relationships of yield and yield attributing characters of cucumber.

With this view point, the present investigation was planned to study the following objectives:

1. To study *per se* performance of selected set of parents and their F_1 hybrids
2. To assess extent and magnitude of heterosis.

3. To identify general and specific combiners.

4. To study nature and magnitude of gene action controlling the inheritance of yield and yield contributing characters.

CHAPTER 2

REVIEW OF LITERATURE

Various studies have been carried out to investigate the concepts of heterosis, combining ability, and gene action in relation to yield and components traits in cucumber. The available relevant literature and information pertaining to present investigation have been presented under following sub-headings.

2.1 HETEROSIS

2.2 GENE EFFECTS AND COMBINING ABILITY

2.1 HETEROSIS

Heterosis, the phenomenon of superior performance of a hybrid over its parents, is a significant development in the history of systematic concepts and their application in crop improvement. This phenomenon was first observed in plants by Koelreuter in 1766, and later explained by Shull in 1908, who proposed the term "heterosis" in 1914 to describe the superiority of hybrids over their parents. The heterozygosity hypothesis proposed by Shull suggests that the presence of heterozygous allele results in complementary physiological actions that lead to greater vigor in hybrid offspring compared to homozygous individuals.

Building Fonseca and Patterson 1968 as well as Mather and Jinks 1971 suggested a term ‘heterobeltiosis’ to describe superiority of F_1 heterozygote in comparison to the better parent. The concept of "standard heterosis" was coined by Meredith and Bridge to explain the superiority of F_1 hybrids compared to well-adapted varieties or hybrids. In 1916 Hays and Jones reported the first instance of heterosis in cucumber, and since then, numerous hybrids have been created for commercial cultivation in western countries and India. Heterosis has become an important tool in crop improvement and is commonly utilized in plant breeding programs to produce hybrids that are disease-resistant and high-yielding.

Literature regarding heterosis studies in cucumber is vast. However, a brief review of available literature pertaining to heterosis in cucumber (*Cucumis sativus* L.) has been summarized below.

Table 2.1 Summary of review reports on heterosis in cucumber (*Cucumis sativus* L.).

References	Studied material	Range (%)		Finding
		Heterobeltiosis	Standard	

			Heterosis	
1	**2**	**3**	**4**	**5**
1. Days to first male flower				
Singh *et al*. (2010a)	8 x 8; Diallel without reciprocals	-14.57 to 17.0	-	Top three hybrids were PCUC 15 x CH C-2, C -9912 x C -986 and C -9912 x C 9910.
Singh *et al*. (2015)	8 x 8; Diallel without reciprocals	-32.34 to 19.78	-	Thirteen crosses were found to be superior. C 98-6 x C 99-10 was the best cross.
Simi *et al*. (2017)	19 x 19; Diallel excluding reciprocals	-3.23 to -36.1.	-	The hybridization of Hero and Piyas did not exhibit heterosis. On the other hand, the cross between Hero and Khira had the highest negative heterobeltiosis for earliness, with Greenboy x Tripti and Tripti x Khira following closely behind.
Punetha *et al*. (2017)	3:10; gynoecious and monoecious diverse	-10.79 to -39.61	-18.42 to - 42.76	The following were the top three hybrids: Pgyn5 × US832, Pgyn4 × PCUC8, and Pgyn-4 × PCUC83.
Chikezie *et al*. (2019)	6 x 6; Diallel without reciprocal	-19.65 to -2.72	-	Two hybrids were Zna x Strght 8' and 'Capso x Strght 8 was best cross.
Chittora *et al*. (2018)	11:3; Line x Tester	-10.91 to -073	-10.65 to -2.20	The hybrid DRG-15 x VRS-24-2 exhibited the significant negative SH. Additionally, four hybrid

				displayed significant negative heterosis for days to first male flower.
Naik *et al.* (2020)	5 x 5; Diallel without reciprocals	-8.18 to -9.53	-	Top two hybrids were Shivam x Bolder Uccha and Galaxy x Special Bolder Uccha maximum HB.

Different researchers have reported varying levels of SH for days to first male flower, ranging from -32.34 to 19.78 days. Among them, the cross C 986 x C 9910 was found to be the most favorable for the trait of days to first male flower.

2. Days to first female flower				
References	**Studied material**	**Range (%)**		**Finding**
		Heterobeltiosis	**Standard Heterosis**	
1	**2**	**3**	**4**	**5**
Singh *et al.* (1999)	10 x 10; Diallel excluding reciprocals	-3.49 to -13.89	-2.69 to -22.02	A total of 20 crosses were found to be heterotic for Heterobeltiosis, while 38 crosses exhibited heterosis for Standard Heterosis. The highest levels of HB & SH was recorded in the cross AC 22 x AC 41.
Singh *et al.* (2010a)	8 x 8; Diallel without reciprocals	-11.97 to 16.88	-	The following were the first three hybrids with the highest HB in the desirable direction: CHC2 x Bihar 1, PCUC15 x CHC2, and Bihar1 x C 986.

Dogra and Kanwar (2011)	8 x 8; Diallel without reciprocals	-11.72 to 82.65	17.72 to 65.19	The F_1s, G 2 x LC 40 and LC 11 x LC 40 gave the maximum HB and SH, respectively, in desired direction.
Singh *et al.* (2015)	7 x 7; Diallel without reciprocals	-12.37 to 7.8	-6.08 to -24.24	12 crosses showed significant HB and 21 crosses showed significant SH. Punjab Naveen x Uday and GPC-1 x Uday recorded the highest HB as well as SH, correspondingly, in preferred direction.
Singh *et al.* (2015)	8 x 8; Diallel without reciprocals	-17.65 to 21.65	-	Twelve crosses were found to be superior with high HB and EC 43342 x C 99-10 was the best cross with the highest HB estimate in desired direction.
Jat *et al.* (2015)	7 x 7; Diallel without reciprocals	38.27 to -47.45	-	Top three hybrids with the highest HB in desirable direction were Punjab Naveen x Pusa Uday, DC-1 x Pusa Uday and DC-1 x Punjab Naveen.
Bhatt *et al.* (2017)	9 x 9; Diallel without reciprocals	-21.74 to -2.22	-	Punjab14 x Karela 1 and Kalyanpur x karela this two hybrids show high degree of average heterosis for in cross combination.(Bitter Gourd)
Simi *et al.* (2017)	19 x19; Diallel excluding reciprocals	-87.23 to -37.74	-25 to -37.74	Sobuhsathi x Khira found to have maximum HB and SH.

Punetha *et al*. (2017)	3:10; gynoecious and monoecious diverse	-19.44 to -44.57	-44.57 to 43.27	The maximum value of significant negative heterobeltiosis was observed in Pgyn-1 × PCUC-35 and Pgyn-4 × PCUC-83. The maximum heterosis was observed for cross Pgyn-5 × US-832 Pgyn-4 × PCUC-8 and Pgyn-4 × PCUC-83
Chikezie *et al*. (2019)	6 x 6; Diallel without reciprocals	-2.12 to 13.76	-	The crosses Zna x Strght-8, BA x Cappso, BA x Strght 8 and Cappso x Strght8 gave the maximum HB.
Chittora *et al*. (2018)	11 :3; Line x Tester	-11.01 to -0.42	-10.85 to -2.32	The hybridization between DRG-3 and VRS-27 (Ridge gourd) exhibited the highest and significant negative standard heterosis. Additionally, four other hybrids demonstrated significant negative standard heterosis concerning the duration until the emergence of the first female flower.
Singh *et al*. (2018)	10 x 10; Diallel without reciprocals	-10.24 to -10.94	-	Top four hybrids with the highest HB in desirable direction were Swarna x Patna3 CU5 x Patna3, Swarna x VRC11-2, and Swarna x Swarna Shital
Sahoo *et al*.	3:11; Line x	-17.00 to19.45		The four hybrids PCUCP-2 x

(2019)	Tester gynoecious and monoecious diverse		-	PCUC The cross combinations PCUCP8 x PCUC-25, PCUCP2 x PCUC25, and PCUCP1 x PCUC8 showed superior performance compared to Better Parents in terms of earliness.
Naik *et al.* (2020)	5 x 5; Diallel without reciprocals	-6.76 to -26.39	-	Top two hybrids with the highest HB were Shivam (Selection 12) x West Godavari and Godavari x Meghdut.

Different researchers have reported variations in the days to the first female flower's appearance, ranging from -87.23 to -37.74. The Sobuhsathi x Khira hybrid emerged as the top performer, exhibiting the highest values for both HB and SH.

3. First fruit bearing node				
References	**Studied material**	**Range (%)**		**Finding**
		Heterobeltiosis	**Standard Heterosis**	
1	**2**	**3**	**4**	**5**
Singh *et al.* (2015)	8 x 8; Diallel without reciprocals	-37.76 to 31.19	-	Top one hybrid was CHC-2 X C-98-6 Show maximum heterobeltiosis.
Bhatt *et al.* (2017)	9 x 9; Diallel without reciprocals	-40.00 to -20.01	-	Punjab-14 x Kalyaanpur Barahmasi, A. Harit x Karela-1 , Phule Green x Pant Karela-1, Pusa Do Mousami x Karela-1and Kalyaanpur x Karela-1 this five hybrids gave the maximum HB.

				(Bitter Gourd)
Kaur *et al.* (2017)	8 x 8; Diallel without reciprocals	-3.01 to 42.2	-	Four hybrids gave the maximum HB Swarna Shital x S- Kheera, PB Naveen × Summer Kheera, Punjab Naveen × NCH-1, Pant Kheera-1 × NCH-1.
Kumar *et al.* (2013)	3:16; Parthenocarpic gynoecious Line × Tester	-50.00 to -19.23	-	CGCN-1933 x K75, CGCN-2953 x Pointsette, LC-11 x K75, LC21-6 x K75, Lc-288 x K75 and Gyne5 x K75 six crosses gave the maximum HB.
Thakur *et al.* (2017)	6 x 6; Diallel without reciprocals	-2.17 to 78.00	-0.67 to 37.35	The hybrids Khira75 x PI-61860, Khira75 x Uhf-CUC1, UHF-CUC1 x Uhf-CUC2, and Khira75 x Uhf-CUC2 exhibited the highest levels of HB as well as SH among all the F_1.
Punetha *et al.* (2017)	3:10; gynoecious and monoecious diverse	-65.22 to 53.85	-62.85 to 53.85	The trait showed significant negative heterobeltiosis in the hybrid combination of PCUC-35 and Pgyn-5 x PCUC-83) recorded the highest HB and SH, respectively.
Chittora *et al.* (2018)	11 :3; Line x Tester	-15.28 to -0.86	-14.59 to -1.56	The trait showed maximum significant negative heterobeltiosis in the hybrid

				combination of VRS-7/10 x VRS-7/10, while the hybrid combination DRG-15 x VRS-27 exhibited significant negative heterosis for the same character. (Ridge gourd)
Singh *et al.* (2018)	10 x 10; Diallel without reciprocal	-57.14 to -52.63	-47.83 to -57.14	VRC18-2 x VRC11-2, Swarna x VRC18-2, Swarna x Swarna Shital, and VRC18-2 x Bsc- recorded the highest SH and SH, respectively, in desired direction.
Sahoo *et al.* (2019)	3:11; Line x Tester gynoecious and monoecious diverse	-1.08 to 494.12	-	The top-performing F_1 hybrids, outperforming the BP, were identified as PGYC3 x PCUC25 and PCUCP-1 x PCUC-8 in terms of first fruit bearing node.
Naik *et al.*(2020)	5 x 5; Diallel without reciprocal	-26.39 to 30.46	-	West Godavari (Short) x Special Bolder Uccha, have shown significant heterobeltiosis.

Various researchers have reported that the degree of heterosis for the first fruit bearing node ranges from -65.22 to 53.85 days. Among the tested hybrids, namely Pgyn 5 x US832, Pgyn4 x PCUC8, Pgyn4 x PCUC 35, Pgyn-4 x PCUC-8, Pgyn-1 x Pant Khira 1, Pgyn 4 x Pant Khira 1, and Pgyn4 x PCUC35, Pgyn5 x PCUC-83 exhibited the highest HB and SH. Notably, Pgyn-4 x Punjab Naveen showed the maximum SH at -65.22%.

4. Days to first harvesting				
References	**Studied material**	**Range (%)**		**Finding**
		Heterobeltiosis	**Standard Heterosis**	

1	2	3	4	5
Munshi *et al*. (2005)	6 x 6; Diallel without reciprocal	-21.2 to 25.2	-	Three crosses were found to be heterobeltiotic, out of which CHC 1 x PCUC 28 exhibited the highest desirable HB.
Dogra and Kanwar (2011)	8 x 8; Diallel without reciprocals	-10.32 to 74.29	-13.81 to 57.46	The hybrid G 2 x LC 40 and LC 11 x LC 40 manifested the maximum HB and SH, respectively, in desired direction.
Airina *et al.* (2013)	12 F_1s derived from top cross involving 13 parents	-21.43 to 6.6	-	Eight hybrids manifested significant HB in desired direction. The best hybrid was EC 709119 x CS 128.
Singh *et al.* (2015)	7 x 7; Diallel without reciprocals	-7.36 to 17.59	-4.32 to -20.74	Total 11 crosses depicted significant HB and 21 crosses showed significant SH. The hybrids DC 1 x Uday & PPC 2 x Pusa Uday recorded the highest HB and SH, respectively.
Singh *et al.* (2016)	8 x 8; Diallel without reciprocals	-14.31 to 18.27	-21.26 to 2.24	13 hybrids registered significant negative HB and all these hybrids also registered significant and negative SH. The hybrids ACC2 x ACC6 & ACC5 x ACC7 exhibited the HB and SH, respectively.
Bhatt *et al.*	9 x 9; Diallel	-26.15 to 1.54		Six crosses were found to be

(2017)	without reciprocals		-	heterobeltiotic, out of which Pusa Do Mousami x Kalyanpur Baramasi, A. Harit x Panipat , A. Harit x P. Green, A. Harit x Kalyanpur Baramasi P. Vishesh x Kalyanpur Baramasi and Mousami x Kalyaanpur Sona exhibited the highest desirable HB.
Chittora *et al.* (2018)	11:3; Line x Tester	10.93 to -0.12	-9.97 to -1.13	For the trait "days to first harvest," the hybrid DRG-3 x VRS-27 recorded the highest negative SH and HB. (Ridge gourd)
Naik *et al.* (2020)	5 x 5; Diallel without reciprocals	2.6 to -5.30	-	Shivam x West Godavari, Galaxy x Godavari and Galaxy x Meghdut Korola Uccha x Meghdut Korola had negative and significant HB.

Various researchers have reported the degree of heterosis for days to first harvesting ranges from -21.43 to 6.6. Among eight hybrids, significant heterosis was observed. The hybrid with the highest level of heterosis was EC 709119 x CS 128.

6. Number of primary branches per vine				
References	**Studied material**	**Range (%)**		**Finding**
		Heterobeltiosis	**Standard Heterosis**	
1	**2**	**3**	**4**	**5**
Cramer and Wehner (1999)	6 inbreeds hybridized to get four F_1s	-1.24 to 0.43	-	Addis x SMR 18 hybrid exhibited the maximum HB.

Singh *et al.* (1999)	10 x 10; Diallel without reciprocals	9.73 to 22.46	15.63 to 68.31	Out of the total number of hybrids evaluated, three hybrids exhibited significant heterobeltiosis (HB) while seventeen hybrids show significant (SH). The hybrid with the highest level of heterotic effects for HB was AC-20 x AC 30, whereas for SH, it was AC 2 x AC 34.
Pandey *et al.* (2005)	15 lines were used to develop 77 hybrids.	-1.86 to 10.83	-	The hybrid DC 1 x B 159 showed the highest and significant HB.
Singh *et al.* (2010b)	10 x 10; Diallel without reciprocals	29.00 (maximum)	-	The cross Swarna Ageti x BSC 2 recorded the highest HB.
Mule *et al.* (2012)	3:9; Line x Tester	41.67 (maximum)	-	Three crosses recorded significant HB. They were Sheetal x DC 2, Sheetal x SPP 44 and Gujarat Local x SPP 93.
Simi *et al.* (2017)	19 x 19; Diallel excluding reciprocals	5.05 to -46.67	-	The crosses F1 Sobuhsathi x Khira, Greenboy x Tripti, and Himaloy x Yuvraj demonstrated significant positive heterosis, with F1 Sobuhsathi x Khira showing the highest positive heterosis, crosses Baromashi x Hero

				and Baromashi x Khira exhibited the highest negative heterosis. Among the crosses showing positive heterosis, the highest value of HB were cross Sobuhssathi x Khirra, follow by Green boy x Trupti.
Chittora *et al.* (2018)	11:3; Line x Tester	9.85 to 18.00	3.60 to 7.46	The crosses DRG-3 x VRS-7 and IC-571716 x VRS-7 exhibited a significantly positive heterosis compared to the standard check for the branches per vine. (Ridge gourd)
Singh *et al.* (2018)	10 x 10; Diallel without reciprocals	23.00 to 29.00	30.68 to 33.51	Top four hybrids recorded the maximum HB and SH, respectively, in desired direction. Swarna ageti x BSC2, Peelibheet local x BSC2, Patna-3 x Peelibhiet, Swarna sheetal x BSC2.
Naik *et al.* (2020)	5 x 5; Diallel without reciprocal	2.19 to 11.83	-	West Godavari (Short) x Meghdut Korola these hybrids gave the maximum HB.

The maximum heterosis for primary branches per vine was reported by various researchers found 41.67 (maximum). Three crosses recorded significant HB. They were Sheetal x DC 2, Sheetal x SPP 44 and Gujarat Local x SPP 93.

7. Internodal length				
References	**Studied material**	**Range (%)**		**Finding**
		Heterobeltiosis	**Standard**	

			Heterosis	
1	**2**	**3**	**4**	**5**
Talekar *et al.* (2013)	11 x 4; Line x Tester	-34.60 to 30.72	-	The highest HB was found in the cross Preethi x HABG-22 and Preethi x Pant Karela-1.
Punetha *et al.* (2017)	3:10; gynoecious and monoecious diverse	-31.43 to 40.11	1.71 to -31.43	The highest HB was found in the cross Pgyn-1 × PCUC-25, Gyn-5×PCUC-28, Gyn-1×PCUC-8 and Gyn-5×Punjab Naveen, Pgyn-5 × PCUC-83 For internodal length.
Chittora *et al.* (2018)	11 x 3; Line x Tester	-12.96 to -18.61	-	The cross between DRG-3 and VRS-27 showed a significant increase in internodal length due to both S. heterosis and heterobeltiosis effects.

The level of heterosis for internodal length was reported by various researchers found to vary between -34.60 to 40.11.Top hybrids were Preethi x HABG-22 and Preethi x Pant Karela-1. These recorded the maximum HB and SH.

8. Vine Length				
References	**Studied material**	**Range (%)**		**Finding**
		Heterobeltiosis	**Standard Heterosis**	
1	**2**	**3**	**4**	**5**
Bhatt *et al.* (2017)	9 x 9; Diallel excluding reciprocals	-31.25 to -6.25	-	PB-14 x K. Baramasi show vastly significant heterosis both over BP (better parent) and SC (standard variety). (Bitter gourd)
Kaur *et al.*	8 x 8; Diallel	3.72 to 29.75		The cross Pant Kheera-1 ×

(2017)	without reciprocals		-	Summer Kheera exhibited maximum significant HB.
Chittora *et al.* (2018)	11:3; Line x Tester	14.41 to 0.43	9.15 to 0.54	DRG-3 x VRS-27 recorded the highest significant positive heterosis as well as heterobeltiosis values for vine length. (Ridge gourd)
Singh *et al*. (2018)	10 x 10; Diallel without reciprocals	29.07 to 33.12	36.53 to 48.65	Top four crosses showed significant positive heterosis. Peelibheet local x Baramasi, Patna-3 x Peelibheet local, VRC-11-2 x Peelibheet local, VRC-11-2 x Patna-3.
Sahoo *et al.* (2019)	3:11; Line x Tester gynoecious and monoecious diverse	11.83 to 142.56	-	The top-performing F1 hybrids that showed the highest performance over the Best Parent (BP) were PCUCP-1 x PCUC8, PCUCP7 x PCUC25, PCUCP1 x Khira 1, and PCUCP 8 x Khira-1.
Naik *et al.* (2020)	5 x 5; Diallel without reciprocals	0.83 to 11.07	-	The cross shows Bolder Uccha x Meghdut, Galaxy x Meghdut, Galaxy x Bolder Uccha and Shivam x Uccha Korola higher positive and significant HB.

The level of heterosis for vine length was reported by Singh *et al*. (2018) found 29.07 to 33.12 cm.

9. Number of fruits per vine			
References	**Studied material**	**Range (%)**	**Finding**

		Heterobeltiosis	Standard Heterosis	
1	**2**	**3**	**4**	**5**
Singh *et al.* (1999)	10 x 10; Diallel excluding reciprocals	16.29 to 91.89	15.26 to 112.65	There were a total of 11 crosses that showed significant positive HB, and 13 crosses that exhibited significant positive SH. The crosses AC20 x AC28 and AC34 x AC38 had the high values of HB and SH, correspondingly.
Munshi *et al.* (2005)	6 x 6; Diallel excluding reciprocals	-12.9 to 22.9	-	Poona Kheera x Poinsette exhibited the highest HB.
Pandey *et al.* (2005)	15 lines were used to develop 77 hybrids	7.47 to 43.51	-	The cross DC 1 x B 159 show the highest and considerable HB.
Singh *et al.* (2010a)	8 x 8; Diallel excluding reciprocals	-30.77 to 81.65	-	Top three hybrids with the highest HB in desirable direction were PCUC 15 x C 99;10, Bihar -1 x C 99;10 and Bihar1 x C 99;12.
Dogra and Kanwar (2011)	8 x 8; Diallel excluding reciprocals	-45.71 to 15.79	-50.00 to 25.18	Poinsette x LC 11 and K 90 x G 2 gave the maximum HB and SH, respectively.
Kushwaha *et al.* (2011)	7 x 7; Diallel without reciprocals	-34.68 to110.59	-	Seven hybrids showed significantly higher HB and the cross BC 11 x BC 16 manifested the highest HB.

Mule *et al.* (2012)	3:9; Line x Tester	75.00 (maximum)	-	Eight crosses provided significant HB. The top three hybrids with the highest HB were Sheetal x CC 9, Sheetal x SPP 44 and Pilibhit Local x K 90.
Singh *et al.* (2012)	12:3; Line x Tester	-46.03 to 45.50	-31.90 to 45.07	Top 3 hybrids with the highest HB in desirable direction were PCUC15 x C99, Bihar1 x C99; 10 and Bihar1 x C99.
Airina *et al.* (2013)	12 F_1s derived from top cross involving 13 parents	-29.94 to271.05	-	Nine hybrids recorded significant HB in desired direction with the cross EC 709119 x IC 538155 having the highest HB.
Singh *et al.* (2015)	7 x 7; Diallel excluding reciprocals	-33.95 to 38.51	3.55 to 141	21 crosses showed significant HB & SH. P Naveen x Uday and GPC 1 x PPC-2 recorded the highest HB and SH, respectively.
Singh *et al.* (2015)	8 x 8; Diallel excluding reciprocals	-63.08 to 63.35	-	Nine crosses were found to be superior with significant HB and PCUC15 1 x C 98 6 was the best cross.
Singh *et al.* (2016)	8 x 8; Diallel excluding reciprocals	-28.15 to 32.15	-16.80 to 34.17	The highest HB were found in the cross Modhaumoti x Barmashi follow by Moti x Hero. & Hima x Yuva didn't show heterosis.
Bhatt *et al.*	9 x 9; Diallel	50.00 to 8.33		The highest standard

(2017)	excluding reciprocals		-	heterosis Punjab-14 x Vishesh, Punjab14 x P. Do Mousami, Kalyaanpur B x Kalyaanpur, and Kalyaanpur Sona x Pant Karela1 for number of fruits per cucumber vine was recorded. (Bitter Gourd)
Simi *et al.* (2017)	19 x 19; Diallel excluding reciprocals	2.58 to -66.67	-	The highest HB were found in the crosses Modhaumoti x Barmashi followed by Modhumoti x Hero. & Himaloy x Yuvraaj didn't show heterosis.
Chittora *et al.* (2018)	11:3; Line x Tester	49.02 to 1.08	28.36 to 0.61	Maximum positive HB and SH for this trait was observed in DRG-15 x VRS-27. (Ridge gourd)
Singh *et al.* (2018)	10 x 10; Diallel without reciprocals	12.46 to 106.52	76.18 to 76.90	The best heterotic hybrid Patnan3 x S. Shital followed by VRC18-2 x Patna3 HB & mid parent respectively.
Naik *et al.* (2020)	5 x 5; half Diallel without reciprocal	24.63 to 44.47	-	Top cross were found to be superior with high HB Galaxy x Bolder Uccha, Galaxy x West Godavari.

The highest SH for number of fruits per vine was reported by Mule *et al.* (2012) .The three hybrids with the highest HB were Sheetal x CC 9, Sheetal x SPP 44 and Pilibhit Local x K 90.

10. Fruit length			
References	**Studied material**	**Range (%)**	**Finding**

		Heterobeltiosis	Standard Heterosis	
1	**2**	**3**	**4**	**5**
Singh *et al.* (1999)	10 x 10; Diallel without reciprocals	3.75 to 13.18	7.15 to 21.63	Four crosses were analyzed and found to have significant estimates for both BH and SH. The cross AC34 x AC38 showed the maximum HB among the four, while the cross AC 30 x AC 32 exhibited the highest SH.
Munshi *et al.* (2005)	6 x 6; Diallel without reciprocals	-14.9 to 3.5	-	The cross CHC 1 x Poinsette was the best heterobeltiotic hybrid.
Pandey *et al.* (2005)	15 lines were used to develop 77 hybrids.	-60.2 to 9.92	-	The result of the 1 x B 159 cross DC demonstrated the most noteworthy and statistically significant HB levels.
Singh *et al.* (2010a)	8 x 8; Diallel without reciprocals	-39.82 to 17.86	-	Top three hybrids with the highest HB in desirable direction were PCC 15 x PUC 15-1, EC-4342 x C99-10 and EC 43342 x Bihar 1.
Kushwaha *et al.* (2011)	7 x 7; Diallel without reciprocals	-26.98 to 25.22	-	Out of 21 hybrids, five hybrids depicted significantly higher HB and the cross BC 16 x Poisette manifested the highest HB.
Mule *et al.* (2012)	3:9; Line x Tester	22.35 (maximum)		Five crosses provided significant HB. The top three

			-	hybrids with the highest HB were Sheetal x SPP 44, Pilibhit x K 90 and Pilibhit x SPP-44.
Singh *et al.* (2012)	12:3; Line x Tester	13.39 to 49.25	-44.24 to 26.60	The cross CC7 x CHC1, CU-5 x BSC-2 and CC7 x BSC2 were found the best heterobeltiotic F1s and the crosses CC-7 x CHC-1, Swarma Agetaa x BSC-2 and CU-5 x BSC 2 depicted higher SH in desirable direction.
Airina *et al.* (2013)	12 F_1s derived from top cross involving 13 parents	-24.69 to 13.78	-	Two hybrids manifested significant HB in desired direction. The cross EC 709119 x CS 128 gave the highest HB.
Singh *et al.* (2015)	7 x 7; Diallel without reciprocals	-1.56 to 15.42	-32.03 to -15.42	21 crosses showed significant HB and 17 crosses showed significant SH. DC 1 x Swarna Poona and Punjab Naveen x Pusa Uday recorded the highest HB and SH, respectively.
Singh *et al.* (2015)	8 x 8; Diallel excluding reciprocals	-41.71 to 30.13	-	Two crosses were found to be superior with significant HB and CHC 2 x C 99-12 was the best one.
Bhatt *et al.* (2017)	9 x 9; Diallel excluding	-52.48 to -2.33		Positive and significant heterosis for fruit length was

	reciprocals		-	observed in 9 crosses involving a standard variety. Meanwhile, the crosses between Panipat L x P. Green and Kalyaanpur B. exhibited a high degree of SH. (Bitter Gourd)
Kaur *et al.* (2017)	8 x 8; Diallel excluding reciprocals	3.72 to 7.37	-	Out of the crosses analyzed, Pant Kheera-1 x NCH-1 showed the highest heterosis over BP for fruit length. On the other hand, Sheetal x EC-275 exhibited the highest heterosis for fruit length.
Thakur *et al.* (2017)	6 x 6; Diallel excluding reciprocals	1.33 to 18.11	1.5 to 67.99	The top performing F_1 hybrids based on top of their performance over the BP and standard heterosis were Khira-75 x CUC-2, Khira75 x PI-6160, Khira75 x CUC1, and CUC1 x CUC2.
Simi *et al.* (2017)	19 x 19; Diallel excluding reciprocals	-11.54 to 65.53	-	The highest negative HB effect was observed in crosses Barmashi x Greenking followed by Greenboy x Trupti, Himaloy x Barmashi and Tripti x Khira.
Chittora *et al.* (2018)	11:3; Line x Tester	15.95 to 0.99	12.73 to 0.99	Two hybrids *viz.*, DRG-15 x VRS-27.and DRG-5 x VRS-27 significant positive SH over SC for fruit length of

				cucumber. (Ridge gourd)
Chikezie *et al*. (2019)	6 x 6; Diallel without reciprocals	9.24 to -17.40	-	Best three F_{1s} hybrids, which give highest show over BP Zna x Strght 8, Zna x Capso, Zna x BA and Capso x Strght 8.
Sahoo *et al*. (2019)	3:11; Line x Tester gynoecious and monoecious diverse	0.56 to 54.56	-	Out of the crosses analyzed, Khira-1 x NVH-1 showed the highest heterosis over BP for fruit length. On the other hand, Sheetal x EC-275 exhibited the maximum heterosis for FL.

The highest heterosis for Fruit length was reported by Simi *et al*. (2017). Five crosses provided significant HB. The top three hybrids with the highest HB were Barmashi x Greenking, Greenboy x Trupti, Himaloy x Barmashi and Tripti x Khira.

11. Fruit girth				
References	**Studied material**	**Range (%)**		**Finding**
		Heterobeltiosis	**Standard Heterosis**	
1	**2**	**3**	**4**	**5**
Singh *et al*. (1999)	10 x 10; Diallel without reciprocals	8.37 to 14.93	13.37 to 63.17	Two hybrids like DTG15 x VPS-27.and DRG-5 x VPS-27 significant positive SH over SC for fruit length of cucumber
Munshi *et al*. (2005)	6 x 6; Diallel without reciprocals	-7.9 to 9.5	-	The cross Poona Khira x PCUC 28 exhibited the highest HB.
Pandey *et al*.	15 lines were	-10.93 to 13.07		Cross DC 1 x B 159 showed

(2005)	used to develop 77 hybrids.		-	the highest and significant HB.
Singh *et al.* (2010b)	10 x 10; Diallel without reciprocals	27.30 (maximum)	-	PCUC 28 x Pilibhit Local recorded significant and the highest HB.
Singh *et al.* (2010a)	8 x 8; Diallel without reciprocals	-22.93 to 8.82	-	Top three hybrids with the highest HB in desirable direction were EC- 4342 x Bihar1, Bihar1 x C-98- 6 and EC 4342 x C-9910.
Kushwaha *et al.* (2011)	7 x 7; Diallel without reciprocals	-19.80 to 16.00	-	Eight hybrids depicted significantly higher HB. The cross BC 14 x BC 16 exhibited the highest HB.
Mule *et al.* (2012)	3:9; Line x Tester	35.94 (maximum)	-	Six crosses provided significant HB. The top three hybrids with the highest HB were Sheetal x SPP 44, Sheetal x CC-9 and Gujarat Local x SPP 93.
Airina *et al.* (2013)	12 F_1s derived from top cross involving 13 parents	-6.08 to 19.5	-	11 hybrids manifested significant HB in desired direction and the cross EC 709119 x CS 128 gave the highest HB.
Singh *et al.* (2015)	7 x 7; Diallel without reciprocals	-18.66 to 15.56	-36.63 to 15.56	20 crosses showed significant HB and 21 crosses showed significant SH. Punjab Naveen x Pusa Uday recorded

				the highest HB and SH both.
Singh *et al*. (2015)	8 x 8; Diallel without reciprocals	-37.92 to 27.19	-	Three crosses had significant and positive HB and PCUC 15 x CHC 2 was the best cross.
Punetha *et al*. (2017)	3:10; gynoecious and monoecious diverse	-27.59 to 29.25	-	Out of the 22 crosses analyzed, no more than 6 crosses showed a significant positive heterosis over the standard variety for fruit diameter. These crosses were Pgyn-4 x PCUC-15, Pgyn-1 x PCUC-126, and Gyn-1 x US-832.
Chittora *et al*. (2018)	11 :3; Line x Tester	23.69 to 10.20	9.76 to 0.99	Only one hybrid DRG-15 x VRS-27.exhibited significant standard heterosis in positive way whiles The max. HB were as found in the cross DRG4 x VRS24-2 and VRS27 × VRS24-2. (Ridge gourd)
Chikezie *et al*. (2019)	6 x 6; Diallel without reciprocals	3.74 to 12.00	-	The highest HB was found in the cross BA x Capso, Zna x Strght 8 and Zna x BA.
Sahoo *et al*. (2019)	3:11; Line x Tester gynoecious and monoecious diverse	0.32 to 34.09	-	The highest HB was found in the cross PGYC-1x P-Khira-1, PGYC 1 x PCUC25, PCUCP2 x P- Khira1, PUCP5 x PCC25, PCCP-4 x PCUC8, PCUCP5 x P Khira-1, and

				PGYC 3 x P Khira-1.
Naik *et al.* (2020)	5 x 5; half Diallel without reciprocals	-3.77 to 16.82	-	The highest HB as well as SH were registered with the crosses ACC-22 x ACC-40 and ACC-18 x ACC-38, respectively.

The maximum heterosis for fruit girth was reported by Mule *et al.*(2012) found 35.94. Six crosses provided significant HB. The three hybrids with the highest HB were Sheetal x SPP 44, Sheetal x CC-9 and Gujarat Local x SPP 93.

12. Fruit weight (g)				
References	**Studied material**	**Range (%)**		**Finding**
		Heterobeltiosis	**Standard Heterosis**	
1	**2**	**3**	**4**	**5**
Cramer and Wehner (1999)	Six inbred hybridized to get four F_1s	-32.2 to 83.1	-	The hybrid Addis x SMR 18 exhibited the maximum heterobeltiosis.
Singh *et al.* (1999)	10 x 10; Diallel without reciprocals	22.01 to 50.09	0.00 to 23.08	Only five and two hybrids exhibit significant HB & SH, correspondingly. The maximum HB as well as SH were registered with the crosses Ac-22 x Ac-40 and Ac-18 x Ac-38, respectively.
Munshi *et al.* (2005)	6 x 6; Diallel without reciprocals	-17.6 to 89.8	-	Total eight hybrids showed significant HB. The cross CHC 1 x PCUC 28 exhibited the highest HB.
Pandey *et al.* (2005)	15 lines were used to	-99.89 to 68.81		The result of the 1 x B 159 cross displayed the maximum

	develop 77 hybrids.		-	and statistically significant HB levels.
Singh *et al.* (2010b)	10 x 10; Diallel without reciprocals	30.09 (maximum)	-	The hybrid PCC 28 x Pilibhit Local recorded significant and the highest HB.
Singh *et al.* (2010a)	8 x 8; Diallel without reciprocals	-56.46 to 122.12	-	Top three hybrids with the highest HB in desirable direction were PCUC15 x PCUC151, EC4342 x C-9910 and EC43342 x Bihar1.
Kushwaha *et al.* (2011)	7 x 7; Diallel without reciprocals	-41.10 to 58.91	-	Four hybrids recorded significantly higher HB. The cross BC 15 x BC 16 registered the highest HB.
Mule *et al.* (2012)	3:9; Line x Tester	22.68 (maximum)	-	Seven crosses provided significant HB. The top three hybrids with the highest HB were Pilibhit L x K90, Gujarat Local x SPP -44 and Shital x CC 9.
Singh *et al.* (2012)	12:3; Line x Tester	-46.50 to 33.33	-39.44 to 27.58	Top 3 F_1 with the highest HB in desirable direction were PCUC15 x PCC15 , EC432 x C 99 10 & EC4332 x Bihar1.
Airina *et al.* (2013)	12 F_1s derived from top cross involving 13 parents	-21.14 to 43.36	-	None of the hybrids gave significant HB.
Singh *et al.* (2015)	7 x 7; Diallel without	-20.32 to 6.92	-35.02 to -6.92	Significant HB was observed in two crosses, while

	reciprocals			significant SH was observed in nine crosses. The cross between DC 1 and Pusa Uday demonstrated the highest levels of both HB and SH.
Singh *et al.* (2015)	8 x 8; Diallel without reciprocals	-45.17 to 35.15	-35.14 to 14.19	Five crosses were found superior with higher significant HB and the cross PCC-15 x PUC-15-1 was the best cross.
Singh *et al.* (2016)	8 x 8; Diallel without reciprocals	-45.17 to 35.15	-35.14 to 14.19	Seven hybrids significant positive HB & SH, correspondingly. The hybrids ACC 3 x ACC 8 and ACC 4 x ACC6 exhibited the maximum HB and SH, respectively.
Kaur *et al.* (2017)	8 x 8; Diallel without reciprocals	0.60 to 12.35	-	Cross Sheetal x EC-2775 , pant Kheera-1 x JLG exhibited maximum heterosis for Average fruit weight over BP.
Chittora *et al.* (2018)	11:3; Line x Tester	12.55 to 0.59	10.50 to 0.39	For fruit weight, the hybrid DRG-4 x VRS-24-2 exhibited the maximum significant positive values for both SH and HB. (Ridge gourd)
Singh *et al.* (2018)	10 x 10; Diallel without reciprocals	18.88 to 30.09	19.21 to 31.06	Top four hybrid PCUC-28 x Peelibheet local, PCUC-28 x VRC-182, VRC-112 x BSC2 ,Swarna sheetal x BSC-2

				gave the highest HB and SH.
Sahoo *et al.* (2019)	3:11; Line x Tester gynoecious and monoecious diverse	0.18 to 100.32	-	The top-performing F1 hybrids, with the highest yield and favorable contributing characteristics over their better parent, were PGYC-1 x Pant Khira-1, PGYC 1 x PUC-5, and PCCP-6 x PUC-5
Naik *et al.* (2020)	5 x 5; Diallel without reciprocals	1.18 to 22.42	-	The cross Galaxy x Meghdut showed higher positive and significant HB.

The maximum heterosis for fruit weight was reported by Singh *et al.* (2010a). PCUC15 x PCUC151, EC4342 x C-9910 and EC43342 x Bihar-1 recorded significant and the highest HB.

13. Fruit yield per vine				
References	**Studied material**	**Range (%)**		**Finding**
		Heterobeltiosis	**Standard Heterosis**	
1	**2**	**3**	**4**	**5**
Bhatt *et al.* (2017)	9 x 9; Diallel excluding reciprocals	9.68 to 3.45	-	The hybrid combination PB-14 x A. Harit, and Panipat L. x Pusa Vishesh, showed the highest significant positive SH and HB for fruit yield per vine.
Simi *et al.* (2017)	19 x 19; Diallel excluding reciprocals	1.39 to -55.32	-	Modhumoti x Tripti exhibited the highest heterobeltiosis, while Baromashi x Greenking showed the lowest negative heterobeltiosis. Himloy x

				Trupti and Modhumti x Khira had intermediate levels of negative heterobeltiosis.
Chittora *et al.* (2018)	11:3; Line x Tester	31.59 to 11.26	41.64 to 1.72	The cross DRG-15 x VRS-27, DRG-3 x VRS-27 and DRG-15 x VRS-24-2 showed the highest and significant HB.
Singh *et al.* (2018)	10 x 10; Diallel excluding reciprocals	8.07 to 80.95	14.51 to 102.11	Significant positive heterosis in the desired direction was pragmatic in the top four hybrids, i.e. VRC18 2 x Patna3, Baraamasi x BSC2, PCUC28 x Peelibheet, and CU5 x Patna3 crosses, over both better and mid-parent.
Preethi *et al.* (2019)	5 x 5; Line x Tester	53.15 to 55.68	-	Green L x Poinsette, Green L x Uday, Pondichery-1 x Naveen hybrids exhibit the maximum significant HB
Sahoo *et al.* (2019)	3:11; gynoecious and monoecious diverse Line x Tester	-1.46 to 141.45	-	The top-performing F_1 hybrids, with the highest yield and its contributing characteristics over their better parent, were PUCP-6 x PCC 25, PUCP-5 x PCC 8, PGYC-1 x P. Khira-1, and PUCP-6 x PUC-8.
Naik *et al.* (2020)	5 x 5; Diallel without reciprocals	4.27 to 44.47	-	The F_1 crosses Galaxy x Bolder Uccha recorded significant heterosis over better parent.

Researchers have reported varying levels of H (heterosis) for fruit yield per vine, ranging from 53.15 to 55.68 (kg). Among the hybrids tested Green L x Poinsette, Green L x Pusa Uday, and Pondichery 1 x Naveen, recorded maximum significant heterobeltiosis.

2.2 COMBINING ABILITY AND GENE EFFECTS

The significance of combining ability has been highlighted as it is observed that parents with similar desirable traits may not always produce superior offspring in subsequent generations, while certain combinations may result in promising segregants. Therefore, the capability of a parent to produce superior segregants in successive generations by combining effectively is a crucial factor to consider when selecting parents for a successful hybridization program.

In 1942, Sprague and Tatum introduced the concept of general combining ability (GCA), which refers to the average performance of lines in a series of crosses, and is mainly attributed to additive genetic variance or gene action. They also defined specific combining ability (SCA) as situations in which certain hybrid combinations exhibit better performance than would be anticipated based on the average performance of the parental lines. This phenomenon is considered to be an indication of non-additive gene action. Griffing later expanded on this concept in 1956. Table 2.2 provides details of the available literature on the genetic variance components and gene effect for the cucumber traits under investigation.

Table 2.2 Combining ability, variances and nature of gene effects reported by various researchers for different characters in cucumber (*Cucumis sativus* L.)

Author	**Materials studied**	**findings**
1	**2**	**3**
1. Days to first male flower		
Lopez-Sese and Staub (2002)	4 x 4; Diallel excluding reciprocals	The estimates of both the combining ability variance were significant, but the value of σ^2gca was found to be larger than that of σ^2_{sca}. The gca effect of the line WI 551 was the biggest. Higher GCA effect than SCA effect revealed prevalence of additive genetic variance.
Yadav *et al.*	15:3;	Both gca as well as sca was significant. The maximum

(2007)	Line x Tester	significant gca and sca effect in desirable direction were depicted by the parental line 2015 and the cross 2332 x 2014, respectively.
Singh *et al.* (2011)	12:3; Line x Tester	σ^2 gca for all lines into testers and σ^2 sca for all the crosses were significant. The line CU 5 manifested the highest gca and the hybrid CC 7 x CHC 1 depicted the highest sca effects.
Reddy *et al.* (2014)	6 x 6; Diallel without reciprocals	The best parent and the cross showing the highest significant desirable gca and sca effects were DC-1 and Poona Khira x Sel 7-7, respectively.
Singh *et al.* (2015)	8 x 8; Diallel without reciprocals	Among the genotypes tested, C-98-6 exhibited the highest level of GCA and is thus considered the best general combiner.
Airina *et al*. (2017)	12 x1; Top cross	For the first female flower, CS-128 exhibited the highest GCA effect among all the genotypes tested, followed by IC-53186, suggesting that they were the most favorable combiners for earliness in flowering. However, not any of the parents demonstrated a significant GCA effect for first male flower.
Nimitha *et al*. (2017)	10 x 10; Diallel without reciprocals	The parents ACUS-1360, GCU-1, ACUS9-51, ACUS9-51, ACUS13-60, ACUS13-60, ACUS14-62, & ACUS 9-44 recorded the highest GCA effect. The crosses depicting highest effect (SCA) for the days to first male flower were GCU-1 x ACUS14-62, ACUS14-63 x ACUS14-65, ACUS13-60 x ACUS14-64, and ACUS9-51 x ACUS 14-62.
Naik *et al.* (2018)	9 x 9; Diallel excluding reciprocals	Tester Haveri L showed a notable negative gca effect for the first male flower on Line US-640, and the gca and SCA effects were both significant.
Sawant *et al*. (2020)	4:6;Line x Tester	Himangi, a single female parent, and 3 male parents DC-2, AAUC-1, and DARL-103 had notable negative effects

		(GCA). Among the resulting hybrids, the ones with the top significant negative effects (SCA), were Phule Himangi x DC-2, Sheetal x Fansu L, and Poona khira x DARL-103.
Kumar *et al.* (2021)	12:3; Line x Tester	Pusa Barkha had good GCA effects for days to first male flower initiation. The crosses depicting highest SCA effect for first male flower were No- 40 x PCUC-8, Swarn Ageti x Boro Patana.
Shah *et al.*(2021)	7 x 7; Diallel including reciprocals	The parents PB Naveen show significant GCA effect. And SPP-63 X Manipur-1 show negative significant effect (GCA)
2. Days to first female flower		
Wadid *et al.* (2003)	5 x 5; Diallel including reciprocals	Significant and the highest gca effect and sca effect were shown by the line PI 267742 and by the cross PI 267742 x PI 135345, respectively.
Yadav *et al.* (2007)	15:3; Line x Tester	The significant gca and sca effects in desirable direction were depicted by the parental line 2016 and the cross 2332 x 2014, respectively.
Sundharaiya *et al.* (2007) Bitter gourd	5:3; Line x Tester	The line Mithipagal recorded negative significant GCA for first female flower and F_1 Mithipagal x Co-1 be the best specific combiner for first female flower.
Dogra and Kanwar (2013)	8 x 8; Diallel excluding reciprocals	GCA as well as SCA was significant with top GCA component signifying the prevalence of additive gene action. The parent G-2 and the cross LC-11 x Gyn-1 were the best general and specific combiners, respectively.
Singh *et al.* (2011)	12:3; Line x Tester	GCA for all lines and testers as well as σ^2_{sca} for all the crosses were significant. The line CU 5 manifested the highest gca and the hybrid CC-7 x CHC-1 depicted the highest sca effect.
Bairagi *et al.* (2013)	8 x 8; Diallel without	The good and specific combiners were PCUC 25 and PGC 1 x PCUC 25, respectively. (gca & sca highly significant).

	reciprocals	
Kumar *et al.* (2013)	6 x 6; Diallel without reciprocals	The parent CRC 8 exhibited the highest GCA effect, while the cross CRC 8 x Pusa Uday demonstrated the highest SCA effect.
Reddy *et al.* (2014)	6 x 6; Diallel without reciprocals	The parent CHC 1 and the cross P. Khira x Sel 97-7 depicted the highest significant desirable gca and sca effects, respectively.
Pati *et al.* (2015)	8 x 8; Diallel without reciprocals	The parent Uday demonstrated the highest GCA effect, while the cross GBS1 x Uday had the highest SCA effect.
Singh *et al.* (2015)	8 x 8; Diallel without reciprocals	General and specific combiner was significant. The parent C98-6 was the top general combiner.
Kumari *et al.* (2017)	6:3; Line x Tester	The following crosses exhibited significant effects: CGN-256 x Japanese, LC22 x Poinsette, LC12-4 x Poinsette, & LC1-1 x K75.
Bhutia *et al.* *(*2017)	8 x 8; Diallel without reciprocals	The highest GCA effects were shown by the crosses Uday × DC-1, DC77 × CHC1, DC83 × Kalyanpur Green, DC-77 × DC-1, DC-83 × CHC-1.
Nimitha *et al*. (2017)	10 x 10; Diallel without reciprocals	The parents ACUS13-60, GCU1, ACUS9-51, ACUS9-51, ACUS13-60, ACUS13-60, ACUS14-62, and ACUS9-44 recorded the highest gca effect. ACUS 9-50 x ACUS 13-58 manifested highest sca effect.
Naik *et al.* (2018)	9 x 9; Diallel without reciprocals	For the trait first female flower appearance, parents as well as hybrids with negative both combining effects were considered desirable. Among the lines evaluated, US-640 exhibited the most significant negative GCA effect, particularly when compared to Haveri local.
Dogra *et al*. (2019)	8 x 8; Diallel without	Crosses LC-11 x Gyn1 and EC-134 x LC40, correspondingly had highest sca effects.

	reciprocals	
Sawant *et al*. (2020)	4: 6; Line x Tester	Female parents, Himangi and Shubhangi, as well as three male parents, AAUC-1, DARL-103, and DC-2 show negative GCA effects. The estimates for SCA effects indicate that the crosses Sheetal x Fansu & Poona khira x DARL103 both had significant negative SCA effects, with the same level of magnitude.
Kumar *et al*. (2013)	12:3; Line x Tester	NO-100 had good gca effects for Day to first female flower initiation. The estimates for SCA effects showed that the crosses 5-URC-11-1 x PCUC-8 and 5-URC-11-1 x Boro Patana had significant negative SCA effects, in that order.
Shah *et al*, (2021)	7 x 7; Diallel including reciprocals	The parent PB-Naveen showed significant GCA effect and K-90 x SPP-63 showed significant SCA effect.
3. First fruit bearing node		
Airina *et al*. (2017)	12 x 1; Top cross	IC 538186 exhibited the most significant negative effects on GCA (General Combining Ability) at the node where the first female flowers.
Kumar *et al*. (2017)	6:3; Line x Tester	The highest GCA as well as SCA effects was shown by the parent LC1-1, CGN-2015, Poinst. LC2-2 and Top significant desirable cross combinations sca LC1-1 x K75, CGN2056 x JLG, LC2-2 x Point. CGN-2015 x JLG, CGN-2056 x JLG.
Dogra *et al*. (2019)	8 x 8; Diallel without reciprocals	SCA was significant and GCA was non-significant. The hybrids K-90 x K-75, G-2 x Poinsette, EC173934 x K-75, EC173934 x Gyn-1, and LC-11 x LC-40 was the best specific combiner.
Sawant *et al*. (2020)	4: 6; Line x Tester	Based on the gca effects, it was found that female parents Puna khira and Shubhangi, as well as the male parents DARL-103, VRC-19, and DC-2, demonstrated significant

		negative effects. Furthermore, the hybrids with the most significant negative SCA effects were ranked in the following order: Sheetal x Fansu, followed by Poona Khira x DC-2.
Shah *et al*.(2021)	7 x 7; Diallel including reciprocals	The parent Naveen show negative significant GCA effect and the cross Naveen x New Manipur-2 showed negative significant SCA effect.
Kumar *et al.* (2021)	12:3; Line x Tester	NO-40 had good gca effects for First fruit bearing node. The cross Pahari Barsati x PCUC-8 and Pahari Barsati x Boro Patana showed negative significant SCA effect.
4. Days to first harvesting		
Kumar *et al.* (2013)	6 x 6; Diallel without reciprocals	The genetic variance components, σ^2gca and σ^2sca, found to be highly significant, with the estimated value of σ^2SCA being larger than σ^2GCA. This suggests that non-additive gene action is of great importance. The parent CRC-8 exhibited the highest gca effect, while the cross CHC-2 x Pusa Uday showed the highest SCA effect.
Reddy *et al.* (2014)	6 x 6; Diallel excluding reciprocals	The parent CHC-1 exhibited the highest significant desirable gca effect, while the cross Poona Khira x Sel 97-7 showed the highest significant desirable sca effect.
Pati *et al.* (2015)	8 x 8; Diallel excluding reciprocals	The parent Uday exhibit the highest GCA effect and the cross GBS-1 x Pusa Uday registered the highest sca effect (GCA & SCA were highly significant).
Singh *et al.* (2016)	8 x 8; Diallel excluding reciprocals	Equally GCA and SCA were significant. The best general and specific combiners were ACC 2 and ACC 2 x ACC 6, respectively.
Airina *et al*. (2017)	12 x 1; Top cross	The character "days to first fruit harvesting," which contribute to earliness, showed the highest GCA value for CS128.
Bhutia *et al.* (2017)	8 x 8; Diallel without	The genetic variance components, σ^2gca and σ^2sca, were found to be significant, with the estimated value of σ^2gca

	reciprocals	being larger. The gca effect was the highest for the crosses Pusa Uday x DC1, DC77 x CHC1, DC77 x Naveen, DC77 x DC1, DC83 x Kalyanpur Green.
Nimitha *et al*. (2017)	10 x 10; Diallel without reciprocals	The parents ACUS 13-60, GCU-1, ACUS-9-51, ACUS9-51, ACUS13-60, ACUS-13-60, ACUS 14-62, and ACUS9-44 recorded the highest gca effect. ACUS 9-50 x ACUS 13-58 manifested highest sca effect.
Golabadi *et al*. (2017)	5 x 5; Diallel without reciprocals	GCA and SCA were highly significant. Salar hybrid was found to have the highest sca effect.
Sawant *et al.* (2020)	4: 6; Line x Tester	The GCA estimates indicated significant negative effects for three female parents, Himangi, Sheetal, and Shubhangi, and for male parents DC2, AAUC2, and DARL103. Additionally, the estimate of sca effects identified two hybrids Sheetal x Fansu and Himangi x AAUC2, as a good specified combination.
Shah *et al*. (2021)	7 x 7; Diallel including reciprocal	New Manipur-1 showed significant general combining ability effect and the cross Swarna Purna x Seven Stars showed significant SCA effect.
Kumar *et al.* (2021)	12:3; Line x Tester	NO-40 had good gca effects for Day to first fruit picking. And crosses 5- URC-11-1 x PCUC-8, Pusa Barkha x Boro Patana showed were highly significant SCA effect.
5. Days to last harvesting		
Nimitha *et al*. (2017)	10 x 10; Diallel without reciprocals	The parents ACUS13-60, GCU1, ACUS9-51, ACUS -9-51, ACUS-13-60, ACUS 60, ACUS 14-62, and ACUS 9-44 recorded the highest gca effect. The cross ACUS13-60 x ACUS9-51 registered highest sca effect.
6. Number of primary branches/vine		
Lopez-Sese and Staub (2002)	4 x 4; Diallel excluding reciprocals	The line H 19 exhibited the highest gca effect. The higher GCA effect compared to SCA effect suggests that additive genetic variance is more predominant.(GCA and SCA both

		significant)
Yadav *et al.* (2007)	15:3; Line x Testers	The highest significant both effects in desirable direction were depicted by the parental line 2225 and the cross 2332 x 2238, respectively.
Singh *et al.* (2010b)	10 x 10; Diallel excluding reciprocals	Swarna Ageti was the best general combiner for Number of primary braches per plant.(GCA and SCA both significant)
Singh *et al.* (2011)	12:3; Line x Tester	GCA for all lines and testers as well as SCA for all the crosses were significant. The line BSC 1 manifested the highest GCA and the hybrid CC 4 x CHC 1 depicted the highest SCA effect.
Mule *et al*. (2012)	3:9; Line x Tester	SCA variance was significant and GCA variance was non-significant. The hybrid Gujarat Local x PCUC 28 was the best specific combiner.
Airina *et al*. (2017)	12x1; Top cross	CS 123 exhibited the greatest genetic combining ability (GCA) effect for the trait of number of branches per plant.
Rani *et al.* (2017)	5 x 5; Diallel excluding reciprocals	High sca effect was observed for this character was PSPL x Pratik. P & low with Ab x PSPi. The crosses PSPl x Pratik. P, AB x IC-92330 and AB x Pratik recorded significant positive sca effects.
Sawant *et al.* (2020)	4:6; Line x Tester	According to the GCA estimates, Sheetal and Puna khira, the female parents, show significant +ve GCA effects. Furthermore, the analysis of the SCA effects of hybrids indicated that Shubhangi x AAUC2 and Poona Khira x Fansu hybrids demonstrated significant positive SCA effects.
Shah *et al*.(2021)	7 x 7; Diallel including reciprocals	The cross combination PB Naveen x SPP63 for NPBPV showed significant SCA effect.
Kumar *et al.* (2021)	12:3; Line x Tester	Punjab Naveen had good gca effects and sca were significant with URC-11-1 x PCUC-8, for primary

		branches per vine.
7. Internodal length		
Golabadi *et al*. (2015)	9 x 9; Diallel without reciprocals	The parent, Neda showed significant GCA effect and SCA is non significant for internodal length.
Dogra *et al*. (2019)	8 x 8; Diallel without reciprocals	There were 9 specific combinations that had a significant –ve value, with the highest negative value observed in the cross between K-90 and Poinsette, as well as the cross between Poinsette and EC 134.
8. Vine length		
Uddin *et al*. (2009)	8:3; Line x Tester	To enhance plant characteristics such as shorter vine length, the cross between CS0102 and CS0058 demonstrated the most effective results. On the other hand, to attain dwarf-type hybrids, the combination of CS0102 and CS0047 was found to be the most suitable.
Airina *et al*. (2017)	12 x 1; Top cross	The highest general combining ability effects for vine length was shown by CS 123(P) and EC 709119 x CS 123 (hybrid)
Rani *et al*. (2017)	5 x 5; Diallel without reciprocals	The maximum significant GCA and SCA effects were depicted by the PSPL x TPT local, AB x PSPL.
Shah *et al*,(2021)	7 x 7; Diallel including reciprocals	New Manipur-1 exhibited a noteworthy General Combining Ability (GCA) effect, while the crossbreed of Seven Star and New Manipur-1 showed a significant Specific Combining Ability (SCA) effect.
Manggoel *et al* (2021)	6 x 6; Diallel excluding reciprocals	These ten hybrid combinations Odukpaani x Griffaton, Odukpaani x Ashlay, Odukpani x Market more, Odukpaani x Monarch, Griffiton x Poinset, Griffiton x Ashlay, Griffiton x Market more, Poinset x Ashlay, Poinsett x Market more, and Market more x Monarch exhibited positive combining ability for VL.

