UDC 575.630
https://doi.org/10.2298/ GENSR2401121P
Original scientific article

HETEROSIS AND COMBINING ABILITY ANALYSIS FOR FRUIT TRAITS IN MELON (*Cucumis melo* L.) INVOLVING MALE STERILE AND SNAPMELON LINES

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Patel A.H. Sayeed, A. S. Dhatt, S. P. Sharma, V. K. Vashisht (2024). *Heterosis and combining ability analysis for fruit traits in melon (Cucumis melo L.) involving male sterile and snapmelon lines* - Genetika, Vol 56, No.1, 121-141.

Ten melon accessions including eight resistant lines involving one snapmelon line (*Cucumismelo* var. *momordica*) and two susceptible lineswith one genetic male sterile line were crossed to generate 45 F_1's through half-dialleldesign. These genotypes wereevaluated for yield, quality and disease resistance traits in randomized block design with three replication. Pooled ANOVA for experimental design revealed significant mean squares due to environments except for β-carotene and TSS of juice and, treatment × environment except for fruit shape index and TSS of juice.The GCA estimates showed that parentsPunjab Sunehri was a good combiner for seed cavity area (-8.80), flesh thickness (0.12), rind thickness (0.42), firmness (0.61), dry matter (1.02) and β carotene (0.80) while SM-2012-12 for fruit yield (4.74), number of fruits vine^{-1}(3.43), average fruit weight (0.06) and fusarium wilt incidence (-0.51) whereas, KP_4HM-15 was good for average fruit weight (0.01), days to first fruit ripening (-2.31), TSS (1.21), pH (0.13), titrable acidity (-3.13), ascorbic acid content (5.89) and β-carotene (0.06). The heterobeltosis ranged from -87.2 to 927.08% for the yield and quality traits whereas for fusarium wilt incidence has -100 to 69.23%.The study offers an opportunity for transferring fusarium wilt incidence into superior horticultural genotype. Hybrids KP_4HM-15 × Kajri Sel. 1, Kajri Sel.1 × MM-202 and MM-314 × KP_4HM-15 were identified as promising on the basis of phenotypic performance, SCA effects and resistance to fusarium wilt disease. These hybrids can be evaluated further at multilocation to assess their suitability for commercial release.

Keywords: Muskmelon, *Cucumismelo* var. *momordica*, Fusarium wilt screening, heterobeltosis

INTRODUCTION

Muskmelon is a member of the genus *Cucumis* in the family Cucurbitaceae. The

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characteristics of *Cucumis melo* L. has typical musky flavor with smooth to netted surface with or without sutures. Different botanical groups where identified based on fruit shape, taste and growing region (PRADEEPKUMAR and PETER, 2020).Certain diversified traits were identified in melon are their sex form expression, fruit color, shape, size, sutures, layer around the seeds, flesh color, and the placenta. Morphological, physiological and biochemical diversity do exists in muskmelon (PITRAT, 2016; CHIKH-ROUHOU *et al*., 2023). Though, it was thought to origin from Africa, SEBASTIAN *et al*., (2010) suggest Asian origin due to wide variability. Its diploid chromosome number is 2n = 2x = 24 with a genome size of 450 Mb (GARCIA-MAS *et al*., 2012). Muskmelon being an important desert fruit fetches best price in local as well as international market as compared to other vegetables. Being a short duration crop with high production potential, muskmelon has gained commercial importance. It is relished for its sweet taste. It is a richsource of dietary fibers, vitamins and minerals such as calcium, phosphorus and iron (PITRAT, 2008). It is considered as "wholesome food" because of magical health benefits as it controls blood pressure, strengthens eyes, helps in weight loss, controls diabetes, boost immunity, prevents kidney stone and even prevents risk of cancer (GÓMEZ-GARCÍA *et al.*, 2020; KAUSHIK, 2023).

Muskmelon (*Cucumismelo* L.) is a valuable cash crop grown in temperate, subtropical and tropical regions of world. China is the largest producer with 50.04% followed by Turkey (5.76%), Iran (4.98 %), Egypt (3.54 %) and India (3.49 %). In 2014, the total production in the world was 29.5 million tons and area was 1.2 million ha with average yield of 24.9 tons ha^{-1} (ANONYMOUS, 2014). In India, it is cultivated over an area of about 47 thousand ha with the total production of 878 thousand MT and the productivity of about 20 tons ha^{-1} (ANONYMOUS, 2021).

In muskmelon, hybrids were preferred over variety due to their early maturity, high yield potential, superior quality, high input efficiency, disease and insect-pest resistance (SHARMA *et al*., 2021).Additionally, the development of F_1 hybrids in muskmelon is quite easy due to its