Kumar *et al.* (2021)	12:3; Line x Tester	The maximum significant gca and sca effect was depicted by the Line Swarn Ageti and the cross NO-1 x Boro Patana, respectively. (Both GCA & SCA were.)
9. Number of fruits per vine		
Lopez Sese & Staub (2002)	4 x 4; Diallel without reciprocals	The gca effect was positive and relatively high for the line WI 5551. Higher GCA effect than SCA effect revealed prevalence of additive genetic variance.
Wadid *et al.* (2003)	5 x 5; Diallel include reciprocals	Significant and highest gca effect as well as sca effect were shown by the line PI 267742 and the cross PI 267742 x PI 135345, respectively.
Sundharaiya *et al.* (2007) Bitter gourd	5:3; Line x Tester	The hybrid Mithipagal x Co-1 was the best specific combiner for NFPV. The line Mithipagal recorded negative significant GCA.
Yadav *et al.* (2007)	15:3; Line x Tester	The highest significant gca and sca effects in desirable direction were depicted by the parental line 2020 and the cross 2337 x 2238, respectively.
Uddin *et al.* (2009)	8:3; Lines x Testers	The tester CS 0047 and the cross CS 0102 x CS 0090 exhibited the highest significant gca and sca effects, respectively.
Kushwaha *et al.* (2011)	7 x 7; Diallel without reciprocals	Among parents, BC 14 and among crosses, BC 11 x BC 16 registered the highest significant gca and sca effects, respectively.
Singh *et al.* (2011)	12:3; Line x Tester	σ^2gca for all lines and testers as well as σ^2sca for all the crosses were significant. The line CHC 129 manifested the highest gca and the hybrid CH 20 x BSC 2 depicted the highest sca effects.
Mule *et al.* (2012)	3:9; Line x Tester	Both were highly significant with better estimate of SCA. The line CC-9 was the top general combiner and Pilibhit Local x K-90 was the best specific combiner.
Kumar *et al.* (2013)	6 x 6; Diallel without	Good general and specific combiners were highly significant with larger σ^2sca estimate representing the

	reciprocals	importance of gene action (NA). The highest gca and sca effects were shown by the parent Uday and the cross CRC-8 x Uday, respectively.
Golabadi *et al.* (2015)	9 x 9; Diallel including reciprocals	GCA was significant and SCA were non-significant. The parent Storm registered the highest “gca” effect.
Reddy *et al.* (2014)	6 x 6; Diallel without reciprocals	The best parent and the cross showing the highest significant desirable sca and gca effects were Pusa Uday and DC 1 x Himangi, respectively.
Singh *et al.*(2015)	8 x 8; Diallel without reciprocals	Both good general and specific combiners were significant. The line PCUC 15-1 was found the top general combiner.
Singh *et al.* (2016)	8 x 8; Diallel without reciprocals	The best general and specific combiners were ACC 2 and ACC 4 x ACC 7, respectively.
Airina *et al*. (2017)	12 x 1; Top cross	CS-123 and CS-121 were effective general combiners, exhibiting the greatest (GCA) effect for increasing the number of fruits/ vine.
Bhutia *et al.* *(*2017)	8 x 8. Diallel without reciprocals	Good general and specific combiners were significant. The crosses Pusa Uday x DC-1, Pusa Uday x Naveen, DC-77 x DC-83, DC-83 x Kalyanpur Green, DC-77 x Kalyanpur Green was found to be the best GCA
Naik *et al.* (2018)	9 x 9; Diallel without reciprocals	Out of 27 crosses three crosses DWD x Haveri Local, US-640 x Haveri Local and Sabra x Bagalkot Local exhibited the significant positive *sca* effect for yield attributing traits.
Dogra *et al*. (2019)	8 x 8. Diallel excluding reciprocals	Gyn-1 and G-2 were identified as good general combiners. The specific combination in order of value were K-90 x G-2, K-90 x Gyn-1 and K-75 x Gyn-1 involving medium into high, medium into high and poor into high general combiner.

Kumar *et al*. (2021)	8 x 8; Diallel without reciprocals	Malini and Nungems were identified as significant positive general combiners with desirable effects, indicating the influence of additive gene action. Malini was also found to be a good GCA for number of fruit per vine. In addition, the cross between Nungems and Green long exhibited the highest significant (SCA) effect, making it a good SCA for the trait as well. Overall, these findings underscore the consequence of both (GCA and SCA) in the development of superior lines for the local Malini character.
Shah *et al*.(2021)	7 x 7; Diallel without reciprocals	The parent, Manipur1 show significant GCA effects and the cross Swarna K-90 x Seven Stars showed significant SCA effect.
Kumar *et al.* (2021)	12:3; Line x Tester	Significant and the highest gca effect as well as sca effect were shown by the line Punjab Naveen and the cross PI Pusa Uday x Boro Patana, respectively.
10. Fruit length (cm)		
Yadav *et al.* (2007)	15:3; Line x Tester	Both GCA and SCA were significant. The highest significant gca and sca effects in desirable direction was depicted by the parental line 2028 and the cross 2332 x 2014, respectively.
Uddin *et al.* (2009)	8:3; Line x Tester	Both σ^2 gca and σ^2 sca were significant with larger estimate of σ^2 sca. $\sigma^2{}_D$ higher than $\sigma^2{}_A$ indicated the predominance of non additive gene action. The tester CS 0047 and the cross CS 0102 x CS 0058 exhibited the highest significant gca and sca effects, respectively.
Dogra and Kanwar (2013)	8 x 8; Diallel without reciprocals	The parent Gyn-1 and the cross Poinsette x LC 40 were the best general and specific combiners, respectively.
Kushwaha *et al.* (2011)	7 x 7; Diallel without reciprocals	Among parents, BC 16 and among crosses, BC 16 x Poin sette registered the highest significant gca and sca effects, respectively.

Singh *et al.* (2011)	12:3; Line x Tester	σ^2gca for all lines and testers as well as σ^2sca for all the crosses were significant. The line Swarna Ageta manifested the highest gca and the hybrid CH 6 x CC 5 depicted the highest sca effect.
Mule *et al*. (2012)	3:9; Line x Tester	Both GCA and SCA were highly significant with better estimate of SCA. SPP 44 was the best general combiner and Pilibhit Local x K 90 was the best specific combiner.
Bairagi *et al.* (2013)	8 x 8; Diallel without reciprocals	GCA and SCA were highly significant with better estimate of GCA which indicates the higher importance of additive gene effect. The general and specific combiners were DC 1 and PGC 1 x PCUC 83, respectively.
Kumar *et al*. (2013)	6 x 6; Diallel without reciprocals	The highest gca and sca effects were shown by the parent DC 1 and the cross CHC 2 x Pusa Uday, respectively.
Golabadi *et al.* (2015)	9 x 9; Diallel without reciprocals	The parents Sco 4184 was found to have the highest gca effect. (gca and sca were highly significant)
Reddy *et al.* (2014)	6 x 6; Diallel without reciprocals	The parent Sel 97-7 and the cross DC 1 x Himangi showed the highest significant desirable GCA and SCA effects, respectively.
Pati *et al.* (2015)	8 x 8; Diallel without reciprocals	The parents Uday exhibit the highest GCA effect and the cross GS4 x DC1-1 registered the highest effect (SCA).
Singh *et al.* (2015)	8 x 8; Diallel exclude reciprocals	A significant effect was pragmatic for both GCA and SCA, and the analysis revealed that Parent C-99-12 demonstrated the highest level of general combining ability.
Airina *et al*. (2017)	12 x 1; Top cross	The GCA analysis indicated that the genotype CS127 exhibited the greatest effect for fruit weight (average).
Bhutia *et al.* (2017)	8 x 8; Diallel without	Significant as well as the highest gca effect and sca effect were shown by the crosses DC70 x DC83, DC7 x CHC-1,

	reciprocals	DC83 x Pusa Uday, and Pusa Uday x Kalyanpur G.
Kumari *et al*. (2017)	6:3; Line x Tester	Significant as well as the highest gca effect and sca effect were shown by the line LC-1-1, LC-2-2 in hybrid and LC-1-1, LC-2-2 and LC-12-4 in F_2
Golabadi *et al*. 2017	5 x 5; Diallel without reciprocals	The parent Janeete and Zohal male parent was found to have the highest gca effect. (GCA & SCA significance)
Naik *et al*. (2018)	9 x 9; Diallel without reciprocal	The line Hnr showed a remarkably significant positive general combining ability (GCA) effect for the length of its fruits.
Dogra *et al*. (2019)	8 x 8; Diallel excluding reciprocals	Parents Gyn-1, LC-11 and K-90 were good combiners (general). The sca effects were high in cross Poinsette x LC-40 and G-2 x Poinsette involving poor x poor general combiner.
Kumar *et al.* (2021)	12:3; Line x Tester	Significant as well as the highest gca effect and sca effect were shown by the line Swarn Ageti and the cross Panjab Naveen x PCUC-8 respectively.
11. Fruit girth		
Yadav *et al.* (2007)	15:3; Line x Tester	GCA and SCA effects were depicted by the parent 2227 and the cross 2015 x 2226, respectively
Singh *et al.* (2010b)	10 x 10; Diallel without reciprocals	Parent Swarna Sheetal was the best general combiner. The cross PCUC 28 x Pilibhit Local was the best with regards to sca effect.
Kushwaha *et al.* (2011)	7 x 7; Diallel without reciprocals	Among parents, Poinsette and among crosses, BC 13 x Poinsette registered the highest significant gca and sca effects, respectively.
Mule *et al*. (2012)	3:9; Line x Tester	σ^2gca was significant and σ^2sca was non-significant. Hybrid Pilibhit Local x K 90 was the best specific combiner.
Golabadi *et al.* (2015)	9 x 9; Diallel including	σ^2gca and σ^2gca highly significant. The parent Tornado was found to have the highest gca effect.

	reciprocals	
Reddy *et al.* (2014)	6 x 6; Diallel without reciprocals	The best parent and the Cross showing the highest significant desirable gca and sca effects were Pusa Uday and Himangi x CHC 2, respectively.
Singh *et al.* (2015)	8 x 8; Diallel without reciprocals	The best combiner (general) was found to be PCUC 15 (GCA and SCA significant).
Singh *et al.* (2016)	8 x 8; Diallel without reciprocals	The best general and specific combiners were ACC 8 and ACC3 x ACC4, respectively. (GCA and SCA significant).
Bhutia *et al.* *(*2017)	8 x 8; Diallel without reciprocals	The cross between DC-70 and DC-1 demonstrated substantial GCA and SCA, with notable effects observed for both GCA and SCA factors.
Naik *et al.* (2018)	9 x 9; Diallel without reciprocals	Both GCA and SCA were significant Himangi x Haveri Local, Himangi x Belgum Local, and NCU1287 & Hnr exhibit the highly significant positive effect (GCA).
Dogra *et al*. (2019)	8 x 8; Diallel without reciprocals	The sca effect was (maximum) in G-2 x Gyn-1. K90, K75 and EC-17934 have highest gca and hence were good general combiners.
Rabou *et al.* (2020)	7 x 7; Diallel without reciprocals	The maximum significant gca and sca effects were depicted by the INDIA-75 x EGY-72. (GCA & SCA significant.)
Manggoel *et al.* (2021)	6 x 6; Diallel without reciprocals	The Odukpani variety exhibited a favorable combination of traits for fruit girth, as it displayed significantly top General Combining Ability (GCA) compared to other varieties. In addition, six crosses involving Odukpani, namely Odukpaani x Griffiton, Odukpaani x Market more, Odukpaani x Monarch, Griffaaton x Poinsette, Griffaaton x Monarch, and Ashlay x Monaarch, showed significantly positive effects on fruit girth.
Shah *et al*.(2021)	7 x 7; Diallel	The parent, Manipur-1 show significant GCA effect and

	include reciprocals	the cross K90 x Swarna showed significant SCA effect.
Kumar *et al.* (2021)	12:3; Line x Tester	The top significant gca and sca effects were depicted by the Line NO-100 and the cross Pusa Barkha x Boro Patana, respectively.
12. Fruit weight		
Wadid *et al.* (2003)	5 x 5; Diallel include reciprocals	Significant as well as the highest gca effect and sca effect were shown by the line PI 267742 and the cross PI 267742 x PI 135345, respectively.
Yadav *et al.* (2007)	15:3; Line x Tester	The high significant GCA and SCA effects in desirable direction were depicted by the parental line 2028 and the cross 2332 x 2014, respectively. (GCA and SCA significant with prevalence of non-additive effect.)
Uddin *et al.* (2009)	8:3; Line x Tester	Both the genetic variances, general combining ability variance and specific combining ability variance, were found to be statistically significant. The estimate of specific combining ability variance was higher than that of general combining ability variance, and dominance genetic variance was greater than additive genetic variance, indicating that gene action (NA) played a predominant role. Among the genotypes studied, line CS 0093 had the highest significant gca effect, while the cross CS 0102 x CS 0058 had the highest significant sca effect.
Singh *et al.* (2010b)	10 x 10; Diallel without reciprocals	Pilibhit Local was the best general combiner. PCUC 28 x Pilibhit Local was the best specific combiner.(GCA & SCA significant)
Kushwaha *et al.* (2011)	7 x 7; Diallel without reciprocals	Among parents, BC 12 and among crosses, BC 15 x BC 16 registered the highest significant gca and sca effects, respectively. (GCA and SCA significant)
Singh *et al.* (2011)	12:3; Line x Tester	Significant values were observed for both the genetic variance, σ^2sca, in all crosses, and the (GCA) in all lines

		and testers. The line BSC 1 exhibited the highest gca effect, while the hybrid BC-2 x CC 5 show the highest SCA effect.
Mule *et al*. (2012)	3:9; Line x Tester	SPP 44 was the best general combiner and Pilibhit Local x K 90 was the best combiner (specific). (GCA and SCA significant)
Kumar *et al.* (2013)	6 x 6; Diallel without reciprocals	The highest gca and sca effects were shown by the parent DC-1 and the cross CRC-8 x DC-1, respectively. (GCA and SCA significant)
Golabadi *et al.* (2015)	9 x 9; Diallel including reciprocals	The parent Sco 4184 depicted the highest gca effect. (GCA and SCA significant)
Reddy *et al.* (2014)	6 x 6; Diallel without reciprocals	The best parent and the cross showing the highest significant desirable sca and gca effects were Pusa Uday and Himangi x CHC 2, respectively. (GCA and SCA significant)
Singh *et al.* (2015)	8 x 8; Diallel without reciprocals	CHC 2 was emerged out as the best general combiner. (GCA and SCA significant)
Singh *et al.* (2016)	8 x 8; Diallel excluding reciprocals	Both GCA and SCA were significant. The best general and specific combiners were ACC4 and ACC3 x ACC8, correspondingly.
Airina *et al*. (2017)	12 x 1; Top cross	The genotype CS 127 exhibited the maximum general combining ability effect for average fruit weight compared to other genotypes.
Bhutia *et al.* (2017)	8 x 8; Diallel without reciprocals	The best general and specific combiners were DC-70 x DC-83, Pusa DC77 x DC83, and DC83 x Punjab Naveen, DC-77 x DC-70.
Naik *et al.* (2018)	9 x 9; Diallel without reciprocal	The significant GCA and SCA effect in desirable direction were depicted by the parental line NCU-1287 and HNR.

Dogra *et al*. (2019)	8 x 8; Diallel excluding reciprocals	Out of the eleven specific cross combinations, significant positive specific combining ability (SCA) effects were observed, with the highest effects being found in the crosses K90 x LC11 and K90 x EC 173934.
Shah *et al*.(2021)	7 x 7; Diallel including reciprocals	New Manipur-1 exhibited a notable general combining ability (GCA) effect, while the hybrid cross between Seven Star and New Manipur-1 displayed a significant specific combining ability (SCA) effect.
Kumar *et al*. (2021)	8 x 8; Diallel excluding reciprocals	The parent Malini exhibited a significant general combining ability (GCA) effect, indicating that it is a good combiner for the trait. On the other hand, the cross between Sabra x Mullu records the highest combining ability (specific).
13. Fruit yield per vine		
Yadav *et al.* (2007)	15:3; Line x Tester	The significant GCA and SCA effects were depicted by the parent 2020 and the cross 2337 x 2226, respectively.
Uddin *et al.* (2009)	8:3; Line x Tester	The highest significant gca effect was observed in the line CS 0008, while the cross CS 0102 x CS 0058 exhibited the maximum significant sca effect.
Singh *et al.* (2010b)	10 x 10; Diallel without reciprocals	The Pilibhit Local variety was found to be the best combiner (general). Out of the 45 crosses, 19 exhibit significant sca effects, indicating the presence of D x E gene actions.
Dogra and Kanwar (2013)	8 x 8; Diallel excluding reciprocals	GCA and SCA were significant with high gca component. The parent G-2 and the cross K 90 x G-2 were the best general and specific combiners, respectively.
Kushwaha *et al.* (2011)	7 x 7; Diallel without reciprocals	Among parents, BC 14 and among crosses, BC 11 x BC 16 registered the highest significant gca and sca effect, respectively.
Singh *et al.* (2011)	12:3; Line x Tester	Significant (GCA) values were pragmatic for all the lines and testers, while significant σ^2sca values were observed

		for all the crosses. The line BSC 1 showed the highest GCA effect, while the hybrid VRC 18 x BSC 2 exhibited the highest SCA effect.
Mule *et al*. (2012)	3:9; Line x Tester	The parent CC 9 was the best general combiner and Pilibhit Local x K 90 was the best combiner (specific).
Bairagi *et al.* (2013)	8 x 8; Diallel without reciprocals	The good general and specific combiners were DC 1 and PCUC 83 x PCUC 25, respectively.
Kumar *et al.* (2013)	6 x 6; Diallel without reciprocals	The parent Uday exhibit the highest GCA effect, while the cross CRC 8 x Uday showed the highest SCA effect. (σ^2gca and σ^2sca, highly significant).
Golabadi *et al.* (2015)	9 x 9; Diallel without reciprocals	Both σ^2gca and σ^2sca were highly significant. The parent Neda had the highest gca effect.
Reddy *et al.* (2014)	6 x 6; Diallel without reciprocals	The best parent and the cross showing the highest significant desirable gca and sca effects were Pusa Uday and DC-1 x Himangi, respectively.
Pati *et al.* (2015)	8 x 8; Diallel without reciprocals	The parent Pusa Uday demonstrated the highest GCA effect, while the cross GBS1 x Pusa Uday displayed the maximum SCA effect. (GCA and SCA highly significant)
Singh *et al.* (2015)	8 x 8; Diallel without reciprocals	Parent PCUC 15 was found to be the best GCA. (GCA and SCA highly significant)
Singh *et al.* (2016)	8 x 8; Diallel without reciprocals	The best general and specific combiners were ACC 8 and ACC 1 x ACC 4, respectively. (GCA and SCA highly significant)
Airina *et al*. (2017)	12 x 1; Top cross	CS-123 was identified as the top combiner (general) for fruit yield among a group of 12 parents.
Golabadi *et al*. (2017)	5 x 5; Diallel without reciprocals	Zohal (male parent) and Yalda R2 (female parent) was found to have the highest gca effect.

Nimitha *et al*. (2017)	10 x 10; Diallel without reciprocals	The parents ACUS13-60, GCU1, ACUS9-51, ACUS9-51, ACUS13-60, ACUS13-60, ACUS 14-62, and ACUS9-44 recorded the highest gca effect. The cross ACUS13-60 x ACUS9-51 registered highest sca effect.
Naik *et al*. (2018)	9 x 9; Diallel without reciprocals	The highest significant gca & sca effects were depicted by the Himangi x Haveri Local, Himangi x Belgum Local, Sabra x Haveri Local; All testers except Belgum Local exhibited the highly significant GCA effect.
Dogra *et al*. (2019)	8 x 8; Diallel without reciprocals	K-90 was the best combiner (general) in adding to Gyn-1 and G-2. The sca effect was high for K-90 x G-2, K-90 x Gyn-1 and LC-11 x Gyn-1.
Kumar *et al*. (2021)	8 x 8; Diallel without reciprocals	The analysis of gca effect revealed that among the 8 parents, namely Malini, Nungems, and Green long, significant positive gca values were observed, indicating that they were GCA.
Kumar *et al*. (2021)	12:3; Line x Tester	The line Pahari Barsati was the best general combiner and Panjab Naveen x Boro Patana was the best specific combiner.

As cited above, variable amount of combining ability effects have been reported in the literature. Similarly desirable gene effects were also reported for the all characters. Thus, similar results would be expected in our germplasm and need to be thoroughly studied to understand to utilize for hybrid development.

CHAPTER 3

MATERIALS AND METHODS

This chapter primarily highlights materials and methods used in this investigation.

3.1 Plan of Work

The present experimental research on Cucumber as entitled **"Study of heterosis and combining ability in cucumber (*Cucumis sativus* L.) using half diallel analysis"** was carried out at experimental farm, Dept. of Genetics and Plant Breeding, Lovely Professional University, Phagwara, Kapurthala, Punjab. In the first year (Jan-May) crosses were made among 12 selected parents following half diallel mating design and data were recorded for traits under study. In successive years F_1 progenies were evaluated along with parent. The evaluation of parent, F_1 progenies was carried out following RBD with three replication and recorded data were statistically analysed to draw inferences based on obtained results.

3.1.1 Location of Experiment

The experimental area was located at, research farm of Department of Genetics and Plant breeding having a latitude 31.2554°N and longitude 75.7058°E respectively.

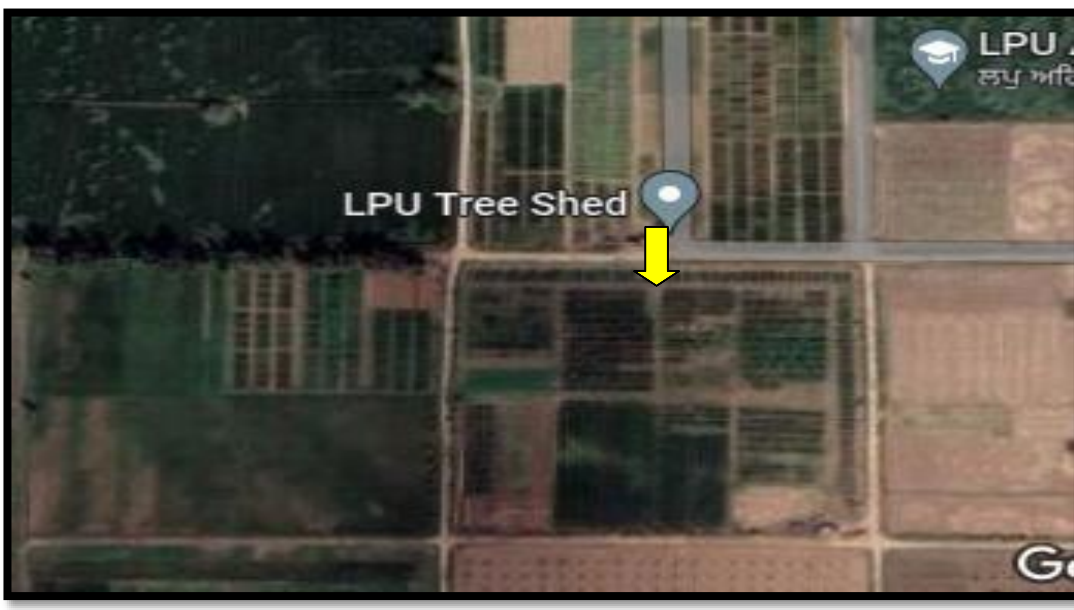

Fig. 1: Location of the experimental trial

3.1.2 Experimental Material

The particulars of materials and methods to be employed in the experimental trial were listed below.

The material used for the experiment consists of twelve genotypes of cucumber which were obtained from All India Coordinated Research Project on Vegetable Crops, Maharashtra, India. Below is a list of the genotypes utilized in this experiment:

Table 3.1: List of selected Cucumber genotypes

SR.No:	LIST OF GENOTYPES	SOURCE OF COLLECTION
1.	Panvel	AICRP (Vegetable), Rahuri, Maharashtra
2.	PLK	AICRP (Vegetable), Rahuri, Maharashtra
3.	Phule Shubhangi	AICRP (Vegetable), Rahuri, Maharashtra
4.	Phule Hemangi	AICRP (Vegetable), Rahuri, Maharashtra
5.	Poona Khira	AICRP (Vegetable), Rahuri, Maharashtra
6.	Rushita	AICRP (Vegetable), Rahuri, Maharashtra
7.	MLKP	AICRP (Vegetable), Rahuri, Maharashtra
8.	KOP-1	AICRP (Vegetable), Rahuri, Maharashtra
9.	Sheetal	AICRP (Vegetable), Rahuri, Maharashtra
10.	KDWD-1	AICRP (Vegetable), Rahuri, Maharashtra
11.	J-2	AICRP (Vegetable), Rahuri, Maharashtra
12.	J-4	AICRP (Vegetable), Rahuri, Maharashtra

3.1.3 Experimental Field:

The experimental area assigned to my crop trials was quite uniform *i.e*. plain topography and sandy loam soil type. The crop was cultivated following the recommended agronomic practices to ensure a favorable outcome.

Total area of experimental field in first, second and third year is 812 m^2, 2736 m^2 and 3,000 m^2 respectively. The selected genotypes were transplanted on bund of 3 m at spacing of 1 m x 1.5 m.

Fig. 2: Experimental trial

3.1.4 Climate and Weather:

Punjab is categorized as having a humid subtropical climate. The dry summer season begins in April and extends until June, after which the monsoon season arrives and lasts from July to September. The winters in the state of Punjab were characterized by significant temperature fluctuations, with warm days and cold nights. The meteorological data gathered throughout the 2021 and 2022 seasons has been compiled. (Fig- 3 and 4)

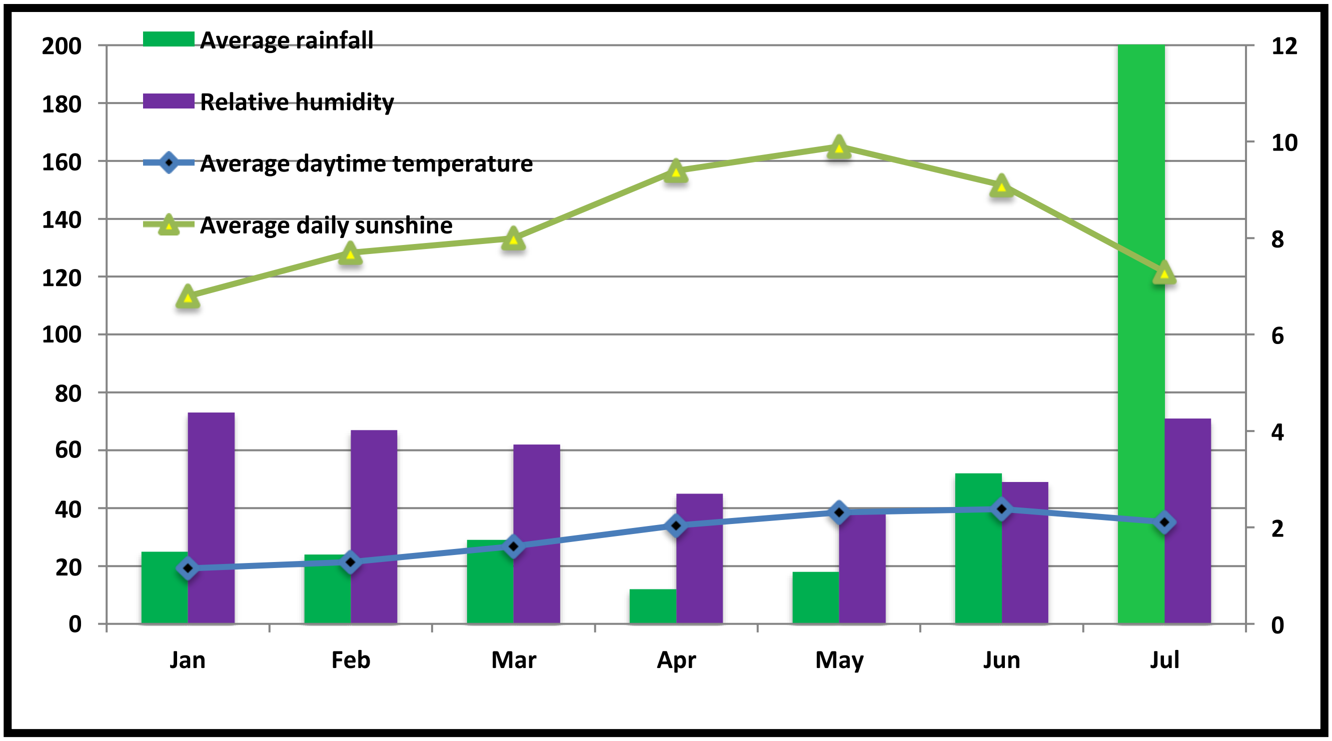

Fig. 3: Monthly weather data 2020

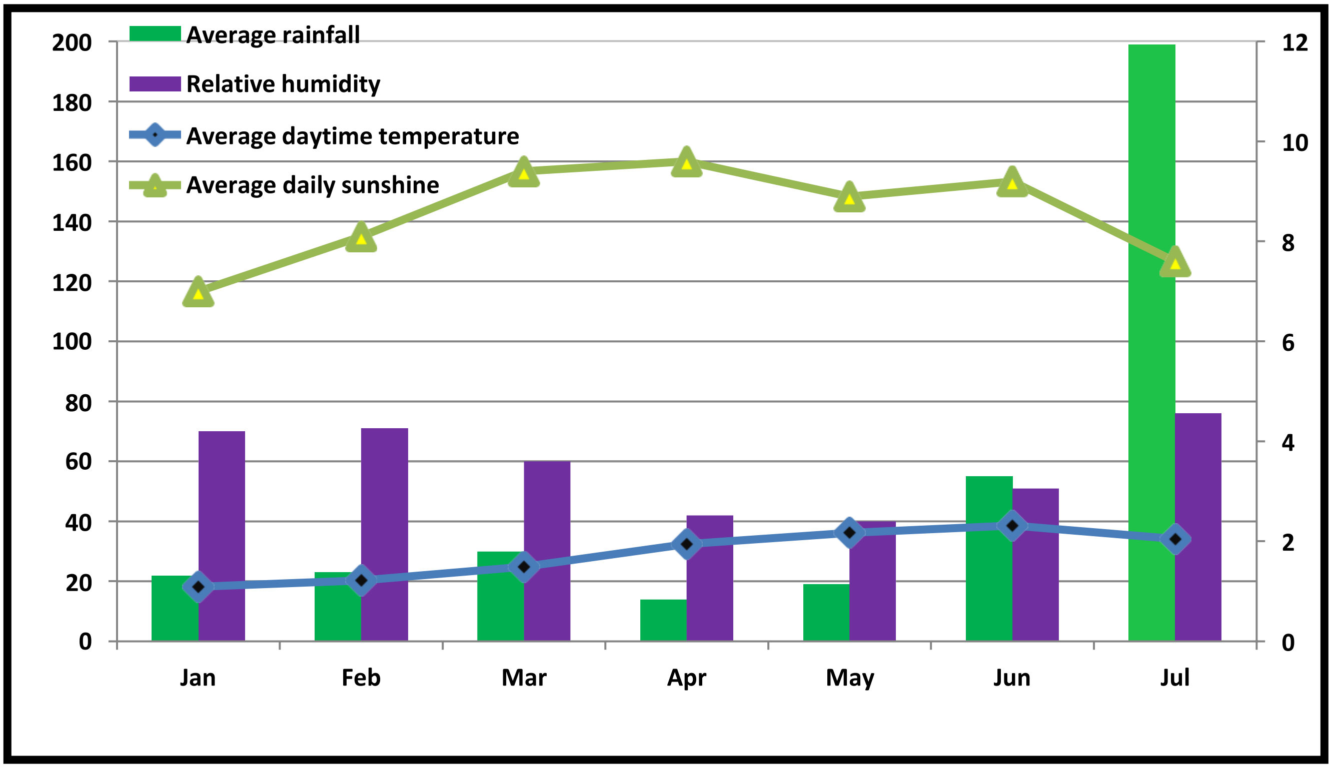

Fig. 4: Monthly weather data 2022

3.1.5 Soil and Field preparation:

In the experimental field, the first step was to perform deep ploughing using a disc plough to loosen the soil. Next, a cultivator was used to further refine the soil and achieve a finer tilt. The ground was then leveled by planking before preparing the ridges and furrows.

3.1.6 Fertilizer application:

In the experimental field, at the time of seedling transplantation 5 kg of DAP was applied. After transplanting, 90-90-90 (N: P: K) was applied after 15 days and 5g of urea was applied to each plant at 25 and 30 days intervals.

3.1.7 Nursery Sowing and transplanting:

Healthy and pure seeds of each genotype were collected before sowing. To ensure proper germination, the seeds were immersed in water for twelve hours. The seed was planted in a germination tray filled with coco-peat, and the tray was positioned inside a poly-house to facilitate seed germination. Watering was done at regular intervals to maintain moisture. Seedlings were transplanted in the main field at true leaf stages. In current investigation the seeds were planted in the tray on December 21st, 2020 in the polyhouse under controlled condition. Seedlings were ready for transplant after twenty one days thereby transferred to main field dated January 16th, 2021.

Fig. 5: Seedlings in nursery

3.1.8 Intercultural operations

The recommended packages of agronomical practices and plant protection measures to raise a healthy crop were followed.

3.1.9 Experimental design:

The experimental material comprised of 66 F_1 hybrids, 12 parents and 1 standard check varieties (Malini) were evaluated in RCBD with 3 replications during January to May 2021. The experimental units consisted of two rows with a total of ten plants each, spaced 1.5 meters apart between rows and 1.0 meter apart within rows. Transplantation of 21-day-old seedlings was carried out at a depth of 4-5 cm.

3.2 CROSSING AND SELFING TECHNIQUES

Cucumber (*Cucumis sativus* L.) is a monoecious crop species in which staminate flowers and pistillate flowers develop separately on the same plant. Sixty-six crosses were made manually to produce F_1 seeds. In cucumber plant anthesis period started at 6:00 am and completed by 8:00 am with the maximum anthesis occurs between 6:00 am to 7:00 am. Thus well developed flower buds were identified a day or two prior to anthesis and covered with wax coated paper bags. On the next day, staminate flowers from donor parents were collected separately and pollinated selected covered pistillate flower-buds by individual pollen parent.

The pollinated flower buds were again covered with wax coated bags and labeled accordingly. To get the seeds of parental lines, matured pistillate flower buds of each parent were covered with white tissue paper bag in the evening prior to flower opening to avoid out crossing. On the next day morning, those were pollinated by the pollens of the male flower collected from the same plant and bagged. The crossed and selfed ripe fruits were harvested and seeds were collected separately for each crosses and parental lines, respectively.

3. 3 CHARACTERS STUDIED

Physiological and fruit trait data, along with their component characteristics, were collected from five selected competitive plants in each experimental unit leaving border plants. These plants were chosen at random from two central rows in evaluation trials. The mean value for all traits was calculated and analyzed using statistical methods. The procedures for recording observations for each trait were as follows:

3.3.1. Days to first male flower

The number of days from when the seedlings were transplanted to when the first male flower appeared on the plant was recorded.

3.3.2. Days to first female flower

The duration between the transplantation of seedlings and the emergence of the first female flower on the plant was recorded.

3.3.3. First fruit bearing node

The node number marking the appearance of the first fruit-bearing node was recorded.

3.3.4. Days to first harvest

The total number of days from date of sowing to first fresh marketable fruit harvest was recorded from tagged plants which were used for recording days to opening of first male flower.

3.3.5. Days to last harvest

The overall of days from date of transplanting to last fresh marketable fruit harvest was recorded from those plants which were used for recording days to first male flower.

3.3.6. Number of primary branches per vine

At the time of the last picking, the number of branches growing directly from the main vine was counted for each experimental unit, starting from tagged plants.

3.3.7. Internodal length (cm)

In each treatment of the three replications, the distance between two nodes was measured using a measuring scale.

3.3.8. Vine length (cm)

A measuring tape was used to measure the height of each plant from each treatment. It was taken towards the end of the crop's growth.

3.3.9. Number of fruits per vine

The mature fruits from each experimental unit's tagged plants were collected and counted during every harvesting stage. Thereafter, average number of fruits per vine was calculated by simple mean.

3.3.10. Fruit length (cm)

The Vernier Caliper was used to measure the polar lengths of selected five fruits from each treatment of three replications.

3.3.11. Fruit girth (cm)

Five fruits selected from each plant to measure fruit length, while the girth of a single randomly selected fruit was measured at its midpoint to calculate the average fruit girth.

3.3.12. Fruit weight (g)

The weight of harvested fruits from each experimental unit was divided by the total number of fruitsharvested.

3.3.13. Fruit yield per vine (kg)

The fruit yield (by weight) from the chosen plants in each plot was calculated, and the averages were given in kilograms.

3.4 STATISTICAL ANALYSIS:

Data recorded for different characters as stated above was subjected to statistical analysis. The different statistical aspects were narrated in the following sub-heads.

3.4.1. Means and Analysis of Variance

3.4.2. Estimation of Heterosis

3.4.3. Diallel Analysis

3.4.4 ANOVA of Combining Ability

3.4.5 Combining ability effects (GCA and SCA)

3.4.1 Means and Analysis of Variance

The data collected for each character from both parents as well as F_1s was subjected to statistical analysis using the methodology recommended by Panse and Sukhatme in 1985.

A randomized complete block design (RCBD) was used to conduct an analysis of variance (ANOVA) and evaluate the significance of difference between genotypes for all measured traits. The ANOVA, which included expected mean squares, is presented in Table 4.2. In order to calculate comparisons among treatments, the treatment sum of squares (TrSS) was divided into three parts: parents, hybrids, and parents vs. hybrids. The statistical model for the RCBD is as follows:

$$Yijk = m + Ti + ßj + eijk$$

Where,

Yijk = the observation of i^{th} treatment in j^{th} block

m = General mean

Ti = the effect due to i^{th} treatment

ßj = the effect due to j^{th} block

eijk = Uncontrolled variation for k^{th} observation due to i^{th} treatment in j^{th} block.

The assumptions of the above model were

1. All the observations should be independent.

2. Error involved in the population should be normally and independently distributed with zero mean and constant variance σ2e.

3. Different effects in the model should be additive.

Table 3.2: ANOVA and expected mean squares

Source	**df**	**Sum of squares**	**Mean sum of squares**	**Expected mean squares**	**Test of significance**
Replication	(r-1)	S_r	M_r	$\sigma^2_e + g\,\sigma^2_r$	M_r/M_e
Genotypes	(g-1)	S_g	M_g	$\sigma^2_e + r\,\sigma^2_g$	M_g/M_e
Parents	(p-1)	S_p	M_p	$\sigma^2_e + r\,\sigma^2_p$	M_p/M_e
Hybrids	$(F_1 – 1)$	S_{F1}	M_{F1}	$\sigma^2_e + r\,\sigma^2_{F1}$	M_{F1}/M_e
Parents *vs* Hybrids	1	$S_g – (S_p + S_{F1})$	M_p *vs* M_{F1}	-	(M_p *vs* M_{F1}) $/M_e$
Error	(r-1)(g-1)	-	M_e ‘	σ^2e.	-

Number of genotypes (Parents + F_1) p = Number of parents

Where,

F_1 = Number of hybrids

r = Number of replications

g = Number of genotype

For comparisons of mean of genotypes, standard error and critical difference were computed asunder.

$$SE = \frac{\sqrt{me}}{r}$$

$$CD\ (5\%) = t_{(0.05,\ edf)} \times \sqrt{2} \times SE$$

Where,

M_e = Error mean squarer = Number of replications

t = table value at (r-1) (g-1) degree of freedom at (0.05 - 0.01) levels of probability

3.4.2 Estimation of Heterosis

In the current study, heterosis was calculated using two methods: heterobeltiosis, which measures the superiority of F_1 hybrids over the better parent, and standard heterosis, which measures the superiority of F_1 over the standard check Malini.

3.4.2.1 Heterobeltiosis (%)

To calculate heterobeltiosis, the percentage increase or decrease of F_1 values over the better parent's value will be determined following the method outlined by Fonseca and Patterson (1968).

Heterobeltiosis (%) = [(F_1 -BP)/BP] x 100

Where,

F_1 = Mean performance of the hybrid

BP = Mean of the better parent

The standard error (SE) and the critical difference (CD) were measured by

$$\mathbf{SE}\ (\overline{F1} - \overline{BP}) = \frac{\sqrt{2Me}}{r}$$

$$CD\left(\overline{BP}\right) = t_{(0.05,edf)} \times SE(\overline{F_1} - \overline{BP})$$

The significance of heterobeltiosis was tested using Students't test.

3.4.2.2 Standard heterosis (SH) (%)

SH as per cent increase or decreases in F_1 hybrid over standard check and will be worked out as per Meredith and Bridge (1972).

Standard heterosis (%) = [(F_1– SC) / SC] × 100

Where,

F_1 = Mean value of the hybrid

SC = Mean performance of standard check (SC)

The standard error (SE) and critical difference (CD) were measured by

$$SE\ (F1- SC) = \frac{\sqrt{2me}}{r}$$

$$CD\ (SC) = t_{(0.05,\ edf)} \times S.E.\ (F_1 - SC)$$

The significance of the results was tested using the Student's t-test.

$$t_{[(r-1)\ (t-1)]} = [F_1 - SC] / [S.E.\ (F_1 - SC]$$

3.4.3 Diallel Analysis

Griffing (1956) proposed that combining ability analysis should be performed on data collected from both parents and F_1 offspring to evaluate their potential for producing desirable traits in subsequent generations. Thus, the computation of combining ability analysis on these data sets is a recommended approach for plant breeding and crop improvement. Method II which includes F_1s excluding reciprocals and their parents, under Model-I.

3.4.4 Analysis of Variance

Analysis of variance (ANOVA) for combining ability (general and specific) was based on the mathematical model as suggested by Griffing (1958) and ANOVA table for combining ability was set as per the Table 3.3 (Model-I and Method-2).

$$X_{ij} = \mu + g_i + g_j + s_{ij} + \frac{1}{r} \Sigma e_{ijKL}$$

Where,

μ = Population mean

g_i = GCA effect of i^{th} parent

g_j = GCA effect of j^{th} parent

s_{ij} = SCA effect of ij^{th} cross combination

e_{ijkl} = the environment component pertaining to $_{ijKL}{}^{th}$ observation.

i and j = Female and male parents responsible for producing ij^{th} F_1 and r = Number of replications

i, j = 1, 2……p (number of parents)

K = 1, 2……..r (number of replications)

L = 1, 2……..c (number of observations)

The restrictions imposed to this model were

$\sum gi$ = 0 and

$\sum (S_{ij} + jS_{ij})$ = 0 (for each i)

3.4.5 Estimation of general and specific combining ability variances

The sum of squares for general combining ability (GCA) can be computed using the following formula:

$$S_s = \sum_{i}^{P} \sum_{\leq j}^{P} (X_{ij})^2 - \frac{1}{P+2} \sum_{i=1}^{P} (X_{i.} + X_{ii})^2 + \frac{2}{(P+1)(P+2)} X_{..}^2$$

Where,

S_g = Sum of squares due to gca

S_s = Sum of squares due to sca

P = Number of parents

$X_{i.}$ = Total of ith (row) array in diallel table summed over j

X_{ii} = Mean value of the ith parent

$X_{..}$ = Grand total of 'P' parents and P (P-1)/2 progenies of diallel table

X_{ij} = The progeny mean value in the diallel table i.e. value of cross between i^{th} and j^{th} parent

Table 3. 3 ANOVA for combining ability analysis

Source of variation	df	SS	MSS	EMSS
GCA	(p-1)	S_g	M_g	$\sigma^2{}_e + \frac{(p+2)}{(p-1)}\Sigma_i g_i{}^2$
SCA	$\frac{p(p-1)}{2}$	S_s	M_s	$\sigma^2{}_e + \frac{2}{p(p-1)}\Sigma_i\Sigma_j s_{ij}{}^2$
Error	(r-1)(g-1)	S_e	M_e	σ_e

To calculate the mean squares of GCA (general) and SCA (specific) effects, the relevant sum of squares was divided by the subsequent degrees of freedom.

Whereas,

Error mean square ($M_{e'}$) for combining ability analysis was obtained as,

$$M_{e'} = M_e/r.$$

Where,

M_e = Error mean square from ANOVA for RCBD.

r = Number of replications

M_e' was used for calculation of variance ratio (F) as a test of GCA and SCA mean squares.

The combining ability variance components were estimated as follows:

$$\sigma_s{}^2 = M_s - M_e{}'$$

$$\sigma_e{}^2 = M_e{}'$$

3.4.5.1 Estimation of combining ability (GCA and SCA) effects

The method used to calculate the effects of combining ability (general and specific) was as follows.

GCA effects of the ith parents

$$\hat{g} = \frac{1}{(P+2)}\left[(X_{i.} + X_{ii}) - \frac{2}{P}X_{..}\right]$$

Specific combining ability (SCA) effect of ij$_{th}$ cross

$$\hat{s}_{ij} = X_{ij} - \frac{1}{(P+2)} \left(X_{i.} + X_{ii} + X_{j.} + X_{jj}\right) + \frac{2}{(P+1)+(P+2)}X_{..}$$

Where,

$\hat{g}_i$ Estimation of general combining ability effect of ith parent

S_{ij} Estimation of specific combining ability effect of the hybrid between ith and jth parents

P = Number of parents

X_i. = Total of the ith (row) array of the ith parent in diallel table

X_j. = Total of the jth (row) array of the jth parent in diallel table

X_{ii} = Mean value of ith parent

X_{jj} = Mean value of jth parent

X_{ij} = Progeny mean value of cross between ith and jth parents and

$X_{..}$ = Grand total of parents and $\frac{P(P-1)}{2}$ progenies of diallel table.

3.4.5.2 Estimation of variances for comparing GCA and SCA effects

a) Variance $\mathbf{g_i} = \frac{(P-1)M_e}{2(P+2)}$; **to test Individual gca effect**

b) Variance $\mathbf{s_{ij}} = \frac{P^2 + (P+2)M_e}{(P+1)(P+2)}$; **to test Individual sca effect**

3.4.5.3 Standard errors and test of significance GCA and SCA effects

Standard error for effects and differences was "calculated by taking square root of variance of various estimates."

The significance of each GCA and SCA estimate was assessed against zero using the Students t-test.

t- Test for GCA effect = $\frac{(gi-1)}{SE\ (gi)}$

t- Test for SCA effect = $\frac{(si-1)}{SE\ (si)}$

The above calculated t-value was tested beside table't-value' at 0.05 & 0.01probability levels (at error DF).

3.4.5.4 Critical differences of the estimates

In order to determine whether there were significant differences among treatments, the critical difference (CD) was computed. This involved multiplying the standard error (diff) for each treatment by The't'-value at the appropriate degree of freedom for error.

C.D (5 %) = $SE_{[d]}$ x 't' $_{(0.05),\ edf}$

CHAPTER 4

RESULTS

The present investigation comprising of twelve parents and their 66 F_1s (diallel crosses excluding reciprocals) was carried out at experimental farm, Dept. of Genetics and Plant Breeding, School of Agriculture Lovely Professional University, Phagwara, Kapurthala (district), Punjab. These materials comprising parent, their F_1s and standard check were grown in during the *spring* season of the year 2021 (S1) and 2022 (S2). The results of present studies have been presented in the following heads:

4. 1 ANOVA AND MEAN PERFORMANCE OF PARENTS AND HYBRIDS

4. 2 ESTIMAION OF HETEROSIS

4. 3 GENERAL AND SPECIFIC COMBINING ABILITY ANALYSIS

4.1.1 ANALYSIS OF VARIANCE OF PARENTS AND HYBRIDS

Analysis of variance is a methodology that partitioned total variability within a data set into different components. The ANOVA test helps to study impact of independent factors on the particular dependent variable. The significant mean sum of squares attributed to genotypes indicates the presence of variability among the genotypes for the studied traits. Upon analyzing the genotypic variance partitioning, it was found that all of the assessed traits showed significant variations among the parents. However, when comparing the parents to the hybrids, significant mean squares was obtained for all character except for days to first harvest, fruit girth, fruit weight, and fruit yield per vine. This suggests the presence of heterotic effects in all the evaluated traits, except for those four mentioned traits.

Table 4.1 ANOVA of different characters in cucumber 2021 (S1), 2022 (S2) and Pooled

Sr. No.	Source	Mean Sum of Squares								
		Replications			Genotypes			Error		
		2021	2022	Pool	2021	2022	Pool	2021	2022	Pool
	Degree of freedom	**2**		**4**	**77**		**77**	**154**		**308**
1.	Days to first male flower	87.59**	15.65**	51.62**	18.04**	6.55**	22.28**	3.56	1.36	2.46
2.	Dyes to first female flower	5.30	0.53*	2.91	15.19**	15.70**	30.83**	2.55	0.12	1.33
3.	First fruit bearing node	2.59*	2.65*	2.58**	2.08**	2.04**	3.80**	0.68	0.81	0.75
4.	Days to first harvest	35.85**	13.41**	24.63**	13.10**	10.50**	22.08**	2.25	2.11	2.18
5.	Days to last harvest	0.22	4.30	2.26	8.04**	6.63**	11.02**	1.15	3.19	2.17
6.	Number of primary branches per vine	1.32	0.88	1.10	4.87**	4.48**	8.34**	0.95	0.83	0.89
7.	Internodal length (cm)	0.02	0.07	0.05	0.19**	0.18**	0.35**	0.06	0.05	0.06
8.	Vine length (cm)	4.34	6.14	5.24	77.20**	76.57**	152.71**	4.01	3.15	3.58
9.	Number of fruits per vine	2.46*	2.52**	2.49**	6.21**	4.10**	9.36**	0.59	0.48	0.54
10.	Fruit length (cm)	4.28*	1.20	2.74*	5.31**	3.32**	7.71**	1.08	0.57	0.83
11.	Fruit girth (cm)	0.02	0.24	0.13	0.23**	0.43*	0.54**	0.09	0.29	0.19
12.	Fruit weight (g)	1597.63	1584.97	1809.03	985.18**	1089.06**	1253.07**	420.81	537.38	639.94
13.	Fruit yield per vine (kg)	0.09	0.20	3.39**	4.88**	5.28**	6.85**	0.67	1.94	3.30

Table 4.2 ANOVA of different characters (Pooled for 2021 and 2022) in cucumber

Sources of variation	df	Days to first male flower	Days to first female flower	First fruit bearing node	Days to first harvest
Environments	**1**	352.21	0.27	12.02**	50.68**
Block within environment	**4**	51.63**	2.92	2.58**	24.64**
Treatments	**77**	22.28**	30.84**	3.80**	22.08**
Parent	**11**	41.64**	9.27**	4.77**	22.38**
Hybrids	**65**	16.03**	34.52**	3.23**	22.34**
Parent vs. Hybrids	**1**	215.05**	28.25**	30.46**	1.74
Treatments x Environments	**77**	2.33	0.06	0.32	1.53
Parent x Environments	**11**	3.21	0.04	0.21	0.54
Hybrids x Environments	**65**	1.89	0.07	0.34	1.67
Parent vs. Hybrids x Env.	**1**	20.73**	0.06	0.00	3.08
Error	**308**	2.46	1.34	0.75	2.18
Total	**467**	6.88	6.00	1.22	5.65

Table 4.2 ANOVA of different characters (Pooled for 2021 and 2022) in cucumber

Sources of variation	df	Days to last harvest	Number of primary branches per vine	Internodal length (cm)	Vine length (cm)
Environments	**1**	508.85**	57.47**	3.13**	110.88**
Block within environment	**4**	2.26	1.10	0.05	5.25
Treatments	**77**	11.03**	8.35**	0.35**	152.72**
Parent	**11**	16.62**	3.80**	0.50**	49.60**
Hybrids	**65**	8.96**	6.44**	0.22**	163.70**
Parent vs. Hybrids	**1**	83.46**	182.56**	6.93**	573.09**
Treatments x Environments	**77**	3.66**	1.02	0.03	1.05
Parent x Environments	**11**	4.38**	1.07	0.03	2.00
Hybrids x Environments	**65**	3.39**	0.97	0.03	0.65
Parent vs. Hybrids x Env.	**1**	12.94**	3.32	0.05	16.96
Error	**308**	2.18	0.89	0.06	3.59
Total	**467**	4.97	2.27	0.11	28.00

Table 4.2 ANOVA of different characters (Pooled for 2021 and 2022) in cucumber

Sources of variation	df	Number of fruits per vine	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Fruit yield per vine (kg)
Environments	**1**	53.34**	43.21**	6.92**	1956.94	19.52
Block within environment	**4**	2.50**	2.75*	0.14	1809.03	3.39**
Treatments	**77**	9.36**	7.71**	0.54**	1253.07**	6.85**
Parent	**11**	5.51**	7.30**	0.24	1655.71	40.04
Hybrids	**65**	8.82**	7.31**	0.60**	1914.92	50.15
Parent vs. Hybrids	**1**	86.92**	38.39**	0.03	4.08	32.17
Treatments x Environments	**77**	0.95**	0.92	0.14	348.34	56.32
Parent x Environments	**11**	0.90	0.32	0.02	4.38	1.21
Hybrids x Environments	**65**	0.95**	1.03	0.16	409.17	66.51
Parent vs. Hybrids x Env.	**1**	1.74	0.56	0.00	178.32	0.14
Error	**308**	0.54	0.83	0.19	639.94	3.31
Total	**467**	2.19	2.09	0.26	596.41	44.73

4.1.2 MEAN PERFORMANCE OF PARENTS AND HYBRIDS

4.1.2.1. Days to first male flower

The parents as well as hybrids were divergent among themselves statistically since mean sum of square due to parents as well as hybrids (F_1) were significant *viz*. indicating variation among them. Opening of first male flower of various parents took 29.20 to 39.06 days (2021; S1), 29.03 to 35.67 days (2022; S2) and 29.11 to 37.37 days (Pool) days respectively after transplanting in S1 and S2. Among the parents Sheetal (29.20; S1) and (36.91; S1) Poona Khira showed lowest number of days for male flower opening correspondingly. Among the hybrids (Pool), KOP-1 x Sheetal was the earliest (27.73), followed by Sheetal x J-4 (28.97) and KOP-1 x KDWD-1 (29.29), whereas, hybrid Phule Hemangi x Poona Khira took the maximum number of days (39.06) for opening of first male flower (Appendix-1).Total 18 (S1), 25 (S2) and 28 (P) hybrids depicted significantly lower number of days to first male flower than the check parent (Malini).

4.1.2.2 Days to first female flower

The mean sum of square estimate showed a significant difference between parents and hybrids, suggesting that there is potential for greater heterotic effects to be observed. The days on which the first female flowers appeared ranged from 39.42 to 46.94 days (S1), 38.99 to 47.93 days (S2) and 39.20 to 47.43 days (P) days. Among parents, Sheetal (39.42) and Sheetal (38.99) was the earliest in both S1 and S2 season respectively. The hybrid KOP-1 x Sheetal (33.06; P) followed by KOP-1 x KDWD-1 (34.93), KOP-1 x J-2 (35.23) were the earliest among hybrids (P) (Appendix-1).Total thirty four (S1), thirty nine (S2) and forty four (P) hybrids depicted significantly lower number of days to first female flower than the check parent Malini (Pool).

4.1.2.3 First fruit bearing node

According to the statistical analysis, there were notable variations in the mean sum of square values for the first fruit-bearing node between the parents and hybrids. This finding suggests that there may be heterotic effects present for this particular trait. The mean values for parents were ranged from 4.81 to 8.08 (S1), 4.93 to 8.20 (S2) and 4.87 to 8.14 (P). Among the parent KOP-1 (4.81; S1), (4.93; S2) and (4.87; P) was the earliest in both S1 and S2 season respectively. The hybrid Panvel x Phule Hemangi (5.18; P) followed by Sheetal x J-4 (5.18; P) Panvel x Phule Hemangi (5.21; P), was the earliest among hybrids (Appendix-1). Fourteen (S1), fifteen (S2) and seventeen (P) hybrids were significantly earlier than the check parent Malini with respect to first fruit bearing node.

4.1.2.4 Days to first fruit harvest

Statistical analysis revealed that both the parents and hybrids exhibited significant differences in their mean square values for the trait, particularly for the first harvest. Furthermore, the high level of significance for the mean square values due to both parents as well as hybrids suggests that heterotic effects may be at play in determining this trait. The minimum and the highest mean values recorded for this character was 45.80 to 55.38 (S1) and 46.22 to 55.07 (S2) and (46.01 to 55.00; P) days, respectively. The hybrid KOP-1x J-4 (43.73; P) was the minimum days for fruit harvest among hybrids, respectively (Appendix-1). Total 15 (S1), 20 (S2) and 20 (P) hybrids depicted significantly lower number of days to first male flower than the check parent Malini.

4.1.2.5 Days to last harvest

Significant value of mean squares due to parents as well as hybrids revealed the similar between the populations for this trait. The mean values of genotypes ranged 88.20 to 96.08 (S1) and 88.40 to 92.00 (S2) and 88.30 to 94.41 (P) days. The parent Phule Shubhangi (88.20; S1); (88.40; S2) and hybrid Rushita x MLKP (88.65; P) ranked first for days to last harvest among the parents and the hybrids, respectively. Compared to the check parent Malini, twenty six (S1), thirty five (S2) and thirty three (P) hybrids had significantly lower number days to last harvest.

4.1.2.6 Number of primary branches per vine

The parents as well as hybrids had more or less number of primary branches per plant as parent’s and hybrids sum of squares were highly significant. The mean values of genotypes ranged from 3.94 to 9.47 (S1) and 4.10 to 9.60 (S2) and (4.27 to 9.53; P) (Appendix-1). The parent Phule Shubhangi 6.82 (S1), KDWD-1 6.63 (S2) and hybrid Panvel x Phule Hemangi (9.53 P), PLK x Phule Hemangi (9.19; P) and PLK x Rushita (8.98; P) ranked the first for number of primary branches per vine among the parents and the hybrids, respectively. Forty-eight S1, fifty S2, and forty-three P F_1s had significantly higher number of primary branches per vine than the check parent Malini.

4.1.2.7 Internodal length (cm)

The parents and hybrids differed statistically because of the highly significant parents and hybrids sum of squares. The minimum and the maximum mean values recorded for this character was 3.19 to 4.71 (S1), 3.41 to 4.66 (S2) and 3.30 to 4.69 (P) respectively. The hybrid KDWD-1 x J-4 (3.69; P), Sheetalx J-2 (3.68; P) and Sheetal x KDWD-1 (3.79; P) recorded the minimum Internodal length among parents and hybrids, respectively (Appendix-1). And total of 54 hybrids in S1, 56 in S2, and 59 in P were found to have significant estimates, all of which were negative values than the check parent Malini.

4.1.2.8 Vine length (cm)

The comparison between the parents and hybrids was found to be highly significant, indicating a statistical difference between them and suggesting the presence of potential heterotic effects. The minimum and the maximum mean values among genotypes were 63.08 to 82.64 cm (S1) and 62.47 to 83.20 cm (S2) and 62.77 to 82.92 (P) respectively. The parent Phule Shubhangi 73.66 cm (S1) and the hybrid Rushita x KOP-1 (82.92 cm; P) had longest vine among parents and hybrids, respectively (Appendix-1). Total 28 (S1), 34 (S2) and 35 (P) table (4.2.8) indicates that all significant estimates for the F_1s were positive than the check parent Malini.

4.1.2.9 Number of fruits per vine

The contrast between the parents and hybrids was found to be highly significant, indicating a statistical difference between them and suggesting the potential presence of heterotic effects. The number of fruits per plant varied from 4.82 to 10.24 (S1) and 5.35 to 10.21 (S2) and 5.23 to 10.13 (P) The parent KOP-1 (8.28) and J-4 (7.93; S2) and hybrid Rushita x KOP-1 (10.13; P), J-2 x J-4 (9.79; P) respectively and Rushita x Sheetal (9.69; P) manifested highest number of fruit per vine among parents and hybrids, respectively (Appendix-1). Out of 66 hybrids, 25 (S1), 51 (S2) and 47 (P) hybrids gave significantly higher number of fruits per vine than the check parent Malini.

4.1.2.10 Fruit length (cm)

The parent's and hybrids evaluation was highly significant indicating that the parents and hybrids differed statistically and also possibility of existence of heterotic effects. The mean values (minimum and maximum) among genotypes were 9.53 to 14.99 cm (S1), 10.43 to 15.21 cm (S2) and 9.98 to 15.10 (P) respectively. The parent MLKP (13.85 cm; S1) 14.55 cm; S2) and hybrids MLKP x KOP-1 (15.10 cm; P), Sheetal x KDWD-1 (14.29 cm; P) and Poona Khira x Rushita (14.18 cm (P) had the longest fruit among parents and hybrids, respectively (Appendix-1). Total 36 (S1), 36 (S2) and 47 (P) F1s was significantly longer than the check parent Malini (Table 4.2.10).

4.1.2.11 Fruit girth (cm)

For fruit girth, statically no difference was observed between parents and hybrids as mean square due to parents and. hybrids was not significant, the fruit girth ranged from 3.57 cm to 4.56 cm (S1), 3.78 cm to 6.57 (S2), and 3.67 to 5.20 (P) respectively. The parent MLKP (4.19 cm) and also S2 4.44 cm, hybrid Panvel x PLK (5.20 cm; P) and Rushita x MLKP (4.44 cm; P) had the highest fruit girth among parents and hybrids, respectively (Appendix-1). Total 37 (S1), 43 (S2) and 46 (P) hybrids had significantly higher girth than the check parent Malini (Table 4.2.11).

4.1.2.12 Fruit weight (g)

The fruit weight of the parents and their respective hybrids was found to be quite similar, and the mean square of the hybrids was significant, indicating a significant effect of the hybrids on fruit weight. The mean values for fruit weight varied from 130.71 to 207.53 (S1) and 135.48 to 201.66 (S2) and 130.84 to 216.27 (P) among the hybrids MLKP x J-4 (218.98 g; P) had the fruits with maximum weight followed by MLKP x KDWD-1 (199.84g P) KOP-1x J-2 (198.65 g; P) recorded the highest fruit weight (Appendix-1). Among all the hybrids, thirty seven (S1), thirty six (S2) and twenty nine (P) hybrids gave significantly higher fruit weight than the check parent Malini (Table 4.2.12).

4.1.2.13 Fruit yield per vine (kg)

The parents as well as hybrids differ statistically as mean square due to parents and hybrids were significant which indicated the possibility of existence of heterotic effects. The maximum and the minimum mean fruit yield values were 1.11 to 7.34 kg (S1), 1.66 to 6.47 kg (S2) and 1.44 to 5.47 (P) respectively. The parental line J-2 (4.82 kg; P) yielded the maximum amongst the parents, while, the hybrid MLKP x J-4 (5.47 kg; P) ranked the first followed by MLKP x KDWD-1 (4.89 kg; P) and MLKP x Sheetal (4.88 kg; P) in comparison to rest of the hybrids (Appendix-1). Total thirty seven (S1), fourteen (S2) and thirty two (P) hybrids gave significantly higher yield than the check parent Malini (Table 4.2.12).

4.2 ESTIMATION OF HETEROSIS

The levels of heterosis i.e. heterobeltiosis (HB) and standard heterosis (SH) were evaluated for all the traits that were examined. The outcomes for each trait were shown in Table 4.2.1 to Table 4.2.13 and elaborated on in the following headings.

Table 4.2.1 Per cent heterobeltiosis (HB) and standard heterosis (SH) of days to first male flower

Hybrid	2021 (S1)		2022 (S2)		Pooled (P)	
	HB	SH	HB	SH	HB	SH
Panvel x PLK	6.98	-16.02**	-5.52	-25.83**	0.93	-20.77**
Panvel x Phule Shubhangi	-0.56	-18.16**	-3.36	-23.33**	-1.89	-20.67**
Panvel x Phule Hemangi	-5.21	-24.9**	-2.81	-25**	-4.06	-24.95**
Panvel x Poona Khira	-13.27**	-28.63	-6.93*	-26.17*	-10.26**	-27.44**
Panvel x Rushita	-8.35	-27.61**	-6.41*	-25.75**	-8.16*	-26.71**
Panvel x MLKP	-8.93*	-25.05	-5.46	-25	-7.28*	-25.02
Panvel x KOP-1	0.86	25.51**	2.03	-24.5**	1.42	-25.02
Panvel x Sheetal	8.63	-25.67**	4.72	-24**	6.68	-24.86**
Panvel x KDWD-1	-1.79	-26.4*	-1.08	-24**	-1.45*	-25.24**
Panvel x J-2	-8.31	-26.02	-5.47	-25.17	-6.95*	-25.61
Panvel x J-4	-8.88*	-25.48**	-2.07*	-24.40**	-5.68	-24.77**
PLK x Phule Shubhangi	-5.24	25.61	-4.67*	25.17	-4.97	-25.4
PLK x Phule Hemangi	-6.44	-26.55	-1.51	-24.22	-4.54	-25.32
PLK x Poona Khira	-1.22	-22.45	-3.82	-24.5	-2.48	-23.44
PLK x Rushita	-5.15	25.54**	-3.61	24.33	-4.41	24.96**
PLK x MLKP	-3.43	-24.19	-0.64	-22**	-2.08	-23.13**
PLK x KOP-1	2.0	-24.66	1.58	-24.83	1.79	-24.75
PLK x Sheetal	1.9	30.28	1.28	26.53	1.59	28.45**
PLK x KDWD-1	-2.24	-26.73	-1.46	-24.29	-1.86	-25.55
PLK x J-2	-4.95	-25.38	-5.10*	-25.5	-5.02*	-25.44**
PLK x J-4	-9.70*	-29.11**	-5.51	-26.67**	-8.19*	-27.93**
Phule Shubhangi x Hemangi	15.09**	-8.82*	12.1**	13.5**	13.66**	11.08**
Phule Shubhangi x Poona Khira	-16.16**	-22.02**	-7.47**	-21.5**	-12.15**	-21.77**
Phule Shubhangi x Rushita	5.78	-16.44	3.72	-16.33	4.77	-16.39
Phule Shubhangi x MLKP	-9.71*	-24.93**	-8.42**	-23.83**	-9.08**	-24.4**
Phule Shubhangi x KOP-1	1.40	-25.11	2.03	-24.5	1.70	-24.81
Phule Shubhangi x Sheetal	14.89**	21.39**	8.86**	21.05**	11.88**	21.2**
Phule Shubhangi x KDWD-1	4.25	21.87	-1.95	-24.67	1.21	23.22
Phule Shubhangi x J-2	-7.30	-25.21	-3.16*	-23.33**	-5.31	-24.3**
Phule Shubhangi x J-4	-7.13	-24.05	-0.57	-22.83	-4.04	-23.46
Phule Hemangi x Poona Khira	15.55**	8.45*	15.55**	10.83**	15.55**	9.6*
Phule Hemangi x Rushita	-2.16	-22.72	-1.51	-24.33	-2.01*	-23.34**
Phule Hemangi x MLKP	-3.60	-23.6	2.16	-21.17	-0.85	-22.43
Phule Hemangi x KOP-1	-3.85	-28.98	0.23	25.83	-1.87	-27.46**
Phule Hemangi x Sheetal	4.19	-28.71	2.43*	-25.67	3.31	-27.23
Phule Hemangi x KDWD-1	-3.91	-27.99	-1.41	-24.25	-2.69	-26.18**
Phule Hemangi x J-2	-12.09**	-30.35**	-5.32**	-26.94**	-8.86**	-28.7
Phule Hemangi x J-4	-2.32	-22.61	0.43	22.5	-1.01	-22.56**
Poona Khira x Rushita	-6.07	-25.8	-6.61*	-24.67	-6.33	-25.25**
Poona Khira x MLKP	-11.04*	-26.04**	-9.22**	-24.5**	-10.16**	-25.3
Poona Khira x KOP-1	-3.95	29.05	-0.23	-26.17	-2.14	-27.66**

Poona Khira x Sheetal		6.37	-27.22	2.66	-25.5	-4.52*	-26.39
Poona Khira x KDWD-1		-7.33	-30.55	-4.96*	-26.98	-6.17**	-28.82
Poona Khira x J-2		-8.56	-26.23	-4.17	-24.14	-6.46	-25.22
Poona Khira x J-4		-11.16*	-27.35*	-3.59*	-25.18**	-7.6*	-26.3**
Rushita x MLKP		1.64	-19.71	-0.62	-19.83	0.54	-19.77**
Rushita x KOP-1		5.13	22.35	8.43**	-19.76	6.73	-21.1
Rushita x Sheetal		13.14*	22.59	7.71*	-21.83	10.43**	22.22**
Rushita x KDWD-1		-5.93	-29.5	-4.99	-27.01*	-5.47	-28.29**
Rushita x J-2		-5.58	-25.42	-4.11*	-24.09*	-5.73	-24.77**
Rushita x J-4		-10.16*	-29.04*	-4.98*	-26.26**	-9.34**	-27.69**
MLKP x KOP-1		4.53	22.79	5.86	21.67	5.17	-22.25
MLKP x Sheetal		11.81*	23.49*	8.16*	21.51**	9.99**	22.53**
MLKP x KDWD-1		5.45	20.97	3.66	-20.35	4.58	-20.67
MLKP x J-2		6.95	13.71	4.00	-17.67	5.54	-15.62
MLKP x J-4		0.85	17.52	4.42	-18.96	2.54	-18.21
KOP-1 x Sheetal		-6.56	-36.06**	-2.93	-29.55**	-4.75	-32.91**
KOP-1 x KDWD-1		-7.10	-31.39	-0.99	-26.73*	-4.14	-29.13**
KOP-1x J-2		-6.68	-31.08	-0.29	-26.21	-3.59	-28.72
KOP-1x J-4		-0.97	-26.85	3.79	-23.19	1.34	-25.08
Sheetal x KDWD-1		13.11*	-22.6*	6.38*	22.8**	9.76*	22.7**
Sheetal x J-2		5.47	-27.83	3.43	-24.94	4.46	-26.43
Sheetal x J-4		-0.73	-32.07	-0.25	-27.61	-0.49	-29.91
KDWD-1 x J-2		1.17	-24.18	-1.74	-24.5	-0.25	-24.34
KDWD-1 x J-4		-2.03	-26.58	-1.95	-24.67	-1.99	-25.65
J-2 x J-4		-12.93**	-29.75**	-5.24**	-26.46**	-9.93**	-28.16**
Range of heterosis	**Minimum**	**-16.16**	**-36.06**	**-9.22**	**-29.55**	**-12.15**	**-32.91**
	Maximum	**15.55**	**30.28**	**15.55**	**26.53**	**15.55**	**28.45**
Significant crosses	**Positive**	**6**	**5**	**7**	**4**	**6**	**9**
	Negative	**11**	**18**	**15**	**25**	**16**	**28**
SE		**1.54**		**0.95**		**1.28**	
CD at 5 %		**3.04**		**1.88**		**2.52**	

4.2.1 Days to first male flower

The estimates of heterobeltiosis varied from -16.16 to 15.55% (S1), -9.22 to 15.55% (S2) and - 12.15 to 15.55% (P). Seventeen (S1), twenty two (S2) and twenty two (P) crosses exhibited significant estimates, of which, 11 crosses (S1), 15 (S2) and 16 (P) had negative heterotic effect. The crosses Phule Shubhangi x Poona Khira (-16.16% S1), Panvel x Poona Khira (-13.27% S1), Poona Khira x MLKP (-9.22% S2), Phule Shubhangi x MLKP (-8.42% S2), Phule Shubhangi x Poona Khira (-7.47% S2), and Phule Shubhangi x Poona Khira (-12.15% P) followed by Panvel x Poona Khira (-10.26% P) and Poona Khira x MLKP (-10.16% P) exhibit the lowest levels of heterobeltiosis.

The minimum and the maximum values of standard heterosis (SH) were -36.06 and 30.28% (S1), - 29.55 and 26.53% (S2), -32.91 to 28.45 % (P) respectively. Twenty three (S1), twenty eight (S2) and thirty seven (P) crosses had significant estimates, and registered the negative estimate in S1(18),S2 (25) and P (28) registered the negative estimate, The cross KOP-1 x Sheetal (-36.06% S1) followed by the cross Phule Hemangi x J-2 (-30.35 % S1), J-2 x J-4 (-29.75%; S1), Phule Shubhangi x MLKP (-8.42 %; S2), KOP-1 x Sheetal (-29.55%; S2) followed by and Phule Hemangi x J-2 (-26.94%; S2) , KOP-1 x KDWD-1 (-26.73; S2) and KOP-1 x Sheetal (-32.91%; P), followed by KOP-1 x KDWD-1 (-29.13%; P), Rushita x KDWD-1 (-28.29; P) manifested the least standard heterosis. These findings are comparable to those reported by Singh *et al.* (2010b) and Singh *et al.* (2015).

Table 4.2.2 Per cent heterobeltiosis (HB) and standard heterosis (SH) of days to first female flower

Hybrid	2021 (S1)		2022 (S2)		Pooled (P)	
	HB	SH	HB	SH	HB	SH
Panvel x PLK	4.01**	-8.78**	2.50	-10.37**	4.01**	-8.78**
Panvel x Phule Shubhangi	-0.57	-12.79**	-0.38	-12.89**	-0.57	-12.79**
Panvel x Phule Hemangi	-0.68	-12.89**	-0.72	-13.19**	-0.68	-12.89**
Panvel x Poona Khira	0.25	-12.07**	0.38	-12.23**	0.25	-12.07**
Panvel x Rushita	5.9**	-7.12**	4.53	-8.59**	5.9**	-7.12**
Panvel x MLKP	3.31**	-9.39**	3.85	-9.19**	3.31**	-9.39**
Panvel x KOP-1	2.43*	-10.16**	2.39	-10.46**	2.43*	-10.16**
Panvel x Sheetal	3.16*	-10.52**	4.31	-9.63**	3.16*	-10.52**
Panvel x KDWD-1	2.00	-10.54**	3.01	-9.93**	2.00	-10.54**
Panvel x J-2	4.96**	-7.95	5.58	-7.67	4.96**	7.95**
Panvel x J-4	1.30	11.15	0.97	11.7	1.30	-11.15**
PLK x Phule Shubhangi	-1.26	-12.46**	-0.71	-11.56**	-1.26	-12.46**
PLK x Phule Hemangi	-4.37**	-15.22	-4.54*	-14.96**	-4.37**	-15.22**
PLK x Poona Khira	-2.46*	-13.53	-1.54	-12.3	-2.46*	-13.53**
PLK x Rushita	-6.14**	-16.78	-6.2*	-16.44**	-6.14**	-16.78**
PLK x MLKP	0.55	-10.86	-0.88	-11.7	0.55	-10.86
PLK x KOP-1	2.90*	-9.30**	1.52	-9.57	2.90*	-9.30**
PLK x Sheetal	1.92	-11.60	1.73	-11.87	1.92	-11.6**
PLK x KDWD-1	2.29	-9.31**	1.02	10.52	2.29	-9.31
PLK x J-2	1.07	-10.39	1.52	-9.72	1.07	-10.39**
PLK x J-4	-0.50	-11.78	-0.06	-10.97	-0.50	-11.78**
Phule Shubhangi x Hemangi	5.44**	4.31**	5.23*	-4.59*	5.44**	4.31**
Phule Shubhangi x Poona Khira	4.59**	4.72**	6.31*	-4.24*	4.59**	4.72**
Phule Shubhangi x Rushita	8.72**	1.01	10.06**	1.91	8.72**	1.01*
Phule Shubhangi x MLKP	17.1**	4.94**	17.98**	6.51*	17.12**	4.94**
Phule Shubhangi x KOP-1	9.07**	3.86**	7.1*	-4.59	9.07**	3.86**
Phule Shubhangi x Sheetal	8.85**	5.59	8.25**	-6.22*	8.85**	-5.59**
Phule Shubhangi x KDWD-1	0.52	-10.49**	0.52	-10.96	0.52	-10.49**
Phule Shubhangi x J-2	3.3**	-7.95**	3.46*	-8.01**	3.3**	7.95**
Phule Shubhangi x J-4	4.93**	4.17**	5.6*	-3.97	4.93**	4.17**
Phule Hemangi x Poona Khira	-4.9**	13.70	-4.43	-13.91	-4.9**	-13.7
Phule Hemangi x Rushita	-6.59**	-15.23**	-6.78*	-15.48**	-6.59**	-15.23**
Phule Hemangi x MLKP	-4.00**	-13.97	-4.15*	-13.47**	-4**	-13.97**
Phule Hemangi x KOP-1	-1.53	-13.21**	-1.66	12.4	-1.53	-13.21**
Phule Hemangi x Sheetal	-0.80	-13.96	-1.14	-14.36	-0.80	-13.96
Phule Hemangi x KDWD-1	1.59	-9.54**	3.19*	-8.59**	1.59	9.54**
Phule Hemangi x J-2	-3.35**	-13.87**	-2.79*	-13.56**	-3.35**	-13.87**

Phule Hemangi x J-4		-3.66**	12.57	-2.70*	-11.78**	-3.66**	-12.57**
Poona Khira x Rushita		-6.14**	-14.49	-4.11	-13.63	-6.14**	-14.49**
Poona Khira x MLKP		-5.82**	-15.60	-6.25*	-15.56**	-5.82**	-15.6**
Poona Khira x KOP-1		-1.67	-13.34**	-2.15*	-12.84**	-1.67	-13.34**
Poona Khira x Sheetal		0.35	-12.96**	0.72	12.74	0.35	-12.96
Poona Khira x KDWD-1		-4.26**	-14.75**	-3.10*	-14.17**	-4.26**	-14.75**
Poona Khira x J-2		-7.10**	17.21	-6.21*	-16.59**	-7.10**	-17.21**
Poona Khira x J-4		-2.88*	-11.52**	-1.17*	-10.98**	-2.88*	-11.52**
Rushita x MLKP		5.66**	5.31**	5.20	-5.04	5.66**	5.31**
Rushita x KOP-1		8.69**	4.20**	6.77*	-4.89	8.69**	4.2**
Rushita x Sheetal		5.17**	-8.78	5.23*	-8.84**	5.17**	-8.78**
Rushita x KDWD-1		-0.97	-11.82**	0.01	-11.41	-0.97	-11.82
Rushita x J-2		0.64	-10.32	-1.23*	-9.98	0.64	-10.32**
Rushita x J-4		-1.14	-9.72**	-0.74*	-9.74**	-1.14	-9.72**
MLKP x KOP-1		9.78**	3.24	7.6**	-4.15	9.78**	-3.24**
MLKP x Sheetal		8.32**	6.05**	9.27**	-5.33*	8.32**	-6.05**
MLKP x KDWD-1		-3.41**	-13.99**	-2.07	-13.25**	-3.41**	-13.99
MLKP x J-2		-0.16	-11.03	0.25	-10.85	-0.16	-11.03
MLKP x J-4		-3.18**	-13.23**	3.76*	-13.12**	-3.18**	-13.23**
KOP-1 x Sheetal		-15.67**	-26.86**	-16.12**	-27.33**	-15.60**	-26.86**
KOP-1 x KDWD-1		-12.31**	-22.71**	-13.03**	-22.96**	-12.31**	-22.72**
KOP-1x J-2		-11.57**	-22.05	-12.58**	-22.26	-11.57**	-22.05
KOP-1x J-4		-10.52**	-21.14**	-12.11**	-21.71**	-10.52**	-21.14**
Sheetal x KDWD-1		-4.89**	17.5	-4.47**	-17.24	-4.89**	-17.5
Sheetal x J-2		-3.47**	-16.28**	-3.25*	-16.18**	-3.47**	-16.28**
Sheetal x J-4		-1.2	-14.31	-0.51	-13.81**	-1.20	-14.31
KDWD-1 x J-2		2.55*	-8.69**	2.57	-9.14**	2.55*	-8.69**
KDWD-1 x J-4		0.65	-10.37**	1.36	-10.21**	0.65	-10.37**
J-2 x J-4		-4.66**	-15.04**	-4.54	-15.11**	-4.66**	-15.04**
Range of heterosis	**Minimum**	**-15.67**	**-26.86**	**-16.12**	**-27.33**	**-15.60**	**-26.86**
	Maximum	**17.10**	**17.50**	**17.98**	**12.74**	**17.12**	**9.54**
Significant crosses	**Positive**	**19**	**9**	**15**	**5**	**21**	**10**
	Negative	**22**	**34**	**18**	**39**	**22**	**44**
SE		**1.30**		**0.28**		**0.94**	
CD at 5 %		**2.57**		**0.56**		**1.85**	

4.2.2 Days to first female flower

The values of heterosis (SH) over better parent range from -15.67 to 17.10 % (S1) and -16.12 to 17.98 % (S2), -15.60 to 17.12 % (P) forty one (S), twenty three (S2) and forty three (P) hybrids exhibited significant heterosis, of which, twenty two (S1), eighteen (S2) and twenty two (P) hybrids registered negative estimates. The hybrid KOP-1 x Sheetal demonstrated the lowest heterobeltiosis, with percentages of -15.67% (S1), -16.12% (S2), and -15.60% (P). Subsequently, KOP-1 x KDWD-1 exhibited the least heterobeltiosis, with percentages of -12.31% (S1), -13.03% (S2), and -12.31% (P).

The minimum and the maximum values of SH were -26.86 and 17.50 % (S1) and- 27.33 and 12.74 % (S2), -26.86 to 9.54 % (P) respectively significant heterosis was observed for forty three (S1), forty four (S2) and fifty four (P) hybrids. Which was depicted negative effect in S1 (34), S2 (39) and P (44). The hybrid KOP-1 x Sheetal (-26.86% S1), (- 27.33 % S2) and (-26.86; P) registered the estimate of SH followed by KOP- 1 x KDWD-1 (-22.71% S1), (-22.96 %; S2) and (-22.72 %; P), KOP-1x J-4 (-21.14; P). The results were in agreement with the observations of Singh *et al.* (2015) (HB). However, moderate estimates of various heterotic effects in both the directions were observed by Singh *et al*. (2015) (HB). In contrast, Dogra and Kanwar (2011) observed high HB and SH in positive direction.

Table 4.2.3 Per cent heterobeltiosis (HB) and standard heterosis (SH) of first fruit bearing node

Hybrid	2021 (S1)		2022 (S2)		Pooled (P)	
	HB	**SH**	**HB**	**SH**	**HB**	**SH**
Panvel x PLK	23.49*	64.44**	25.3*	60**	24.4**	86.36**
Panvel x Phule Shubhangi	-1.73	-93.24**	-1.96*	46.09**	0.17	65.38**
Panvel x Phule Hemangi	-0.29	-66.58	3.18	23.82	1.48	41.31**
Panvel x Poona Khira	0.59	84.44**	4.18	33.85*	2.40	54.55**
Panvel x Rushita	-0.32	-1.11	-10.75	27.69	-5.73*	53.64**
Panvel x MLKP	-7.30	-6.78**	-4.05	-4.51**	-5.61*	61.8**
Panvel x KOP-1	-17.53**	88.62**	-26.97**	-44.43**	22.3**	-62.51**
Panvel x Sheetal	-16.2	75.87	-12.17	35.38*	-14.12*	-51.95
Panvel x KDWD-1	-0.15	49.56**	-1.14	52.38**	-0.66*	75.77**
Panvel x J-2	-23.73**	-39.58**	25.7	-53.26**	24.74**	76.3**
Panvel x J-4	-21.91**	42.56**	-33.14*	-64.17**	27.46**	-88.05**
PLK x Phule Shubhangi	-5.01	72.64	-5.37	-90.83**	-5.19*	-42.03**
PLK x Phule Hemangi	-14.96**	-92.07**	-23.21**	-47.85**	19.16*	-65.94**
PLK x Poona Khira	28.12*	32.87**	26.53*	-61.57**	27.32**	90.74**
PLK x Rushita	27.82*	32.32**	20.95	54.45**	24.36**	-86.3**
PLK x MLKP	1.30	-4.11	2.86	-31.34*	-2.08*	-52.93
PLK x KOP-1	3.71	-6.44	15.86	-31.8*	-9.86*	-45.97**
PLK x Sheetal	-7.40*	-5.20**	-13.82**	45.34**	-10.63*	-65.74**
PLK x KDWD-1	6.43	93.44**	18.16	50.88**	-12.34**	68.29**
PLK x J-2	42.09**	-40.67**	33.35*	62.58**	37.64**	94.53**
PLK x J-4	11.09	-01.90	11.28	37.22*	10.93	63.68**
Phule Shubhangi x Hemangi	23.42	6.19	27.4*	-2.88*	25.45**	74.69**
Phule Shubhangi x Poona Khira	-8.89**	-99.65**	-18.14	51.78**	13.54	-71.37**
Phule Shubhangi x Rushita	-2.42	87.1**	3.25	47.72**	-0.52*	63.83**
Phule Shubhangi x MLKP	-19.65**	-35.28**	-8.81*	55.89**	14.09*	-88.37**
Phule Shubhangi x KOP-1	52.09**	44.09**	60.87**	-83.32**	56.53**	77.99**
Phule Shubhangi x Sheetal	22.97*	41.81**	-11.51**	59.77**	17.09**	-63.33
Phule Shubhangi x KDWD-1	24.93*	45.67**	24.45*	78.31**	24.68**	75.86**
Phule Shubhangi x J-2	-24.35**	-30.62**	-16.69**	-42.28**	20.45**	-70.24**
Phule Shubhangi x J-4	35.56**	47.47**	45.85**	79.85**	40.64**	87.51**
Phule Hemangi x Poona Khira	35.09**	55.69**	38.78**	66.54**	36.97**	-60.74**
Phule Hemangi x Rushita	54.89**	58.78**	25.64	50.77**	40**	94.95**
Phule Hemangi x MLKP	47.69**	46.73**	39.73**	67.68**	43.63**	80.02**
Phule Hemangi x KOP-1	33.26*	13.87**	36.27*	55.02**	34.78**	79.09**
Phule Hemangi x Sheetal	34.96**	55.47**	37.91**	65.49**	36.46**	70.03**
Phule Hemangi x KDWD-1	21.91	43.67**	16.67	40.25*	19.24*	66.05**

Phule Hemangi x J-2	32.62*	61.56**	35.9**	63.08**	34.29**	-87.30**
Phule Hemangi x J-4	55.97**	60.58**	49.72**	79.66**	52.79**	82.76**
Poona Khira x Rushita	26.72*	52.36**	27.73*	64.11**	27.23**	92.03**
Poona Khira x MLKP	9.51	50.8**	27.31*	63.57**	18.47**	-78.8**
Poona Khira x KOP-1	67.03**	88.07**	62.88**	85.28**	64.93**	89.15**
Poona Khira x Sheetal	24.89*	29.01**	22.46	57.34**	23.67**	86.65**
Poona Khira x KDWD-1	1.88	6.80**	-3.77*	33.32*	-2.83*	-55.2**
Poona Khira x J-2	45.53**	46.49**	35.99**	65.8**	40.66**	98.81**
Poona Khira x J-4	-8.07**	-57.29**	-34.11**	-65.37**	20.93**	-78.43**
Rushita x MLKP	7.95	26.98**	-12.20	25.62	-2.50*	-58.9**
Rushita x KOP-1	42.45**	48.62**	51.73**	72.6**	47.15**	-95.52**
Rushita x Sheetal	13.73	58.07**	15.05	64.62**	14.42*	86.48**
Rushita x KDWD-1	25.61*	60.82**	14.44	63.74**	19.81**	95.27**
Rushita x J-2	26.82*	64.8**	36.9**	66.91**	31.95**	86.5**
Rushita x J-4	31.24**	69.58**	45.68**	79.63**	38.37**	94.15**
MLKP x KOP-1	25.71	51.76**	39.3**	58.46**	32.59**	76.17**
MLKP x Sheetal	8.32	58.24**	-2.47	46.88**	-2.72*	76.07**
MLKP x KDWD-1	26.02*	63.93**	11.23	67.51**	18.34**	72.86**
MLKP x J-2	42.74**	71.78**	42.78**	74.08**	42.76**	81.77**
MLKP x J-4	30.41**	68.07**	30.79*	61.28**	30.6**	92.69**
KOP-1 x Sheetal	25.88	52.02	40.84**	-60.22	33.45**	77.32
KOP-1 x KDWD-1	39.63**	44.09**	37.54**	56.46**	38.57**	84.13**
KOP-1x J-2	48.44**	88.22**	65.19**	87.91**	56.91**	98.49**
KOP-1x J-4	67.75**	79.22**	66.42**	89.31**	67.08**	92.25**
Sheetal x KDWD-1	-13.59	-92.76	-24.14*	-31.63*	-19.17**	-56.64**
Sheetal x J-2	37.12**	52.24**	26.86*	54.68**	31.89**	86.41**
Sheetal x J-4	-6.75*	-70.24**	-1.51	-21.45**	-4.16*	-41.41**
KDWD-1 x J-2	18.25	50.28**	26.78*	54.57**	22.59**	73.27
KDWD-1 x J-4	42.44**	70.03**	40.75**	73.55**	41.6**	108.93**
J-2 x J-4	3.00	74.47**	9.78	33.85*	6.46	50.46**
Range of heterosis – **Minimum**	**-24.35**	**-99.65**	**-34.11**	**-90.83**	**-19.17**	**-95.52**
Range of heterosis – **Maximum**	**67.75**	**93.44**	**66.42**	**89.31**	**67.08**	**108.93**
Significant crosses – **Positive**	**31**	**45**	**32**	**48**	**45**	**42**
Significant crosses – **Negative**	**10**	**14**	**12**	**15**	**13**	**17**
SE	**0.67**		**0.73**		**0.70**	
CD at 5 %	**1.33**		**1.45**		**1.39**	

4.2.3 First fruit bearing node

The minimum and the maximum values of HB were -24.35 and 67.75% (S1), -34.11 and 66.42% (S2), -19.17 and 67.08% (P) respectively. Total forty one (S1), forty four (S2) and fifty eight (P) F_1s registered significant estimates, of which, 10 (S1), 12 (S2) and 13 (P) had negative effect. The hybrid Phule Shubhangi x J-2 (-24.35% S1), Poona Khira x J-4 (-34.11 % S2) and Sheetal x KDWD-1 (-19.17% P) exerted the highest negative heterobeltiotic effect followed by Panvel x J-2 (-23.73 % S1), Panvel x J-4 (-21.91%; S1), (-33.14 % S2) and PLK x KDWD-1 (-12.34%; P).

The estimates of SH range from -99.65 to 93.44% (S1), -90.83 to 89.31% (S2) and -95.52

and 108.93% (P) respectively. Significant standard heterosis was observed for fifty nine (S1), sixty three (S2) and fifty nine (P) hybrids. Which was depicted negative effect in S1 (14), S2 (15) and P (17). The hybrid Phule Shubhangi x Poona Khira (-99.65% S1), PLK x Phule Shubhangi (-90.83 % S2) and Rushita x KOP-1 (-95.52%; P) least estimate of standard heterosis (SH) followed by Panvel x Phule Shubhangi (-93.24% S1), PLK x Phule Hemangi (-92.07%; S1), Phule Shubhangi x KOP-1 (-83.32%; S2) and Phule Hemangi x J-2 (- 87.30%; P)" These results were consistent with Singh *et al.* (1999) observations, indicating moderate heterobeltiosis estimates in a positive direction for the mentioned trait. Conversely, Cramer and Wehner (1999) and Pandey *et al.* (2015) reported low estimates of heterotic effects in both directions for the identical trait.

Table 4.2.4 Per cent heterobeltiosis (HB) and standard heterosis (SH) of days to first harvest

Hybrid	2021 (S1)		2022 (S2)		Pooled (P)	
	HB	SH	HB	SH	HB	SH
Panvel x PLK	-0.08	-8.99**	-1.70	-7.95	-0.89	-8.48
Panvel x Phule Shubhangi	-1.48	-10.27**	-2.76	-8.94	-2.12	-9.62
Panvel x Phule Hemangi	1.05	-7.97**	0.94	-7.24	0.05	-7.61*
Panvel x Poona Khira	-0.36	-9.24	-1.15*	-7.43*	-0.75*	-8.35**
Panvel x Rushita	1.94	-7.15	0.02	-6.34**	0.98*	-6.75**
Panvel x MLKP	-1.93	-10.67**	3.56	-9.69**	-2.74**	10.19*
Panvel x KOP-1	-0.70	-10.38	-2.05	-9.02	-1.37**	-9.71**
Panvel x Sheetal	0.90	8.10**	-1.70	-7.95**	-0.40**	-8.03**
Panvel x KDWD-1	-0.29	-9.19	0.83	-7.13	-0.56**	-8.17**
Panvel x J-2	0.97	8.15**	-0.24	-6.58**	0.30**	7.38**
Panvel x J-4	8.72**	-10.02	7.39	-7.50	8.05**	-8.77**
PLK x Phule Shubhangi	-5.88*	-13.01**	-8.26**	-12.67**	-7.07**	-12.84
PLK x Phule Hemangi	-2.41	-9.80	1.38	-7.58**	-1.94*	-8.71**
PLK x Poona Khira	-1.00	8.50**	-3.95*	-8.57	-2.48*	-8.54
PLK x Rushita	2.89	-6.04	2.03	-7.67	0.43	-6.84
PLK x MLKP	1.08	6.65**	-0.44*	-5.47*	0.32*	6.06**
PLK x KOP-1	10.09**	-0.64	4.05**	-3.35	7.07**	-1.98*
PLK x Sheetal	-1.21	-8.69	1.21	-5.96	-1.21	-7.35
PLK x KDWD-1	-1.10	-8.59	-0.67	-6.30	-1.33	-7.46
PLK x J-2	-1.74	-10.62	-2.88*	-8.70*	-2.31*	9.67**
PLK x J-4	11.68**	-7.55	8.17	-6.83	9.91	-7.20
Phule Shubhangi x Hemangi	-4.61*	-11.76**	1.51**	7.70*	-3.07*	-9.76**
Phule Shubhangi x Poona Khira	-0.39	4.47*	-3.27	-4.35	-1.83	-4.41
Phule Shubhangi x Rushita	0.26	-8.45	0.83	-4.97	0.55	-6.73
Phule Shubhangi x MLKP	1.64	6.13**	0.06	-4.99	0.85	-5.56
Phule Shubhangi x KOP-1	8.74**	-1.86	4.18**	3.23*	6.46*	2.53*
Phule Shubhangi x Sheetal	-4.48*	8.59**	-5.26	-7.67	-4.86	-8.14
Phule Shubhangi x KDWD-1	2.47	-4.44	3.25	-2.61	2.86	-3.54
Phule Shubhangi x J-2	8.41**	-1.39	1.84	-4.26	5.12	-2.80
Phule Shubhangi x J-4	14.19**	-5.47*	11.77**	3.73*	12.98**	4.61*
Phule Hemangi x Poona Khira	4.81*	-3.04	2.09	-4.33	3.46	-3.67
Phule Hemangi x Rushita	2.25	-6.63**	4.99**	1.61*	3.32*	4.16*
Phule Hemangi x MLKP	2.73	5.12*	1.94	-4.47	2.25	-4.80
Phule Hemangi x KOP-1	6.91**	3.51	2.85	-4.47	4.88*	-3.98

Phule Hemangi x Sheetal		-0.68	-8.12	2.41*	6.36*	13.07*	7.57**
Phule Hemangi x KDWD-1		3.77	-4.01	3.79	-2.73	3.78	-3.38
Phule Hemangi x J-2		-0.45	-9.44	1.52	-7.71	-1.14**	-8.59
Phule Hemangi x J-4		7.65**	10.88**	6.87**	7.95**	7.26	-9.44
Poona Khira x Rushita		-2.69	-11.14	-4.03*	-9.56*	-3.36*	-10.36
Poona Khira x MLKP		-1.25	-8.8**	-3.84*	-8.70*	-2.55	8.75**
Poona Khira x KOP-1		-0.16	9.89**	0.62	-6.54	0.23	-8.24*
Poona Khira x Sheetal		-6.82**	-10.84	-7.28**	-9.64**	-7.05	-10.25**
Poona Khira x KDWD-1		-0.27	7.01**	-0.55	-6.19	-0.41	-6.60
Poona Khira x J-2		5.43*	-4.10	1.74	-4.35	3.58	4.22*
Poona Khira x J-4		4.85	-13.2	5.16	-9.43	5.00	-11.34**
Rushita x MLKP		9.36**	-0.13	7.42**	1.24**	8.39	0.54
Rushita x KOP-1		4.39	5.79**	4.45	-2.98*	4.42	-4.41*
Rushita x Sheetal		8.73**	-0.71	-8.87**	2.61*	8.80	0.92
Rushita x KDWD-1		2.91	-6.02	2.64	-3.27	2.77	-4.67**
Rushita x J-2		4.06	-5.34*	8.74	2.24	6.41	-1.61
Rushita x J-4		11.48**	7.72**	14.26**	11.58**	12.88*	4.70**
MLKP x KOP-1		10.05**	-0.68	10.20**	2.36**	10.12**	0.82*
MLKP x Sheetal		8.37**	0.09	3.74**	-1.49	6.06	-0.69
MLKP x KDWD-1		2.02	5.77**	-0.97	-6.58	0.20	-6.17
MLKP x J-2		2.65	6.63**	1.89	-4.20	2.27	-5.43
MLKP x J-4		13.56**	5.99**	10.33**	4.97**	11.94**	-5.49
KOP-1 x Sheetal		-4.87*	-14.14	-5.02*	-11.78**	-4.95**	12.98**
KOP-1 x KDWD-1		4.13	6.02**	0.97	-6.21**	2.55	-6.11
KOP-1x J-2		-3.34	12.77**	-3.48	10.35**	-3.41**	11.58**
KOP-1x J-4		-5.11	-21.45**	-4.81	-18.01**	-4.96	-19.76*
Sheetal x KDWD-1		-5.32*	-11.71**	-4.26*	-9.69*	-4.80*	-10.71**
Sheetal x J-2		-4.14	-12.81	-2.88	-8.70	-3.51	-10.78
Sheetal x J-4		9.58**	9.29**	8.81**	-6.27	9.19	-7.81
KDWD-1 x J-2		2.36	-6.89**	2.67	-3.48*	2.51*	-5.21*
KDWD-1 x J-4		12.04**	-7.26**	9.24**	-5.91*	10.63*	-6.59*
J-2 x J-4		12.06**	-7.24**	9.03**	-6.09**	10.54**	-6.67*
Range of heterosis	**Minimum**	**-6.82**	**-21.45**	**-8.87**	**-18.01**	**-7.07**	**-19.76**
	Maximum	**14.19**	**12.77**	**14.26**	**11.58**	**13.07**	**12.98**
Significant crosses	**Positive**	**19**	**18**	**15**	**12**	**15**	**13**
	Negative	**6**	**15**	**11**	**20**	**15**	**20**
SE		**1.26**		**1.18**		**1.20**	
CD at 5 %		**2.42**		**2.34**		**2.37**	

4.2.4 Days to first harvest

The values of heterobeltiosis ranged from -6.82 to 14.19% (S1),-8.87 to 14.26% (S2) and -7.07 to 13.07% (P) Total twenty five (S1), twenty six (S2) and thirty (P) cross combinations showed significant estimates, of which, only six (S1), eleven (S2) ,and fifteen (P) crosses had negative effect. The highest HB in negative direction was observed with the cross Poona Khira x Sheetal (-6.82% S1) followed by Sheetal x KDWD-1 (-5.32 % S1), Rushita x Sheetal (-8.87% S2) followed by PLK x Phule Shubhangi (-8.26 % S2), Poona Khira x Sheetal (-7.27%; S2) and PLK x Phule Shubhangi (-7.07%; P) followed by KOP-1 x Sheetal (-4.95%; P), Sheetal x

KDWD-1 9-4.80%; P).

The lowest and highest estimates of SH were for S1, -21.45% and 12.77%; for S2, -18.01% and 11.58%; and for P, -19.76% and 12.98%. Out of thirty three (S1), thirty two (S2) and thirty three (P) cross combinations with significant standard heterosis, Fifteen (S1), Twenty (S2) and Twenty (P) had negative effects. The cross KOP-1x J-4 (-21.45%; S1), (- 18.01%; S2) and (-19.76%; P) registered the highest estimate of standard heterosis in negative direction followed by PLK x Phule Shubhangi (-13.01%; S1), Phule Shubhangi x Hemangi (- 11.76%; S1), PLK x Phule Shubhangi (-12.67% S2), KOP-1 x Sheetal (-11.78% S2) and Poona Khira x J-4 (-11.34% P), Sheetal x KDWD-1 (-11.71% P).

The estimates of heterotic effects for days to first harvest were found to be low in both directions over several days. These findings partially concur with the observations presented by Munshi *et al.* (2005) (SH), Airina *et al.* (2013) (SH), Singh *et al.* (2015) (HB and SH), and Singh *et al.* (2016) (HB and SH) who reported low to moderate estimates of heterotic effect. However, the results differ from those of Dogra and Kanwar (2011) (HB and SH) who reported high estimate of heterosis in the positive direction.

Table 4.2.5 Per cent heterobeltiosis (HB) and standard heterosis (SH) of days to last harvest

Hybrid	2021 (S1)		2022 (S2)		Pooled (P)	
	HB	SH	HB	SH	HB	SH
Panvel x PLK	-1.76	-4.73**	-0.75	-5.7**	-1.27	-5.22**
Panvel x Phule Shubhangi	2.24*	-5.08**	0.98	-5.7**	1.61	-5.39**
Panvel x Phule Hemangi	-1.24	-4.38**	-0.32	-5.1**	-1.30	-4.74**
Panvel x Poona Khira	0.07	-4.16**	-0.44	-5.21**	-0.20	-4.69**
Panvel x Rushita	-2.16*	-4.76**	-0.52	5.28**	-1.74	-5.02**
Panvel x MLKP	-1.91*	-3.55**	0.53	4.28**	-0.71	-3.92**
Panvel x KOP-1	0.72	-0.96	0.22	4.58**	0.48	-2.77
Panvel x Sheetal	-0.56	-2.31*	0.52	-4.30**	-0.07*	-3.30*
Panvel x KDWD-1	0.79	-0.98	0.00	-4.79**	0.36	-2.88*
Panvel x J-2	0.73	-1.68	1.11*	-3.73*	-0.54*	-2.70
Panvel x J-4	-0.63	-2.29	1.22	-3.63*	-0.28*	-2.96*
PLK x Phule Shubhangi	4.24**	3.22**	1.89*	-4.86	3.06*	-4.04**
PLK x Phule Hemangi	-2.24*	-5.35**	-0.75**	-5.7**	1.59**	-5.53**
PLK x Poona Khira	-2.18*	-6.31**	-0.53**	5.49**	-1.47	-5.90**
PLK x Rushita	-1.9*	-4.86**	0.51	-4.51	-0.71	-4.68**
PLK x MLKP	0.35	2.68**	-0.09	-5.07	0.13	-3.87
PLK x KOP-1	-0.53	3.53**	-0.01	5.00**	-0.27*	-4.26**
PLK x Sheetal	-2.87**	-5.81**	-0.20**	-5.18**	-1.55	-5.49**
PLK x KDWD-1	-2.88**	5.81**	-1.35	-6.27	-2.12*	-6.04**
PLK x J-2	0.48	-2.56**	-0.46	-5.42	0.02*	-3.99**
PLK x J-4	-0.80	-3.80	1.03	-4.01	0.10*	-3.90
Phule Shubhangi x Hemangi	2.73**	4.62**	1.21*	-5.49**	-1.97**	-5.06**
Phule Shubhangi x Poona Khira	7.21**	-0.46	1.06*	-5.63	4.13**	-3.04*

Phule Shubhangi x Rushita		5.63**	-1.93*	3.85*	3.03*	4.74**	-2.48
Phule Shubhangi x MLKP		7.30**	-0.38	2.19*	-4.58	4.74**	-2.48
Phule Shubhangi x KOP-1		4.75**	-2.75**	1.06	-5.63**	2.90	4.19**
Phule Shubhangi x Sheetal		6.46**	-1.16	1.66*	-5.07	4.06**	-3.11*
Phule Shubhangi x KDWD-1		5.67**	-1.89	-1.81*	-4.93	3.74*	-3.41*
Phule Shubhangi x J-2		2.99**	4.38**	1.13*	-5.56**	-2.06*	4.97**
Phule Shubhangi x J-4		4.69**	-2.81**	2.11*	-4.65**	3.40*	-3.73*
Phule Hemangi x Poona Khira		-0.41	-4.62**	-1.57	-6.27	-0.99	5.44**
Phule Hemangi x Rushita		-1.49	-4.62**	-1.81	-5.76	-1.76*	5.19**
Phule Hemangi x MLKP		-2.97**	6.05**	-2.34**	-6.05**	-2.66**	6.05**
Phule Hemangi x KOP-1		-2.41*	5.51**	-2.50*	6.20**	-2.46*	5.85**
Phule Hemangi x Sheetal		0.36	-2.83**	-1.16	-4.90	-0.39	3.86**
Phule Hemangi x KDWD-1		0.59	-2.61	-1.10	-4.85**	-0.25*	-3.73*
Phule Hemangi x J-2		0.20	-2.98**	-1.31*	-5.05**	-0.55*	-4.02**
Phule Hemangi x J-4		0.69	-2.51	-1.40*	-5.14	-0.35	3.82**
Poona Khira x Rushita		2.45**	1.88*	2.05*	2.82	-2.25**	-2.35
Poona Khira x MLKP		0.31	-3.93	0.18*	-4.60	0.25*	-4.26**
Poona Khira x KOP-1		-0.10	4.33**	-0.39	-5.14**	-0.24*	4.73**
Poona Khira x Sheetal		1.86*	2.45**	0.94	3.87*	1.40**	-3.16*
Poona Khira x KDWD-1		0.24	-4.22**	-1.35*	-6.06**	-0.55	5.03**
Poona Khira x J-2		5.6**	1.13	0.65*	-4.15	3.13*	-1.51
Poona Khira x J-4		2.17*	2.15*	0.57*	4.23**	1.37	-3.19
Rushita x MLKP		-3.64**	-6.20**	-2.93*	-6.83**	-3.29*	6.52**
Rushita x KOP-1		0.21	-2.45	-1.32	-5.28	-0.55*	-3.87
Rushita x Sheetal		-2.67**	5.26**	-2.71*	-6.62**	-2.69*	5.94**
Rushita x KDWD-1		1.37	-1.33	-0.29*	-4.3**	0.54	-2.81
Rushita x J-2		1.11	-1.58	0.55*	-3.48*	0.83	-2.53
Rushita x J-4		-1.33	3.96**	-1.07	-5.04**	-1.20	-4.5*
MLKP x KOP-1		-1.47	-1.35	-0.58*	-3.66*	-1.03*	-2.50
MLKP x Sheetal		-0.30	2.05*	3.08*	4.86**	-1.69*	3.45*
MLKP x KDWD-1		-3.09**	-4.79	-2.90**	5.81**	-2.99*	-5.3**
MLKP x J-2		-0.31	2.68**	3.08*	-4.79**	-2.95*	3.73*
MLKP x J-4		-1.47	-2.39	-1.96*	5.07**	-1.71**	3.73
KOP-1 x Sheetal		2.07*	0.27	-0.73*	-3.80*	0.03	-1.76
KOP-1 x KDWD-1		-1.16	-2.90	-0.36	-3.45*	-0.82	-3.18*
KOP-1x J-2		-2.31*	-4.64**	8.27**	-11.11	-6.48**	7.87**
KOP-1x J-4		-3.08**	-3.98**	-2.33	-5.42**	-2.71*	-4.70**
Sheetal x KDWD-1		1.16	-0.62	-1.56*	-4.51**	-0.19	-2.56
Sheetal x J-2		0.85	-1.56	-2.51*	4.30**	-1.15	2.92*
Sheetal x J-4		-1.17	-2.90**	-2.04	-5.14**	-2.01	-4.02**
KDWD-1 x J-2		-0.28	-2.66**	-2.36	-5.28**	-1.63	-3.97**
KDWD-1 x J-4		-1.82*	-3.55**	-8.44**	-11.34**	-5.19**	-7.44**
J-2 x J-4		1.11	-1.30	-0.99	-4.13**	-0.68	-2.71
Range of heterosis	**Minimum**	**-3.64**	**-6.31**	**-8.44**	**-11.34**	**-6.48**	**-7.44**
	Maximum	**7.30**	**6.05**	**8.27**	**6.20**	**4.74**	**7.87**
Significant crosses	**Positive**	**16**	**16**	**18**	**14**	**14**	**16**
	Negative	**15**	**26**	**18**	**35**	**26**	**33**
SE		**0.87**		**1.46**		**1.20**	
CD at 5 %		**1.73**		**2.88**		**2.37**	

4.2.5 Days to last harvest

The values of heterobeltiosis ranged from -3.64 to 7.30 % (S1),-8.44 to 8.27 % (S2) and

-6.48 to 4.74 % (P) Total thirty one (S1), thirty six (S2) and forty (P) cross combinations showed significant estimates, of which, fifteen, eighteen and twenty six in S1, S2 and Pool respectively crosses had negative effect. The highest HB in negative direction was observed with the cross Rushita x MLKP (-3.64 % S1) followed by MLKP x KDWD-1 (-3.09 % S1), KDWD-1 x J-4 (-8.44 % S2) followed by Rushita x MLKP (-2.93%; S2), MLKP x KDWD-1 (-2.90% S2) and KOP-1x J-2 (-6.48%; P) followed by KDWD-1 x J-4 (-5.19%; P), Rushita x MLKP (- 3.29%; P), MLKP x KDWD-1 (-2.99 %; P).

The minimum and the maximum estimates of SH were -6.31 and 6.05% (S1), - 11.34 And 6.20% (S2) and -7.44 and 7.78% (P) respectively. Out of twenty six (S1), thirty five (S2) and thirty three (P) cross combination with significant heterosis all had negative effects. The cross PLK x Poona Khira (-6.31%; S1) analysed the highest estimate of standard heterosis in negative direction followed by Rushita x MLKP (-6.20%; S1), PLK x Sheetal (- 5.81%; S1). The cross KDWD-1 x J-4 (-11.34%; S2) registered the maximum estimate of standard heterosis in negative direction followed Rushita x MLKP (-6.83%; S2), Rushita x Sheetal (- 6.62%; S2) and the cross KDWD-1 x J-4 (-7.44%; P) registered the highest estimate of standard heterosis (SH) in negative direction followed by PLK x KDWD-1 (-6.04%; P), PLK x Poona Khira (-5.90% P).

Table 4.2.6 Per cent heterobeltiosis (HB) and standard heterosis (SH) of number of primary braches per vine

Hybrid	2021 (S1)		2022 (S2)		Pooled (P)	
	HB	SH	HB	SH	HB	SH
Panvel x PLK	23.00	91.04**	6.11	-45.53**	13.66	64.49**
Panvel x Phule Shubhangi	-10.05	84.02**	0.03	32.33*	-5.26	53.87**
Panvel x Phule Hemangi	-20.51	31.32	-3.30	9.40	-12.08	-18.53
Panvel x Poona Khira	-6.73	75.62**	28.81*	-43.53**	9.37	56.9**
Panvel x Rushita	48.66**	86.54**	31.14*	40.36**	42.96**	59.39**
Panvel x MLKP	59.07**	-51.6**	73.30**	-64.76**	71.03**	84.28**
Panvel x KOP-1	70.25**	76.44**	44.93**	-78.57**	56.5**	-66.67**
Panvel x Sheetal	28.76*	70.36	32.48**	71.43**	30.64*	95.83
Panvel x KDWD-1	12.11	-50.64**	-8.46*	54.13**	10.19	-73.51**
Panvel x J-2	-15.80**	-92.02**	-7.37*	-48.17**	11.26	-66.44**
Panvel x J-4	-4.30*	-91.52**	-7.75*	-43.39	6.04	63.44
PLK x Phule Shubhangi	38.82**	84.25	50**	55.71**	46.75**	-88.33**
PLK x Phule Hemangi	70.3**	81.33	40.63**	-92.86**	58.74**	-89.72**
PLK x Poona Khira	33.92**	52.17	42.71**	95.71**	51.49**	59.24**
PLK x Rushita	68.04**	-61.21**	44.79**	98.57**	55.19**	-64.58**
PLK x MLKP	44.85**	94.98	41.67**	-94.29**	43.09**	97.08**
PLK x KOP-1	51.3**	-85.25**	39.58**	91.43**	44.82**	89.58**
PLK x Sheetal	27.80*	-88.28**	34.26**	-84.13**	35.1**	92.53**

PLK x KDWD-1		-13.34**	-82.84**	19.30	69.53	16.48	83.41**
PLK x J-2		33.48*	-81.33**	32.51**	-82.86**	32.95**	98.89**
PLK x J-4		-0.41	82.87**	36.46**	87.14	20.26	-85.36**
Phule Shubhangi x Hemangi		-11.07	81.93	10.48	-46.14**	-0.83	-61.06**
Phule Shubhangi x Poona Khira		-23.29*	-56.94*	-3.67*	-37.14*	-10.48	-45.39
Phule Shubhangi x Rushita		-8.65	86.89**	-10.36*	-45.99	0.38	63.03
Phule Shubhangi x MLKP		-3.70**	72.15	22.22*	61.69**	12.50	82.71
Phule Shubhangi x KOP-1		-37.77**	27.30	37.15**	-81.43	-2.18	-58.88**
Phule Shubhangi x Sheetal		-14.74	-74.43**	-6.79*	-41.27	-4.51	-55.09
Phule Shubhangi x KDWD-1		7.18	79.26	31.7**	-87.14**	23.47*	80.53**
Phule Shubhangi x J-2		-31.64**	89.3	36.28**	-88.07**	36.64**	81.92**
Phule Shubhangi x J-4		-9.97	-84.18	37.41**	-82.86	12.93	83.41
Phule Hemangi x Poona Khira		-5.83	-77.32	40.17**	-58.57**	15.98	66.38
Phule Hemangi x Rushita		-22.06**	71.64**	25.76*	-42.27**	23.87	67.01
Phule Hemangi x MLKP		-30.90*	-56.24**	36.99**	-54.97**	33.88*	80.50**
Phule Hemangi x KOP-1		20.94	99.85**	-19.32*	-47.01**	25.35	69.01
Phule Hemangi x Sheetal		-45.2**	89.36	51.23**	-95.69**	48.24**	-82.22**
Phule Hemangi x KDWD-1		-32.32*	-86.8**	30.5**	85.44	31.36**	-86.84**
Phule Hemangi x J-2		-32.18*	59.18**	12.84	55.71**	21.77	82.16
Phule Hemangi x J-4		-34.06**	21.08	-4.46	-27.14	-19.15	24.62
Poona Khira x Rushita		-15.04	59.98**	42.31**	58.57	10.94	59.16
Poona Khira x MLKP		5.34	98.36**	27.55*	-42.13**	15.41	-65.56
Poona Khira x KOP-1		-22.89**	51.4**	26.38*	55.71	30.53*	-87.25**
Poona Khira x Sheetal		-10.70**	48.44**	-15.89**	-49.96**	16.29	-74.33
Poona Khira x KDWD-1		-12.85*	-52.5**	-6.19*	-50.90	12.14	-76.57
Poona Khira x J-2		-2.67	83.28**	-10.18**	52.04**	10.34	65.06
Poona Khira x J-4		31.02*	-66.72	23.32*	64.17**	28.8*	-98.53**
Rushita x MLKP		-17.64*	-56.48*	-17.74**	25.70	24.25	38.53
Rushita x KOP-1		5.73	52.72	-5.67	16.23	-0.47	-31.43**
Rushita x Sheetal		19.56**	-53.56*	27.69*	65.23	23.65*	85.37
Rushita x KDWD-1		-4.43	71.04**	-6.38*	33.03*	-5.46	-48.87**
Rushita x J-2		13.04	-87.44**	10.77	52.86**	11.82	67.27**
Rushita x J-4		-4.39**	91.68**	18.64	57.87**	11.56	71.96**
MLKP x KOP-1		61.46**	83.22**	55.35**	91.41	58.14**	-88.83**
MLKP x Sheetal		-18.95	-44.78	26.96*	64.29**	4.17	-56.16**
MLKP x KDWD-1		-13.83**	-83.72	22.06*	73.44**	18.16	86.06**
MLKP x J-2		39.44**	-41.22*	34.03**	84.96	36.53**	84.23
MLKP x J-4		-23.33*	76.46**	30.25**	-73.33**	26.82*	95.47**
KOP-1 x Sheetal		26.97*	-76.84*	37.03**	77.31	32.04**	97.93
KOP-1 x KDWD-1		36.33**	73.98**	28.04**	-81.94**	31.97**	77.79**
KOP-1x J-2		3.49	71.6**	-2.70*	41.73**	3.06	54.18**
KOP-1x J-4		-4.62	-75.14	-10.11**	46.53	2.80	58.45
Sheetal x KDWD-1		-45.64**	90.64**	39.1**	97.66	42.2**	100.90**
Sheetal x J-2		30.72*	83.5	32.13**	-82.34	35.86**	-83.66**
Sheetal x J-4		5.18	93.13**	39.56**	85.71**	22.49	88.81**
KDWD-1 x J-2		-4.76	70.43**	3.74	47.41**	-0.29	57.01**
KDWD-1 x J-4		17.55	55.85**	14.78	63.1**	17.54	85.08**
J-2 x J-4		27.02*	73.24**	26.61*	74.73**	29.18*	99.11**
Range of heterosis	**Minimum**	**-45.64**	**-92.02**	**-19.32**	**-95.69**	**-19.15**	**-98.53**
	Maximum	**70.31**	**99.85**	**73.30**	**98.57**	**71.03**	**100.90**
Significant crosses	**Positive**	**20**	**29**	**40**	**20**	**29**	**25**
	Negative	**21**	**19**	**14**	**30**	**28**	**18**
SE		**0.79**		**0.74**		**0.77**	
CD at 5 %		**1.57**		**1.47**		**1.51**	

4.2.6 Number of primary branches per vine

The minimum and maximum values of heterobeltiosis were -45.64 and 70.31% (S1), -19.32 and 73.30 % (S2) and -19.15 and 71.03% (P) respectively. Total forty one (S1), fifty four (S2) and fifty seven F_1s registered significant estimates, of which, 20 (S1), 40 (S2) and 29 (P) had positive effect. The hybrid Panvel x KOP-1 (70.25% S1), Panvel x MLKP (73.30% S2) and Panvel x MLKP (71.03% P) exerted the highest positive heterobeltiotic effect followed by PLK x Rushita (68.04% S1), Panvel x KOP-1 (70.25% S2) and PLK x Phule Hemangi (58.74% P), MLKP x KOP-1 (58.14% P).

The estimated values of standard heterosis varied widely, ranged from -92.02% to 99.75% for S1, -95.69% to 98.57% for S2, and -98.53% to 100.90% for P. Notably, all significant estimates for the forty-eight S1, fifty S2, and forty-three P F_1s had positive values. The cross Phule Hemangi x KOP-1 (99.85 %; S1), PLK x Rushita (98.57 % S2), Sheetal x KDWD-1 (100.90 % P) registered the highest estimate of standard heterosis in positive direction. These results align with Singh *et al*. (1999) discoveries, indicating moderate heterobeltiosis in a positive direction. In contrast, Cramer and Wehner (1999) and Pandey *et al*. (2015) documented lower estimates of heterotic effects, manifesting in both directions for number of primary branches per vine.

Table 4.2.7 Per cent heterobeltiosis (HB) and standard heterosis (SH) of internodal length (cm)

Hybrid	2021 (S1)		2022 (S2)		Pooled (P)	
	HB	SH	HB	SH	HB	SH
Panvel x PLK	4.92	-5.04	19.32**	13.13*	12.09**	3.79
Panvel x Phule Shubhangi	5.45	3.49	8.60	15.15**	7.04**	9.16**
Panvel x Phule Hemangi	6.64	2.76	3.19	14.7**	4.84*	8.57**
Panvel x Poona Khira	13.83*	4.47*	18.35**	16.05**	16.11**	10.11**
Panvel x Rushita	-1.12	-0.19	-2.00	9.71	-1.57	4.63*
Panvel x MLKP	-1.24	-0.30	0.22	12.2*	-0.49	-5.77*
Panvel x KOP-1	23.81**	8.00**	23.96**	18.55**	23.88**	13.13**
Panvel x Sheetal	2.80	0.64	5.05	17.6**	2.44	8.89**
Panvel x KDWD-1	28.1**	3.59*	24.32**	13.65**	26.15**	8.48**
Panvel x J-2	24.26**	8.58**	21.15**	20.93**	22.65**	14.58**
Panvel x J-4	18.86**	2.47*	14.52**	13.56**	16.6**	-7.86**
PLK x Phule Shubhangi	20.25**	8.83**	30.92**	24.13**	25.56**	16.27**
PLK x Phule Hemangi	13.76*	2.96*	13.79*	7.89	13.78**	-5.36*
PLK x Poona Khira	15.19**	4.25*	24.92**	18.44**	20.03**	11.15**
PLK x Rushita	19.18**	7.87**	26.11**	19.57**	22.63**	13.56**
PLK x MLKP	17.56**	6.40**	22.25**	15.91**	19.89**	11.02**
PLK x KOP-1	-22.87**	-7.19**	-22.09**	-15.76**	-21.94**	-11.36**
PLK x Sheetal	19.01**	7.72*	24.91**	18.43**	21.95**	12.92**
PLK x KDWD-1	38.55**	12.04*	29.92**	18.77**	34.09**	15.31**

PLK x J-2	-36.81**	-19.54**	-31.96**	-25.12**	-32.02**	-22.25**
PLK x J-4	12.31*	3.18*	16.55**	10.50*	11.86**	3.47
Phule Shubhangi x Hemangi	0.87*	2.80*	-5.94*	-12.33*	-2.53*	-4.55*
Phule Shubhangi x Poona Khira	-12.81*	3.53*	-16.07**	-13.81**	14.45**	8.53**
Phule Shubhangi x Rushita	-7.39*	5.39**	4.32	10.61*	-5.84**	-7.93**
Phule Shubhangi x MLKP	11.96*	9.88*	-3.71*	9.96	7.79**	9.92**
Phule Shubhangi x KOP-1	-10.12*	-3.93*	-21.32**	-16.03**	-15.83**	-5.77*
Phule Shubhangi x Sheetal	-5.64*	-3.43*	-11.15*	-17.85**	-8.32**	-10.44**
Phule Shubhangi x KDWD-1	33.42**	7.88**	32.45**	21.07**	32.92**	14.3**
Phule Shubhangi x J-2	21.89**	6.51**	12.76*	12.56*	17.15**	9.45**
Phule Shubhangi x J-4	23.1**	6.13**	13.53*	12.58*	18.11**	9.26**
Phule Hemangi x Poona Khira	15.13**	5.66**	18.32**	16.01**	16.73**	10.69**
Phule Hemangi x Rushita	7.53	3.62	-1.11	-9.93**	-3.02	-6.69**
Phule Hemangi x MLKP	-0.81*	-2.86*	-3.73*	-7.01*	-1.56*	-1.94*
Phule Hemangi x KOP-1	18.53**	3.41*	20.07**	14.83**	19.32**	8.96**
Phule Hemangi x Sheetal	-7.13*	-3.23*	-4.67	16.35**	-5.84**	9.61**
Phule Hemangi x KDWD-1	22.8**	-0.70	21.17**	-10.77*	21.96**	4.87*
Phule Hemangi x J-2	15.75**	1.14*	9.32	9.12	-12.41**	5.02*
Phule Hemangi x J-4	14.51*	-1.29*	5.50	-4.62*	-9.81**	-1.58*
Poona Khira x Rushita	-11.04	1.91*	-13.23*	11.02*	-12.14**	6.34**
Poona Khira x MLKP	18.3**	8.57*	23.24**	20.84**	20.78**	14.53**
Poona Khira x KOP-1	-10.04**	-4.00*	14.65**	-9.64**	12.38**	-2.63*
Poona Khira x Sheetal	15.12**	5.65*	15.64**	13.38*	15.38**	9.41**
Poona Khira x KDWD-1	-17.25**	-5.39*	-18.67**	-8.48*	-17.86**	-1.35*
Poona Khira x J-2	31.31**	14.74**	21.8**	19.43**	25.25**	17.02**
Poona Khira x J-4	11.87	-3.55*	7.02	4.94	8.72**	0.57
Rushita x MLKP	0.60	1.71	-2.29	9.96	-0.88	-5.72*
Rushita x KOP-1	18.21**	3.13*	17.66**	12.52*	17.93**	7.72**
Rushita x Sheetal	3.11	0.95	-1.05	11.36*	-0.61	-6.01**
Rushita x KDWD-1	-29.29**	4.55*	-26.18**	-15.35**	-27.69**	9.80**
Rushita x J-2	18.73**	-3.74*	-5.48*	-5.30*	11.85**	-4.50*
Rushita x J-4	-20.31**	-3.72*	-15.86**	-14.88**	-17.99**	-9.15**
MLKP x KOP-1	-14.22*	-0.36*	-13.04*	-8.10*	-13.62**	-3.76*
MLKP x Sheetal	3.25	1.08*	-7.98	-6.30*	-3.17*	-3.62
MLKP x KDWD-1	20.03**	2.94*	15.48**	-5.56*	17.68**	-1.19**
MLKP x J-2	11.31	-2.74	8.51	-8.32*	9.86**	-2.63*
MLKP x J-4	13.68*	-2.00*	11.76*	-10.82*	12.68**	4.23
KOP-1 x Sheetal	-8.13*	-5.67*	-16.14**	11.07*	-12.21**	-2.47*
KOP-1 x KDWD-1	22.56**	0.90*	20.74**	10.38*	21.62**	4.58*
KOP-1x J-2	16.85**	1.95**	16.52**	11.43*	16.68**	6.56**
KOP-1x J-4	17.10**	-0.95*	18.5**	13.33*	17.13**	6.97**
Sheetal x KDWD-1	16.41*	-5.87*	13.48*	3.74	14.9**	-1.20
Sheetal x J-2	-6.37*	-7.06**	-0.77*	-0.95*	-2.66*	-4.09*
Sheetal x J-4	13.29*	2.33*	9.87	8.94	11.51**	3.15
KDWD-1 x J-2	32.29**	6.97**	24.01**	13.36*	28.01**	10.08**
KDWD-1 x J-4	13.78*	-7.99*	9.98	0.54	11.82**	-3.85*
J-2 x J-4	30.23**	12.27*	22.95**	21.91**	26.43**	16.96**
Range of heterosis **Minimum**	**-36.81**	**-19.54**	**-31.96**	**-25.12**	**-32.02**	**-22.25**
Maximum	**38.55**	**14.74**	**32.45**	**24.13**	**34.09**	**17.02**
Significant crosses **Positive**	**38**	**35**	**33**	**36**	**42**	**35**
Negative	**15**	**19**	**16**	**20**	**18**	**24**
SE	**0.20**		**0.19**		**0.20**	
CD at 5 %	**0.41**		**0.38**		**0.39**	

4.2.7 Internodal length (cm)

The minimum and the maximum values of heterobeltiosis (HB) were -36.81 and 38.55% (S1), -31.96 and 32.45% (S2) and -32.02 and 34.09% (P) respectively. Total 53 (S1), 49 (S2) and 60 (P) F_1s registered significant estimates, of which, thirty eight (S1), thirty three (S2) and forty two (P) had positive effect. The hybrid PLK x KDWD-1 (38.55%; S1), Phule Shubhangi x KDWD-1 (32.45%; S2), and PLK x KDWD-1 (34.09%; P) exerted the highest positive heterobeltiotic effect followed by Phule Shubhangi x KDWD-1 (33.42%; S1), KDWD-1 x J-2 (32.29%; S1), PLK x Phule Shubhangi (30.92%; S2), PLK x KDWD-1 (29.92%; S2), Phule Shubhangi x KDWD-1 (32.92%; P), KDWD-1 x J-2 (28.01%; P).

The estimation of SH for this characteristic ranged from -19.54% to 14.74% in S1, -25.12% in S2, and -22.25% to 17.02% in P. A total of 54 hybrids in S1, 56 in S2, and 59 in P were found to have significant estimates, all of which were negative values, as shown in Table 4.2.7. These results were consistent with Singh *et al.*'s (1999) findings of a moderate estimate for heterobeltiosis in a positive direction. However, Cramer and Wehner (1999) and Pandey *et al.* (2015) reported low estimates of heterotic effects (both HB and SH) in both directions for the same characteristic.

Table 4.2.8 Per cent heterobeltiosis (HB) and standard heterosis (SH) of vine length (cm)

Hybrid	2021 (S1)		2022 (S2)		Pooled (P)	
	HB	SH	HB	SH	HB	SH
Panvel x PLK	6.02*	14.82*	5.81**	17.71**	5.92**	16.25**
Panvel x Phule Shubhangi	-1.83	13.41*	0.67	16.46**	-0.58	14.92**
Panvel x Phule Hemangi	3.16	11.41**	4.44*	14.93**	3.8**	13.16**
Panvel x Poona Khira	6.19**	14.67**	6.57**	17.28**	6.38**	15.97**
Panvel x Rushita	4.68*	13.05*	6.05**	16.71**	5.37**	14.87**
Panvel x MLKP	6.6**	15.12**	7.61**	18.43**	7.11**	16.76**
Panvel x KOP-1	3.19	11.43	3.88	14.32**	3.53**	12.87
Panvel x Sheetal	4.23	12.56**	5.14*	15.71**	4.68**	14.12**
Panvel x KDWD-1	2.96	11.19	3.78	14.22	3.37**	12.69**
Panvel x J-2	3.65	13.82**	1.79	16.91**	2.7*	15.35**
Panvel x J-4	2.81	11.03**	4.53*	15.04	3.67**	13.02
PLK x Phule Shubhangi	-2.63	-12.49**	0.07	-15.76**	-1.29	14.11
PLK x Phule Hemangi	-2.75	-5.32*	1.60	-13.02**	-0.56	9.15**
PLK x Poona Khira	2.36	10.85**	3.65	15.31**	3.01**	13.06**
PLK x Rushita	2.37	10.86**	3.32	14.94**	2.85**	12.89**
PLK x MLKP	2.54	11.04**	3.48	15.11**	3.01**	13.06**
PLK x KOP-1	-0.21	-8.07**	1.58	-13.25**	0.69	10.52
PLK x Sheetal	2.70	11.22**	4.21*	15.92**	3.46**	13.55**
PLK x KDWD-1	2.78	11.31**	2.85	14.41**	2.81**	12.85**
PLK x J-2	0.22	10.05	-1.18	13.5**	-0.49	-11.77
PLK x J-4	4.10	12.73	4.18	15.9**	4.14**	14.3**
Phule Shubhangi x Hemangi	-5.05*	-9.69**	-1.95	-13.42**	-3.51**	-11.54**

Phule Shubhangi x Poona Khira		-4.27	-10.58**	-2.27	-13.05**	-3.28**	-11.81**
Phule Shubhangi x Rushita		-2.88	-12.19**	-0.46	-15.14**	-1.68	-13.66
Phule Shubhangi x MLKP		-2.30	12.87**	-0.42	15.19**	-1.37	-14.02**
Phule Shubhangi x KOP-1		-1.93	-13.29**	0.25	-15.96**	-0.85	-14.62**
Phule Shubhangi x Sheetal		-3.61	-11.35**	-1.30	-14.18**	-2.46*	-12.75**
Phule Shubhangi x KDWD-1		-3.36	-11.64**	-1.59	-13.84**	-2.48*	12.73
Phule Shubhangi x J-2		-2.21	-12.97**	-0.32	-15.31**	-1.27	14.13
Phule Shubhangi x J-4		-3.42	-11.57**	-1.27	-14.21**	-2.35*	12.88
Phule Hemangi x Poona Khira		1.97	-5.08*	2.30	-8.29**	2.13	6.68**
Phule Hemangi x Rushita		1.38	4.48	2.80	8.83**	2.10	6.64**
Phule Hemangi x MLKP		0.46	4.77	2.09	8.07	1.69	6.41**
Phule Hemangi x KOP-1		0.82	-3.90*	2.43	-8.43**	1.63	6.15**
Phule Hemangi x Sheetal		0.37	4.26	1.30	7.24**	1.24	5.74**
Phule Hemangi x KDWD-1		-4.52	-1.63*	-3.23	-5.77*	-3.87**	-3.69
Phule Hemangi x J-2		-5.49*	-3.79*	-6.96**	-6.86**	-6.23**	-5.31**
Phule Hemangi x J-4		3.17	8.43**	6.47**	12.71**	5.85**	10.56**
Poona Khira x Rushita		2.72	5.66*	3.91	9.10	3.32**	7.37
Poona Khira x MLKP		-7.65**	-3.68*	-3.11	-1.73*	-5.39**	-0.99*
Poona Khira x KOP-1		-1.95	-0.85*	-1.40	-3.52*	-1.68	-2.18*
Poona Khira x Sheetal		-6.86**	-3.24*	-4.30	-0.48*	-5.11**	-1.39*
Poona Khira x KDWD-1		-7.67**	-1.72*	-7.37**	-1.26*	-7.52**	-0.24*
Poona Khira x J-2		-12.26**	-3.65*	-11.86**	-1.23*	-12.06**	-1.23*
Poona Khira x J-4		-8.39**	-3.72*	-6.1**	-1.41*	-6.59**	-2.57*
Rushita x MLKP		22.83**	28.11**	25.21**	31.47**	24.02**	29.78**
Rushita x KOP-1		26.09**	29.59**	26.74**	32.19**	26.42**	30.88**
Rushita x Sheetal		22.89**	27.66**	25.06**	30.43**	24.6**	29.04**
Rushita x KDWD-1		20.49**	28.25**	18.99**	30.07**	19.74**	29.16
Rushita x J-2		15.28**	26.59**	12.84**	29.6**	14.04**	28.08**
Rushita x J-4		22.25**	28.48**	26.62**	32.04**	24.89**	30.25**
MLKP x KOP-1		12.23**	17.05**	13.91	19.61**	13.07**	18.32
MLKP x Sheetal		10.87**	-15.63	12.45**	-18.08**	11.66**	-16.85**
MLKP x KDWD-1		8.82**	15.83**	7.89**	17.93**	8.35**	16.88**
MLKP x J-2		3.82	14.87	1.25	16.29**	2.51*	15.14**
MLKP x J-4		8.47**	14.02**	11.09**	16.64**	10.19**	15.32**
KOP-1 x Sheetal		-6.85**	-3.23*	-3.38	-0.26*	-5.13**	-1.76*
KOP-1 x KDWD-1		-4.01	2.17	-4.27*	4.64	-4.14**	3.4**
KOP-1x J-2		0.88	10.78**	-1.29	13.37**	-0.22	12.07**
KOP-1x J-4		-2.36	2.62	1.65	5.19*	-0.38	3.9**
Sheetal x KDWD-1		-12.58**	-6.95**	-12.94**	-4.84*	-12.76**	-5.9**
Sheetal x J-2		-7.84**	1.20	-10.7**	2.56	-9.3**	1.88
Sheetal x J-4		-7.3**	-2.58*	-2.47	-0.92*	-4.92**	-0.84*
KDWD-1 x J-2		-8.46**	0.52	-8.39**	5.21*	-8.43**	2.85*
KDWD-1 x J-4		-3.12	3.12	-4.66*	4.21	-3.9**	3.66**
J-2 x J-4		0.44	10.29**	-1.38	13.26**	-0.49	11.77**
Range of heterosis	**Minimum**	**-12.58**	**-15.63**	**-12.94**	**-18.08**	**-12.76**	**-16.85**
	Maximum	**26.09**	**29.59**	**26.74**	**32.19**	**26.42**	**30.88**
Significant crosses	**Positive**	**14**	**28**	**18**	**34**	**28**	**35**
	Negative	**11**	**25**	**9**	**24**	**18**	**18**
SE		**1.63**		**1.45**		**1.54**	
CD at 5 %		**3.23**		**2.86**		**3.04**	

4.2.8 Vine length (cm)

The minimum and the maximum values of heterobeltiosis (HB) were -12.58 and 26.09% (S1), -12.94 and 26.74 (S2) -12.76 and 26.42 % (P) respectively. Total 25 (S1), 27 (S2) and 46 (P) F_1s registered significant estimates, of which, fourteen (S1), eighteen (S2) and twenty eight (P) had positive effect. The hybrid Rushita x KOP-1 (26.09%; S1), (26.74%; S2) and (26.42%; P) exerted the highest positive heterobeltiotic effect followed by Rushita x Sheetal (22.89%; S1), Rushita x KDWD-1 (20.49%S1), Rushita x J-4 (26.62%; S2), Rushita x MLKP (25.61%; S2) and Rushita x J-4 (24.89%; P), Rushita x MLKP (24.02%; P).

The estimates of SH ranged from -15.63 to 29.59% (S1), -18.08 to 32.19% (S2) and -16.85 to 30.88% (P). Total 28 (S1), 34 (S2) and 35 (P) table (4.2.8) indicates that all significant estimates for the F_1s were positive. The current study found moderate heterotic effects in both directions for this characteristic, with the majority of the F_1s demonstrating a positive effect. The findings align with Singh *et al*. (1999) indication of a moderate estimate for heterobeltiosis in a favorable direction. Conversely, Cramer and Wehner (1999) as well as Pandey *et al.* (2015) reported contrasting results, observing low estimates of heterotic effects in both directions for the same trait.

Table 4.2.9 Per cent heterobeltiosis (HB) and standard heterosis (SH) of number of fruits per vine

Hybrid	2021 (S1)		2022 (S2)		Pooled (P)	
	HB	SH	HB	SH	HB	SH
Panvel x PLK	21.95*	-2.10	-2.38	27.5**	12.61	11.06
Panvel x Phule Shubhangi	11.90	2.52	15.60	30.7**	13.74	15.04
Panvel x Phule Hemangi	37.93**	10.73	24.8**	43.53**	37.29**	25.31*
Panvel x Poona Khira	17.39	3.27	28.18**	38.75	22.74*	19.04
Panvel x Rushita	31.4**	5.49	37.66**	46.26	35.51**	23.61*
Panvel x MLKP	24.73*	0.13	30.16**	41.84**	30.09*	18.67
Panvel x KOP-1	-13.11	7.91	-5.95	36.58	-9.65	-20.65**
Panvel x Sheetal	36.21**	9.35	29.67**	-36.01**	32.87**	21.20
Panvel x KDWD-1	-2.25	-1.25	4.35	37.5**	1.12	15.97
Panvel x J-2	11.26	2.65	-2.40	22.21*	4.15	11.34
Panvel x J-4	-10.17	5.10	-2.13*	-45.59**	-6.11	-23.09*
PLK x Phule Shubhangi	38.05**	26.48**	31.27**	71.45**	44.8**	46.47**
PLK x Phule Hemangi	72.1**	25.69**	30.04**	-69.85**	47.34**	45.31**
PLK x Poona Khira	44.19**	26.84**	24.74**	62.93**	44.87**	42.88**
PLK x Rushita	58.21**	20.97*	22.94**	60.58**	40.51**	38.57**
PLK x MLKP	46.37**	12.19	22.21**	59.63**	35.13**	33.27**
PLK x KOP-1	-21.35**	-2.33	4.73	-52.09**	-8.74	21.86
PLK x Sheetal	31.47**	0.89	16.53*	52.20	25.42*	23.69*
PLK x KDWD-1	3.55	4.61	15.74*	52.50	9.78	25.89*
PLK x J-2	-2.31	-9.87	17.39*	53.33**	10.58	18.22
PLK x J-4	-6.27	9.66	2.66	52.71**	-1.77	28.8*
Phule Shubhangi x Hemangi	-18.20	-25.06**	-6.67	-7.33*	-11.68**	-10.66*

Phule Shubhangi x Poona Khira		-12.62	-19.94*	-2.11*	15.45	-5.30	-4.21*
Phule Shubhangi x Rushita		1.98	-6.57	14.57	29.54**	8.23	9.48
Phule Shubhangi x MLKP		24.46*	14.03	29.85**	46.81**	27.14*	28.6*
Phule Shubhangi x KOP-1		2.58	27.39**	12.01	62.65**	7.14	43.06**
Phule Shubhangi x Sheetal		27.09**	16.44	42.95**	61.63**	34.97**	36.52**
Phule Shubhangi x KDWD-1		-4.63	-3.66	14.64*	-51.05**	5.21	20.66
Phule Shubhangi x J-2		32.06**	21.84*	33.22**	66.81**	32.67**	41.83**
Phule Shubhangi x J-4		-23.9**	-10.96	-4.75*	41.69	-14.24*	-12.44**
Phule Hemangi x Poona Khira		22.94*	8.15	35.87**	56.25**	33.56**	29.53**
Phule Hemangi x Rushita		19.16	-8.89	35.87**	-56.25**	31.54*	20.06
Phule Hemangi x MLKP		4.76	-19.7*	-6.52	22.50	8.53	-0.94*
Phule Hemangi x KOP-1		-12.80	8.29	1-1.90	62.5**	-0.86	32.38**
Phule Hemangi x Sheetal		41.54**	8.62	38.04**	58.75	43.42**	30.9**
Phule Hemangi x KDWD-1		-17.64*	-16.80	19.53**	-57.5**	1.34	-16.22**
Phule Hemangi x J-2		7.14	-1.15	25.55**	57.2**	16.72	24.78*
Phule Hemangi x J-4		-6.30	9.63	5.04	56.25**	-0.58*	30.35**
Poona Khira x Rushita		29.25**	13.70	22.4*	-32.55*	25.85*	22.06*
Poona Khira x MLKP		17.23	3.13	35.35**	47.5**	26.67*	22.85*
Poona Khira x KOP-1		-7.69	14.64	-7.72*	56.43	-0.24	33.21**
Poona Khira x Sheetal		24.37*	9.41	44.25**	56.15	34.23**	30.18**
Poona Khira x KDWD-1		8.79	9.90	12.89	-48.75**	10.89	27.17*
Poona Khira x J-2		-29.08**	-34.57**	-10.15*	12.50	-19.23	-13.65*
Poona Khira x J-4		-14.75	-0.26	-4.02*	42.78**	-9.34	18.87
Rushita x MLKP		91.02**	46.42**	61.32**	75.8**	75.22**	59.48**
Rushita x KOP-1		21.51**	50.9**	31.8**	91.39**	26.48**	68.89**
Rushita x Sheetal		97.80**	51.79**	63.53**	73.75**	80.10**	61.55**
Rushita x KDWD-1		52.11**	53.66**	26.17**	-66.25**	38.87**	59.26**
Rushita x J-2		28.07**	18.16*	20.79**	-51.25	24.28*	32.87**
Rushita x J-4		-5.51	10.55	-2.93*	53.11**	-1.25*	29.47**
MLKP x KOP-1		-48.31**	-35.81**	-25.97**	-7.50	-37.51**	-16.56**
MLKP x Sheetal		-0.85	-23.91**	-4.48	-4.09*	-2.73*	-11.47**
MLKP x KDWD-1		-33.19**	-32.51**	-17.47*	-8.75*	-25.16*	-14.17***
MLKP x J-2		-2.44	-9.99	-0.29*	-25.58**	-1.02*	-5.82*
MLKP x J-4		-8.36	7.22	-1.68	46.25**	-4.99	24.57*
KOP-1 x Sheetal		-17.29*	2.72	-9.14	31.94**	-13.35*	15.71
KOP-1 x KDWD-1		3.87	29**	15.35*	67.5**	9.42	46.11**
KOP-1x J-2		5.97	31.61**	15.75*	68.09**	10.70	47.82**
KOP-1x J-4		5.03	30.44**	10.92	65.24**	-9.19*	45.8**
Sheetal x KDWD-1		-40.39**	-39.78**	-34.02**	-13.06**	-37.14**	-27.91*
Sheetal x J-2		-8.79	-15.85	-9.19*	13.70	-9.00	-2.72
Sheetal x J-4		-33.02**	-21.63*	-18.12**	21.80	-25.5**	-2.33*
KDWD-1 x J-2		-23.22**	-22.44*	-12.72	15.00	-17.86	-5.80
KDWD-1 x J-4		-28.57**	-16.43	-2.36	45.24**	-15.35*	10.98
J-2 x J-4		27.42**	49.08**	21.4**	80.59**	24.39**	63.08**
Range of heterosis	**Minimum**	**-48.31**	**-39.78**	**-34.02**	**-69.85**	**-37.51**	**-27.91**
	Maximum	**97.80**	**53.66**	**63.53**	**91.39**	**80.10**	**68.89**
Significant crosses	**Positive**	**24**	**15**	**32**	**35**	**26**	**36**
	Negative	**11**	**10**	**13**	**16**	**13**	**11**
SE		**0.63**		**0.57**		**0.60**	
CD at 5 %		**1.24**		**1.12**		**1.18**	

4.2.9 Number of fruits per vine

The values of HB varied from -48.31 to 97.80% (S1), -34.02 to 63.53% (S2) and -37.51 to 80.10% (P) (Table 4.2.9). Out of total 35 (S1), 45 (S2) and 39 (P) significant crosses. The cross Rushita x Sheetal (97.80%; S1), (63.53%; S2) and (80.10%; P) ranked first, followed by Rushita x MLKP (91.02% S1), (61.32%; S2) and (75.22%; P).

The minimum and maximum estimates of SH were -39.78 and 53.66% (S1), -69.85 and 91.39% (S2) and -27.91 to 68.89 (P) respectively. Total 25 (S1), 51 (S2) and 47 (P) cross depict significant standard heterosis, of which, 15 (S1), 35 (S2) and 36 (P) exhibited positive effect. The cross Rushita x KDWD-1 (53.66% S1), Rushita x KOP-1 (91.39%; S2) and Rushita x KOP-1 (68.89%; P) register the maximum standard heterosis followed by Rushita x Sheetal (51.79%; S1), KOP-1x J-2 (68.09%; S2) and Rushita x Sheetal (61.55%; P). The results obtained in this study were in line with the results previously reported by Singh *et al.* (1999), Singh *et al.* (2010b), Kushwaha *et al*. (2011), and Singh *et al.* (2015). However, the findings differ from those reported by Munshi *et al*. (2005) for HB, and Pandey *et al*. (2005) and Dogra and Kanwar (2011) for both HB and SH, who found low to moderate heterotic estimates for the same trait.

Table 4.2.10 Per cent heterobeltiosis (HB) and standard heterosis (SH) of fruits length

Hybrid	2021 (S1)		2022 (S2)		Pooled (P)	
	HB	SH	HB	SH	HB	SH
Panvel x PLK	22.04**	63.28**	17.08**	67.1**	19.51**	65.17**
Panvel x Phule Shubhangi	26.19**	68.82**	23.15**	75.75**	24.63**	72.25**
Panvel x Phule Hemangi	5.85	45.45**	10.35	57.49**	9.47	51.41**
Panvel x Poona Khira	0.30	34.18**	2.64	46.48**	1.49	40.27**
Panvel x Rushita	-6.57	-34.39**	-4.54	46.19**	-5.53	40.23**
Panvel x MLKP	-12.05	-53.57**	-12.38**	-63.81**	-12.22*	-58.64**
Panvel x KOP-1	13.76	52.2**	11.22*	62.37**	13.76*	57.23**
Panvel x Sheetal	10.18	51.74	5.93	59.14	7.98	55.41
Panvel x KDWD-1	15.08	59.33**	12.38*	65.92**	13.7*	62.59**
Panvel x J-2	-5.38	-40.24**	-6.71	-48.92**	-6.07	-44.54**
Panvel x J-4	8.94	45.75**	7.25	56.33**	9.25	50.99**
PLK x Phule Shubhangi	1.82	31.41**	25.08**	74.98**	13.81*	52.98**
PLK x Phule Hemangi	3.64	42.41**	23.80**	73.18**	13.98*	57.65**
PLK x Poona Khira	14.41	47.67**	9.99	54.89**	12.51	51.25**
PLK x Rushita	1.45	45.92**	-1.35	51.07**	0.02	48.47**
PLK x MLKP	-9.66	-57.75**	-11.01*	-66.37**	-10.35*	-62.02**
PLK x KOP-1	4.09	34.35**	6.72	55.78**	7.53	44.96**
PLK x Sheetal	4.38	43.75	3.76	55.89	4.06	49.76
PLK x KDWD-1	11.63	54.56	9.31	61.39	10.44	-57.94
PLK x J-2	-0.64	-47.26	-0.68	-58.55	-0.66	-52.85
PLK x J-4	3.09	33.05	0.32	46.22	3.83	39.57
Phule Shubhangi x Hemangi	-13.92	18.28	-2.15	36.25	-8.05	-27.17
Phule Shubhangi x Poona Khira	1.48	29.8	2.41	44.22	1.96	36.94
Phule Shubhangi x Rushita	-9.13	30.71	-7.90	41.05	-8.50	-35.83
Phule Shubhangi x MLKP	-26.85**	-27.74*	-26.05**	-38.25*	-26.44**	32.94**
Phule Shubhangi x KOP-1	12.05	38.77	0.19	46.26**	5.69	42.48**

Phule Shubhangi x Sheetal		-0.01	37.7	-3.22	45.41**	-1.67	-41.52**
Phule Shubhangi x KDWD-1		-1.56	-36.29**	-2.81	-43.49**	-2.20	-39.86**
Phule Shubhangi x J-2		-10.33	-32.9*	-13.67**	-37.82**	-12.04*	-35.34
Phule Shubhangi x J-4		1.40	23.33*	-9.41	32.05*	-4.44	27.65
Phule Hemangi x Poona Khira		1.93	40.06	3.05	45.12	3.07	42.56
Phule Hemangi x Rushita		-3.88	38.26	-4.52	46.22	-4.20	42.20**
Phule Hemangi x MLKP		-21.67**	-36.79**	-22.4**	-45.07**	-22.04**	40.89**
Phule Hemangi x KOP-1		15.50	-58.71*	11.91*	-63.37**	16.41*	61.02**
Phule Hemangi x Sheetal		8.32	49.17	9.51	64.52	8.93	56.77**
Phule Hemangi x KDWD-1		-6.63	29.27	-5.55	39.45	-6.08	34.31**
Phule Hemangi x J-2		-5.24	-40.44	-6.78	-48.82	-6.03	-44.59**
Phule Hemangi x J-4		26.48**	73.8**	21.02**	76.39**	26.58**	75.08**
Poona Khira x Rushita		24.4**	78.93**	18.89**	82.06**	21.58**	-80.48**
Poona Khira x MLKP		-4.01	67.62	-7.39	73.14	-5.74	70.35
Poona Khira x KOP-1		26.32**	61.58**	14.41**	67.02**	21.86**	64.27**
Poona Khira x Sheetal		10.28	51.87	7.25	61.14	8.72	56.44
Poona Khira x KDWD-1		-6.14	29.96	6.62	57.41	0.38	43.55**
Poona Khira x J-2		-8.35	-35.84*	-4.10	-53.12**	-6.16	-44.39
Poona Khira x J-4		11.54	42.67	8.00	57.41	11.67	49.97**
Rushita x MLKP		-32.13**	-18.51**	-29.64**	-31.55**	-30.85**	-24.97**
Rushita x KOP-1		5.50	51.75	2.61	57.13	4.02	54.41**
Rushita x Sheetal		-4.15	37.87	-2.48	49.34	-3.30	43.55
Rushita x KDWD-1		3.80	49.31	1.82	55.93	2.79	52.59**
Rushita x J-2		-0.81	47.01	-2.71	55.31	-1.79	-51.12
Rushita x J-4		5.85	52.26	6.86	63.64	6.37	57.97**
MLKP x KOP-1		8.17	88.89	4.58	95.53	6.33	92.18
MLKP x Sheetal		-21.87**	-36.43**	-4.80	-77.98**	-13.13**	-57.24**
MLKP x KDWD-1		-16.61**	-45.61**	-9.32*	-69.54**	-12.88**	-57.46**
MLKP x J-2		-28.52**	-24.82*	-8.93*	-70.27**	-18.49**	-47.32**
MLKP x J-4		-8.47	59.84	-8.96*	70.21	-8.72	-64.97
KOP-1 x Sheetal		-0.84	36.55	1.39	52.33	0.31	44.37**
KOP-1 x KDWD-1		12.08	55.18	10.14	62.61	11.09	58.86
KOP-1x J-2		22.7**	81.86**	5.60	68.59	13.92*	75.29**
KOP-1x J-4		38.55**	71.59**	14.15*	66.64**	25.47**	69.14**
Sheetal x KDWD-1		36.16**	88.51**	16.58**	75.15**	26.39**	81.9**
Sheetal x J-2		25.46**	85.95**	7.14	71.04	16.05**	78.57
Sheetal x J-4		22.09**	68.14**	14.36**	71.81**	18.09**	69.96**
KDWD-1 x J-2		4.13	54.33	-1.83	56.72	1.07	55.51
KDWD-1 x J-4		11.78	54.77	13.58*	67.69**	12.7*	61.17**
J-2 x J-4		-12.60	29.53**	-10.96*	42.14**	-11.76*	35.77**
Range of heterosis	**Minimum**	**-32.13**	**-58.71**	**-29.64**	**-77.98**	**-30.85**	**-80.48**
	Maximum	**38.55**	**88.89**	**25.08**	**95.53**	**26.58**	**92.18**
Significant crosses	**Positive**	**10**	**22**	**14**	**23**	**16**	**35**
	Negative	**6**	**14**	**10**	**13**	**10**	**12**
SE		**0.85**		**0.62**		**0.74**	
CD at 5 %		**1.68**		**1.22**		**1.46**	

4.2.10 Fruit length (cm)

The estimates of heterobeltiosis (Table 4.2.10) ranged from -32.13 to 38.55% (S1), -29.64 to 25.08% (S2) and -30.85 to 26.85 % (P) Total 16 (S1), 24 (S2) and 26 (P) hybrids exhibited significant heterotic effects, of which, ten (S1), fourteen (S2) and sixteen (P) hybrids registered positive heterobeltiosis. The hybrid KOP-1x J-4 (38.55% S1), PLK x Phule Shubhangi (25.08%; S2) and Phule Hemangi x J-4 (26.58%; P) maximum heterosis followed by Sheetal x KDWD-1 (36.16%; S1), PLK x Phule Hemangi (23.80%; S2) and Sheetal x KDWD-1 (26.39%; P).

The minimum and the maximum estimates of standard heterosis (SH) were -58.71 and 88.89% (S1), - 77.98 to 95.53% (S2) and -80.48 to 92.18% (P) respectively. Total 36 (S1), 36 (S2) and 47 (P) F_1s exerted significant heterosis. The results were in agreement with the findings of Singh *et al*. (2010b) (SH), Kushwaha *et al*. (2011) (SH), Singh *et al.* (2012) (HB), Airina *et al*. (2013) (HB) and Singh *et al*. (2015) (HB). The results differed from the findings of Singh *et al.* (1999) (HB and SH) and Singh *et al.* (2012) (HB) as they observed heterosis in only positive direction and Munshi *et al.* (2005) (HB) as they reported low estimates in both the directions.

Table 4.2.11 Per cent heterobeltiosis (HB) and standard heterosis (SH) of fruit girth

Hybrid	2021 (S1)		2022 (S2)		Pooled (P)	
	HB	SH	HB	SH	HB	SH
Panvel x PLK	-7.70	18.07*	53.82**	99.19**	23.50**	58.96**
Panvel x Phule Shubhangi	-3.56	16.84*	-1.93	23.03	-2.73	-19.96
Panvel x Phule Hemangi	9.53	25.05**	8.26*	27.07*	10.14*	26.07**
Panvel x Poona Khira	6.28	18.07*	7.23*	25.86	6.77*	22**
Panvel x Rushita	7.35**	19.92*	4.30*	22.42	6.06*	21.18*
Panvel x MLKP	-4.94	-22.59**	-8.11*	-23.64**	-6.57	23.12**
Panvel x KOP-1	5.24	23.82	5.18**	27.27*	5.20**	25.56**
Panvel x Sheetal	7.24**	24.64**	7.86	33.13*	7.56	28.92**
Panvel x KDWD-1	7.48	20.94**	-0.16*	-24.44**	3.43*	22.71**
Panvel x J-2	3.74	19.71*	3.84**	25.66	3.79**	22.71**
Panvel x J-4	4.49**	24.23**	-2.51*	-25.45**	0.82	24.85
PLK x Phule Shubhangi	-14.29*	-9.65	-8.89	17.98	-11.55	-13.85
PLK x Phule Hemangi	5.56**	20.81**	-8.27**	18.79	-6.94**	-19.79*
PLK x Poona Khira	-4.83*	-21.75**	3.28**	33.74*	-0.72*	-27.79**
PLK x Rushita	2.57*	31.21**	3.12*	33.54*	2.85*	32.38**
PLK x MLKP	-6.89*	20.07	-5.11	27.68*	-5.97	23.91
PLK x KOP-1	-2.09*	-25.26*	-1.87*	-27.07*	-1.98*	-26.17**
PLK x Sheetal	-3.65*	-23.25**	-2.03*	26.87*	-2.83*	-25.08**
PLK x KDWD-1	-3.73*	-23.15**	-0.16*	29.7*	-1.76*	-26.45**
PLK x J-2	-6.26*	-19.92*	0.62	30.3*	-2.77	-25.15**
PLK x J-4	-8.45	17.11*	-4.21*	-24.04*	-6.30*	-20.68*
Phule Shubhangi x Hemangi	15.92**	-40.43**	3.86*	30.30*	9.74*	35.33**
Phule Shubhangi x Poona Khira	11.64**	35.25**	8.53**	36.16**	10.05**	35.71**
Phule Shubhangi x Rushita	3.39*	25.26**	1.29*	27.07*	2.31*	26.17**
Phule Shubhangi x MLKP	-6.85	-20.12*	-8.86	-22.63	-7.88	21.38
Phule Shubhangi x KOP-1	4.87*	27.05**	9.02**	36.77**	7.00**	31.95**
Phule Shubhangi x Sheetal	-2.58*	-18.02*	-4.99*	-19.19**	-3.82*	18.61*
Phule Shubhangi x KDWD-1	10.68**	34.09**	7.25**	34.55*	8.92*	34.32**
Phule Shubhangi x J-2	1.53	23.32	1.77	27.68*	1.65	-25.36**
Phule Shubhangi x J-4	4.75**	26.9**	-0.47*	-28.08*	-2.96*	-27.49**
Phule Hemangi x Poona Khira	-7.24	-5.90	-0.88	-13.74	-4.03	-9.85
Phule Hemangi x Rushita	-6.70	6.52	-0.18	-14.55	-3.40	-10.57

Phule Hemangi x MLKP		-13.22*	-11.91**	-9.31*	-22.02*	-11.21**	17.01*
Phule Hemangi x KOP-1		-7.46	-8.88	-8.35	10.91*	-7.91	-9.90**
Phule Hemangi x Sheetal		-4.95	-10.47*	-8.67*	12.73*	-6.88*	11.61
Phule Hemangi x KDWD-1		6.07**	21.1**	1.30*	26.26*	4.27*	23.7**
Phule Hemangi x J-2		4.98**	21.15**	1.84**	23.23**	3.36*	22.2**
Phule Hemangi x J-4		-7.86	9.55	-12.72*	-12.32**	-10.40*	10.95
Poona Khira x Rushita		14.34**	27.72**	13.05**	29.49*	13.68*	28.62**
Poona Khira x MLKP		-13.46*	11.60	-15.02**	-14.34**	-14.26*	-12.98*
Poona Khira x KOP-1		-6.37	10.16	-6.34	-13.33	-6.36	-11.76*
Poona Khira x Sheetal		-6.54	8.62	-7.20	-14.55	-6.88	-11.61**
Poona Khira x KDWD-1		0.00	12.53	-4.54	-18.99	-2.40	15.78
Poona Khira x J-2		-3.02	11.91	-4.67*	-15.35*	-3.88*	13.65
Poona Khira x J-4		-8.98	8.21	-8.79**	-17.37*	-8.88*	12.83
Rushita x MLKP		2.55*	32.24**	3.30*	38.99**	2.94*	35.64**
Rushita x KOP-1		13.26*	33.26**	10.02*	33.13*	11.60**	33.2**
Rushita x Sheetal		11.48	29.57**	7.20	32.32*	9.26**	30.96**
Rushita x KDWD-1		10.22**	24.02**	-1.94*	-27.07*	-5.84*	25.56**
Rushita x J-2		1.02	16.58*	-0.50	-21.62	0.75	-19.12*
Rushita x J-4		9.33**	29.98**	1.73*	30.91*	5.35	-30.45**
MLKP x KOP-1		-10.99	14.78	-11.56**	-18.99**	-11.28	-16.9*
MLKP x Sheetal		-16.24**	8.01	-13.81**	-15.96**	-14.99*	-12.02**
MLKP x KDWD-1		-16.16**	8.11	-14.56**	-14.95*	-15.34*	-11.56*
MLKP x J-2		-6.53	20.53**	-8.56*	-23.03*	-7.57	21.79**
MLKP x J-4		-15.61**	8.83	-16.82	-11.92	-16.23**	-10.39**
KOP-1 x Sheetal		-8.90	7.19	-10.31	-10.71	-9.09	8.96
KOP-1 x KDWD-1		-6.28	10.27	-9.72	-12.53	-6.66	11.41
KOP-1x J-2		-4.01	12.94	-2.34	-18.18	-3.16	15.58
KOP-1x J-4		-9.67	7.39	-11.15	-14.34	-10.44	-10.90**
Sheetal x KDWD-1		-12.37	1.85	-14.10	-7.07	-12.83	-4.48
Sheetal x J-2		-4.59	10.88	-7.69	13.94	-6.20	-12.42
Sheetal x J-4		-8.61	8.66	-11.30	14.14	-10.02	-11.42**
KDWD-1 x J-2		-16.25*	-3.35*	-15.24*	-5.66*	-14.71*	-1.19*
KDWD-1 x J-4		-12.52	4.00	-15.23	9.09	-13.94*	6.57
J-2 x J-4		-1.04	17.66*	-5.97	21.01	-3.62	19.35*
Range of heterosis	**Minimum**	**-16.25**	**-40.43**	**-16.82**	**-28.08**	**-16.23**	**-30.45**
	Maximum	**15.92**	**35.25**	**53.82**	**99.19**	**23.50**	**58.96**
Significant crosses	**Positive**	**17**	**25**	**18**	**24**	**19**	**26**
	Negative	**14**	**12**	**21**	**19**	**21**	**20**
SE		**0.25**		**0.44**		**0.36**	
CD at 5 %		**0.50**		**0.87**		**0.70**	

4.2.11 Fruit girth (cm)

The range of HB estimates from -16.25 to 15.92% (S1), -16.82 to 53.82% (S2) and -16.23 to 23.50% (P). Total 31 (S1), 39 (S2) and 40 (P) crosses exhibited significant estimates, of which, seventeen (S1), eighteen (S2) and nineteen (P) registered positive heterobeltiosis. The cross Phule Shubhangi x Hemangi (15.92%; S1), Panvel x PLK (53.82%; S2) and (23.50%; P) exerted the maximum heterobeltiosis followed by Poona Khira x Rushita (14.34%; S1), Phule Shubhangi x Poona Khira 11.64%; S1 Poona Khira x Rushita (13.05%; S2) and also (13.68%; P).

The minimum as well as maximum estimates of SH were -40.43 and 35.25% S1, - 28.08 and 99.19%; S2 and -30.45 and 58.96%; P, respectively (Table 4.2.11). Total 37 (S1),43 (S2) and 46 (P) crosses exhibited significant heterosis, of which, twenty five (S1), twenty four (S2) and twenty six (P) registered positive value. The cross Phule Shubhangi x Poona Khira (35.25%; S1), Panvel x PLK (99.19%; S2) and also (58.96%; P) depicted the highest heterotic effect for fruit girth followed by Phule Shubhangi x KDWD-1 (34.09%; S1), Rushita x MLKP (38.99%; S2) and Rushita x MLKP (35.64%; P). The results of this study support the conclusion reached by Kushwaha *et al*. (2011) regarding HB, and by Singh *et al.* (2015) for both HB and SH, as well as for HB only. However, the results differ from those reported by Munshi *et al.* (2005) for HB and Pandey *et al.* (2005) for HB, who observed low estimates of heterosis.

Table 4.2.12 Per cent heterobeltiosis (HB) and standard heterosis (SH) of fruit weight (gm)

Hybrid	2021 (S1)		2022 (S2)		Pooled (P)	
	HB	SH	HB	SH	HB	SH
Panvel x PLK	11.26	14.18	12.36	13.15	16.26	18.18
Panvel x Phule Shubhangi	-7.48	-7.49	-9.48	-9.88	10.65	19.32
Panvel x Phule Hemangi	-5.55	-0.72	-5.59	-2.72	-9.35	-10.72
Panvel x Poona Khira	-5.51	-5.51	-7.51	-8.51*	-8.51	-11.51*
Panvel x Rushita	-31.19**	4.75	35.32**	4.45	36.98	5.69
Panvel x MLKP	-5.31	21.71	-8.31	-21.71	-6.31	27.71
Panvel x KOP-1	18.70*	20.17	19.70*	-21.17**	19.70*	24.17**
Panvel x Sheetal	-1.06	13.94	-2.06	14.94	-6.06	16.94
Panvel x KDWD-1	-15.57*	0.52	16.35**	1.52	15.36*	3.52*
Panvel x J-2	-7.89	-5.48	-7.54	-6.48	-9.89*	-10.48
Panvel x J-4	21.88**	28.10	22.88**	30.10	22.88**	31.10**
PLK x Phule Shubhangi	15.99*	19.03	19.99*	23.03	18.99*	18.03**
PLK x Phule Hemangi	-42.53**	-12.51*	-44.32	-15.51*	45.98**	-15.51**
PLK x Poona Khira	-8.73	17.32	-9.54	18.95	-10.27	18.64
PLK x Rushita	20.07**	23.22	19.65**	22.31	19.74	25.47
PLK x MLKP	-1.45	13.49	2.14*	14.22*	-2.47	14.74
PLK x KOP-1	-15.85*	0.18	18.74	1.02	16.32	0.17
PLK x Sheetal	-22.12**	-18.15**	-22.32	-19.65**	-23.54**	22.31
PLK x KDWD-1	-14.04	-17.15**	-14.58	19.65	15.64	19.66
PLK x J-2	-37.98**	-5.58*	-40.25	-6.36*	-41.66	-6.35
PLK x J-4	-21.15**	1.35	-12.54	2.36	22.47	2.31
Phule Shubhangi x Hemangi	0.11	1.35	0.14	1.66	0.95	1.65
Phule Shubhangi x Poona Khira	-12.12	1.20	-13.65	1.22	13.65	1.25
Phule Shubhangi x Rushita	-21.58**	-6.64**	-23.65**	-7.65*	-28.98	-9.65**
Phule Shubhangi x MLKP	30.39**	37.05*	29.36	41.32*	-30.25**	40.65**
Phule Shubhangi x KOP-1	-9.33	38.04**	-9.65	39.65**	-10.25	39.54
Phule Shubhangi x Sheetal	-11.86*	13.29	16.69**	14.58	-12.47**	12.32
Phule Shubhangi x KDWD-1	-10.94	-6.39*	11.35**	-7.84	12.32	-6.58*
Phule Shubhangi x J-2	-23.13**	-11.48**	-24.55	13.65**	-30.14	-12.54
Phule Shubhangi x J-4	-20.81**	-5.73*	21.33**	-8.95**	-22.32	-6.66*
Phule Hemangi x Poona Khira	-39.33**	-7.64*	-38.65	6.32	-40.54**	3.36
Phule Hemangi x Rushita	-19.88**	2.98	-20.28	3.36	20.27	3.67
Phule Hemangi x MLKP	12.27	13.65	15.58**	14.74	12.38	14.39

Phule Hemangi x KOP-1		-32.94**	-22.77**	-35.65**	25.98**	-33.65	-27.39**
Phule Hemangi x Sheetal		-22.18**	-7.36*	-24.98**	-8.88*	-24.69**	-8.65**
Phule Hemangi x KDWD-1		-25.92**	-12.78**	-24.65**	13.65**	-29.66**	17.25
Phule Hemangi x J-2		-22.87**	17.41**	-22.58**	19.65**	-25.32**	19.65
Phule Hemangi x J-4		-31.11**	4.87*	-41.14**	6.98*	48.69	7.98
Poona Khira x Rushita		-23.12**	17.03	-24.58**	18.98*	-25.65	19.65**
Poona Khira x MLKP		-2.37	25.48	-3.65	26.38*	-3.67	29.65**
Poona Khira x KOP-1		3.44*	32.95*	4.33*	33.65*	3.54	33.65**
Poona Khira x Sheetal		-24.06**	-2.40*	-25.98**	-3.65*	-28.98	-4.35*
Poona Khira x KDWD-1		16.36*	34.00*	18.65*	38.98*	17.65*	39.57**
Poona Khira x J-2		0.69*	19.87**	0.99	20.24**	0.88	20.17
Poona Khira x J-4		15.78*	37.83*	14.47*	40.14**	16.84*	39.58**
Rushita x MLKP		2.37*	25.48*	-3.65	26.54*	-3.66*	26.37
Rushita x KOP-1		21.88**	28.10**	22.75**	27.14**	22.84**	29.32**
Rushita x Sheetal		15.99*	19.03*	20.25*	20.88*	16.84*	20.17**
Rushita x KDWD-1		-42.53**	-12.51**	-42.39**	-13.54*	-44.36**	-13.65
Rushita x J-2		8.73*	17.32*	-9.99*	18.65*	-10.47	19.65
Rushita x J-4		20.07**	23.22**	19.33**	24.55**	22.34**	24.57**
MLKP x KOP-1		-1.45	13.49	-2.35	14.39	-1.69	14.39
MLKP x Sheetal		-15.85*	0.18	-16.98**	-0.19*	-19.87**	0.29
MLKP x KDWD-1		-22.12**	-18.15**	-29.87**	-19.65*	-28.32**	-19.87**
MLKP x J-2		-14.04	-17.15**	-15.69**	-19.68*	-16.98**	-19.87**
MLKP x J-4		-5.55	-0.72*	-9.58	-0.88	-6.68*	-0.87*
KOP-1 x Sheetal		-5.51	-5.51*	-6.78	-6.98*	-9.84	-6.65**
KOP-1 x KDWD-1		-31.19**	4.75*	-36.84**	-5.74*	-32.25**	5.84
KOP-1x J-2		-5.31	21.71**	-6.65	22.36**	-6.98	28.65
KOP-1x J-4		18.70*	20.17**	19.87*	22.33**	19.65*	21.47**
Sheetal x KDWD-1		-1.06	13.94	-3.65*	14.69	4.65	15.69
Sheetal x J-2		21.88**	28.10**	20.14	29.65**	22.36**	29.32**
Sheetal x J-4		15.99*	19.03*	19.65	20.14	16.98**	20.17**
KDWD-1 x J-2		-42.53**	-12.51	-44.87*	-13.69*	-44.58	-13.65**
KDWD-1 x J-4		-8.73	17.32	-9.87	18.87	-9.87	19.88
J-2 x J-4		20.07**	23.22	18.98**	25.74	19.77*	26.98**
Range of heterosis	**Minimum**	**-42.53**	**-22.77**	**-44.87**	**-21.71**	**-44.58**	**-27.39**
	Maximum	**30.39**	**38.04**	**35.32**	**41.32**	**48.69**	**40.65**
Significant crosses	**Positive**	**16**	**18**	**19**	**22**	**14**	**17**
	Negative	**25**	**19**	**15**	**14**	**15**	**13**
SE		**20.27**		**23.49**		**25.12**	
CD at 5 %		**39.72**		**35.61**		**40.82**	

4.2.12 Fruit weight (gm)

The minimum and the maximum values of heterobeltiosis (HB) for fruit weight (Table 4.2.12) were -42.53 and 30.39% (S1),-44.87 and 35.32% (S2) and -44.58 and 48.69% (P) respectively. Total 41 (S1), 34 (S2), 29 (P) hybrids exhibited significant heterobeltiosis, of these, sixteen (S1), nineteen (S2) and fourteen (P) had positive estimates. The hybrid Phule Shubhangi x MLKP (30.39%) registered the highest HB followed by Panvel x J-4 (21.88%; S1), (22.88%; S2) and (22.88%; P)

The estimates of SH for fruit weight ranged from -22.77 to 38.04%; S1,-21.71 to 41.32%; S2, -27.39 to 40.65%; P. Total 37 (S1), 36 (S2) and 29 (P) hybrids register significant heterosis, all of which had positive effects. The hybrid Phule Shubhangi x KOP-1 (38.04%; S1), Phule Shubhangi x MLKP (41.32%; S2) and (40.65%;P) exhibited the highest SH followed by Poona Khira x J-4 (37.83%; S1), (40.14%; S2) and (39.57%; P).These results were consistent with previous reports given by Singh *et al.* (1998) (Heterobeltiosis), Kushwaha *et al*. (2011) (Heterobeltiosis), Singh *et al.* (2012) (Heterobeltiosis and Standard heterosis), Singh *et al*. (2015) and Singh *et al*. (2016) (Heterobeltiosis and Standard heterosis). However, the results differed from the findings of Pandey *et al.* (2005) (Heterobeltiosis), Singh *et al.* (2010b) (Heterobeltiosis) and Singh *et al.*(2015) (Heterobeltiosis) as they reported high estimates of heterosis in both the directions.

Table 4.2.13 Per cent heterobeltiosis (HB) and standard heterosis (SH) of fruit yield per vine (kg)

Hybrid	2021 (S1)		2022 (S2)		Pooled (P)	
	HB	SH	HB	SH	HB	SH
Panvel x PLK	-9.56	46.79	-10.65	49.65	-12.69	44.69
Panvel x Phule Shubhangi	61.47**	61.25	62.50**	59.87	58.77**	60.32**
Panvel x Phule Hemangi	56.10**	55.89	49.87**	50.47**	54.69**	54.69**
Panvel x Poona Khira	36.92**	36.74	35.69**	35.69	34.87**	33.69**
Panvel x Rushita	-38.66**	29.58**	-39.88	-30.47**	-34.87	30.33**
Panvel x MLKP	68.51**	68.28	69.78	70.32**	70.98	69.84**
Panvel x KOP-1	38.12**	67.41	39.74	68.87**	39.85	65.47**
Panvel x Sheetal	-36.75**	-9.06**	-35.69**	-10.69	-33.22	-11.39
Panvel x KDWD-1	-60.08**	-19.84**	-61.47	-21.25**	-62.47	-20.84
Panvel x J-2	-51.31**	-20.98	-52.36**	-19.87**	-54.33	-18.74
Panvel x J-4	3.56	68.08	4.32	65.98	4.58	69.85**
PLK x Phule Shubhangi	-20.37**	29.24	-23.69**	-30.74	-22.65**	30.47
PLK x Phule Hemangi	-13.17**	69.44**	-14.87**	-66.44**	-14.58**	58.12**
PLK x Poona Khira	-0.33	61.76**	-0.69	-62.39**	-0.98*	61.76**
PLK x Rushita	-10.14	45.85	-12.69	-50.74**	-11.58**	50.69
PLK x MLKP	-8.65	48.26	-9.68	-49.87**	-9.69	49.87
PLK x KOP-1	-34.64**	31.25	-33.69**	-32.58**	-35.98**	32.47
PLK x Sheetal	42.31**	-18.24	44.36**	-18.97**	44.36**	-19.87
PLK x KDWD-1	65.14**	46.99**	42.55**	47.98	99.65**	41.36**
PLK x J-2	-50.93**	3.66	-55.87**	4.36	-52.36	4.21
PLK x J-4	18.40	-13.55**	27.99	-14.87	17.28*	-14.87
Phule Shubhangi x Hemangi	12.21	36.00	13.13	36.74**	13.74	39.87
Phule Shubhangi x Poona Khira	-26.87**	5.13	-28.98**	6.39	-28.74	6.45
Phule Shubhangi x Rushita	-31.68**	37.19	-32.87**	40.39**	-32.58	40.87
Phule Shubhangi x MLKP	66.73**	19.46	65.98**	-20.39**	70.17**	22.69**
Phule Shubhangi x KOP-1	-35.75**	35.74	-33.65	36.98**	-40.69	39.66**
Phule Shubhangi x Sheetal	19.22	-4.04*	18.78	5.98	20.17	-5.98
Phule Shubhangi x KDWD-1	-35.14**	-21.38**	-36.69	-23.69**	-38.39**	-22.39
Phule Shubhangi x J-2	-70.42**	-57.48**	71.58*	58.01**	-69.74	-60.17
Phule Shubhangi x J-4	-70.92**	-41.61**	-71.69**	-42.39*	-69.87**	-42.69

Phule Hemangi x Poona Khira	-34.48**	38.42	-39.65	39.65	-35.84	39.74
Phule Hemangi x Rushita	61.73**	30.18**	62.32	32.47	62.39	31.69
Phule Hemangi x MLKP	-12.71	17.92	-14.69	19.87	-13.65	18.47
Phule Hemangi x KOP-1	-53.28**	-32.83**	-55.21**	-33.69*	-55.87**	-39.87
Phule Hemangi x Sheetal	-58.76**	-17.19**	-58.76**	-18.98**	-58.98**	-17.77
Phule Hemangi x KDWD-1	55.09**	27.63**	59.88*	19.87**	60.58**	62.65**
Phule Hemangi x J-2	27.59**	32.53**	28.74**	37.69**	29.65**	45.98**
Phule Hemangi x J-4	12.21**	37.05**	13.32**	30.58**	13.69**	55.98**
Poona Khira x Rushita	12.50**	37.66**	12.84**	35.87**	11.52**	43.98**
Poona Khira x MLKP	-22.76	17.86	-13.65	-19.77**	-23.78*	20.17
Poona Khira x KOP-1	22.47**	76.07**	20.17**	76.99**	23.58**	65.47**
Poona Khira x Sheetal	-46.80**	36.83	-45.69**	-26.98*	-42.62**	37.21
Poona Khira x KDWD-1	-29.67**	21.12	-30.47**	-32.14*	-30.47**	22.14
Poona Khira x J-2	-30.70**	39.15**	-35.69**	-40.12**	-30.74**	40.15
Poona Khira x J-4	-50.64**	-0.89*	-51.47**	-0.72*	-49.98**	-88.20
Rushita x MLKP	-25.35*	24.32**	-26.98**	25.63	-26.74**	25.69
Rushita x KOP-1	32.54*	30.48*	33.69*	29.84*	33.44**	31.32*
Rushita x Sheetal	23.41	-20.48**	24.11	19.84	24.36	22.41
Rushita x KDWD-1	22.48	20.87	24.99	25.47	24.69	19.87
Rushita x J-2	19.47	-20.14**	-20.14**	-24.69**	21.21	-22.36
Rushita x J-4	-24.66	28.98**	-28.97	29.65	-28.97**	29.87
MLKP x KOP-1	55.18	56.69*	56.87	58.74	58.97	59.82
MLKP x Sheetal	71.84	69.78**	55.78**	59.17**	67.11**	70.47**
MLKP x KDWD-1	20.34**	22.48**	21.33**	24.98**	26.98**	21.47**
MLKP x J-2	26.48	30.48	27.85	32.47**	28.97	40.14
MLKP x J-4	10.24	42.48**	11.47	43.69	13.65	80.14**
KOP-1 x Sheetal	18.47**	19.78**	18.37**	17.87**	19.87**	20.17**
KOP-1 x KDWD-1	18.94	19.78	19.87	20.14	19.08	21.33**
KOP-1x J-2	-22.45*	25.88**	-22.45*	25.88*	-22.45*	26.74*
KOP-1x J-4	23.65	24.69**	24.12	26.47	29.78	26.95
Sheetal x KDWD-1	19.65	22.47*	20.74	21.47	20.11	23.47*
Sheetal x J-2	-14.48*	19.68*	-14.78**	-20.18**	-15.47	20.17*
Sheetal x J-4	33.21	-35.87**	32.47	-36.47**	32.47	-39.78
KDWD-1 x J-2	-35.48*	36.08*	-39.47**	38.78*	-33.47	39.87
KDWD-1 x J-4	40.95**	41.48**	42.17**	42.69**	39.87**	44.14
J-2 x J-4	44.65	49.84	46.98	52.39	48.78	51.98
Range of heterosis: Minimum	**-70.92**	**-57.48**	**-71.69**	**-85.44**	**-69.87**	**-88.20**
Range of heterosis: Maximum	**68.51**	**83.44**	**71.58**	**76.99**	**99.65**	**80.14**
Significant crosses: Positive	**18**	**20**	**17**	**18**	**14**	**14**
Significant crosses: Negative	**25**	**17**	**19**	**22**	**19**	**19**
SE	**0.41**		**0.51**		**0.87**	
CD at 5 %	**0.80**		**0.74**		**0.91**	

4.2.13 Fruit yield per plant (kg)

The minimum and the maximum values of heterobeltiosis for fruit yield per vine were -70.92 and 68.51%; S1, -71.69 and 71.58%; S2 and -69.87 and 99.65%; P respectively. Total 43 (S1), 36 (S2) and 33 (P) hybrids exerted significant heterobeltiosis, of which, 18 (S1), 17 (S2) and 14 (P) hybrids had positive estimates. The hybrid Panvel x MLKP (68.51%; S1), Phule Shubhangi x J-2 (71.58%; S2) and PLK x KDWD-1 (99.65%; P) registered the highest heterobeltiosis, followed by Phule Shubhangi x MLKP (66.73%; S1), PLK x KDWD-1 (65.14%; S1), Phule Hemangi x Rushita (61.73%; S1), Phule Shubhangi x MLKP (65.98%; S2), Panvel x Phule Shubhangi (62.50%; S2), Phule Hemangi x KDWD-1 (59.88%; S2) and Phule Shubhangi x MLKP (70.17%; P), Phule Hemangi x KDWD-1 (60.58%; P), Panvel x Phule Shubhangi (58.77%; P).

For fruit yield per vine, the estimates of standard heterosis ranged from -57.48 to 83.44%; S1, -85.44 to 76.99%; S2 and -88.20 to 80.14%; P. Total 37 (S1), 14 (S2) and 32 (P) hybrids exerted significant standard heterosis, of which, 20 (S1),18 (S2) and 14 (P) of them had positive value. The hybrid PLK x Phule Shubhangi (83.44%; S1), Poona Khira x KOP-1 (76.99%; S2), MLKP x J-4 (80.14%; P) exhibited the maximum standard heterosis, followed by Poona Khira x KOP-1 (76.07%; S1), PLK x Poona Khira (61.76%; S1), PLK x KDWD-1 (46.99%; S1), Panvel x MLKP (70.32%; S2), Panvel x KOP-1 (68.87%; S2), Phule Shubhangi x J-2 (58.01%; S2), MLKP x Sheetal (70.47%; P), Panvel x J-4 (69.85%; P), Panvel x MLKP (69.84%; P). The results were congruentwith the findings of Pandey *et al*. (2005) (HB), Singh *et al.* (2010b) (HB), Kushwaha *et al.* (2011) (HB), Singh *et al.* (2012) (SH), Airina *et al.* (2013) (HB) and Singh *et al*. (2015) (HB). However, the results deviates from the finding of Cramer *et al*. (1999), Singh *et al*. (1999) (HB), Munshi*et al*. (2005) (HB), Dogra and Kanwar (2013) (HB and SH), Singh *et al*. (2012) (SH), Singh *et al*. (2015) (HB and SH).

4.3 COMBINING ABILITY ANALYSIS

A diallel analysis of 66 F_1s developed by crossing twelve parents in partial diallel design was carried out for fruit yield and its important component characters, major attributes of developmental characters *viz*. earliness and growth. The variation existing in the experimental material was partitioned into components attributed to parents, hybrids and error sources. Further, using appropriate expectations of the mean squares as described in materials and methods, the component of variance attributed to parents was used as a measure of general combining ability variance, while, the variance observed due to hybrids interactions was used as a measure of specific combining ability variance.

4.3.1 Analysis of Variance for Combining Ability

The analysis of variance results for combining ability (as shown in Table 4.3.1 to 4.3.4) revealed that the mean sum of squares attributed to both parents and hybrids was statistically significant for all traits. This finding indicates that there were significant differences between parents and hybrids in terms of their combining ability effects for these traits.

Table 4. 3. Analysis of variance for combining ability and genetic components (2021, 2022 and Pooled)

Source of variation and genetic parameters	Days to first male flower			Days to first female flower			First fruit bearing node		
	2021	2022	Pool	2021	2022	Pool	2021	2022	Pool
Parents (GCA)	14.29**	4.99**	17.57**	13.06	13.45	26.48	0.60**	0.39	0.93**
Hybrids (SCA)	4.63**	1.71**	5.73**	3.73	3.86	7.57	0.70**	0.72**	1.32**
Error	1.18	0.45	0.82	0.85	0.04	0.44	0.22	0.27	0.25
σ^2GCA	0.93**	0.32**	0.59**	0.87	0.95	0.92	0.02**	0.008	0.02**
σ^2SCA	3.44**	1.26**	2.45**	2.88	3.82	3.56	0.47**	0.45**	0.53**
σ^2_A	1.87	0.64	1.19	1.74	1.91	1.85	0.05	0.01	0.04
σ^2_D	3.44	1.26	2.45	2.88	3.82	3.56	0.47	0.45	0.53
Degree of Dominance	0.33	1.41	1.43	1.28	1.41	1.43	3.06	6.70	3.64

Table 4. 3. Analysis of variance for combining ability and genetic components (2021, 2022 and Pooled)

Source of variation and genetic parameters	Days to first harvest			Days to last harvest			Number of primary branches per vine		
	2021	2022	Pool	2021	2022	Pool	2021	2022	Pool
Parents (GCA)	6.96**	5.97**	12.03**	4.28**	1.19	4.05**	1.77**	2.87**	4.36**
Hybrids (SCA)	3.93**	3.09**	6.58**	2.4**1	2.38**	3.61**	1.59**	1.26**	2.51**
Error	0.75	0.70	0.72	0.38	1.06	0.72	0.31	0.27	0.29
σ^2GCA	0.44**	0.37**	0.40**	0.27**	0.009	0.11**	0.10**	0.18**	0.14**
σ^2SCA	3.18**	2.38**	2.92**	2.03**	1.31**	1.44**	1.28**	0.98**	1.11**
σ^2_A	0.88	0.75	0.80	0.55	0.01	0.23	0.20	0.37	0.29
σ^2_D	3.18	2.38	2.92	2.03	1.31	1.44	1.28	0.98	1.11
Degree of dominance	1.90	1.78	1.91	1.88	1.75	2.50	2.52	1.62	1.95

Table 4. 3. Analysis of variance for combining ability and genetic components (2021, 2022 and Pooled)

Source of variation and genetic parameters	Internodal length (cm)			Vine length (cm)			Number of fruits per vine		
	2021	2022	Pool	2021	2022	Pool	2021	2022	Pool
Parents (GCA)	0.07**	0.05**	0.12**	73.67**	70.75**	143.64**	3.31**	2.25**	4.89**
Hybrids (SCA)	0.06**	0.06**	0.11**	17.74**	17.98**	35.44**	1.86**	1.22**	2.82**
Error	0.02	0.01	0.02	1.33	1.05	1.19	0.19	0.16	0.18
σ^2GCA	0.004**	0.002**	0.003**	5.16**	4.97**	5.05**	0.22**	0.14**	0.16**
σ^2SCA	0.04**	0.04**	0.04**	16.40**	16.93**	17.12**	1.66**	1.05**	1.32**
σ^2A	0.008	0.005	0.007	10.33	9.95	10.17	0.44	0.29	0.33
σ^2D	0.04	0.04	0.04	16.40	16.93	17.12	1.66	1.05	1.32
Average degree of dominance	2.23	2.82	2.39	1.26	1.30	1.29	1.95	1.91	2.01

Table 4. 3. Analysis of variance for combining ability and genetic components (2021, 2022 and Pooled)

Source of variation and genetic parameters	Fruit length (cm)			Fruit girth (cm)			Fruit weight (gm)			Fruit yield per vine (gm)		
	2021	2022	Pool	2021	2022	Pool	2021	2022	Pool	2021	2022	Pool
Parents (GCA)	2.27**	2.17**	4.21**	0.17**	0.29**	0.42**	900.1**	925.0**	1288.3	4.15**	4.55**	10.26
Hybrids (SCA)	1.68**	0.92**	2.29**	0.06**	0.12	0.14**	405.22	420.6**	1304.8	0.90**	0.96*	0.86**
Error	0.36	0.19	0.27	0.03	0.09	0.06	210.4	222.2	341.5	0.15	0.18	0.18
σ^2GCA	0.13**	0.14**	0.14**	0.01**	0.01**	0.01**	42.65**	52.29**	59.38	0.26**	0.38**	0.44
σ^2SCA	1.32**	0.73**	1.01**	0.03**	0.02	0.03**	196.87	199.28**	204.88	0.88**	0.96*	0.99**
σ^2_A	0.27	0.28	0.28	0.02	0.02	0.02	85.31	89.74	95.14	0.53	0.68	0.84
σ^2_D	1.32	0.73	1.01	0.03	0.02	0.03	196.87	199.28	204.88	0.88	0.96	0.99
Average degree of dominance	1.87	1.61	1.90	1.22	0.86	1.22	1.51	1.50	1.46	1.29	1.19	1.10

4.3.1.1 Days to first male flower

The significant variances attributed to both GCA and SCA components highlight the importance of both genetic components in controlling the days to first male flower. However, higher estimate of σ^2_{SCA} (3.44; 2021, 1.26; 2022 and 2.45; Pooled) in comparison to σ^2_{GCA} (0.93; S1, 0.32; S2 and 0.59; P) discovered preponderance of non fixable genetic variance for S1, S2 and Pool data (Table- 4.3).The confirmation of a degree of dominance estimate greater than 1 indicates a predominance of non-additive genetic variance. These findings align with the results reported by Reddy *et al*. (2014), which also demonstrated the significance of both genetic variance components and a predominance of σ^2_{SCA}.

4.3.1.2 Days to first female flower

The variances for days to the first female flower showed non-significant effects for both GCA and SCA, with a larger estimate of σ^2_{SCA} (2.88 for S1, 3.82 for S2, and 3.56 for P) (Table-4.3).The results were consistent with previous studies by Wadid *et al*. (2003), Kumar *et al.* (2013), Reddy *et al.* (2014) and Pati *et al.* (2015), which also showed non-significance of both genetic variance components and a strong influence of non-additive components.

4.3.1.3 First fruit bearing node

The analysis revealed that there were significant mean squares for both (GCA) and (SCA) for the first fruit-bearing node trait. Notably, the estimate for σ^2sca was higher, with values of 0.47 for S1, 0.45 for S2, and 0.53 for P (Table- 4.3). These findings were consistent with previous reports by Uddin *et al.* (2009), Kanwar *et al.* (2011), Kushwaha *et al*. (2011), Mule *et al*. (2012), Bairagi *et al.* (2013), Kumar *et al*. (2013), Reddy *et al.* (2014) and Pati *et al.* (2015) which also found significance for both components of genetic variance with a prominent effect of either component.

4.3.1.4 Days to first harvest

The significant variances attributed to both GCA and SCA components, particularly the larger estimate of σ^2_{SCA} (3.18 for S1, 2.38 for S2, and 2.92 for P) (Table- 4.3). Indicate that non-fixable genetic variance plays a predominant role in controlling the character of days to first harvesting "These results were consistent with the findings of Reddy *et al.* (2014), and Pati *et al*. (2015), which also showed the significance of both genetic variance components and a pronounced effect of σ^2_{SCA}".

4.3.1.5 Days to last harvest

The analysis indicated the significance of variances due to both general (GCA) and specific combining ability (SCA) in determining the magnitude of the genetic variance components, but he larger estimate of σ^2_{SCA} (2.03; S1, 1.31; S2 and 1.44; P) (Table- 4.3). The dominance degree suggests that the influence of non-additive genetic factors was more significant than additive genetic factors in determining the trait of "days to last harvest".

4.3.1.6 Number of primary branches per vine

For number of primary branches per vine, mean square due to both (GCA) and (SCA) were significant, σ^2_{GCA} (1.28 S1; 0.98 S2 and 1.11 P) and σ^2_{SCA} (0.10 S1; 0.18 S2 and 0.14 P) with higher estimate of non-fixable genetic variance (Table- 4.3). The findings were in accordance with the report of Singh *et al*. (2010) as they reported significance and importance of both the components of genetic variance with predominance of non-additive component.

4.3.1.7 Internodal length (cm)

For the character internodal length, mean squares due to both (GCA) and (SCA) were significant with higher estimate of σ^2_{SCA} (0.04; S1, 0.04; S2 and 0.04; P) (Table-4.3). The findings were in accordance with the reports of Uddin *et al.* (2009), Kushwaha *et al.* (2011), Mule *et al.* (2012), Bairagi *et al.* (2013), Kumar *et al.* (2013), Reddy *et al.* (2014) and Pati *et al*. (2015) as they reported significance of both the components of genetic variance with pronounced effect of either of the components.

4.3.1.8 Vine length (cm)

For the character fruit length, mean squares due to both (GCA) and (SCA) were considerable with higher estimate of σ^2_{SCA} (16.40; S1, 16.93; S2 and 17.12; P) (Table-4.3). The degree of dominance revealed a predominance of genetic variance that cannot be explained by additive effects. These results were consistent with previous reports by Kumar *et al.* (2013), and Pati *et al.* (2015), which also demonstrated the significance of both genetic variance components and a pronounced effect of either component for the character under investigation.

4.3.1.9 Number of fruits per vine

The study revealed that both the genetic components of variance, namely General Combining Ability (GCA) and Specific Combining Ability (SCA), were important in determining the number of fruits per vine. The larger estimate of SCA variance (1.66 in S1, 1.05 in S2, and

1.32 in P) indicated that non-additive genetic variance played a predominant role in controlling the trait (Table- 4.3). These findings were consistent with previous reports by Uddin *et al.* (2009), Mule *et al.* (2012), Kumar *et al.* (2013), and Reddy *et al*. (2014), which also emphasized the significance of both components of genetic variance, with a greater contribution of non-additive genetic variance.

4.3.1.10 Fruit length (cm)

For the character fruit length, mean squares due to both GCA as well as SCA were significant with higher estimate of σ^2_{SCA} (1.32; S1, 0.73; S2 and 1.01; P) (Table- 4.3). Non-additive genetic variance was found to be predominant through the analysis of dominance. The results were consistent with previous studies by Uddin *et al.* (2009), Dogra and Kanwar (2011), Kushwaha *et al.* (2011), Mule *et al*. (2012), Bairagi *et al.* (2013), Kumar *et al*. (2013), Reddy *et al*. (2014), and Pati *et al.* (2015), which all found that both components of genetic variance were significant, and that either component could have a significant effect.

4.3.1.11 Fruit girth (cm)

The variances due to both GCA and SCA were significant with higher estimate of SCA (0.03; S1, 0.02; S2 and 0.02; P) (Table- 4.3). The significant influence of non-additive genetic variance was indicated by the degree of dominance, which was prominently observed in the study. These findings were consistent with the observations made by Uddin *et al*. (2009) and Reddy *et al.* (2014), who also reported the significance of both GCA as well as SCA, with a higher estimate of non-additive genetic variance.

4.3.1.12 Fruit weight (gm)

Significance of variances due to both GCA as well as SCA concealed importance of both additives along with non-additive genetic variances. The σ^2_{SCA} was higher than σ^2_{GCA}. The degree of dominance suggests the presence of a significant amount of non-fixable genetic variation. The outcomes of the study were consistent with the observations made by several researchers including Uddin *et al.* (2009), Singh *et al.* (2010a), Dogra and Kanwar (2011), Kushwaha *et al.* (2011), Mule *et al.* (2012), Kumar *et al.* (2013), Reddy *et al*. (2014), and Pati *et al.* (2015). These studies have reported the significance of both the components of genetic variance with a predominance of either one of them.

4.3.1.13 Fruit yield per vine (kg)

For fruit yield per vine, general and specific combining ability components of genetic variance were significant with larger estimate of σ^2_{SCA} (0.88; S1, 0.96; S2 and 0.99; P) (Table-4.3).The degree of dominance indicated that non- additive genetic variance was pronounced for inheritance of the character. The findings were consistent with previous studies conducted by Uddin *et al.* (2009), Kushwaha *et al.* (2011), Mule *et al.* (2012), Kumar *et al.* (2013), Reddy *et al*. (2014), and Pati *et al*. (2015).

4.3.2 COMBINING ABILITY EFFECTS

In the combining ability analysis, all the traits being studied exhibited significant mean squares for both parents and hybrids, indicating that there were significant differences between both parents as well as their F_1 hybrids for all the traits. The estimates of GCA of parents and SCA of parents and experimental hybrids respectively were presented in Table 4.4 and the results were discussed here after.

4.3.2.1 Days to Opening of First Male Flower

For days to first male flower appearance, the values of GCA effect ranged from -1.48 to 1.97 (2021), -0.73 to 0.22 (2022) and -1.11 to 1.42 (Pooled) (Table- 4.4). Out of seven parents (S1), nine (S2) and nine (P) depicted significant estimates of GCA effect of which, three (Sheetal, KOP-1 and KDWD-1 in S1), four (MLKP, Sheetal, KOP-1 and KDWD-1 in S2) and five (Sheetal, KOP-1, J-4, PLK and KDWD-1 in Pooled) had desirable negative value. Sheetal (-1.48 (S1); -0.73 (S2) and (-1.11; P) reported least GCA effect, hence identified as better general combiner. Whereas Phule Shubhangi 1.97 (S1), 0.87 (S2) and 1.42 (P) was adjusted as poor general combiners for earliness. The parents which did not register significant GCA effect were classified as average general combiners.

The estimates of SCA effect ranged from -3.48 to 5.12 (S1), -2.13 to 3.82 (S2) and -2.8 to 4.47 (P) (Table 4.5). A total of 16 hybrids exhibited significant SCA effect in (S1), 13 (S2) and 27 (P) respectively hybrids exhibited significant SCA effect of which, ten (S1), eight (S2) and eighteen (P) registered negative values favored for earliness. The hybrid Phule Shubhangi x MLKP -3.48(S1), Phule Shubhangi x MLKP -2.13 (S2) and Phule Shubhangi x MLKP -2.80 (P) had the least estimate of SCA effect followed by Panvel x Poona Khira -3.19 (S1) Poona Khira x KDWD-1 -2.06 (S2) and Phule Shubhangi x MLKP -2.80 (P) but all hybrids were statistically as par. Therefore, those were selected as good specific combiners for imparting earliness.

Table 4.4 General Combining Ability (GCA) of different characters in cucumber

Parent		Days to first male flower			Days to first female flower			First fruit bearing node		
		2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Panvel		0.18	-0.30	-0.06	0.34	0.24**	0.29*	-0.40**	-0.27	-0.34**
PLK		-0.27	-0.37*	-0.32*	-0.26	-0.38**	-0.32**	-0.35**	-0.34**	-0.35**
Phule Shubhangi		1.97**	0.87**	1.42**	2.43**	2.46**	2.44**	-0.02	0.02	0.00
Phule Hemangi		0.54*	0.37*	0.45**	-0.44	-0.41**	-0.43**	0.00	-0.10	-0.05
Poona Khira		0.90**	0.77**	0.83**	-0.61**	-0.50**	-0.56**	0.08	0.06	0.07
Rushita		0.11	0.22	0.17	0.92**	1.01**	0.97**	0.08	0.06	0.07
MLKP		1.06**	0.89**	0.98**	0.75**	0.74**	0.74**	0.08	0.09	0.08
KOP-1		-1.34**	-0.71**	-1.02**	-0.88**	-0.92**	-0.90**	0.00	0.18	0.09
Sheetal		-1.48**	-0.73**	-1.11**	-0.85**	-0.84**	-0.84**	-0.02	0.02	0.00
KDWD-1		-0.77**	-0.42*	-0.60**	-0.54*	-0.61**	-0.58**	0.39**	0.23	0.31**
J-2		-0.37	-0.23	-0.30	-0.60**	-0.61**	-0.60**	0.03	-0.03	0.00
J-4		-0.53	-0.35*	-0.44**	-0.26	-0.17**	-0.22	0.15	0.09	0.12
Range of GCA effects	**Lowest**	-1.48	-0.73	-1.11	-0.88	-0.92	-0.90	-0.40	-0.34	-035
	Highest	1.97	0.22	1.42	2.43	4.46	2.44	0.39	0.23	0.31
Significant positive		4	5	4	3	4	4	1	0	1
Significant negative		3	4	5	5	7	7	2	1	2
S.E. (g_i)		0.27	0.17	0.16	0.23	0.05	0.12	0.12	0.13	0.09
CD (g_i) at 5 %		0.81	0.50	0.47	0.68	0.15	0.35	0.36	0.38	0.26

Table 4.4 General Combining Ability (GCA) of different characters in cucumber

Parent		Days to first harvest			Days to last harvest			Number of primary branches per vine		
		2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Panvel		-0.71**	-0.79**	-0.75**	-0.04	0.11*	0.03	-0.44**	-0.66**	-0.55**
PLK		-0.26	-0.53*	-0.40**	-1.00**	-0.23	-0.61**	0.73**	0.93**	0.83**
Phule Shubhangi		0.55*	0.35	0.45**	-0.26	-0.30	-0.28	-0.04	0.08	0.02
Phule Hemangi		0.24	0.02	0.13	-0.88**	-0.35	-0.61**	-0.04	-0.26*	-0.15
Poona Khira		0.26	-0.15	0.06	-0.19	-0.04**	-0.11	0.06	-0.35*	-0.15
Rushita		0.57*	1.33**	0.95**	-0.35*	0.11*	-0.12	-0.66**	-0.64**	-0.65**
MLKP		1.12**	0.78**	0.95**	0.27	0.30	0.28	-0.16	-0.14	-0.15
KOP-1		-0.36	-0.32	-0.34*	0.55**	-0.18	0.19	-0.08	0.15	0.03
Sheetal		-0.05	-0.06	-0.05	0.62**	0.46	0.54**	0.25	0.46**	0.35**
KDWD-1		0.36	0.30	0.33*	0.24	-0.32	-0.04	0.30*	0.27*	0.28**
J-2		-0.10	0.11	0.01	0.62**	0.46	0.54**	0.20	0.15	0.18*
J-4		-1.62**	-1.03**	-1.33**	0.41**	-0.04	0.19	-0.13	0.03	-0.05
Range of GCA effects	**Lowest**	-1.62	-1.03	-1.33	-1.00	-0.35	-0.61	-0.66	-0.66	-0.65
	Highest	1.12	1.33	0.95	0.62	0.46	0.54	0.73	0.93	0.83
Significant positive		3	2	4	4	2	2	2	3	4
Significant negative		2	3	4	3	1	2	2	4	2
S.E. (g_i)		0.22	0.21	0.15	0.15	0.26	0.15	0.14	0.13	0.09
CD (g_i) at 5 %		0.64	0.62	0.44	0.46	0.77	0.44	0.42	0.39	0.28

Table 4.4 General Combining Ability (GCA) of different characters in cucumber

Parent		Internodal length (cm)			Vine length (cm)			Number of fruits per vine		
		2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Panvel		0.04	0.11**	0.07**	1.81**	1.82**	1.82**	-0.21	-0.48**	-0.35**
PLK		0.10**	0.07*	0.09**	0.76**	1.34**	1.05**	0.15	0.45**	0.30**
Phule Shubhangi		0.09**	0.07*	0.08**	2.02**	1.65**	1.84**	0.03	-0.08	-0.02
Phule Hemangi		-0.02	-0.02	-0.02	-2.26**	-1.70**	-1.98**	-0.47**	0.21*	-0.13
Poona Khira		0.01	0.00	0.00	-3.70**	-3.48**	-3.59**	-0.12	-0.17	-0.14
Rushita		0.06*	0.02	0.04*	4.65**	4.58**	4.62**	0.86**	0.38**	0.62**
MLKP		0.02	-0.01	0.00	1.58**	1.41**	1.49**	-0.66**	-0.50**	-0.58**
KOP-1		-0.09**	-0.05	-0.07**	-1.11**	-1.29**	-1.20**	0.89**	0.57**	0.73**
Sheetal		-0.05	0.02	-0.02	-1.95**	-2.25**	-2.10**	-0.40**	-0.58**	-0.49**
KDWD-1		-0.12**	-0.12**	-0.12**	-1.30**	-1.42**	-1.36**	-0.31**	-0.17	-0.24**
J-2		0.06*	0.00	0.03	0.06	0.30	0.18	-0.04	-0.05	-0.05
J-4		-0.11**	-0.09**	-0.10**	-0.56	-0.97**	-0.77**	0.29**	0.43**	0.36**
Range of GCA effects	**Lowest**	-0.12	-0.12	-0.12	-3.70	-3.48	-3.59	-0.66	-0.58	-0.58
	Highest	0.10	0.11	0.09	4.65	4.58	4.62	0.89	0.57	0.73
Significant positive		3	3	4	5	5	5	3	5	4
Significant negative		3	2	3	5	6	6	4	3	4
S.E. (gi)		0.03	0.03	0.02	0.29	0.26	0.19	0.11	0.10	0.07
CD (gi) at 5 %		0.10	0.10	0.07	0.86	0.76	0.57	0.33	0.30	0.22

Table 4.4 General Combining Ability (GCA) of different characters in cucumber

Parent		Fruit length (cm)			Fruit girth (cm)			Fruit weight (g)		
		2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Panvel		0.12	0.00	0.06	0.07	0.21**	0.14**	-3.48	-2.17	-0.40
PLK		-0.21	0.06	-0.08	0.13**	0.29**	0.21**	1.20	1.81	1.99
Phule Shubhangi		-1.01**	-0.85**	-0.93**	0.20**	0.13	0.16**	-17.83**	-11.55**	-9.60**
Phule Hemangi		-0.27	-0.34**	-0.30**	-0.06	-0.14	-0.10*	-0.90	0.41	-0.39
Poona Khira		-0.11	-0.06	-0.09	-0.09	-0.09	-0.09*	-9.90*	-9.43*	-10.10**
Rushita		-0.13	-0.28*	-0.21*	0.16**	0.08	0.12**	9.25*	8.74*	8.47**
MLKP		0.41**	0.79**	0.60**	0.01	0.00	0.01	10.26**	-9.71	8.42
KOP-1		0.48**	0.30**	0.39**	-0.03	-0.09	-0.06	6.71	5.12	6.79**
Sheetal		0.38*	0.27*	0.33**	-0.12**	-0.13	-0.13**	4.79	-1.88	-1.09
KDWD-1		0.22	0.09	0.16	-0.12**	-0.10	-0.11**	-0.09	-2.43	-4.27**
J-2		0.13	-0.02	0.05	-0.07	-0.08	-0.08*	2.01	1.07	1.54
J-4		0.01	0.04	0.02	-0.07	-0.09	-0.08*	-2.77	-3.98	-3.38
Range of GCA effects	**Lowest**	-1.01	-0.85	-0.93	-0.20	-0.14	-0.13	-17.83	-11.55	-10.10
	Highest	0.48	0.79	0.60	0.20	0.29	0.21	10.26	8.74	8.47
Significant positive		3	3	3	3	2	4	1	1	2
Significant negative		1	3	3	2	0	6	2	2	3
S.E. (gi)		0.15	0.11	0.09	0.04	0.08	0.04	3.97	3.80	3.89
C.D. (gi) at 5 %		0.44	0.32	0.27	0.13	0.23	0.13	7.78	7.42	7.69

Table 4.4 General Combining Ability (GCA) of different characters in cucumber

Parent		Fruit yield per vine (kg)		
		2021	2022	Pooled
Panvel		-0.03	-0.21	-0.39
PLK		0.31**	0.24**	0.65**
Phule Shubhangi		-0.56**	0.93**	0.55**
Phule Hemangi		-0.75**	-0.36*	-1.15**
Poona Khira		0.15	-0.86	-1.15
Rushita		1.37**	-1.69**	1.19*
MLKP		-0.45**	0.60**	2.29**
KOP-1		0.12	1.38**	2.69**
Sheetal		-0.18*	-0.07	-0.29*
KDWD-1		0.04	0.10*	-0.26
J-2		-0.06	-1.50*	-0.78
J-4		-3.06**	-2.55**	-2.81**
Range of GCA effects	**Lowest**	-3.06	-2.55	-2.81
	Highest	1.37	1.38	2.69
Significant positive		2	4	5
Significant negative		5	4	3
S.E. (gi)		0.08	0.07	0.09
CD (g_i) at 5 %		0.17	0.22	0.26

4.3.2.2 Days to first female flower

The range of GCA effect for days to opening of first female flower was -0.88 to 2.43 (S1), -0.92 to 4.46 (S2) and -0.90 to 2.44 (P) respectively (Table 4.4). Five (S1), Seven (S2) and Seven (P) parent depicted significantly negative value of GCA effect and KOP-1 (-0.88; S1), (-0.92; S2) and (-0.90; P) were best GCA for earliness. Whereas, Phule Shubhangi (2.44; P) reportedsignificant positive estimates of GCA effect, therefore classified as poor GCA for earliness.

The range of specific combining ability effects for days to first female flower appearance ranged from -05.17 to 4.14 (S1), -5.26 to 4.07 (S2) and -5.22 to 4.11 (P) (Table 4.5). A total of twelve (S1), twenty five (S2) and seventeen (P) exhibit negative values. The cross KOP-1 x Sheetal -5.17 (S1), -5.26 (S2) and -5.22 (P) exhibited the minimum value of specific combining ability effect followed by KOP-1 x KDWD-1 (-3.70; S1), KOP-1 x KDWD-1 (-3.84; S2) Panvel x Phule Shubhangi (-3.54; P) were good SCA effects for early female flowers.

4.3.2.3 First fruit bearing node

The estimates of GCA effect for first fruit bearing node ranged from -0.40 to 0.39 (S1), -0.34 to 0.23 (S2) and -0.35 to 0.31 (P) (Table- 4.4). Two parents Panvel and PLK -0.40 , -0.35 (S1),one parent PLK -0.34 (S2) and two parent Panvel and PLK -0.34 and -0.35 (P) respectively, noticed negative and significant estimates of GCA effect were designated as good GCA for First fruit bearing node. While, the parents KDWD-1 0.39 (S1), 0.31 (P) depicted significant positive GCA effects.

For first fruit bearing node, the estimates of specific combining ability effect varied from -1.48 to 1.57 (S1), -1.78 to 1.39 (S2) and -1.63 to 1.44 (P) (Table- 4.6). Total 15 (S1), 13 (S2) and 25 (P) F_1s exhibited significant SCA effects, of these, 4 (S1), 6 (S2) and 8 (P) F_1s exerted negative SCA effect. The hybrid Sheetal x J-4 (-1.48; S1), -1.78; S2) and (-1.63; P) followed by J-2 X J-4 (-1.20; S1), Rushita x MLKP (-1.49; S2), (-1.00; P) manifested the highest SCA effects and regarded as good SCA for first fruit bearing node.

Table 4.5 SCA effects for days to first male flower and days to first female flower.

Hybrids	Days to first male flower			Days to first female flower		
1	2			3		
	2021	2022	Pooled	2021	2022	Pooled
Panvel x PLK	3.64**	-0.04	1.80**	1.74*	2.05**	1.89**
Panvel x Phule Shubhangi	0.41	-0.27	0.07	-3.45**	-3.63**	-3.54**
Panvel x Phule Hemangi	-1.17	-0.77	-0.97	-0.54	-0.52**	-0.53
Panvel x Poona Khira	-3.19**	-1.84**	-2.52**	-0.06	-0.29	-0.17
Panvel x Rushita	-1.74	-0.96	-1.35*	1.25	1.43**	1.34**
Panvel x MLKP	-1.69	-1.30*	-1.49*	-0.37	-0.16	-0.26
Panvel x KOP-1	0.38	0.63	0.51	1.14	1.12**	1.13*
Panvel x Sheetal	0.52	0.66	0.59	0.41	0.50**	0.46
Panvel x KDWD-1	-0.19	0.68	0.25	0.22	-0.08	0.07
Panvel x J-2	-0.93	-0.18	-0.55	1.61	1.61**	1.61**
Panvel x J-4	-0.43	0.28	-0.08	0.19	-0.12	0.04
PLK x Phule Shubhangi	-2.48*	-1.20	-1.84**	-3.15**	-3.07**	-3.11**
PLK x Phule Hemangi	-1.38	-0.37	-0.88	-1.24	-1.07**	-1.16*
PLK x Poona Khira	-0.07	-0.77	-0.42	-0.74	-0.77**	-0.75
PLK x Rushita	-0.62	-0.23	-0.42	-3.36**	-3.47**	-3.41**
PLK x MLKP	-0.91	0.11	-0.40	0.04	-0.08	-0.02
PLK x KOP-1	1.50	0.37	0.94	2.12*	2.18**	2.15**
PLK x Sheetal	-1.02	-0.27	-0.65	1.04	0.92**	0.98*
PLK x KDWD-1	-0.07	0.42	0.17	2.20	2.18**	2.19**
PLK x J-2	0.19	-0.11	0.04	0.92	0.83**	0.88
PLK x J-4	-1.64	-0.65	-1.15	-0.11	-0.26	-0.19
Phule Shubhangi x Hemangi	4.05**	2.39**	3.22**	1.26	1.24**	1.25*
Phule Shubhangi x Poona Khira	-1.98	-1.01	-1.49*	0.91	0.88**	0.89

Phule Shubhangi x Rushita	1.14	1.54*	1.34*	1.78*	1.83**	1.81**
Phule Shubhangi x MLKP	-3.48**	-2.13**	-2.80**	3.45**	3.74**	3.59**
Phule Shubhangi x KOP-1	-1.07	-0.54	-0.80	2.11*	2.39**	2.25**
Phule Shubhangi x Sheetal	0.74	0.82	0.78	1.25	1.17**	1.21*
Phule Shubhangi x KDWD-1	-0.31	-1.15	-0.73	-1.36	-1.41**	-1.39**
Phule Shubhangi x J-2	-2.05*	-0.68	-1.36*	-0.33	-0.65**	-0.49
Phule Shubhangi x J-4	-1.55	-0.23	-0.89	0.93	0.95**	0.94
Phule Hemangi x Poona Khira	5.12**	3.82**	4.47**	0.00	-0.17	-0.08
Phule Hemangi x Rushita	-0.10	-0.96	-0.53	-2.20*	-2.22**	-2.21**
Phule Hemangi x MLKP	-1.38	-0.30	-0.84	-1.80*	-2.01**	-1.90**
Phule Hemangi x KOP-1	-0.98	-0.70	-0.84	0.04	0.11	0.07
Phule Hemangi x Sheetal	-1.17	-0.68	-0.92	0.21	0.34	0.27
Phule Hemangi x KDWD-1	-1.55	-0.32	-0.93	1.30	1.69**	1.49**
Phule Hemangi x J-2	-2.95**	-1.51*	-2.23**	-0.33	-0.25	-0.29
Phule Hemangi x J-4	0.55	0.28	0.41	-0.28	-0.29	-0.29
Poona Khira x Rushita	-1.45	-1.37*	-1.41*	-2.20*	-2.16**	-2.18**
Poona Khira x MLKP	-3.07**	-2.04**	-2.55**	-2.16*	-1.86**	-2.01**
Poona Khira x KOP-1	-2.00*	-1.11	-1.55**	0.29	0.71**	0.50
Poona Khira x Sheetal	-0.52	-1.08	-0.80	0.56	0.48**	0.52
Poona Khira x KDWD-1	-3.24**	-2.06**	-2.65**	-0.73	-0.36*	-0.54
Poona Khira x J-2	-1.31	-0.92	-1.11	-1.80	-1.82**	-1.81**
Poona Khira x J-4	-1.81	-1.13	-1.47**	0.48	0.66**	0.57
Rushita x MLKP	0.38	0.18	0.28	0.87	0.90**	0.89
Rushita x KOP-1	1.79	1.78**	1.78**	3.44**	3.45**	3.44**
Rushita x Sheetal	1.93	0.80	1.36*	1.04	1.19**	1.11*
Rushita x KDWD-1	-1.79	-1.18	-1.48*	-0.86	-0.97**	-0.91
Rushita x J-2	-0.19	-0.70	-0.45	-0.08	-0.10	-0.09
Rushita x J-4	-2.02*	-1.25*	-1.64**	0.01	-0.14	-0.06
MLKP x KOP-1	0.83	0.44	0.64	4.14**	4.07**	4.11**
MLKP x Sheetal	0.31	0.47	0.39	2.11*	1.85**	1.98**
MLKP x KDWD-1	1.26	0.82	1.04	-1.81*	-1.82**	-1.82**
MLKP x J-2	3.52**	1.63**	2.58**	-0.16	-0.44*	-0.30
MLKP x J-4	2.02*	1.08	1.55**	-1.47	-1.41**	-1.44**
KOP-1 x Sheetal	-2.29*	-0.94	-1.61**	-5.17**	-5.26**	-5.22**
KOP-1 x KDWD-1	-0.67	-0.58	-0.63	-3.70**	-3.84**	-3.77**
KOP-1x J-2	-1.41	-0.44	-0.92	-3.36**	-3.39**	-3.38**
KOP-1x J-4	0.76	1.01	0.89	-3.12**	-3.47**	-3.29**
Sheetal x KDWD-1	2.81**	1.11	1.96**	-1.60	-1.70**	-1.65**
Sheetal x J-2	0.41	0.58	0.50	-0.91	-0.88**	-0.89
Sheetal x J-4	-1.43	-0.96	-1.20*	-0.53	-0.25	-0.39
KDWD-1 x J-2	1.02	0.28	0.65	2.48**	2.72**	2.60**
KDWD-1 x J-4	0.52	0.39	0.46	1.10	1.26**	1.18*
J-2 X J-4	-1.55	-0.80	-1.17*	-0.86	-0.64**	-0.75
Range of SCA effect — **Lowest**	-3.48	-2.13	-2.8	-5.17	-5.26	-5.22
Range of SCA effect — **Highest**	5.12	3.82	4.47	4.14	4.07	4.11
Significant crosses — **Positive**	6	5	9	9	25	17
Significant crosses — **Negative**	10	8	18	12	25	17

SE (Sij)	0.01	0.62	0.59	0.85	0.18	0.43
CD (Sij) at 5%	1.97	1.97	1.96	1.97	1.97	1.96

4.3.2.4 Days to first harvest

For days to first harvest, the GCA effects ranged from -1.62 to 1.12 (S1),-1.03 to 1.33 (S2) and -1.33 to 0.95 (P) (Table 4.4). In pooled analysis parental line J-4 (-1.33) and MLKP (0.95) registered significant negative and positive GCA effect, respectively, therefore, both were classified as good and poor GCA respectively.

The values of SCA effect ranged from -5.79 to 4.42 (S1), -5.1 to 4.1 (S2) and -5.44 to 3.46 (P) (Table 4.6). The crosses KOP-1x J-4 (-5.79; S1), (-5.10; S2) and (-5.44; P) showed significant negative SCA effect, respectively, therefore, both were classified as good SCA, respectively.

4.3.2.5 Days to last harvest

For days to last harvest, the GCA effects ranged from -1.00 to 0.62 (S1), -0.35 to 0.46 (S2) and -0.61 to 0.54 (P) (Table-4.4). The parental lines J-2 (0.62), Sheetal (0.62), J-4 (0.41) registered the significant positive in S1, S2 and P (0.11) and Rushita (0.11) registered the significant positive. Phule Hemangi -0.88 (S1), Poona Khira-0.04 (S2) and Phule Hemangi -0.61, PLK -0.61(P) manifested significant negative GCA effect, respectively. Therefore, they were classified as good and poor GCA, respectively.

The values of specific combining ability effect ranged from -3.06 to 3.41 (S1), -6.35 to 1.79 (S2) and -4.5 to 1.81 (P) (Table-4.7). The crosses Rushita x MLKP -3.06 (S1) Poona Khira x J-2 (3.41), KOP-1 x J-2 (-6.35) and KOP-1 x J-2 (-4.5), Poona Khira x J-2 (1.96; P) registered the highest significant positive and negative SCA effects, respectively; therefore, both were classify as good and poor SCA, respectively.

4.3.2.6 Number of primary branches per vine

The lowest and the highest values of GCA effect for number of primary branches per plant were -0.66 to 0.73 (S1), -0.66 to 0.93 (S2) and -0.65 to 0.83 (P) (Table 4.4). The parental lines PLK (0.73; S1) followed by KDWD-1 (0.30; S1), PLK (0.93; S2) followed by Sheetal (0.46; S2) and PLK (0.83; P) followed by Sheetal (0.35; P) depicted the highest positive GCA effect and were classified as good GCA.

The values of SCA effect ranged from -2.46 to 2.32 (S1), -1.50 to 1.81 (S2) and -1.78 to 1.88 (P) (Table-4.7). A total of 25 (S1), 21 (S2) and 31 (P) respectively F_1s exhibited significant SCA estimates, of which, (16; S1), (15; S2) and (19; P) F_1s depicted positive SCA effect. The F_1 MLKP x J-4 (2.32; S1), Phule Hemangi x Sheetal (1.81; S2) and Panvel x KOP-1(1.81; P) had the highest value of SCA effect and were classified as good SCA for increasing number of primary branches per vine.

Table 4.6 SCA effects for first fruit bearing node and days to first harvest.

Hybrids	First fruit bearing node			Days to first harvesting		
1	2			3		
	2021	2022	Pooled	2021	2022	Pooled
Panvel x PLK	1.07*	1.27**	1.17**	0.21	0.21	0.21
Panvel x Phule Shubhangi	0.07	-0.09	-0.01	-1.27	-1.33	-1.30*
Panvel x Phule Hemangi	-0.96*	-0.97*	-0.96**	0.37	0.00	0.19
Panvel x Poona Khira	-0.36	-0.47	-0.42	-0.32	0.17	-0.08
Panvel x Rushita	-0.36	-0.80	-0.58	0.37	-0.64	-0.14
Panvel x MLKP	-0.36	-0.16	-0.26	-2.17**	-2.10**	-2.14**
Panvel x KOP-1	-0.29	-0.59	-0.44	-0.70	-0.67	-0.68
Panvel x Sheetal	-0.60	-0.42	-0.51	0.66	0.07	0.37
Panvel x KDWD-1	-0.01	0.03	0.01	-0.41	-0.29	-0.35
Panvel x J-2	0.35	0.29	0.32	0.71	0.24	0.47
Panvel x J-4	0.57	0.84	0.70*	1.23	1.38	1.31*
PLK x Phule Shubhangi	-0.65	-1.02*	-0.83**	-3.39**	-3.60**	-3.49**
PLK x Phule Hemangi	-0.34	0.10	-0.12	-1.41	-0.26	-0.84
PLK x Poona Khira	0.92**	0.94	0.93**	-0.44	-0.76	-0.60
PLK x Rushita	0.92**	0.27	0.60	0.59	-1.91**	-0.66
PLK x MLKP	-0.41	-0.42	-0.42	-0.29	-0.02	-0.16
PLK x KOP-1	-1.01*	-0.85	-0.93	4.52**	2.41**	3.46**
PLK x Sheetal	-0.32	-0.02	-0.17	-0.46	0.48	0.01
PLK x KDWD-1	-0.72	0.10	-0.31	-0.53	0.12	-0.21
PLK x J-2	1.30**	0.70	1.00**	-1.41	-1.02	-1.22*
PLK x J-4	-0.15	-0.42	-0.29	1.78*	1.12	1.45*
Phule Shubhangi x Phule Hemangi	-0.01	0.08	0.04	-2.89**	-1.48*	-2.18**
Phule Shubhangi x Poona Khira	-0.74	-0.09	-0.42	0.76	0.36	0.56
Phule Shubhangi x Rushita	-0.74	-0.42	-0.58	-1.89*	-1.12	-1.50**
Phule Shubhangi x MLKP	0.59	-0.11	0.24	-0.77	-0.57	-0.67
Phule Shubhangi x KOP-1	1.00*	1.13*	1.06**	3.04**	1.52*	2.28**
Phule Shubhangi x Sheetal	1.02*	0.29	0.66**	-0.94	-1.41*	-1.17*
Phule Shubhangi x KDWD-1	0.61	0.75	0.68*	0.66	1.24	0.95
Phule Shubhangi x J-2	-0.36	-0.33	-0.34	2.78**	0.76	1.77**
Phule Shubhangi x J-4	0.52	1.22*	0.87**	2.30**	1.91**	2.10**
Phule Hemangi x Poona Khira	0.57	0.36	0.47	2.06*	1.02	1.54**
Phule Hemangi x Rushita	1.23	0.03	0.63*	-0.25	1.21	0.48
Phule Hemangi x MLKP	0.90	0.67	0.79*	0.21	-0.24	-0.02
Phule Hemangi x KOP-1	-0.03	0.25	0.11	2.35**	1.19	1.77**
Phule Hemangi x Sheetal	0.33	0.75	0.54	-0.29	-1.41*	-0.85
Phule Hemangi x KDWD-1	-0.74	-0.80	-0.77*	1.64*	1.57*	1.60**
Phule Hemangi x J-2	0.28	0.46	0.37	-0.91	-1.24	-1.08
Phule Hemangi x J-4	1.50**	1.34**	1.42**	-0.39	-0.10	-0.24

Poona Khira x Rushita		0.50	0.20	0.35	-2.94**	-2.95**	-2.94**
Poona Khira x MLKP		-0.51	0.51	0.00	-2.15**	-2.07*	-2.11**
Poona Khira x KOP-1		1.57**	1.08*	1.32**	-1.01	0.36	-0.33
Poona Khira x Sheetal		0.59	-0.09	0.25	-1.98*	-1.57*	-1.78**
Poona Khira x KDWD-1		-1.15**	-0.97*	-1.06**	-0.06	-0.60	-0.33
Poona Khira x J-2		0.88*	0.63	0.75*	1.73*	0.93	1.33*
Poona Khira x J-4		-0.58	0.17	-0.20	-1.75*	-0.60	-1.17*
Rushita x MLKP		-0.51	-1.49**	-1.00**	2.54*	1.79*	2.16**
Rushita x KOP-1		0.23	0.41	0.32	0.68	0.55	0.62
Rushita x Sheetal		-0.08	0.58	0.25	3.37**	3.29**	3.33**
Rushita x KDWD-1		0.19	0.36	0.28	-0.03	-0.07	-0.05
Rushita x J-2		-0.13	0.63	0.25	0.76	2.79**	1.77**
Rushita x J-4		0.42	1.17*	0.80*	0.61	1.93**	1.27*
MLKP x KOP-1		-0.43	0.06	-0.19	2.80**	4.10**	3.45**
MLKP x Sheetal		-0.08	-0.11	-0.09	3.16**	1.50*	2.33**
MLKP x KDWD-1		0.52	0.67	0.60	-0.58	-1.19	-0.89
MLKP x J-2		0.54	0.94	0.74*	-0.46	0.00	-0.23
MLKP x J-4		0.76	-0.18	0.29	1.73*	0.81	1.27*
KOP-1 x Sheetal		-0.01	0.13	0.06	-3.03**	-2.41**	-2.72**
KOP-1 x KDWD-1		-0.08	-0.09	-0.08	0.90	-0.10	0.40
KOP-1x J-2		0.95*	1.17*	1.06**	-2.32**	-2.24**	-2.28**
KOP-1x J-4		1.50**	1.39**	1.44**	-5.79**	-5.10**	-5.44**
Sheetal x KDWD-1		-0.72	-1.26**	-0.99**	-2.41**	-2.02**	-2.22**
Sheetal x J-2		0.64	0.01	0.32	-2.63	-1.83*	-2.23**
Sheetal x J-4		-1.48**	-1.78**	-1.63**	0.56	0.64	0.60
KDWD-1 x J-2		-0.43	-0.21	-0.32	0.30	1.14	0.72
KDWD-1 x J-4		0.78	0.34	0.56	1.49	0.95	1.22*
J-2 X J-4		-1.20**	-1.06*	-1.13**	1.95*	1.14	1.54**
Range of SCA effect	**Lowest**	-1.48	-1.78	-1.63	-5.79	-5.1	-5.44
	Highest	1.57	1.39	1.44	4.52	4.1	3.46
Significant crosses	**Positive**	11	7	17	15	10	19
	Negative	4	6	8	12	14	16
SE (Sij)		0.44	0.48	0.32	0.80	0.71	0.56
CD (Sij) at 5%		1.97	1.97	1.96	1.97	1.97	1.96

Table 4.7 SCA effects for days to last harvest and primary branches per vine.

Hybrids	**Days to last harvest**			**Number of primary branches per vine**		
1	**2**			**3**		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
Panvel x PLK	-0.44	-0.61	-0.53	-0.58	-0.93	-0.76*
Panvel x Phule Shubhangi	-1.52**	-0.54	-1.03	-0.15	-0.41	-0.28
Panvel x Phule Hemangi	-0.56	-0.16	-0.36	-1.82**	-1.08*	-1.45**
Panvel x Poona Khira	-0.92	-0.47	-0.69	-0.25	0.35	0.05
Panvel x Rushita	-1.42*	-0.61	-1.02	0.80	0.64	0.72*
Panvel x MLKP	-0.71	0.20	-0.25	0.97	1.14*	1.05**

Panvel x KOP-1	1.34*	0.01	0.68	2.23**	1.52**	1.88**
Panvel x Sheetal	-0.06	0.03	-0.02	1.23*	0.88	1.05**
Panvel x KDWD-1	1.65**	0.48	1.07	0.18	0.40	0.29
Panvel x J-2	0.60	0.36	0.48	0.28	0.19	0.23
Panvel x J-4	0.15	1.20	0.68	0.61	-0.03	0.29
PLK x Phule Shubhangi	1.10	0.79	0.95	2.02**	1.33**	1.67**
PLK x Phule Hemangi	-0.28	-0.16	-0.22	2.02**	1.00*	1.51**
PLK x Poona Khira	-1.97**	-0.14	-1.05	1.25*	1.43*	1.34**
PLK x Rushita	-0.13	0.39	0.13	2.32**	1.38*	1.84**
PLK x MLKP	1.25*	-0.14	0.56	0.13	0.88	0.51
PLK x KOP-1	-0.04	0.34	0.15	0.73	0.59	0.66
PLK x Sheetal	-2.11**	-0.64	-1.37	0.06	-0.05	0.01
PLK x KDWD-1	-2.06**	-0.85	-1.46**	-0.65	-0.86	-0.76*
PLK x J-2	0.89	-0.97	-0.04	-0.56	-0.08	-0.32
PLK x J-4	0.10	1.20	0.65	-1.22*	0.38	-0.42
Phule Shubhangi x Phule Hemangi	-0.35	0.25	-0.05	-0.56	-0.15	-0.35
Phule Shubhangi x Poona Khira	2.63**	-0.40	1.12*	-1.32*	-0.72	-1.02*
Phule Shubhangi x Rushita	1.46*	1.79	1.63**	0.40	-0.10	0.15
Phule Shubhangi x MLKP	2.51**	0.27	1.39*	0.56	0.40	0.48
Phule Shubhangi x KOP-1	0.22	-0.26	-0.02	-2.18**	0.78	-0.70*
Phule Shubhangi x Sheetal	1.49**	-0.56	0.46	-1.18*	-1.19*	-1.19**
Phule Shubhangi x KDWD-1	1.20*	0.56	0.88	0.11	1.00*	0.55
Phule Shubhangi x J-2	-1.52**	-0.90	-1.21*	2.21**	1.12*	1.66**
Phule Shubhangi x J-4	0.03	0.60	0.32	-0.13	0.90	0.39
Phule Hemangi x Poona Khira	-0.42	-1.02	-0.72	-0.65	0.62	-0.02
Phule Hemangi x Rushita	-0.25	-0.83	-0.54	0.73	0.23	0.48
Phule Hemangi x MLKP	-2.21**	-1.02	-1.61**	0.56	0.40	0.48
Phule Hemangi x KOP-1	-1.82**	-0.54	-1.18*	0.49	-0.22	0.14
Phule Hemangi x Sheetal	0.44	-0.18	0.13	1.82**	1.81**	1.82**
Phule Hemangi x KDWD-1	0.82	0.60	0.71	1.11*	1.33**	1.22**
Phule Hemangi x J-2	0.10	-0.52	-0.21	0.54	0.12	0.33
Phule Hemangi x J-4	0.65	0.32	0.48	-2.46**	-1.10*	-1.78**
Poona Khira x Rushita	1.39*	1.53	1.46**	-0.37	1.33**	0.48
Poona Khira x MLKP	-0.90	0.01	-0.44	0.13	-0.17	-0.02
Poona Khira x KOP-1	-1.52**	-0.18	-0.85	1.06*	0.54	0.80*
Poona Khira x Sheetal	0.08	0.51	0.29	0.06	-0.43	-0.19
Poona Khira x KDWD-1	-1.21*	-1.04	-1.12*	0.02	-0.24	-0.11
Poona Khira x J-2	3.41**	0.51	1.96**	-0.56	-0.12	-0.34
Poona Khira x J-4	0.96	0.67	0.82	1.44**	0.66	1.05**
Rushita x MLKP	-3.06**	-2.14*	-2.60**	-0.49	-0.55	-0.52
Rushita x KOP-1	0.32	0.01	0.16	-0.89	-1.50**	-1.20**
Rushita x Sheetal	-2.42**	-1.97*	-2.19**	0.78	0.52*	0.65
Rushita x KDWD-1	1.63**	0.82	1.22*	-0.60	-0.96	-0.78*
Rushita x J-2	0.91	0.70	0.81	0.16	0.50	0.33
Rushita x J-4	-0.87	-0.47	-0.67	0.49	0.62	0.55
MLKP x KOP-1	0.70	0.82	0.76	1.28*	1.66**	1.47**
MLKP x Sheetal	-0.04	-0.83	-0.43	-2.06**	0.02	-1.02**
MLKP x KDWD-1	-1.99**	-1.04	-1.52**	0.23	0.54	0.39
MLKP x J-2	-0.71	-0.49	-0.60	1.32*	1.00*	1.16**
MLKP x J-4	-0.16	-0.33	-0.24	1.32*	0.78	1.05**
KOP-1 x Sheetal	2.01**	0.65	1.33*	0.54	0.40	0.47
KOP-1 x KDWD-1	-0.61	1.77	0.58	1.16*	0.93	1.04**
KOP-1x J-2	-2.66**	-6.35**	-4.50**	-1.08*	-0.96**	-1.02**
KOP-1x J-4	-2.11**	-0.18	-1.15*	-0.41	-0.50	-0.46
Sheetal x KDWD-1	1.32*	0.13	0.72	1.49**	1.28**	1.39**

Sheetal x J-2		0.27	-0.33	-0.03	0.59	0.40	0.49
Sheetal x J-4		-0.85	-0.83	-0.84	-0.41	0.85	0.22
KDWD-1 x J-2		-0.35	-0.87	-0.61	-1.13*	-0.74	-0.94**
KDWD-1 x J-4		-1.13*	-5.71**	-3.42**	0.54	-0.29**	0.13
J-2 X J-4		0.49	0.17	0.33	0.97	0.50	0.73*
Range of SCA effect	**Lowest**	-3.06	-6.35	-4.5	-2.46	-1.50	-1.78
	Highest	3.41	1.79	1.96	2.32	1.81	1.88
Significant crosses	**Positive**	13	0	7	16	15	19
	Negative	16	4	10	9	6	12
SE (Sij)		0.57	0.96	0.56	0.52	0.49	0.35
CD (Sij) at 5%		1.97	1.97	1.96	1.97	1.97	1.96

Table 4.7 SCA effects for internodal length and vine length.

Hybrids	**Internodal length(cm)**			**Vine length(cm)**		
1	**2**			**3**		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
Panvel x PLK	-0.39**	-0.10	-0.25**	1.04	0.38	0.71
Panvel x Phule Shubhangi	-0.02	-0.07	-0.04	-1.12	-0.73	-0.92
Panvel x Phule Hemangi	0.06	0.02	0.04	1.90	1.66	1.78*
Panvel x Poona Khira	0.06	0.08	0.07	5.40**	4.94**	5.17**
Panvel x Rushita	-0.16	-0.18	-0.17	-3.94**	-3.49**	-3.72**
Panvel x MLKP	-0.11	-0.08	-0.10	0.46	0.72	0.59
Panvel x KOP-1	0.33*	0.22	0.27**	0.75	0.88	0.81
Panvel x Sheetal	-0.01	0.09	0.04	2.35*	2.71**	2.53**
Panvel x KDWD-1	0.16	0.09	0.12	0.84	0.94	0.89
Panvel x J-2	0.18	0.24*	0.21*	1.11	0.89	1.00
Panvel x J-4	0.11	0.07	0.09	-0.03	0.96	0.46
PLK x Phule Shubhangi	0.09	0.30*	0.20*	-0.60	-0.72	-0.66
PLK x Phule Hemangi	0.00	-0.21	-0.10	-0.92	0.97	0.03
PLK x Poona Khira	0.04	0.18	0.11	4.02**	4.15**	4.08**
PLK x Rushita	0.08	0.26*	0.17	-4.29**	-4.15**	-4.22**
PLK x MLKP	0.10	0.08	0.09	-1.13	-0.87	-1.00
PLK x KOP-1	0.23	0.12	0.18*	-0.33	0.52	0.09
PLK x Sheetal	0.23	0.16	0.19*	2.50*	3.36**	2.93**
PLK x KDWD-1	0.46**	0.33**	0.40**	1.92	1.56	1.74*
PLK x J-2	0.55**	0.44**	0.50**	-0.24	-0.76	-0.50
PLK x J-4	-0.15	-0.04	-0.09	2.12*	2.04**	2.08**
Phule Shubhangi x Phule Hemangi	-0.23	-0.05	-0.14	0.59	0.89	0.74
Phule Shubhangi x Poona Khira	0.01	0.01	0.01	2.59*	2.47**	2.53**
Phule Shubhangi x Rushita	0.03	-0.11	-0.04	-4.72**	-4.33**	-4.52**
Phule Shubhangi x MLKP	0.24	-0.15	0.04	-1.22	-1.11	-1.17
Phule Shubhangi x KOP-1	-0.19	0.15	-0.02	1.78	2.11*	1.94**
Phule Shubhangi x Sheetal	0.03*	0.16	0.10	1.34	1.91*	1.63*
Phule Shubhangi x KDWD-1	0.30	0.39**	0.35**	0.87	0.88	0.87
Phule Shubhangi x J-2	0.06	-0.03	0.02	0.37	0.09	0.23
Phule Shubhangi x J-4	0.23	0.06	0.14	0.09	0.66	0.38
Phule Hemangi x Poona Khira	0.19	0.20	0.19*	3.38**	2.79**	3.08**
Phule Hemangi x Rushita	0.07	-0.05	0.01	-5.36**	-4.94**	-5.15**
Phule Hemangi x MLKP	-0.15	-0.13	-0.14	-2.07	-2.23*	-2.15**
Phule Hemangi x KOP-1	0.19	0.18	0.18*	0.03	0.69	0.36
Phule Hemangi x Sheetal	0.15	0.18	0.16	1.13	0.93	1.03
Phule Hemangi x KDWD-1	0.08	0.08	0.08	-1.18	-0.84	-1.01

Phule Hemangi x J-2	-0.03	-0.07	-0.05	-1.18	-1.89*	-1.54*
Phule Hemangi x J-4	0.04	-0.18	-0.07	2.38*	3.04**	2.71**
Poona Khira x Rushita	-0.06	-0.04	-0.05	-3.16**	-2.99**	-3.08**
Poona Khira x MLKP	0.25	0.36**	0.30**	-6.07**	-4.45**	-5.26**
Poona Khira x KOP-1	-0.15	0.00	-0.07	-0.47	-0.66	-0.57
Poona Khira x Sheetal	0.18	0.03	0.11	-2.24*	-1.56	-1.90**
Poona Khira x KDWD-1	-0.15	0.00	-0.07	-1.92	-1.92*	-1.92**
Poona Khira x J-2	0.47**	0.32**	0.39**	-4.51**	-3.67**	-4.09**
Poona Khira x J-4	-0.10	-0.16	-0.13	-3.92**	-4.04**	-3.98**
Rushita x MLKP	-0.07	-0.03	-0.05	5.86**	6.22**	6.04**
Rushita x KOP-1	0.10	0.04	0.07	9.49**	9.38**	9.43**
Rushita x Sheetal	0.00	-0.05	-0.03	9.15**	9.21**	9.18**
Rushita x KDWD-1	0.20	0.25*	0.22*	8.88**	8.18**	8.53**
Rushita x J-2	-0.02	-0.24*	-0.13	6.44**	6.16**	6.30**
Rushita x J-4	0.12	0.19	0.15	8.27**	8.93**	8.60**
MLKP x KOP-1	0.02	-0.10	-0.04	4.58**	4.62**	4.60**
MLKP x Sheetal	0.04	-0.20	-0.08	4.52**	4.63**	4.57**
MLKP x KDWD-1	-0.09	-0.09	-0.09	4.01**	3.69**	3.85**
MLKP x J-2	-0.24	-0.11	-0.17	1.48	0.94	1.21
MLKP x J-4	0.00	0.11	0.06	2.07	2.44*	2.25**
KOP-1 x Sheetal	-0.12	0.01	-0.06	-4.82**	-4.22**	-4.52**
KOP-1 x KDWD-1	0.15	0.11	0.13	-2.03	-1.99*	-2.01**
KOP-1x J-2	0.03	0.03	0.03	2.10	1.76	1.93*
KOP-1x J-4	0.17	0.22	0.19*	-2.47*	-2.07*	-2.27**
Sheetal x KDWD-1	-0.13	-0.19	-0.16	-6.97**	-6.95**	-6.96**
Sheetal x J-2	-0.34**	-0.47**	-0.40**	-3.20**	-4.03**	-3.62**
Sheetal x J-4	0.03	-0.01	0.01	-4.94**	-3.83**	-4.39**
KDWD-1 x J-2	0.26*	0.20	0.23*	-4.24**	-3.20**	-3.72**
KDWD-1 x J-4	-0.14	-0.21	-0.17	-1.95	-2.57*	-2.26**
J-2 X J-4	0.45**	0.51**	0.48**	1.22	1.41	1.32
Range of SCA effect – **Lowest**	-0.34	-0.47	-0.4	-6.97	-6.95	-6.96
Range of SCA effect – **Highest**	0.55	0.51	0.5	9.49	9.38	9.43
Significant crosses – **Positive**	7	10	16	17	21	21
Significant crosses – **Negative**	2	2	2	14	19	20
SE (Sij)	0.13	0.12	0.09	1.07	0.95	0.72
CD (Sij) at 5%	1.97	1.97	1.96	1.97	1.97	1.96

4.3.2.7 Internodal length

The minimum and the maximum values of GCA effect for Internodal length were -0.12 to 0.10 (S1), -0.12 to 0.11 (S2) and -0.12 to 0.09 (P), respectively (Table 4.4). The parent PLK (0.10; S1), Panvel (0.11; S2) and PLK (0.09; P) followed by Phule Shubhangi (0.09; S1), PLK (0.07; S2) and Phule Shubhangi (0.08; P) respectively registered positive significant general combining ability effect, of which, the former parent was significantly superior; hence it was identified as the best GCA for increasing internodal length. Whereas, the parents KDWD-1 (-0.12; S1), and also (S2) and (P) KDWD-1 recorded the significant as well as negative estimates of GCA effect, and those were designated as poor GCA.

The estimates of SCA effect range from -0.34 to 0.55 (S1), -0.47 to 0.51 (S2) and -0.40 to 0.50 (Pool) (Table 4.8). Total nine (S1), twelve (S2) and eighteen (P) hybrids exhibited significant values; of which, seven, ten and sixteen respectively hybrids had positive estimates. The hybrid PLK x J-2 (0.55; S1), J-2 x J-4 (0.51; S2) and J-2 x J-4 (0.50; P) registered the highest SCA effect followed by Poona Khira x J-2 (0.47; S1), PLK x J-2 (0.44; S2) and J-2 x J-4 (0.48; P) the former hybrid was statistically the longest, hence was designated as the best SCA for internodal length. Among the poor SCA hybrids, hybrid Sheetal x J-2 (-0.34; S1), (-0.47; S2) and (-0.40; P).

4.3.2.8 Vine length

For Vine length, the GCA effects ranged from -3.70 to 4.65 (S1), -3.48 to 4.58 (S2) and -3.59 to 4.62 (P), respectively (Table 4.4). The parent Rushita (4.65; S1), (4.58; S2) and (4.62; P) followed by Panvel and MLKP (0.09, 1.58; S1 respectively), Panvel and MLKP (1.82, 1.41; S2) and Phule Shubhangi and Panvel (1.84, 1.82; P) respectively registered positive significant GCA effect, of which, the former parent was significantly superior, "hence it was identified as the best GCA for increasing vine length". Whereas, the parents Poona khira (-3.70; S1), (-3.48; S2) and - 3.59; P) recorded the significant and negative estimates of GCA effect, and those were designated as poor GCA.

The estimates of SCA effect varied from -6.97 to 9.49 (S1), -6.95 to 9.38 (S2) and -6.96 to 9.43 (P) (Table 4.8). Total thirty one (S1), forty (S2) and forty one (P) hybrids exhibited significant values; of which, seventeen, nineteen and twenty respectively hybrids had positive estimates. The hybrid Rushita x KOP-1 (9.49; S1), (9.38; S2) and (0.50; P) registered the maximum SCAeffect followed by Rushita x Sheetal (9.15; S1), (9.21; S2) and (9.18; P) the former hybrid wasstatistically the longest, hence was designated as the best SCA for internodal length.

Table 4. 8 SCA effects for number of fruits per vine and Fruit length (cm).

Hybrids	Number of fruits per vine			Fruit length (cm)		
1	2			3		
	2021	2022	Pooled	2021	2022	Pooled
Panvel x PLK	-0.14	-0.84*	-0.49	1.46**	0.76	1.11**
Panvel x Phule Shubhangi	-0.02	0.01	0.00	2.70**	2.34**	2.52**
Panvel x Phule Hemangi	0.82*	0.39	0.60*	0.11	0.42	0.27
Panvel x Poona Khira	0.46	0.78*	0.62*	-0.94	-0.69	-0.81*
Panvel x Rushita	-0.85*	0.23	-0.31	-0.89	-0.57	-0.73*
Panvel x MLKP	0.67	0.78*	0.72**	0.11	-0.23	-0.06
Panvel x KOP-1	-0.21	-0.30	-0.25	-0.10	0.15	0.03
Panvel x Sheetal	1.08**	0.51	0.80**	-0.03	-0.08	-0.06
Panvel x KDWD-1	0.32	0.44	0.38	0.73	0.63	0.68*
Panvel x J-2	0.39	-0.34	0.02	-0.68	-0.56	-0.62
Panvel x J-4	-0.28	0.18	-0.05	-0.13	-0.08	-0.11

PLK x Phule Shubhangi	1.29**	1.08**	1.19**	0.09	2.21**	1.15**
PLK x Phule Hemangi	1.79**	0.80*	1.30**	0.24	1.57**	0.90**
PLK x Poona Khira	1.77**	0.85*	1.31**	0.45	-0.11	0.17
PLK x Rushita	0.13	-0.04	0.05	0.34	-0.22	0.06
PLK x MLKP	0.98*	0.85*	0.91**	0.73	-0.09	0.32
PLK x KOP-1	-1.23**	-0.56	-0.90**	-1.17**	-0.43	-0.80*
PLK x Sheetal	0.05	0.58	0.32	-0.34	-0.40	-0.37
PLK x KDWD-1	0.29	0.18	0.24	0.68	0.24	0.46
PLK x J-2	-0.64	0.06	-0.29	0.18	0.16	0.17
PLK x J-4	0.03	-0.08	-0.03	-0.80	-0.91*	-0.85*
Phule Shubhangi x Phule Hemangi	-1.09**	-2.01**	-1.55**	-0.89	-0.39	-0.64
Phule Shubhangi x Poona Khira	-1.11**	-0.96*	-1.04**	-0.14	-0.04	-0.09**
Phule Shubhangi x Rushita	-1.42**	-0.84*	-1.13**	-0.06	-0.08	-0.07
Phule Shubhangi x MLKP	1.43**	1.04**	1.24**	-0.83	-1.35**	-1.09
Phule Shubhangi x KOP-1	0.89*	0.97**	0.93**	0.00	-0.26	-0.13
Phule Shubhangi x Sheetal	1.51*	1.78**	1.64**	0.00	-0.30	-0.15
Phule Shubhangi x KDWD-1	-0.26	0.70	0.22	0.02	-0.26	-0.12
Phule Shubhangi x J-2	1.15**	1.58**	1.37**	-0.11	-0.61	-0.36
Phule Shubhangi x J-4	-1.19**	-0.56	-0.87**	-0.76	-1.10**	-0.93**
Phule Hemangi x Poona Khira	1.05*	1.08**	1.07**	-0.06	-0.52	-0.29
Phule Hemangi x Rushita	-1.26**	0.20	-0.53*	-0.21	-0.19	-0.20
Phule Hemangi x MLKP	-0.40	-0.58	-0.49	-0.84	-1.36**	-1.10**
Phule Hemangi x KOP-1	0.05	0.35	0.20	0.82	0.56	0.69*
Phule Hemangi x Sheetal	1.34**	1.16**	1.25**	0.15	0.69	0.42
Phule Hemangi x KDWD-1	-0.76	1.08**	0.16	-1.26	-1.10**	-1.18**
Phule Hemangi x J-2	0.32	0.63	0.47	-0.26	-0.25	-0.26
Phule Hemangi x J-4	0.65	0.16	0.40	2.46**	1.85**	2.16**
Poona Khira x Rushita	-0.28	-0.75*	-0.52	2.84**	2.30**	2.57**
Poona Khira x MLKP	0.58	1.13**	0.85**	1.44*	0.60	1.02**
Poona Khira x KOP-1	-0.30	0.39	0.05	0.87	0.58	0.73*
Poona Khira x Sheetal	0.98*	1.54**	1.26**	0.20	0.15	0.17
Poona Khira x KDWD-1	0.89*	0.47	0.68*	-1.38*	0.02	-0.68*
Poona Khira x J-2	-2.38**	-1.32**	-1.85**	-0.78	-0.16	-0.47
Poona Khira x J-4	-0.38	-0.13	-0.25	-0.16	0.08	-0.04
Rushita x MLKP	2.60**	1.92**	2.26	-2.44**	-2.45**	-2.45**
Rushita x KOP-1	1.72**	1.85**	1.78**	0.12	0.04	0.08
Rushita x Sheetal	3.01**	1.66**	2.33**	-0.85	-0.57	-0.71*
Rushita x KDWD-1	2.91**	0.92*	1.91**	0.21	0.15	0.18
Rushita x J-2	0.32	0.47	0.39**	0.10	0.23	0.17
Rushita x J-4	-0.35	-0.34	-0.35	0.66	0.80*	0.73*
MLKP x KOP-1	-2.76**	-1.94**	-2.35**	2.55**	1.94**	2.24**
MLKP x Sheetal	-0.80	-0.80*	-0.80**	-1.52**	0.60	-0.46
MLKP x KDWD-1	-1.23**	-0.87*	-1.05**	-0.63	0.15	-0.24
MLKP x J-2	-0.50	-0.32	-0.41	-2.17**	0.30	-0.94**
MLKP x J-4	0.51	0.54	0.52	0.69	0.27	0.48
KOP-1 x Sheetal	-0.69	-0.54	-0.61**	-1.59**	-0.91*	-1.25**
KOP-1 x KDWD-1	1.22**	0.73*	0.97**	0.07	0.10	0.08
KOP-1x J-2	1.29**	0.94*	1.12**	2.26**	0.65	1.45**
KOP-1x J-4	0.63	0.13	0.38	1.55**	0.42	0.98**
Sheetal x KDWD-1	-2.16**	-2.13**	-2.15**	2.80**	1.10**	1.95**
Sheetal x J-2	-0.76	-0.92*	-0.84**	2.69**	0.88*	1.78**
Sheetal x J-4	-1.42**	-0.73*	-1.07**	1.38*	0.88*	1.13**
KDWD-1 x J-2	-1.19**	-0.99**	-1.09**	0.35	-0.05	0.15
KDWD-1 x J-4	-1.52**	-0.13	-0.82**	0.50	0.76	0.63
J-2 X J-4	2.89**	1.75**	2.32**	-1.47**	-1.13**	-1.30**

Range of SCA effect	**Lowest**	-2.76	-2.13	-2.35	-2.44	-2.45	-2.45
	Highest	3.01	1.92	2.33	2.84	2.34	2.57
Significant crosses	**Positive**	21	22	24	10	10	17
	Negative	14	12	15	7	8	14
SE (Sij)		0.41	0.37	0.27	0.56	0.40	0.34
CD (Sij) at 5%		1.97	1.97	1.96	1.97	1.97	1.96

4.3.2.9 Number of fruit per vine

For number of fruits per vine, the estimates of GCA effect ranged from -0.66 to 0.89 (S1), -0.58 to 0.57 (S2) and -0.58 to 0.73 (P), respectively (Table 4.4). In 2021 only three parents KOP-1 (0.89), Rushita (0.86), and J-4 (0.29); in 2022 KOP-1 (0.57), PLK (0.45) and J-4 (0.43) .In case of pooled KOP-1 (0.73), Rushita (0.62) and J-4 (0.36) exerted significant positive GCA values and were designated as good GCA for increasing number of fruits per vine. The poor GCA parent with the lowest GCA effect was MLKP (-0.58; P).

The values of SCA effect ranged from -2.76 to 3.01 (S1), -2.13 to 1.92 (S2) and -2.35 to 2.33 (P) (Table 4.9). In (S1) total of thirty five, (S2) thirty four and (P) thirty nine crosses registered significant values of SCA effect, of which 21 (S1), 22 (S2) and 24 (P) had positive estimates.The cross Rushita x Sheetal (3.01; S1), Rushita x MLKP (1.92; S2) and Rushita x Sheetal (2.33; P). Depict the highest SCA effect followed by Rushita x MLKP (2.60; S1), Rushita x KOP-1 (1.85; S2) and Rushita x KDWD-1 (1.91; P) were identified as better specific combiners.

4.3.2.10 Fruit length (cm)

The minimum and the maximum values of general combining ability effect for fruit length were -1.01 to 0.48 (S1), -0.85 to 0.79 (S2) and -0.93 to 0.60 (P), respectively (Table 4.4). The parent KOP-1 (0.48; S1), MLKP (0.79; S2) and MLKP (0.60; P) followed by MLKP (0.41; S1), KOP-1 (0.30; S2) and KOP-1 (0.39; P) “registered positive significant GCA effect, of which, the former parent was significantly superior; hence it was identified as the best GCA for increasing fruit length”.

Whereas, the parents Phule Shubhangi (-1.01,-0.85, and -0.93 respectively) recorded the significant and negative estimates of GCA effect, and those were designated as poor general combiners. The estimates of specific combining ability effect varied from -2.44 to 2.84 (S1), -2.45 to 2.34 (S2) and -2.45 to 2.57 (P) (Table 4.9).Total 35, 34 and 39 (S1), (S2) and (P) respectively hybrids exhibited significant values, of which, twenty one in (S1), twenty two in (S2) and twenty four in (P) hybrids had positive estimates. The hybrid Poona Khira x Rushita (2.84; S1) followed by Phule

Hemangi x J-4 (2.46), Panvel x Phule Shubhangi (2.34; S2) followed by Poona Khira x Rushita (2.30) and Poona Khira x Rushita (2.57; P) followed by Panvel x Phule Shubhangi (2.52) registered the highest SCA effect. The former hybrid was statistically the longest, hence was designated as the best SCA for fruit length.

Table 4.9 SCA effects for fruit girth and fruit weight

Hybrids	Fruit girth (cm)			Fruit weight (g)		
1	2			3		
	2021	2022	Pooled	2021	2022	Pooled
Panvel x PLK	-0.16	1.96**	0.90**	10.19	-8.68	-15.00
Panvel x Phule Shubhangi	-0.32*	-0.34	-0.33*	-0.31	0.77	15.07
Panvel x Phule Hemangi	0.20	0.06	0.13	-8.02	-9.54	-5.50
Panvel x Poona Khira	0.04	-0.06	-0.01	-5.56	-3.34	-1.65
Panvel x Rushita	-0.15	-0.33	-0.24	-10.72	-8.81	-10.88
Panvel x MLKP	0.10	-0.18	-0.04	11.39	13.38	14.35
Panvel x KOP-1	0.18	0.01	0.09	12.84	-11.28	3.28
Panvel x Sheetal	0.30	0.26	0.28	6.27	5.74	17.25
Panvel x KDWD-1	0.16	-0.05	0.06	-7.15	-6.98	-6.41
Panvel x J-2	0.05	-0.06	-0.01	-2.26	3.72	9.88
Panvel x J-4	0.25	-0.05	0.10	26.58*	23.12**	23.13**
PLK x Phule Shubhangi	-0.59**	-0.59*	-0.59**	23.21	21.78	15.25
PLK x Phule Hemangi	0.03	-0.29	-0.13	-38.94**	39.66**	-6.26
PLK x Poona Khira	0.07	0.16	0.11	0.72	-0.13	5.67*
PLK x Rushita	0.15	-0.04	0.05	12.32	-14.34	-4.32
PLK x MLKP	-0.07	-0.16	-0.12	0.98	-1.33	0.70
PLK x KOP-1	0.17	-0.08	0.05	-12.29	-12.43	-8.88
PLK x Sheetal	0.16	-0.03	0.07	-17.43	15.55	12.88
PLK x KDWD-1	0.16	0.00	0.08	-7.07	8.40	18.78
PLK x J-2	0.01	0.02	0.02	-10.44	-9.55	-25.69
PLK x J-4	-0.09	-0.17	-0.13	-2.01	2.18	18.71
Phule Shubhangi x Phule Hemangi	0.57**	0.24	0.41*	1.54	-1.26	-14.86
Phule Shubhangi x Poona Khira	0.47**	0.39	0.43**	3.25	1.70	-0.49
Phule Shubhangi x Rushita	-0.11	-0.08	-0.10	-2.55	-1.88	-13.70
Phule Shubhangi x MLKP	-0.14	-0.16	-0.15	49.89**	7.32**	3.06*
Phule Shubhangi x KOP-1	0.14	0.39	0.27	32.08*	-30.00*	-8.16
Phule Shubhangi x Sheetal	-0.07	-0.16	-0.12	-2.66	-23.26	-11.46
Phule Shubhangi x KDWD-1	0.43	0.37	0.40*	-25.94	29.76	4.62

Phule Shubhangi x J-2	0.05	0.12	0.08	-30.96*	-17.05*	-13.42
Phule Shubhangi x J-4	0.15	0.13	0.14	-18.24	-1.96	-7.70
Phule Hemangi x Poona Khira	-0.24	-0.08	-0.16	-21.19	-5.19	0.27
Phule Hemangi x Rushita	-0.46**	-0.24	-0.35*	-7.73	-18.53	-15.91
Phule Hemangi x MLKP	-0.15	0.11	-0.02	10.38	22.99	7.33
Phule Hemangi x KOP-1	-0.24	-0.21	-0.22	-37.36**	21.01**	38.20**
Phule Hemangi x Sheetal	-0.08	-0.06	-0.07	-11.47	-11.85	-6.63**
Phule Hemangi x KDWD-1	0.28	0.33	0.31	-13.52	-12.49	-1.31
Phule Hemangi x J-2	0.24	0.25	0.25	-3.64	-5.93	-6.43
Phule Hemangi x J-4	-0.13	-0.14	-0.14	-18.82	-20.26	0.63
Poona Khira x Rushita	0.25	0.20	0.23	2.63	-4.66	-4.57
Poona Khira x MLKP	-0.11	-0.21	-0.16	6.34	-7.78	-8.15
Poona Khira x KOP-1	-0.10	-0.13	-0.11	18.44	-20.12	-18.16
Poona Khira x Sheetal	-0.11	-0.08	-0.10	-24.87	-22.86	-10.20
Poona Khira x KDWD-1	0.06	0.05	0.05	23.42	-24.06	-4.94
Poona Khira x J-2	-0.02	-0.07	-0.05	9.04	10.89	16.15
Poona Khira x J-4	-0.16	0.01	-0.08	35.45**	-34.69**	-4.42
Rushita x MLKP	0.31	0.42	0.36*	-12.36	14.19	28.50**
Rushita x KOP-1	0.39*	0.34	0.36*	10.24	13.18	12.94
Rushita x Sheetal	0.31	0.35	0.33*	2.30	1.60	-0.86
Rushita x KDWD-1	0.17	0.15	0.16	1.22	1.83	0.74
Rushita x J-2	-0.14	-0.07	-0.11	-8.65	-9.66	-8.56
Rushita x J-4	0.29	0.24	0.27	-11.32	-10.86	-9.89**
MLKP x KOP-1	-0.11	-0.05	-0.08	-9.47	-12.54	-18.08
MLKP x Sheetal	-0.25	-0.10	-0.18	-15.97	-18.54	-23.75
MLKP x KDWD-1	-0.19	-0.17	-0.18	-12.35	-13.72	-18.85
MLKP x J-2	0.14	0.08	0.11	1.08	0.54	0.66
MLKP x J-4	-0.23	-0.31	-0.27	13.40**	14.23**	27.84**
KOP-1 x Sheetal	-0.21	-0.18	-0.19	-7.65	-8.38	4.09
KOP-1 x KDWD-1	-0.11	-0.19	-0.15	14.47	15.87	30.59**
KOP-1x J-2	-0.05	0.00	-0.03	10.58	11.48	15.95
KOP-1x J-4	-0.22	-0.13	-0.17	-3.35	-4.32	-21.15
Sheetal x KDWD-1	-0.29	-0.27	-0.28	0.28	0.58	0.73
Sheetal x J-2	-0.03	-0.12	-0.08	3.54	2.66	2.20
Sheetal x J-4	-0.10	-0.11	-0.11	-20.47	-19.72	-13.60
KDWD-1 x J-2	-0.53*	-0.43	-0.48**	-7.65	-5.38	-7.30*
KDWD-1 x J-4	-0.24	-0.32	-0.28	2.54	2.45	1.07

J-2 X J-4		0.12	0.10	0.11	9.47	9.94	10.06
Range of SCA effect	**Lowest**	-0.59	-0.59	-0.59	-38.94	-34.69	-25.69
	Highest	0.57	0.42	0.43	49.89	39.66	38.20
Significant crosses	**Positive**	3	1	7	5	5	7
	Negative	4	1	4	3	3	3
SE (Sij)		0.16	0.29	0.16	26.18	25.58	22.01
CD (Sij) at 5%		1.97	1.97	1.96	1.97	1.97	1.96

4.3.2.11 Fruit Girth (cm)

The estimates of general combining ability (GCA) effect for fruit ranged from -0.20 to 0.20 (S1), -0.14 to 0.29 (S2) and -0.13 to 0.21 (P), respectively (Table 4.4). Only three parents Phule Shubhangi (0.20), Rushita (0.16) and PLK 90.13) in (S1), two parents PLK and Panvel (0.29, 0.21) in (S2) and in case of pool four parents noticed positive and significant estimates of general combining ability effect were designated as good GCA for increasing fruit girth. While, the parents KDWD-1 and Sheetal (-0.20; S1), PLK, Phule Shubhangi, Panvel and Rushita (0.21, 0.16, 0.14 and 0.12 respectively) depicted significant negative GCA effects. These parents could be good general combining ability (GCA) when thin fruits were favored as a superiority parameter.

For fruit girth, the estimates of specific combining ability effect varied from -0.59 to 0.57 (S1), -0.59 to 0.42 (S2) and -0.59 to 0.43 (P) (Table 4.10). Total seven, two and eleven respectively F_1s exhibited significant SCA effects, of these, three (S1), one (S2) and seven (P) F1s exerted positive SCA effect. The hybrid Phule Shubhangi x Phule Hemangi (0.57) followed by Phule Shubhangi x Poona Khira (0.47; S1), Rushita x MLKP (0.42; S2) and Phule Shubhangi x Poona Khira (0.43; P) manifested the highest SCA effects and regarded as good SCA for increasing fruit girth. Whereas, the cross PLK x Phule Shubhangi (-0.59; S1), (-0.59; S2) and (-0.59; P) followed by Phule Hemangi x Rushita (-0.46), had the most estimate of SCA effect followed by ACUS 9-50 x ACUS 13- 60 (-2.48) were designated as good SCA, if thin fruit girth is desired in respect to quality parameter.

4.3.2.12 Fruit weight (g)

The range of GCA effects for average fruit weight was determined to be between the minimum and maximum values of -17.83 to 10.26 (S1), -11.55 to 8.74 (S2) and -10.10 to 8.47 (P), respectively (Table 4.4). In (S1) three parents exerted significant GCA effect, in (S2) also three and four (P) parents exerted GCA significant effect of which, in S1 and S2 equally number of parents had positive as well as negative values.The parent MLKP exhibited the highest GCA effect, with a value of 10.26 followed by Rushita (9.25; S1), Rushita (8.74; S2) followed by KOP-1 (5.12; S2) and Rushita (8.47; P) followed by KOP-1 (6.79; P).The parent Phule Shubhangi (-17.83; S1) followed by Poona khira (-9.90), Phule Shubhangi (-11.55; S2) followed by Poona khira (-9.43) and Poona khira (-10.10; Pool) followed by Rushita (-8.47) exhibited the least value of GCA effect these parents were considered as poor general combiners.

The estimates of specific combining ability (SCA) effect for average fruit weight ranged from -38.94 to 49.89 (S1), -34.69 to 39.66 (S2) and -25.69 to 38.20 (P) (Table 4.10). A total of eight (S1), eight (S2) and ten (P) respectively crosses depicted significant SCA effect, of which, five (S1), five (S2) and seven (P)exerted positive effect. The maximum specific combining ability (SCA) effect was depicted by cross Phule Shubhangi x MLKP (49.89) followed by Poona Khira x J-4 (35.45; S1).

Table 4.10 SCA effects for Fruit yield per vine

Hybrids	**Fruit yield per vine (kg)**		
1	**2**		
	2021	**2022**	**Pooled**
Panvel x PLK	0.05	-0.06	-0.89
Panvel x Phule Shubhangi	1.24**	1.00*	-2.87
Panvel x Phule Hemangi	1.32**	1.92	3.68**
Panvel x Poona Khira	0.58	2.82**	2.20
Panvel x Rushita	-1.39**	-1.26	3.42
Panvel x MLKP	0.69*	-1.52	-0.98*
Panvel x KOP-1	0.70*	-0.36	-0.45
Panvel x Sheetal	-0.71*	1.69*	2.60**
Panvel x KDWD-1	-1.17**	1.69*	2.99
Panvel x J-2	-0.94**	0.62	6.30
Panvel x J-4	1.25**	2.56**	4.96*
PLK x Phule Shubhangi	0.08	0.28	0.77
PLK x Phule Hemangi	-0.52	-0.02	2.31
PLK x Poona Khira	0.21	0.78*	6.23**
PLK x Rushita	-0.12	0.34	4.83
PLK x MLKP	0.24	2.23**	6.91**
PLK x KOP-1	-0.37	-1.94	-3.60
PLK x Sheetal	0.19	-0.75	-1.99
PLK x KDWD-1	1.34**	1.30	7.73**
PLK x J-2	-1.44**	-1.43	-2.18
PLK x J-4	-0.61*	-0.84*	-6.89
Phule Shubhangi x Phule Hemangi	0.53	-0.10	1.72
Phule Shubhangi x Poona Khira	0.14	-0.97	-1.17
Phule Shubhangi x Rushita	0.64*	-0.14	-6.01

Phule Shubhangi x MLKP		0.92**	-1.50**	-5.16
Phule Shubhangi x KOP-1		-0.53	1.73	2.14**
Phule Shubhangi x Sheetal		-0.20	1.97	7.19
Phule Shubhangi x KDWD-1		-0.56	1.11	2.25
Phule Shubhangi x J-2		-1.07**	1.05	7.04
Phule Shubhangi x J-4		-0.94**	-1.67	-5.34
Phule Hemangi x Poona Khira		-0.78**	2.72	6.12
Phule Hemangi x Rushita		0.26	0.35	5.75
Phule Hemangi x MLKP		0.02	-0.58	-2.76
Phule Hemangi x KOP-1		-0.82**	-0.40**	1.80
Phule Hemangi x Sheetal		-0.69*	-0.63	-1.77
Phule Hemangi x KDWD-1		2.87**	-2.27**	0.89
Phule Hemangi x J-2		1.59**	-2.64	-8.49**
Phule Hemangi x J-4		1.17**	-1.44	-5.64
Poona Khira x Rushita		0.96**	0.97*	1.86
Poona Khira x MLKP		-0.58	0.19	4.35
Poona Khira x KOP-1		1.02**	0.62	3.27
Poona Khira x Sheetal		-0.75*	-0.87	-1.20
Poona Khira x KDWD-1		-0.63*	-0.23	-1.62
Poona Khira x J-2		0.00	0.13*	1.80
Poona Khira x J-4		-0.59*	0.67	3.13
Rushita x MLKP		1.18	1.09	2.72
Rushita x KOP-1		0.98	-1.81	-2.82
Rushita x Sheetal		0.99	1.16	4.42**
Rushita x KDWD-1		2.10*	-1.23	-4.22
Rushita x J-2		1.98	1.27*	3.81
Rushita x J-4		0.87	-1.70	-2.27
MLKP x KOP-1		-0.88	-0.13	0.48
MLKP x Sheetal		-0.58	0.57	8.59**
MLKP x KDWD-1		1.55**	1.65	5.90**
MLKP x J-2		-0.84	-0.80	6.10**
MLKP x J-4		0.86	0.96	9.19**
KOP-1 x Sheetal		1.08	-2.46	-5.32
KOP-1 x KDWD-1		0.08	0.22	0.32
KOP-1x J-2		1.06	1.73*	1.49
KOP-1x J-4		1.57**	1.39	1.90**
Sheetal x KDWD-1		0.77	1.10	2.34
Sheetal x J-2		0.98	5.71**	4.02
Sheetal x J-4		-0.89	1.16	6.92
KDWD-1 x J-2		-0.88	-0.34	6.49**
KDWD-1 x J-4		-0.58	-2.08	-1.42
J-2 X J-4		1.55	2.90*	4.14*
Range of SCA effect	**Lowest**	-1.44	-2.64	-8.49
	Highest	2.87	5.71	9.19
Significant crosses	**Positive**	16	13	13
	Negative	14	4	2
SE (Sij)		0.29	0.31	0.26
CD (Sij) at 5%		1.97	1.97	1.96

4.3.2.13 Fruit yield per plant (kg)

The estimate of GCA effect for fruit yield per plant ranged from -3.06 to 1.37 (S1), -2.55 to 1.38 (S2) and -2.81 to 2.69 (P), respectively (Table 4.4). Total seven parents exerted significant GCA effect in (S1), eight parents exerted significant GCA effect in (S2) and eight parents significant GCA effect in (P) of which, two parents Rushita 1.37, and PLK 0.31 (S1), KOP-1 1.38, Phule Shubhangi 0.93, Poona khira 0.60 PLK 0.24 and KDWD-1 (S2), KOP-1 2.69, MLKP 2.29, Rushita 1.19, PLK 0.65, Phule Shubhangi 0.55, (P) had positive estimates, the precede parent was significantly better than rest of the parents, hence, it was designated as better GCA. The least estimate of GCA effect was depicted by parents J-4 (-3.06; S1) followed by Phule Hemangi (-0.75), J-4 (-2.55; S2) followed by Rushita (-1.69; S2) and J-4 (-2.81; P) followed by Phule Hemangi -1.15; P). The parents with significant and negative values of GCA effect were classified as poor GCA.

The estimates of specific combining ability (SCA) effects ranged from -1.44 to 2.87 (S1), -2.64 to 5.71 (S2) and -8.49 to 9.19 (P) (Table-4.11). A total of 30 (S1), 17 (S2) and 15 (P) hybrids exerted significant SCA effect, of which, 16 hybrids had positive values in 2021 (S1), 13 hybrids had positive values in 2022 (S2) and 13 hybrids had positive values in Pool. The hybrid Phule Hemangi x KDWD-1 (2.87) manifested the highest SCA effect followed by Phule Hemangi x J-2 (1.59; S1), Sheetal x J-2 (5.71; S2) followed by Panvel x Poona Khira (2.82; S2) and MLKP x J-4 (9.19; P) followed by MLKP x Sheetal (8.59; P) and PLK x KDWD-1 (7.73; P) The former hybrid was significantly the highest from the other hybrids; hence it was identified as better specific combiners.

CHAPTER 5

DISCUSSION

Studies in the field of genetics and plant breeding have made possible to exploit hybrid vigour for yield and quality improvement. The major objective of cucumber breeding is to develop homogeneous high yielding hybrids with desirable fruit shape, size and colour and disease resistance. The present investigation entitled “Study of heterosis and combining ability in cucumber (*Cucumis sativus* L.) using half diallel analysis” was conducted at Lovely Professional University, Genetics and Plant Breeding farm during 2020-2022 to examine the heterotic effects and combining ability effect of hybrids for different traits. The results obtained from the present study have been discussed under the following sub heads:

5.1 ANALYSIS OF VARIANCE (ANOVA)

The field data revealed differences among genotypes (*i.e.* highly significant) for all studied traits (Table 4.1). Variance among parents and hybrids were also found significant. Differences due to parents vs. hybrids was also found highly significant (except fruit girth) indicating presence of heterosis in the material selected for study.

5.2 HETEROSIS

In a systematic breeding programme, the cross combination having high heterotic effect along with high estimate of combining ability effect help in rapid and effective identification of superior hybrids. In the present study, hybrids showed considerable heterosis for fruit yield as well as component traits. Heterosis for fruit yield per vine ranged from -88.20% (Poona Khira x J-4) to 80.14% (MLKP x J-4).Three cross combinations namely, MLKP x J-4, Panvel x MLKP and Panvel x J-4 had yielded maximum fruit yield per vine. Positive estimation of heterosis for this trait was also reported by Sahoo *et al*, (2019, -1.46 to 174.99) Bhatt *et al,* (2017), Simi *et al,* (2017), Chittora *et al,* (2018), Preethi *et al*, (2019), and Naik *et al*, (2020) whereas negative heterosis was reported by Munshi *et al*, (2005).

In case of days to first male flower standard heterosis was ranged from -32.91% (KOP-1 x Sheetal) to 28.45% (PLK x Sheetal). Top three hybrid namely KOP-1 x Sheetal (-32.91%), Sheetal x J-4 (-29.91%) and KOP-1 x KDWD-1 (-29.13%) had significant and negative standard heterosis for days to first male flower (Malini). Significant and favorable heterosis for days to opening first male flower was also reported by Chikezie *et al*, (2019) and Naik *et al*, (2020).

For days to first female flower, forty four experimental hybrids were significantly earlier than standard check (Malini). Top three promising hybrid KOP-1 x Sheetal (-26.86%), KOP-1 x KDWD-1 (-22.71%) and KOP-1 x J-2 (-22.05 %) had early emergence for first female flower. The experimental hybrid developed in our study have heterosis ranged from -26.86 % (KOP-1 x Sheetal) to 9.54 % (Phule Hemangi x KDWD-1). Favorable heterotic effect for days to first female flower was also noted earlier by Singh *et al*, (1999) and Chikezie *et al*, (2019), Singh *et al*, (2010), Dogra and Kanwar (2011), Singh *et al*. (2015), and Jat *et al*. (2015).

Heterosis for first fruit bearing node, was ranged from -95.52% (Rushita x KOP-1) to 108.93% (KDWD x J-4). Top three hybrid like Rushita x KOP-1 (-95.52 %), Phule Shubhangi x MLKP (-88.37%) and Panvel x J-4 (-88.05%) had early emergence of fruit bearing node over SC (standard check Malini). Significant heterosis for fruit bearing node was also reported by Singh *et al*. (2018), Singh *et al*, (2015), Thakur *et al*. (2017), Punetha *et al*, (2017) and Chittora *et.al*. (2018).

Twenty hybrids exhibited better heterosis than standard check (Malini 55.98) for days to first fruit harvest. It was range between -19.76 % (KOP-1 x J-4) to 12.98 % (KOP-1 x Sheetal). Three cross combination KOP-1 X J-4 (-19.76%), PLK x Phule Shubhangi (-12.84%) and Poona Khira x J-4 (-11.34%) were reported earlier fruit harvest than other experimental hybrids. These findings confirmed results of Dogra and Kanwar (2011), Airina *et al*. (2013), Singh *et al*. (2015) and Singh.*et al*. (2016) and Chittora *et al.* (2018).

For days to last harvesting, thirty-three hybrids demonstrated heterosis compared to the standard check (Malini 94.47). It was range between -7.44 % (KDWD-1 x J-4) to 7.87 % (KOP-1 x J-2), KDWD-1 x J-4 (-7.44%), PLK x KDWD-1 (-6.04%) and PLK x Poona khira (-5.90%) were ready for harvesting even better than standard check (94.47). These findings confirmed the results of those reported by Singh *et al*. (2015), Naik *et al*. (2020), and Chittora *et al*. (2018).

Twenty five hybrids exhibited better heterosis than standard check (Malini 4.29) for number of primary branches per vine. Sheetal x KDWD-1 (100.90%) followed by J-2 x J-4 (99.13%) and PLK x J-2 (98.89%) were exhibited maximum number of primary branches. Similar findings were also reported by Chaubey and Ram (2004) and Jadhav *et al*. (2009).

For internodal length, out of 66 crosses, thirty five crosses had depicted significant and desirable estimates of heterosis than standard check (Malini 3.83cm) and ranged from - 22.25% (PLK x J-2) to 17.02% (Poona Khira x J-2). Top three crosses were Poona khira x J-2, J- 2 x J-4 and PLK x

Phule Shubhangi. The internodal length position is beneficial and contributes for this trait result were noted by Talekar *et al*. (2013), Punetha *et al*. (2017), Reddy *et al*, (2018), and Chittora *et al*. (2018).

For vine length, thirty five hybrids exhibited significant heterosis over check (Malini 63.04 cm). Rushita x KOP-1(30.88%), Rushita x J-4 (30.25%) and Rushita x MLKP (29.78%) was showed maximum vine length heterosis. This result is in agreement with Kaur *et al*. (2017), Chittora *et.al*. (2018) and Singh *et al.* (2018).

The number of fruits per vine plays an important role in determining the fruit yield. Thirty six crosses exceeded the Malini (6.01) for number of fruits per vine. Top three hybrid namely Rushita x KOP-1 (68.89 %), J-2 x J-4 (63.08%) and Rushita x Sheetal (61.55 %) had significant heterosis for Number of fruit per vine over SC (standard check Malini). Similar findings were also reported by Singh *et al*. (2015), Pandey *et al*. (2005), Singh *et al*. (2010a), Mule *et al.* (2012), Kushwaha *et al*. (2011), and Airina *et al*. (2013).

Fruit length is important yield contributing traits. Thirty five crosses exhibited significant heterosis for FL (Malini 7.86 cm), MLKP x KOP-1 (92.18 %) had highest standard heterosis. It has been followed by Sheetal x KDWD-1 (81.90%) and Sheetal x J-2 (78.57%). Positive estimation of heterosis for this trait was reported by Singh *et al*. (1999), Pandey *et al*. (2005), Singh *et al*. (2015), Kushwaha *et al*. (2011), Mule *et al*. (2012), Singh *et al*. (2012), Airina *et al*. (2013), Singh *et al*. (2010b), Chittora *et al*. (2018), and Chikezie *et al*. (2019).

In case of fruit girth, twenty six crosses exhibited desirable and significant heterosis for FG (Malini 3.27). It was ranged from -30.45% (Rushita x J-4) to 58.96% (Panvel x PLK). Panvel x PLK (5.20 cm) had reported maximum heterosis followed by Phule Shubhangi x Poona Khira and Rushita x MLKP. This result is in agreement with Singh *et al*. (1999), Munshi *et al*. (2005), Pandey *et al*. (2005), Kushwaha *et al*. (2011), Mule *et al*. and Punetha *et al*. (2015).

For fruit weight (Malini 144.32 gm), sixteen crosses have exhibited significant heterosis compared to the standard check (Malini). The hybrid Phule Shubhangi x MLKP (40.65%) had exerted the highest positive heterosis for Fruit weight followed by Poona Khira x KDWD-1 (39.87%) and Poona Khira x J-4 (39.58%). Positive estimation of heterosis for this trait was reported by Pandey *et al*. (2005), Kushwaha *et al*. (2011) and Singh *et al*. (2012).

5.3 COMBINING ABILITY ANALYSIS

To improve the potential fruit yield of hybrids, it is crucial to carefully select parents for hybridization. However, sometimes parents with good combining ability estimates may not perform well when combined. Therefore, in addition to evaluating per se performance and general and specific combining abilities, knowledge about the type of gene action involved can be helpful in planning a breeding program. In theory, general combining ability (GCA) results from additive genetic effects and additive x additive interaction effects, and it is a fixed. On the other hand, specific combining ability (SCA) results from non-additive gene action, which can be due to dominance or epistasis, or both, and it is a non-fixable.

The GCA effect of the parents for different characters was estimated and classified as good (G), average (A) and poor (P) combiners accordingly (Table 5.2). The results revealed that parents PLK, Phule Shubhangi, Phule Hemangi and Poona Khira were good general combiners for fruit yield.

The parent PLK was observed to a good general combiner for fruit yield and nine other important traits (days to first male flower, days to first female flower, days to first harvest, days to last harvest, number of primary braches per vine, internodal length, vine length, number of fruit per vine and fruit girth). In addition it was average general combiner for fruit length and fruit weight. The parent J-2 was good general combiner for days to first female flower and number of primary braches per vine and average combiner for all other characters except days to last harvest and Fruit girth. Similarly Rushita was good combiner for internodal length, vine length, number of fruit per vine and fruit girth. Sheetal was good general combiner for days to first male flower, days to first female flower, number of primary braches per vine and fruit length. The other average general combiner parents for fruit yield were Panvel, Rushita, MLKP, Sheetal, KDWD and J-2. The parent KOP- 1 was good combiner for days to first male flower, days to first female flower, number of fruit per vine, fruit length and fruit weight but poor for fruit yield per vine, vine length, and internodal length.

The parent MLKP was average general combiner for First fruit bearing node, Days to last harvest, Number of primary braches per vine, Internodal length, Fruit girth and Fruit weight. The parent Poona Khira was average combiner for First fruit bearing node, Days to first harvest, Days to last harvest, Number of primary braches per vine, Internodal length and Number of fruit per vine. None of the parents was identified as good general combiner for all the characters under study that may be due to invariable relationships among yield contributing characters. Best performing parents (with respect to GCA) PLK and J-2 could be exploited usefully in future cucumber breeding programme by adopting appropriate breeding procedures. These parents expected to throw better transgressive segregates carrying fixable gene effects.

The hybrid MLKP x J-4, MLKP x Sheetal, PLK x Poona Khira, MLKP x KDWD-1, Panvel x J-4 and Rushita x Sheetal had highest *per se* performance, along with SCA effect and heterosis for fruit yield per vine.

Hybrids involving MLKP (MLKP x J-4, MLKP x Sheetal and MLKP x KDWD-1) as parent could be successfully exploited for varietal improvement even though is an average combiner. Hybrids exhibiting favorable and higher additive effects also results in higher SCA effects.

As stated above the crosses, involving MLKP with J-4, Sheetal and KDWD-1 could be exploited for the production of F_1 hybrids and can be used for recombination breeding in order to develop high yielding hybrid suitable for this region. In this investigation, yield and yield traits of cucumber were governed by additive as well as non-additive genes alike but there is preponderance of non-additive gene action, Therefore, improvement in those traits can best be done by heterosis breeding programme. Based on estimates of heterosis, the cross between MLKP x J-4 showed the highest heterosis in terms of total fruit yield per vine, followed by the crosses between MLKP x Sheetal and MLKP x KDWD-1.

Table 5.1 Magnitude of better parent (BP) and standard heterosis (SH) for various characters in cucumber (Pooled)

Sr. No.	Characters	Range of heterosis		Number of crosses with significant heterosis			
		BP	SH	BP		SH	
				Positive	Negative	Positive	Negative
1	Days to first male flower	-12.15 to 15.55	-32.91 to 28.45	6	16	9	28
2	Days to first female flower	15.60 to 17.12	-26.86 to 9.54	21	22	10	44
3	First fruit bearing node	-19.17 to 67.08	-95.52 to 108.93	45	13	42	17
4	Days to first harvest	-7.07 to 13.07	-19.76 to 12.98	15	15	13	20
5	Days to last harvest	-6.48 to 4.74	-7.44 to 7.87	14	26	16	33
6	Number of primary branches per vine	-19.15 to 71.03	-98.53 to 100.90	29	28	25	18
7	Internodal length (cm)	-32.02 to 34.09	-22.25 to 17.02	42	18	35	24
8	Vine length (cm)	-12.76 to 26.42	-16.85 to 30.88	28	18	35	18
9	Number of fruits per vine	-37.51 to 80.10	-27.91 to 68.89	26	13	36	11
10	Fruit length (cm)	-30.85 to 26.58	-80.48 to 92.18	16	10	35	12
11	Fruit girth (cm)	-16.23 to 23.50	-30.45 to 58.69	19	21	26	20
12	Fruit weight (g)	-44.58 to 48.69	-27.39 to 40.65	14	15	16	13
13	Fruit yield per vine (kg)	-69.87 to 99.65	-88.20 to 80.14	14	19	14	19

Table 5.2 Classification of parents with respect to general combining ability effect for various characters (Pooled)

Parents	Days to first male flower	Days to first female flower	First fruit bearing node	Days to first harvest	Days to last harvest
Panvel	A	P	P	G	A
PLK	G	G	P	G	G
Phule Shubhangi	P	P	A	P	A
Phule Hemangi	P	G	A	A	G
Poona Khira	P	G	A	A	A
Rushita	A	P	A	P	A
MLKP	P	P	A	P	A
KOP-1	G	G	A	G	A
Sheetal	G	G	A	A	P
KDWD-1	G	G	G	P	A
J-2	A	G	A	A	P
J-4	G	A	A	G	A

[G = Good; A = Average; P = Poor]

Table 5.2 Classification of parents with respect to general combining ability effect for various characters (Pooled)

Parents	Number of primary branches per vine	Internodal length (cm)	Vine length (cm)	Number of fruits per vine	Fruit length (cm)
Panvel	P	G	G	P	A
PLK	G	G	G	G	A
Phule Shubhangi	A	G	G	A	P
Phule Hemangi	A	A	P	A	P
Poona Khira	A	A	P	A	A
Rushita	P	G	G	G	P
MLKP	A	A	G	P	G
KOP-1	A	P	P	G	G
Sheetal	G	A	P	P	G
KDWD-1	G	P	P	P	A
J-2	G	A	A	A	A
J-4	A	P	A	G	A

[G = Good; A = Average; P = Poor]

Table 5.2 Classification of parents with respect to general combining ability effect for various characters (Pooled)

Parents	Fruit girth (cm)	Fruit weight (g)	Fruit yield per vine (kg)
Panvel	G	A	A
PLK	G	A	G
Phule Shubhangi	G	P	G
Phule Hemangi	P	A	G
Poona Khira	P	P	G
Rushita	G	A	A
MLKP	A	A	G
KOP-1	A	G	P
Sheetal	P	A	A
KDWD-1	P	P	A
J-2	P	A	A
J-4	P	A	P

[G = Good; A = Average; P = Poor]

Table 5.3 Hybrid *per se* performance, heterotic effects, GCA effect of parents and significant SCA effect of top ten performing F_1's

Crosses	SCA effect	Heterosis		GCA effect		Fruit yield par vine (kg)	Significant specific combining ability effect for othertraits in desired direction
		HB	SH		Male		
MLKP x J-4	9.19**	13.65	80.14**	5.47	-2.81**	9.19**	DFFF,VL,FW,FYPV
MLKP x Sheetal	8.59**	67.11**	70.47**	4.88	-0.29*	8.59**	NFPV,FYPV
PLK x Poona Khira	6.23**	-0.98*	61.76**	3.65	2.29**	6.23**	FFBN,NPBPV,VL, NFPV,FW
MLKP x KDWD-1	5.90**	26.98**	21.47**	4.89	-0.26	5.90**	DFFF,DLH,VL, FYPV
Panvel x J-4	4.96*	4.58	69.85**	3.65	-2.81**	4.96*	FFBN,FW,
Rushita x Sheetal	4.42**	24.36	22.41	3.90	-0.29*	4.42**	DFMF,DFFF,DLH,NFPV, FG,
J-2 x J-4	4.14*	48.78	51.98	2.18	-2.81**	4.14*	DFFF,IL,NFPV,
Panvel x Phule Hemangi	3.68**	58.77**	60.32**	3.22	-1.15**	3.68**	VL,NFPV,
Phule Shubhangi x KOP-1	2.14**	-40.69	39.66**	2.64	2.69	2.14**	VL,NFPV,
Panvel x Sheetal	2.60**	-33.22	11.39	2.47	-0.29*	2.60**	NFPV,VL,NPBPV,

[DFMF-Days to first male flower, DFFF-Days to first female flower, FFBN- First fruit bearing node, DLH- Days to last harvest, FL- Fruit length, NPBPV-Number of primary branches per vine, VL- Vine length, NFPV- Number of fruits per vine, IL- Internodal length, FW- Fruit weight and FYPV- Fruit yield per vine]

PLATE 1: PROMISING TOP THREE HYBRIDS

MLKP

MLKP X J-4

J-4

MLKP

MLKP X Sheetal

Sheetal

MLKP

MLKP X KDWD- 1

KDWD-1

Table 5.4 Better performing parents (*per se* performance and GCA effect)

Character	Best parents	
	***per se* performance**	**GCA effects**
Days to first male flower	Sheetal (29.11) KOP-1(30.56) KDWD-1 (31.35)	Sheetal (-1.11) KOP -1 (-1.02) KDWD -1 (-0.60)
Days to first female flower	Sheetal (39.20) Panvel (39.64) KOP-1 (39.84)	KOP-1 (-0.90) Sheetal (-0.84) KDWD-1 (-0.58)
First fruit bearing node	KOP-1 (4.87) Phule Hemangi (5.11) J-2 (5.18)	KDWD-1 (0.31) J-4 (0.12) KOP-1 (0.09)
Days to first harvest	J-4 (46.01) KOP-1 (49.89) J-2 (50.39)	J-2 (-1.33) Panvel (-0.75) KOP-1 (-0.34)
Days to last harvest	Phule Hemangi (88.30) Poona Khira (90.57) PLK (91.04)	PLK (-0.61) Phule Hemangi (-0.61) Panvel (-0.59)
Number of primary branches per vine	Phule Shubhangi (6.50) KDWD-1 (6.30) J-4 (6.17)	PLK (0.83) Sheetal (0.35) KDWD-1 (0.28)
Internodal length	MLKP (4.18) Sheetal (4.10) Rushita (4.09)	PLK (0.09) Phule Shubhangi (0.08) Panvel (0.07)
Vine length (cm)	Phule Shubhangi (73.24) J-2 (71.16) PLK (69.54)	Rushita (4.62) Phule Shubhangi (1.84) Panvel (1.82)
Number of fruits per vine	KOP-1 (8.01) J-4 (7.87) KDWD- 1 (6.88)	KOP-1 (0.73) Rushita (0.62) J-4 (0.36)
Fruit length (cm)	MLKP (14.20) J-2 (12.09) Rushita (11.66)	MLKP (0.60) KOP-1(0.39) Sheetal (0.33)
Fruit girth (cm)	MLKP (4.31) PLK (4.21) J-2 (4.05)	PLK (0.21) Phule Shubhangi (0.16) Panvel (0.14)
Fruit weight (g)	Rushita (210.47) J-4 (190.27) MLKP (182.56)	Rushita (8.47) MLKP (8.42) KOP-1 (6.79)
Fruit yield per vine (kg)	MLKP (4.31) PLK (4.21) J-4 (4.05)	KOP-1 (2.69) MLKP (2.29) Rushita (1.19)

Table 5.5 Better performing hybrids (BH, SH, *per se* and SCA effect) for different characters

Character	Top three heterotic (%) hybrids	
	Better parent	Standard Heterosis
Days to first male flower	Phule Shubhangi x Poona Khira (-12.15) Panvel x Poona Khira (-10.26) Poona Khira x MLKP (-10.16)	KOP-1 x Sheetal (-32.91) Sheetal x J-4 (-29.91) KOP-1 x KDWD-1 (-29.13)
Days to first female flower	KOP-1 x Sheetal (-15.67) KOP-1 x KDWD-1 (-12.31) KOP-1x J-2 (-11.57)	KOP-1 x Sheetal (-26.86) KOP-1 x KDWD-1 (-22.71) KOP-1x J-2 (-22.05)
First fruit bearing node	Sheetal x KDWD-1 (-19.17) Panvel x Sheetal (-14.12) PLK x KDWD-1 (-12.34)	Rushita x KOP-1 (-95.52) Phule Shubhangi x MLKP (-88.37) Panvel x J-4 (-88.05)
Days to first harvest	PLK x Phule Shubhangi (-7.07) Poona Khira x Sheetal (-7.05) KOP-1x J-4 (-4.96)	KOP-1x J-4 (-19.76) PLK x Phule Shubhangi (-12.84) Poona Khira x J-4 (-11.34)
Days to last harvest	KOP-1x J-2 (-6.48) KDWD-1 x J-4 (-5.19) Rushita x MLKP (-3.29)	KDWD-1 x J-4 (-7.44) PLK x KDWD-1 (-6.04) PLK x Poona Khira (-5.90)
Number of primary branches per vine	Panvel x MLKP (71.03) PLK x Phule Hemangi (58.74) MLKP x KOP-1 (58.14)	Sheetal x KDWD-1 (100.90) J-2 x J-4 (99.13) PLK x J-2 (98.89)
Internodal length	PLK x KDWD-1 (34.09) Phule Shubhangi x KDWD-1 (32.92) KDWD-1 x J-2 (28.01)	Poona Khira x J-2 (17.02) J-2 x J-4 (16.96) PLK x Phule Shubhangi (16.27)
Vine length (cm)	Rushita x KOP-1 (26.42) Rushita x J-4 (24.89) Rushita x Sheetal (24.60)	Rushita x KOP-1 (30.88) Rushita x J-4 (30.25) Rushita x MLKP (29.78)
Number of fruits per vine	Rushita x Sheetal (80.10) Rushita x MLKP (75.22) PLK x Phule Hemangi (47.36)	Rushita x KOP-1 (68.89) J-2 x J-4 (63.08) Rushita x Sheetal (61.55)
Fruit length (cm)	Phule Hemangi x J-4 (26.58) Sheetal x KDWD-1 (26.39) KOP-1x J-4 (25.47)	MLKP x KOP-1 (92.18) Sheetal x KDWD-1 (81.90) Sheetal x J-2 (78.57)
Fruit girth (cm)	Panvel x PLK (23.50) Poona Khira x Rushita (13.68) Rushita x KOP-1 (11.60)	Panvel x PLK (58.96) Phule Shubhangi x Poona Khira (35.71) Rushita x MLKP (35.64)
Fruit weight (g)	Phule Hemangi x J-4 (48.69) PLK x Phule Hemangi (45.98) Panvel x Rushita (36.98)	Phule Shubhangi x MLKP (40.65) Poona Khira x KDWD-1 (39.87) Poona Khira x J-4 (39.58)
Fruit yield per vine (kg)	PLK x KDWD-1 (99.65) Panvel x MLKP (70.98) Phule Shubhangi x MLKP (70.17)	MLKP x J-4 (80.14) MLKP x Sheetal (70.47) Panvel x J-4 (69.85)

Table 5.5 Better performing hybrids (BH, SH, *per se* and SCA effect) for different characters

Character	Better parent	
	***per se* performance**	**SCA effect**
Days to first male flower	KOP-1 x Sheetal (27.73) Sheetal x J-4 (28.97) KOP-1 x KDWD-1 (29.31)	Phule Shubhangi x MLKP (-2.80) Poona Khira x KDWD-1 (-2.65) Panvel x Poona Khira (-2.52)
Days to first female flower	KOP-1 x Sheetal (33.06) KOP-1 x KDWD-1 (34.93) KOP-1x J-2 (35.23)	KOP-1 x Sheetal (-5.22) KOP-1 x KDWD-1 (-3.77) Panvel x Phule Shubhangi (-3.54)
First fruit bearing node	Phule Hemangi x J-4 (7.80) Poona Khira x KOP-1 (8.04) KOP-1x J-4 (8.14)	Sheetal x J-4 (-1.63) J-2 X J-4 (-1.13) Poona Khira x KDWD-1 (-1.06)
Days to first harvest	Rushita x MLKP (54.80) MLKP x KOP-1 (54.95) Rushita x Sheetal (55.00)	KOP-1x J-4 (-5.44) PLK x Phule Shubhangi (-3.49) Poona Khira x Rushita (-2.94)
Days to last harvest	Poona Khira x Rushita (92.61) KOP-1 x Sheetal (93.16) Poona Khira x J-2 (93.41)	KOP-1x J-2 (-4.50) KDWD-1 x J-4 (-3.42) Rushita x MLKP (-2.60)
Number of primary branches per vine	PLK x Rushita (8.98) PLK x Phule Hemangi (9.19) PLK x Phule Shubhangi (9.53)	Panvel x KOP-1 (1.88) PLK x Rushita (1.84) Phule Hemangi x Sheetal (1.82)
Internodal length	J-2 X J-4 (4.48) Poona Khira x J-2 (4.49) PLK x J-2 (4.69)	J-2 X J-4 (0.48) PLK x J-2 (0.50) PLK x KDWD-1 (0.40)
Vine length (cm)	Rushita x MLKP (82.22) Rushita x J-4 (82.52) Rushita x KOP-1 (82.92)	Rushita x KOP-1 (9.43) Rushita x Sheetal (9.18) Rushita x J-4 (8.60)
Number of fruits per vine	Rushita x Sheetal (9.69) J-2 X J-4 (9.79) Rushita x KOP-1 (10.13)	Rushita x Sheetal (2.33) J-2 X J-4 (2.32) Rushita x MLKP (2.26)
Fruit length (cm)	Poona Khira x Rushita (14.18) Sheetal x KDWD-1 (14.29) MLKP x KOP-1 (15.10)	Poona Khira x Rushita (2.57) Panvel x Phule Shubhangi (2.52) MLKP x KOP-1 (2.24)
Fruit girth (cm)	Rushita x MLKP (4.43) Phule Shubhangi x Poona Khira (4.44) Panvel x PLK (5.20)	Panvel x PLK (0.90) Phule Shubhangi x Poona Khira (0.43) Phule Shubhangi x Phule Hemangi (0.41)
Fruit weight (g)	KOP-1x J-2 (198.65) MLKP x J-4 (198.98) MLKP x KDWD-1 (199.84)	Phule Hemangi x KOP-1 (38.20) KOP-1 x KDWD-1 (30.59) Rushita x MLKP (28.50)
Fruit yield per vine (kg)	Phule Hemangi x KDWD-1 (4.91) Phule Hemangi x J-4 (4.99) Phule Shubhangi x MLKP (5.65)	MLKP x J-4 (9.19) MLKP x Sheetal (8.59) PLK x KDWD-1 (7.73)

SUGGESTION FOR FURTHER WORK

The study's results and subsequent discussions have led to recommendations for improving cucumber breeding programs.

A population with preponderance of additive genetic variance would lead to the improvement of a character through selection in segregating generations. The presence and magnitude of various components of non-additive gene effect could be justified with heterosis breeding. Whereas, in case of equal magnitude of both additive and non-additive components of genetic variance, population improvement scheme such as reciprocal recurrent selection and *inter se* mating would be more effective.

The heterosis breeding can be effectively utilized due to high magnitude of non-fixable effects for fruit yield and its contributing traits. The production of F_1 hybrids at commercial scale in cucumber is easy due to cross pollinated nature of the crop (monoecious). The fruits, being large in size and good number of seeds per fruit, proved to be more advantageous from seed production point of view. Thus, commercially hybrid seeds production is possible with little involvement of technical skill.

Among the parents empirical selection could be made (e.g. PLK, MLKP and J-2 were found to have good general combining ability effects for most of the character. These parents may be helpful in building up a desirable gene pool in cucumber. The present investigation revealed that the cross combinations, MLKP x J-4, MLKP x KDWD-1 and MLKP x Sheetal were most promising combinations for fruit yield per vine, on the basis of specific combining ability effects, besides being high heterotic effect and high *per se* performance and can be utilized effectively in heterosis breeding.

CHAPTER 6

SUMMARY AND CONCLUSION

The present investigation entitled "Study of heterosis and combining ability in cucumber (*Cucumis sativus* L.) using half diallel analysis" was undertaken to examine the magnitude of heterotic combining ability variances of parents and hybrids for different characters in cucumber. The experiment was conducted at experimental farm, Dept. of Genetics & Plant Breeding, School of Agriculture, Lovely Professional University, Phagwara, Kapurthala, Punjab. The experimental material compressing of sixty six F_{1s} hybrids their twelve parents and standard check (Malini) were evaluated in randomized complete block design with three replications for two successive year *i.e*. January-May 2021 and 2022 respectively. The observations were recorded on days to first male flower, days to first female flower, first fruit bearing node, days to first harvest, days to last harvest, number of primary branches per vine, internodal length, vine length (cm), number of fruits per vine, fruit length (cm), fruit girth (cm), fruit weight (g), fruit yield per vine (kg). The parent PLK was good general combiners for fruit yield per vine and other important traits. Even though parent MLKP was average general combiners for fruit yield and other six traits but performed very well in cross combinations *viz.*, MLKP x J-4, MLKP x Sheetal and MLKP x KDWD-1. Among sixty six hybrids developed for this study, thirteen hybrids depicted significant and positive estimates of SCA effect for fruit yield. Overall MLKP x J-4, MLKP x KDWD-1 and MLKP x Sheetal stood first in terms of *per se* performance GCA, SCA as well as heterotic effect.

CONCLUSIONS

1. The present investigation revealed that both additive and non-additive gene actions play a significant role in governing the inheritance of various characters, with a greater preponderance of non-additive gene action.
2. On the basis of high *per se* performance, high heterosis, desirable SCA effects for fruit yield per vine, cross combinations MLKP x J-4, MLKP x KDWD-1 and MLKP x Sheetal could be exploited for improvement in fruit yield of cucumber (Plate-1).
3. The above cited hybrids can be developed directly for commercial cultivation as well

as further studied and in corporate in breeding program for development of inbred and hybrid accordingly.

APPENDIX-1: Mean performance of parents and hybrids

Genotypes	Days to first male flower			Days to first female flower			First fruit bearing node		
	2021	2022	Pool	2021	2022	Pool	2021	2022	Pool
Parents									
Panvel	35.11	31.73	33.42	39.94	39.35	39.64	6.30	6.68	6.49
PLK	33.50	31.40	32.45	40.06	40.08	40.07	5.45	5.53	5.49
Phule Shubhangi	39.69	33.93	36.81	43.48	42.89	43.18	5.90	6.21	6.05
Phule Hemangi	33.81	30.87	32.34	41.24	40.80	41.02	5.01	5.20	5.11
Poona Khira	40.91	36.91	38.89	41.82	40.53	41.18	5.50	5.57	5.53
Rushita	33.70	32.27	32.98	42.32	41.67	41.99	5.75	6.20	5.98
MLKP	35.47	33.27	34.37	40.39	40.62	40.51	6.04	6.53	6.29
KOP-1	31.51	29.60	30.56	39.59	40.09	39.84	4.81	4.93	4.87
Sheetal	29.20	29.03	29.11	39.42	38.99	39.20	6.69	7.52	7.11
KDWD-1	31.98	30.73	31.35	40.63	39.86	40.25	8.02	7.73	7.88
J-2	34.42	31.67	33.05	40.54	40.02	40.28	5.08	5.28	5.18
J-4	34.89	31.04	32.97	41.63	40.92	41.28	5.48	5.34	5.41
Hybrids									
Panvel x PLK	35.83	29.67	32.75	42.13	40.33	41.23	6.73	6.93	6.83
Panvel x Phule Shubhangi	34.92	30.67	32.79	39.63	39.20	39.42	5.80	6.33	6.06
Panvel x Phule Hemangi	32.04	30.00	31.02	39.68	39.07	39.38	5.00	5.37	5.17
Panvel x Poona Khira	30.45	29.53	29.99	39.99	39.50	39.74	5.53	5.80	5.67
Panvel x Rushita	30.89	29.70	30.29	42.83	41.13	41.98	5.73	5.53	5.63
Panvel x MLKP	31.98	30.00	30.99	41.04	40.87	40.96	5.60	6.26	5.93
Panvel x KOP-1	31.78	30.20	30.99	40.92	40.29	40.61	5.66	6.26	5.96
Panvel x Sheetal	31.72	30.40	31.06	40.22	40.67	40.44	5.28	5.87	5.57
Panvel x KDWD-1	31.40	30.40	30.90	40.34	40.53	40.44	6.29	6.60	6.45
Panvel x J-2	31.56	29.93	30.75	41.67	41.55	41.61	6.29	6.64	6.46
Panvel x J-4	31.79	30.40	31.10	40.59	39.73	40.16	6.68	7.11	6.90
PLK x Phule Shubhangi	31.74	29.93	30.84	39.33	39.80	39.57	5.18	5.24	5.21
PLK x Phule Hemangi	31.34	30.40	30.87	38.38	38.27	38.32	5.76	6.41	6.08
PLK x Poona Khira	33.09	30.20	31.64	38.71	39.47	39.09	6.99	7.00	6.99
PLK x Rushita	31.77	30.27	31.02	37.63	37.60	37.61	6.97	6.69	6.83
PLK x MLKP	32.35	31.20	31.77	40.85	39.73	40.29	5.52	5.69	5.61
PLK x KOP-1	32.14	30.07	31.11	41.29	40.70	40.99	4.99	5.71	5.35
PLK x Sheetal	29.75	29.40	29.57	40.25	39.66	39.96	5.86	6.30	6.08
PLK x KDWD-1	31.26	30.28	30.77	41.72	40.27	40.99	5.80	6.54	6.17
PLK x J-2	31.84	29.80	30.82	40.38	40.62	40.50	7.22	7.05	7.13
PLK x J-4	30.25	29.33	29.79	39.69	40.06	39.87	6.06	5.95	6.00
Phule Shubhangi x Phule Hemangi	38.91	34.60	36.75	43.57	42.93	43.25	6.19	6.62	6.41
Phule Shubhangi x Poona Khira	33.27	31.40	32.34	43.05	43.09	43.07	5.99	6.58	6.28
Phule Shubhangi x Rushita	35.65	33.47	34.56	45.46	45.86	45.66	5.61	6.40	6.01
Phule Shubhangi x MLKP	32.03	30.47	31.25	46.94	47.93	47.43	7.06	6.76	6.91
Phule Shubhangi x KOP-1	31.96	30.20	31.08	43.98	42.93	43.45	7.32	7.93	7.63
Phule Shubhangi x Sheetal	33.54	31.60	32.57	43.15	42.20	42.67	7.25	6.92	7.09

Phule Shubhangi x KDWD-1	33.33	30.13	31.73	40.85	40.07	40.46	7.37	7.73	7.55
Phule Shubhangi x J-2	31.91	30.67	31.29	41.82	41.40	41.61	6.32	6.17	6.24
Phule Shubhangi x J-4	32.41	30.87	31.64	43.41	43.21	43.31	7.42	7.79	7.61
Phule Hemangi x Poona Khira	39.06	35.67	39.06	39.27	38.74	39.01	6.77	7.22	6.99
Phule Hemangi x Rushita	32.97	30.40	31.69	38.60	38.03	38.32	7.76	6.53	7.15
Phule Hemangi x MLKP	32.59	31.53	32.06	38.83	38.94	38.89	7.40	7.27	7.33
Phule Hemangi x KOP-1	30.30	29.67	29.98	39.04	39.42	39.23	6.42	6.72	6.57
Phule Hemangi x Sheetal	30.42	29.73	30.08	39.24	38.54	38.89	6.76	7.17	6.97
Phule Hemangi x KDWD-1	30.72	30.30	30.51	40.64	41.13	40.89	6.11	6.07	6.09
Phule Hemangi x J-2	29.72	29.22	29.47	38.96	38.90	38.93	6.65	7.07	6.86
Phule Hemangi x J-4	33.02	31.00	32.01	39.34	39.70	39.52	7.82	7.79	7.80
Poona Khira x Rushita	31.66	30.13	30.90	38.43	38.87	38.65	6.97	7.11	7.04
Poona Khira x MLKP	31.56	30.20	30.88	38.30	38.00	38.15	6.02	7.09	6.56
Poona Khira x KOP-1	30.27	29.53	29.90	39.12	39.22	39.17	8.04	8.03	8.04
Poona Khira x Sheetal	31.05	29.80	30.43	39.42	39.27	39.34	6.87	6.82	6.84
Poona Khira x KDWD-1	29.63	29.21	29.42	38.44	38.62	38.53	5.60	5.78	5.69
Poona Khira x J-2	31.48	30.35	30.91	37.31	37.53	37.42	7.39	7.18	7.29
Poona Khira x J-4	31.00	29.93	30.46	39.93	40.06	39.99	5.92	7.17	6.54
Rushita x MLKP	34.26	32.07	33.16	42.87	42.73	42.80	6.21	5.44	5.83
Rushita x KOP-1	33.13	32.10	32.61	43.80	42.80	43.30	6.86	7.48	7.17
Rushita x Sheetal	33.03	31.27	32.15	41.44	41.02	41.23	6.54	7.13	6.84
Rushita x KDWD-1	30.08	29.20	29.64	39.85	39.87	39.86	7.22	7.10	7.16
Rushita x J-2	31.82	30.37	31.09	40.56	40.51	40.54	6.44	7.23	6.84
Rushita x J-4	30.28	29.50	29.89	41.00	40.62	40.81	7.19	7.78	7.49
MLKP x KOP-1	32.94	31.33	32.14	44.33	43.13	43.73	6.05	6.87	6.46
MLKP x Sheetal	32.64	31.40	32.02	42.33	42.60	42.47	6.55	6.36	6.46
MLKP x KDWD-1	33.72	31.86	32.79	38.72	39.04	38.88	7.62	7.26	7.44
MLKP x J-2	36.82	32.93	34.88	40.31	40.12	40.21	7.25	7.54	7.40
MLKP x J-4	35.19	32.42	33.80	39.34	39.10	39.22	7.14	6.99	7.07
KOP-1 x Sheetal	27.73	28.18	27.73	33.06	32.70	33.06	6.06	6.94	6.50
KOP-1 x KDWD-1	29.29	29.31	29.29	35.20	34.67	34.93	6.72	6.78	6.75
KOP-1x J-2	29.41	29.51	29.46	35.48	34.98	35.23	7.15	8.14	7.64
KOP-1x J-4	31.21	30.72	30.97	36.06	35.23	35.65	8.08	8.20	8.14
Sheetal x KDWD-1	33.02	30.88	31.95	37.33	37.24	37.29	5.78	5.70	5.74
Sheetal x J-2	30.79	30.03	30.41	37.97	37.72	37.84	6.97	6.70	6.84
Sheetal x J-4	28.97	28.96	28.97	38.68	38.79	38.73	5.11	5.26	5.18
KDWD-1 x J-2	32.35	30.20	31.27	41.66	40.89	41.27	6.01	6.70	6.35
KDWD-1 x J-4	31.33	30.13	30.73	40.62	40.40	40.51	7.80	7.52	7.66
J-2 X J-4	29.97	29.42	29.70	38.61	38.20	38.40	5.23	5.80	5.52
Malini (Standard Check)	43.02	40.10	41.08	45.14	45.18	44.84	5.94	4.15	6.29
Range									
Parents Minimum	29.20	29.03	29.11	39.42	38.99	39.20	4.81	4.93	4.87
Parents Maximum	40.91	36.87	38.89	43.48	42.89	43.18	8.02	7.73	7.88
Hybrids Minimum	27.28	28.18	27.73	33.06	32.70	33.06	4.99	5.24	5.18
Hybrids Maximum	39.06	35.67	39.06	46.94	47.93	47.43	8.08	8.20	8.14
SE_m	1.08	0.65	1.33	0.92	0.80	1.27	0.45	0.49	0.63

CD (5%)	3.01	1.81	3.72	2.56	2.23	3.55	1.25	1.38	1.76
CV%	5.73	3.64	4.81	3.93	3.45	3.64	12.25	12.97	11.31

Genotypes	**Days to first harvest**			**Days to last harvest**			**Number of primary braches per vine**		
	2021	**2022**	**Pool**	**2021**	**2022**	**Pool**	**2021**	**2022**	**Pool**
Parents									
Panvel	50.40	50.26	50.33	93.41	90.13	91.77	4.18	4.44	4.31
PLK	51.14	51.09	51.11	92.13	89.94	91.04	5.18	6.40	5.79
Phule Shubhangi	53.07	53.07	53.07	88.20	88.40	88.30	6.82	6.17	6.50
Phule Hemangi	51.19	50.29	50.74	91.99	91.08	91.53	5.51	5.28	5.39
Poona Khira	54.88	53.13	54.01	90.98	90.15	90.57	6.28	5.20	5.74
Rushita	50.53	50.58	50.55	92.47	90.87	91.67	3.94	4.98	4.46
MLKP	51.11	50.96	51.03	95.42	93.00	94.21	4.43	4.10	4.27
KOP-1	49.94	49.85	49.89	95.12	91.73	93.43	4.81	5.75	5.28
Sheetal	52.95	52.30	52.63	93.33	92.93	93.13	5.95	6.04	6.00
KDWD-1	51.60	50.62	51.11	93.33	91.83	92.58	5.97	6.63	6.30
J-2	50.33	50.46	50.39	92.73	95.40	94.07	5.53	6.44	5.98
J-4	45.80	46.22	46.01	94.11	91.67	92.89	6.12	6.21	6.17
Hybrids									
Panvel x PLK	50.36	49.40	49.88	90.51	89.27	89.89	6.37	6.79	6.58
Panvel x Phule Shubhangi	49.65	48.87	49.26	90.17	89.27	89.72	6.13	6.18	6.15
Panvel x Phule Hemangi	50.93	49.78	50.35	90.84	89.84	90.34	4.38	5.11	4.74
Panvel x Poona Khira	50.22	49.68	49.95	91.05	89.73	90.39	5.85	6.70	6.28
Panvel x Rushita	51.38	50.27	50.82	90.47	89.67	90.07	6.22	6.53	6.38
Panvel x MLKP	49.43	48.47	48.95	91.63	90.61	91.12	7.05	7.69	7.37
Panvel x KOP-1	49.59	48.83	49.21	94.08	90.33	92.21	8.20	8.33	8.27
Panvel x Sheetal	50.85	49.40	50.13	92.81	90.60	91.70	7.67	8.00	7.83
Panvel x KDWD-1	50.25	49.84	50.05	94.06	90.13	92.10	6.69	7.19	6.94
Panvel x J-2	50.82	50.13	50.48	93.41	91.13	92.27	6.40	6.91	6.66
Panvel x J-4	49.80	49.64	49.72	92.82	91.23	92.03	6.38	6.69	6.54
PLK x Phule Shubhangi	48.13	46.87	47.50	91.94	90.07	91.00	9.47	9.60	9.53
PLK x Phule Hemangi	49.91	49.60	49.76	89.92	89.27	89.59	9.38	9.00	9.19
PLK x Poona Khira	50.63	49.07	49.85	89.00	89.47	89.23	8.41	9.13	8.77
PLK x Rushita	51.99	49.55	50.77	90.38	90.40	90.39	8.70	9.27	8.98
PLK x MLKP	51.66	50.73	51.19	92.45	89.87	91.16	7.50	9.07	8.28
PLK x KOP-1	54.98	51.87	53.42	91.65	89.93	90.79	7.83	8.93	8.38
PLK x Sheetal	50.53	50.47	50.50	89.48	89.76	89.62	7.61	8.59	8.10
PLK x KDWD-1	50.58	50.29	50.43	89.48	88.73	89.11	6.76	7.91	7.34
PLK x J-2	49.46	49.00	49.23	92.57	89.53	91.05	7.38	8.53	7.96
PLK x J-4	51.15	50.00	50.58	91.39	90.87	91.13	6.10	8.73	7.41
Phule Shubhangi x Phule Hemangi	48.83	49.53	49.18	90.61	89.47	90.04	6.06	6.82	6.44
Phule Shubhangi x Poona Khira	52.86	51.33	52.10	94.56	89.33	91.95	5.23	6.40	5.82
Phule Shubhangi x Rushita	50.66	51.00	50.83	93.17	91.80	92.48	6.23	6.81	6.52

Phule Shubhangi x MLKP	51.94	50.99	51.47	94.63	90.33	92.48	7.07	7.55	7.31
Phule Shubhangi x KOP-1	54.31	51.93	53.12	92.39	89.33	90.86	4.24	8.47	6.36
Phule Shubhangi x Sheetal	50.58	49.55	50.07	93.90	89.87	91.88	5.81	6.59	6.20
Phule Shubhangi x KDWD-1	52.88	52.27	52.57	93.21	90.00	91.60	7.31	8.73	8.02
Phule Shubhangi x J-2	54.56	51.38	52.97	90.84	89.40	90.12	8.98	8.78	8.88
Phule Shubhangi x J-4	52.30	51.67	51.99	92.33	90.27	91.30	6.14	8.53	7.34
Phule Hemangi x Poona Khira	53.65	51.34	52.50	90.61	88.73	89.67	5.91	7.40	6.66
Phule Hemangi x Rushita	51.67	52.80	52.23	90.61	89.22	89.92	6.72	6.64	6.68
Phule Hemangi x MLKP	52.50	51.27	51.88	89.25	88.94	89.10	7.21	7.23	7.22
Phule Hemangi x KOP-1	53.39	51.27	52.33	89.77	88.80	89.28	6.66	6.86	6.76
Phule Hemangi x Sheetal	50.84	49.13	49.99	92.32	90.02	91.17	8.65	9.13	8.89
Phule Hemangi x KDWD-1	53.12	52.20	52.66	92.52	90.07	91.30	7.89	8.65	8.27
Phule Hemangi x J-2	50.11	49.53	49.82	92.17	89.88	91.03	7.31	7.27	7.29
Phule Hemangi x J-4	49.31	49.40	49.36	92.62	89.80	91.21	4.04	5.93	4.98
Poona Khira x Rushita	49.17	48.54	48.85	93.21	92.00	92.61	5.33	7.40	6.37
Poona Khira x MLKP	50.46	49.00	49.73	91.26	90.32	90.79	6.61	6.63	6.62
Poona Khira x KOP-1	49.86	50.16	50.01	90.89	89.80	90.34	7.71	7.27	7.49
Poona Khira x Sheetal	49.34	48.49	48.91	92.67	91.00	91.84	6.95	7.00	6.97
Poona Khira x KDWD-1	51.46	50.34	50.90	91.20	88.93	90.07	7.08	7.04	7.06
Poona Khira x J-2	53.06	51.33	52.20	96.08	90.73	93.41	6.11	7.10	6.60
Poona Khira x J-4	48.03	48.61	48.32	92.96	90.67	91.81	8.22	7.66	7.94
Rushita x MLKP	55.26	54.33	54.80	89.11	88.20	88.65	5.22	5.87	5.54
Rushita x KOP-1	52.13	52.07	52.10	92.67	89.67	91.17	5.09	5.42	5.26
Rushita x Sheetal	54.94	55.07	55.00	90.00	88.40	89.20	7.12	7.71	7.41
Rushita x KDWD-1	52.00	51.91	51.96	93.74	90.60	92.17	5.70	6.21	5.95
Rushita x J-2	52.38	54.87	53.62	93.50	91.37	92.43	6.25	7.13	6.69
Rushita x J-4	51.06	52.82	51.94	91.24	89.90	90.57	6.39	7.37	6.88
MLKP x KOP-1	54.96	54.93	54.95	93.72	91.20	92.46	7.77	8.93	8.35
MLKP x Sheetal	55.38	52.87	54.13	93.05	90.07	91.56	4.83	7.67	6.25
MLKP x KDWD-1	52.14	50.13	51.14	90.45	89.17	89.81	6.79	8.09	7.44
MLKP x J-2	51.67	51.41	51.54	92.45	90.13	91.29	7.71	8.63	8.17
MLKP x J-4	52.02	51.00	51.51	92.73	89.87	91.30	7.55	8.09	7.82
KOP-1 x Sheetal	47.51	47.34	47.43	95.26	91.07	93.16	7.56	8.27	7.92
KOP-1 x KDWD-1	52.00	50.33	51.17	92.24	91.40	91.82	8.13	8.49	8.31
KOP-1x J-2	48.27	48.11	48.19	90.59	84.15	87.37	5.72	6.61	6.17
KOP-1x J-4	43.46	44.00	43.73	91.21	89.53	90.37	5.84	6.84	6.34
Sheetal x KDWD-1	48.86	48.47	48.66	94.41	90.40	92.41	8.69	9.22	8.96
Sheetal x J-2	48.25	49.00	48.62	93.52	90.60	92.06	7.78	8.51	8.15
Sheetal x J-4	50.19	50.30	50.25	92.24	89.80	91.02	6.44	8.67	7.55
KDWD-1 x J-2	51.52	51.80	51.66	92.47	89.67	91.07	5.68	6.88	6.28
KDWD-1 x J-4	51.32	50.49	50.91	91.63	83.93	87.78	7.20	7.61	7.40
J-2 X J-4	51.33	50.40	50.86	93.76	90.76	92.26	7.77	8.15	7.96
Malini (Standard Check)	55.25	54.24	55.98	95.47	94.36	94.47	3.58	5.17	4.29
Range									
Parents Minimum	45.80	46.22	46.01	88.20	88.40	88.30	3.94	4.10	4.27
Maximum	54.88	53.13	54.01	95.42	95.40	94.21	6.82	6.79	6.50
Hybrids Minimum	43.46	44.00	43.73	89.00	83.93	87.37	4.04	5.11	4.74

	Maximum	55.38	55.07	55.00	96.08	92.00	94.41	9.47	9.60	9.53
SE_m		0.84	0.83	1.18	0.60	1.00	0.84	0.54	0.47	0.71
CD (5%)		2.35	2.33	3.29	1.68	2.78	2.35	1.50	1.32	1.98
CV%		2.58	2.86	2.67	1.13	1.91	1.06	14.14	11.25	12.02

Genotypes	**Internodal length (cm)**			**Vine length (cm)**			**Number of fruits per vine**		
	2021	**2022**	**Pool**	**2021**	**2022**	**Pool**	**2021**	**2022**	**Pool**
Parents									
Panvel	3.98	4.17	4.07	68.86	69.27	69.06	5.35	5.59	5.47
PLK	3.57	3.53	3.55	69.05	70.02	69.54	4.87	6.97	5.92
Phule Shubhangi	3.87	3.95	3.91	73.66	72.81	73.24	6.11	6.03	6.07
Phule Hemangi	3.80	4.14	3.97	65.71	66.63	66.17	4.82	6.13	5.48
Poona Khira	3.62	3.65	3.64	65.59	66.09	65.84	5.86	5.77	5.82
Rushita	3.98	4.19	4.09	65.54	65.65	65.59	5.10	5.67	5.38
MLKP	4.05	4.30	4.18	66.50	66.09	66.30	5.11	5.81	5.46
KOP-1	3.44	3.56	3.50	63.08	62.47	62.77	8.28	7.74	8.01
Sheetal	3.86	4.35	4.10	66.24	64.98	65.61	5.12	5.35	5.23
KDWD-1	3.19	3.41	3.30	67.87	68.80	68.34	6.73	7.03	6.88
J-2	3.44	3.72	3.58	70.02	72.29	71.16	6.15	6.68	6.41
J-4	3.40	3.70	3.55	67.02	65.13	66.08	7.80	7.93	7.87
Hybrids									
Panvel x PLK	3.74	4.22	3.98	73.21	74.09	73.65	6.53	6.80	6.66
Panvel x Phule Shubhangi	4.08	4.29	4.18	72.31	73.30	72.81	6.83	6.97	6.90
Panvel x Phule Hemangi	4.05	4.27	4.16	71.04	72.34	71.69	7.38	7.65	7.52
Panvel x Poona Khira	4.12	4.32	4.22	73.12	73.82	73.47	6.88	7.40	7.14
Panvel x Rushita	3.93	4.09	4.01	72.09	73.46	72.77	7.03	7.80	7.42
Panvel x MLKP	3.93	4.18	4.05	73.40	74.54	73.97	6.68	7.56	7.12
Panvel x KOP-1	4.26	4.42	4.34	71.05	71.96	71.51	7.19	7.28	7.24
Panvel x Sheetal	3.97	4.38	4.17	71.77	72.83	72.30	7.29	7.25	7.27
Panvel x KDWD-1	4.08	4.24	4.16	70.90	71.89	71.40	6.58	7.33	6.96
Panvel x J-2	4.28	4.51	4.39	72.58	73.59	73.08	6.84	6.52	6.68
Panvel x J-4	4.04	4.23	4.13	70.80	72.41	71.60	7.01	7.76	7.39
PLK x Phule Shubhangi	4.29	4.63	4.46	71.73	72.86	72.29	8.43	9.14	8.79
PLK x Phule Hemangi	4.06	4.02	4.04	67.16	71.14	69.15	8.38	9.06	8.72

PLK x Poona Khira	4.11	4.41	4.26	70.68	72.58	71.63	8.46	8.69	8.57
PLK x Rushita	4.25	4.46	4.35	70.69	72.35	71.52	8.06	8.56	8.31
PLK x MLKP	4.19	4.32	4.26	70.81	72.45	71.63	7.48	8.51	8.00
PLK x KOP-1	4.22	4.31	4.27	68.91	71.13	70.02	6.51	8.11	7.31
PLK x Sheetal	4.24	4.41	4.33	70.92	72.97	71.94	6.73	8.12	7.42
PLK x KDWD-1	4.41	4.43	4.42	70.98	72.01	71.49	6.97	8.13	7.55
PLK x J-2	4.71	4.66	4.69	70.18	71.44	70.81	6.01	8.18	7.09
PLK x J-4	3.81	4.12	3.97	71.88	72.95	72.42	7.31	8.14	7.73
Phule Shubhangi x Phule Hemangi	3.83	4.19	4.01	69.94	71.39	70.67	5.00	5.72	5.36
Phule Shubhangi x Poona Khira	4.08	4.24	4.16	70.51	71.16	70.84	5.34	6.16	5.75
Phule Shubhangi x Rushita	4.15	4.12	4.14	71.54	72.48	72.01	6.23	6.91	6.57
Phule Shubhangi x MLKP	4.33	4.10	4.21	71.97	72.50	72.24	7.60	7.83	7.72
Phule Shubhangi x KOP-1	3.79	4.32	4.05	72.24	72.99	72.61	8.49	8.67	8.58
Phule Shubhangi x Sheetal	4.08	4.39	4.23	71.00	71.87	71.43	7.76	8.62	8.19
Phule Shubhangi x KDWD-1	4.25	4.51	4.38	71.19	71.65	71.42	6.42	8.06	7.24
Phule Shubhangi x J-2	4.20	4.19	4.20	72.04	72.58	72.31	8.12	8.90	8.51
Phule Shubhangi x J-4	4.18	4.20	4.19	71.14	71.89	71.51	5.94	7.56	6.75
Phule Hemangi x Poona Khira	4.16	4.32	4.24	67.01	68.16	67.58	7.21	8.33	7.77
Phule Hemangi x Rushita	4.08	4.10	4.09	66.62	68.50	67.56	6.07	8.33	7.20
Phule Hemangi x MLKP	3.83	3.99	3.91	66.81	68.02	67.42	5.35	6.53	5.94
Phule Hemangi x KOP-1	4.07	4.28	4.18	66.25	68.25	67.25	7.22	8.67	7.94
Phule Hemangi x Sheetal	4.07	4.34	4.20	66.48	67.50	66.99	7.24	8.47	7.85
Phule Hemangi xKDWD-1	3.91	4.13	4.02	64.81	66.58	65.69	5.55	8.40	6.97
Phule Hemangi x J-2	3.99	4.07	4.03	66.18	67.26	66.72	6.59	8.38	7.49
Phule Hemangi x J-4	3.89	3.90	3.89	69.14	70.94	70.04	7.31	8.33	7.82
Poona Khira x Rushita	4.02	4.14	4.08	67.38	68.67	68.02	7.58	7.07	7.32
Poona Khira x MLKP	4.28	4.50	4.39	61.42	64.03	62.73	6.88	7.87	7.37
Poona Khira x KOP-1	3.78	4.09	3.93	64.31	65.16	64.73	7.64	8.34	7.99
Poona Khira x Sheetal	4.16	4.23	4.19	61.70	63.25	62.47	7.29	8.33	7.81
Poona Khira x KDWD-1	3.73	4.04	3.89	62.67	63.73	63.20	7.33	7.93	7.63

Poona Khira x J-2		4.52	4.45	4.49	61.44	63.71	62.58	4.36	6.00	5.18
Poona Khira x J-4		3.80	3.91	3.86	61.39	62.05	61.72	6.65	7.61	7.13
Rushita x MLKP		4.01	4.10	4.05	81.69	82.75	82.22	9.76	9.38	9.57
Rushita x KOP-1		4.06	4.19	4.13	82.64	83.20	82.92	10.06	10.21	10.13
Rushita x Sheetal		3.98	4.15	4.06	81.40	82.10	81.75	10.12	9.27	9.69
Rushita x KDWD-1		4.12	4.30	4.21	81.78	81.87	81.83	10.24	8.87	9.56
Rushita x J-2		4.09	3.92	4.01	80.72	81.57	81.15	7.88	8.07	7.97
Rushita x J-4		4.09	4.28	4.18	81.93	83.11	82.52	7.37	8.17	7.77
MLKP x KOP-1		3.93	4.03	3.98	74.64	75.28	74.96	4.28	5.73	5.01
MLKP x Sheetal		3.98	3.96	3.97	73.73	74.32	74.03	5.07	5.55	5.31
MLKP x KDWD-1		3.82	3.93	3.88	73.86	74.23	74.05	4.50	5.80	5.15
MLKP x J-2		3.83	4.04	3.93	72.69	73.19	72.94	6.00	6.70	6.35
MLKP x J-4		3.86	4.13	4.00	72.69	73.42	73.06	7.15	7.80	7.47
KOP-1 x Sheetal		3.72	4.14	3.93	61.70	62.78	62.24	6.85	7.04	6.94
KOP-1 x KDWD-1		3.90	4.11	4.01	65.15	65.86	65.51	8.60	8.93	8.77
KOP-1x J-2		4.02	4.15	4.08	70.64	71.36	71.00	8.77	8.96	8.87
KOP-1x J-4		3.98	4.22	4.10	65.43	66.21	65.82	8.70	8.80	8.75
Sheetal x KDWD-1		3.71	3.87	3.79	59.33	59.90	59.62	4.01	4.64	4.33
Sheetal x J-2		3.66	3.69	3.68	64.53	64.56	64.54	5.61	6.06	5.84
Sheetal x J-4		3.85	4.06	3.95	62.12	63.52	62.82	5.22	6.50	5.86
KDWD-1 x J-2		4.21	4.22	4.22	64.09	66.22	65.16	5.17	6.13	5.65
KDWD-1 x J-4		3.63	3.75	3.69	65.76	65.59	65.68	5.57	7.75	6.66
J-2 X J-4		4.42	4.54	4.48	70.33	71.29	70.81	9.94	9.63	9.79
Malini (Standard Check)		3.94	3.73	3.83	63.8	62.9	63.4	6.71	5.33	6.01
Range										
Parents	Minimum	3.19	3.41	3.30	63.08	62.47	62.77	4.82	5.35	5.23
	Maximum	4.05	4.35	4.18	73.66	74.09	73.24	8.28	7.93	8.01
Hybrids	Minimum	3.63	3.69	3.68	59.33	59.90	59.62	4.01	4.64	4.33
	Maximum	4.71	4.66	4.69	82.64	83.20	82.92	10.24	10.21	10.13
SE_m		0.15	0.14	0.20	1.15	1.05	1.63	0.42	0.36	0.53
CD (5%)		0.41	0.38	0.55	3.21	2.93	4.55	1.17	1.00	1.47
CV%		6.36	5.69	5.59	2.86	2.58	2.69	10.60	8.22	8.61

Genotypes	Fruit length (cm)			Fruit girth (cm)		
	2021	2022	Pool	2021	2022	Pool
Parents						
Panvel	10.61	11.10	10.86	3.61	3.87	3.74
PLK	10.24	10.88	10.56	4.15	4.27	4.21
Phule Shubhangi	9.53	10.43	9.98	3.93	4.14	4.04
Phule Hemangi	10.90	10.83	10.87	3.71	3.79	3.75
Poona Khira	10.15	10.96	10.55	3.57	3.78	3.67
Rushita	11.41	11.91	11.66	3.63	3.78	3.70
MLKP	13.85	14.55	14.20	4.19	4.44	4.31
KOP-1	9.83	11.36	10.59	3.82	3.99	3.91
Sheetal	10.93	11.69	11.31	3.77	4.07	3.92
KDWD-1	10.98	11.49	11.24	3.65	4.11	3.88
J-2	11.76	12.42	12.09	3.75	3.99	3.87
J-4	9.65	11.34	10.49	3.86	4.25	4.05
Hybrids						
Panvel x PLK	12.95	13.00	12.98	3.83	6.57	5.20
Panvel x Phule Shubhangi	13.39	13.67	13.53	3.79	4.06	3.93
Panvel x Phule Hemangi	11.54	12.25	11.90	4.06	4.19	4.13
Panvel x Poona Khira	10.65	11.40	11.02	3.83	4.15	3.99
Panvel x Rushita	10.66	11.37	11.02	3.89	4.04	3.97
Panvel x MLKP	12.18	12.74	12.46	3.98	4.08	4.03
Panvel x KOP-1	12.07	12.63	12.35	4.02	4.20	4.11
Panvel x Sheetal	12.04	12.38	12.21	4.05	4.39	4.22
Panvel x KDWD-1	12.64	12.91	12.77	3.93	4.11	4.02
Panvel x J-2	11.13	11.59	11.36	3.89	4.15	4.02
Panvel x J-4	11.56	12.16	11.86	4.03	4.14	4.09
PLK x Phule Shubhangi	10.43	13.61	12.02	3.56	3.89	3.73
PLK x Phule Hemangi	11.30	13.47	12.39	3.92	3.92	3.92
PLK x Poona Khira	11.72	12.05	11.88	3.95	4.41	4.18
PLK x Rushita	11.58	11.75	11.66	4.26	4.41	4.33
PLK x MLKP	12.52	12.94	12.73	3.90	4.21	4.06
PLK x KOP-1	10.66	12.12	11.39	4.07	4.19	4.13
PLK x Sheetal	11.40	12.13	11.77	4.00	4.19	4.09

PLK x KDWD-1	12.26	12.56	12.41	4.00	4.28	4.14
PLK x J-2	11.68	12.34	12.01	3.89	4.30	4.10
PLK x J-4	10.56	11.38	10.97	3.80	4.09	3.95
Phule Shubhangi x Phule Hemangi	9.38	10.60	9.99	4.56	4.30	4.43
Phule Shubhangi x Poona Khira	10.30	11.22	10.76	4.39	4.49	4.44
Phule Shubhangi x Rushita	10.37	10.97	10.67	4.07	4.19	4.13
Phule Shubhangi x MLKP	10.13	10.76	10.44	3.90	4.05	3.97
Phule Shubhangi x KOP-1	11.01	11.38	11.19	4.13	4.51	4.32
Phule Shubhangi x Sheetal	10.92	11.31	11.12	3.83	3.93	3.88
Phule Shubhangi x KDWD-1	10.81	11.16	10.99	4.35	4.44	4.40
Phule Shubhangi x J-2	10.54	10.72	10.63	3.99	4.21	4.10
Phule Shubhangi x J-4	9.78	10.27	10.03	4.12	4.23	4.17
Phule Hemangi x Poona Khira	11.11	11.29	11.20	3.44	3.75	3.60
Phule Hemangi x Rushita	10.97	11.38	11.17	3.46	3.78	3.62
Phule Hemangi x MLKP	10.85	11.29	11.07	3.63	4.03	3.83
Phule Hemangi x KOP-1	12.59	12.71	12.65	3.54	3.66	3.60
Phule Hemangi x Sheetal	11.83	12.80	12.32	3.59	3.72	3.65
Phule Hemangi x KDWD-1	10.26	10.85	10.55	3.93	4.17	4.05
Phule Hemangi x J-2	11.14	11.58	11.36	3.93	4.07	4.00
Phule Hemangi x J-4	13.79	13.72	13.76	3.56	3.71	3.63
Poona Khira x Rushita	14.20	14.16	14.18	4.15	4.27	4.21
Poona Khira x MLKP	13.30	13.47	13.38	3.62	3.77	3.70
Poona Khira x KOP-1	12.82	12.99	12.91	3.58	3.74	3.66
Poona Khira x Sheetal	12.05	12.54	12.29	3.53	3.78	3.65
Poona Khira x KDWD-1	10.31	12.25	11.28	3.65	3.93	3.79
Poona Khira x J-2	10.78	11.91	11.34	3.63	3.81	3.72
Poona Khira x J-4	11.32	12.25	11.78	3.51	3.87	3.69
Rushita x MLKP	9.40	10.23	9.82	4.29	4.59	4.43
Rushita x KOP-1	12.04	12.22	12.13	4.33	4.39	4.36
Rushita x Sheetal	10.94	11.62	11.28	4.21	4.37	4.29
Rushita x KDWD-1	11.85	12.13	11.99	4.03	4.19	4.11
Rushita x J-2	11.66	12.08	11.87	3.79	4.01	3.90
Rushita x J-4	12.08	12.73	12.41	4.22	4.32	4.27
MLKP x KOP-1	14.99	15.21	15.10	3.73	3.93	3.83

MLKP x Sheetal		10.82	13.85	12.34	3.51	3.83	3.67
MLKP x KDWD-1		11.55	13.19	12.37	3.51	3.79	3.65
MLKP x J-2		9.90	13.25	11.57	3.91	4.06	3.99
MLKP x J-4		12.68	13.24	12.96	3.53	3.69	3.61
KOP-1 x Sheetal		10.83	11.85	11.34	3.48	3.65	3.57
KOP-1 x KDWD-1		12.31	12.65	12.48	3.58	3.71	3.65
KOP-1x J-2		14.43	13.12	13.77	3.67	3.90	3.78
KOP-1x J-4		13.61	12.96	13.29	3.49	3.77	3.63
Sheetal x KDWD-1		14.96	13.63	14.29	3.31	3.53	3.42
Sheetal x J-2		14.75	13.31	14.03	3.60	3.76	3.68
Sheetal x J-4		13.34	13.37	13.35	3.53	3.77	3.65
KDWD-1 x J-2		12.24	12.19	12.22	3.14	3.49	3.31
KDWD-1 x J-4		12.28	13.05	12.66	3.38	3.60	3.49
J-2 X J-4		10.28	11.06	10.67	3.82	3.99	3.91
Malini (Standard Check)		7.93	7.78	7.86	3.25	3.30	3.27
Range							
Parents	Minimum	9.53	10.43	9.98	3.57	3.78	3.67
	Maximum	13.85	14.55	14.20	4.19	6.57	4.31
Hybrids	Minimum	9.38	10.23	9.82	3.14	3.49	3.31
	Maximum	14.99	15.21	15.10	4.56	6.57	5.20
SE_m		0.61	0.44	0.79	0.18	0.31	0.27
CD (5%)		1.70	1.23	2.20	0.49	0.86	0.76
CV%		9.13	6.27	7.75	8.02	11.21	8.06

Genotypes	Fruit weight			Fruit Yield per vine		
	2021	**2022**	**Pool**	**2021**	**2022**	**Pool**
Parents						
Panvel	136.31	140.32	130.84	2.24	2.30	2.50
PLK	139.89	142.32	138.65	3.64	3.50	3.21
Phule Shubhangi	130.71	135.98	135.32	1.29	1.33	1.90
Phule Hemangi	143.28	150.14	150.14	1.27	1.33	1.39
Poona Khira	131.38	135.48	134.36	1.61	1.70	1.80
Rushita	139.53	142.66	155.47	2.73	2.60	2.66

MLKP	175.21	180.32	182.56	3.80	3.70	4.31
KOP-1	138.00	137.25	140.32	2.72	2.75	2.80
Sheetal	156.98	159.32	160.22	3.22	3.65	3.66
KDWD-1	162.29	165.32	169.32	4.50	4.20	4.80
J-2	160.30	168.14	169.48	4.22	4.25	4.82
J-4	185.32	189.39	216.27	3.65	3.14	4.05
Hybrids						
Panvel x PLK	155.65	155.77	160.47	3.29	2.90	3.74
Panvel x Phule Shubhangi	126.11	130.58	135.95	3.61	3.10	4.05
Panvel x Phule Hemangi	135.33	140.74	140.32	3.49	3.21	3.22
Panvel x Poona Khira	128.80	130.41	131.28	3.06	3.09	3.54
Panvel x Rushita	142.79	146.98	146.98	2.90	2.99	2.98
Panvel x MLKP	165.91	170.28	170.25	3.77	3.45	3.47
Panvel x KOP-1	163.81	170.25	166.33	2.98	3.05	3.27
Panvel x Sheetal	155.32	160.47	168.74	2.04	2.84	2.47
Panvel x KDWD-1	137.02	140.27	140.28	1.80	1.95	1.90
Panvel x J-2	162.85	169.56	174.25	3.77	3.80	3.20
Panvel x J-4	174.62	180.17	178.28	3.77	3.55	3.65
PLK x Phule Shubhangi	162.26	170.65	174.39	2.90	2.48	2.47
PLK x Phule Hemangi	119.26	120.69	120.36	4.11	3.90	3.99
PLK x Poona Khira	159.92	160.48	165.98	3.62	3.65	3.65
PLK x Rushita	167.97	170.69	174.32	3.27	3.45	3.47
PLK x MLKP	154.71	159.66	160.39	3.32	3.47	3.98
PLK x KOP-1	136.56	140.39	140.32	2.94	2.84	2.47
PLK x Sheetal	111.58	110.47	110.25	1.83	1.84	1.47
PLK x KDWD-1	112.94	111.47	115.36	3.29	3.62	3.94
PLK x J-2	128.72	120.48	122.25	2.32	2.44	2.47
PLK x J-4	138.16	140.47	140.32	1.94	1.84	1.90
Phule Shubhangi x Phule Hemangi	138.15	130.48	139.14	3.05	3.60	3.47
Phule Shubhangi x Poona Khira	137.95	140.84	145.32	2.36	2.65	2.61
Phule Shubhangi x Rushita	127.27	125.47	130.28	3.07	3.47	3.50
Phule Shubhangi x MLKP	186.82	180.49	190.24	2.68	3.90	3.65
Phule Shubhangi x KOP-1	188.17	170.28	191.32	3.04	2.65	2.64
Phule Shubhangi x Sheetal	154.44	159.36	160.17	2.15	2.44	2.84

Phule Shubhangi x KDWD-1	127.60	130.59	135.77	1.76	1.91	2.84
Phule Shubhangi x J-2	174.67	159.25	155.32	2.32	2.39	2.65
Phule Shubhangi x J-4	128.51	120.14	127.87	1.31	1.37	1.47
Phule Hemangi x Poona Khira	125.90	120.47	133.29	3.10	3.62	3.65
Phule Hemangi x Rushita	140.38	130.47	144.44	2.92	2.90	2.48
Phule Hemangi x MLKP	154.93	150.69	156.84	2.64	2.64	2.47
Phule Hemangi x KOP-1	105.28	110.48	110.22	1.51	1.47	1.44
Phule Hemangi x Sheetal	126.29	130.59	130.30	1.86	1.87	1.90
Phule Hemangi x KDWD-1	153.74	148.50	160.26	3.65	3.47	3.91
Phule Hemangi x J-2	160.06	170.39	165.55	6.04	6.20	4.52
Phule Hemangi x J-4	142.96	150.39	155.55	5.31	5.20	2.99
Poona Khira x Rushita	159.54	150.44	160.14	5.32	4.62	4.14
Poona Khira x MLKP	171.05	165.32	174.14	2.64	2.94	2.65
Poona Khira x KOP-1	181.24	180.14	190.21	3.94	3.92	3.99
Poona Khira x Sheetal	133.05	130.45	140.32	2.39	2.74	2.47
Poona Khira x KDWD-1	182.66	180.65	185.21	2.27	2.47	2.47
Poona Khira x J-2	163.40	170.12	165.21	3.12	3.65	3.70
Poona Khira x J-4	187.89	190.21	195.65	2.22	2.98	2.47
Rushita x MLKP	147.22	150.69	150.21	1.55	1.54	1.95
Rushita x KOP-1	165.21	170.36	175.14	1.65	1.36	1.62
Rushita x Sheetal	169.14	170.14	170.32	2.98	3.10	3.90
Rushita x KDWD-1	135.32	140.32	140.32	3.54	3.66	3.47
Rushita x J-2	168.14	169.47	169.54	2.44	2.87	2.80
Rushita x J-4	179.25	174.69	180.80	1.65	1.65	1.77
MLKP x KOP-1	149.32	150.21	155.55	1.95	1.99	1.47
MLKP x Sheetal	188.65	190.47	190.28	3.65	3.55	4.88
MLKP x KDWD-1	190.47	195.65	199.84	4.21	4.12	4.89
MLKP x J-2	166.47	170.36	165.14	2.33	2.25	2.50
MLKP x J-4	211.14	219.36	218.98	4.29	4.90	5.47
KOP-1 x Sheetal	142.58	150.21	144.32	1.65	1.47	1.90
KOP-1 x KDWD-1	147.25	150.84	155.33	2.33	2.55	2.54
KOP-1x J-2	189.35	190.47	198.65	2.68	2.70	2.99
KOP-1x J-4	155.65	140.30	144.25	3.65	3.40	4.10
Sheetal x KDWD-1	154.84	154.36	155.22	1.74	1.76	1.84

Sheetal x J-2		129.25	130.54	135.65	1.11	1.55	1.54
Sheetal x J-4		166.54	165.25	170.32	2.39	2.98	2.64
KDWD-1 x J-2		168.48	168.97	170.39	1.84	1.87	1.90
KDWD-1 x J-4		170.47	175.65	176.69	2.47	2.48	3.10
J-2 X J-4		187.32	188.65	190.28	2.08	2.14	2.18
Malini (Standard Check)		142.58	150.21	144.32	3.65	3.45	3.78
Range							
Parents	Minimum	130.71	135.48	130.84	1.27	1.33	1.39
	Maximum	207.53	201.66	216.27	4.73	4.60	4.82
Hybrids	Minimum	105.28	110.25	110.22	1.11	1.66	1.44
	Maximum	194.14	195.65	218.98	7.34	6.47	5.47
SE_m		20.51	18.47	19.87	0.45	0.48	0.51
CD (5%)		41.11	39.58	40.28	0.91	0.98	0.97
CV%		13.89	12.65	13.57	15.37	14.58	13.51

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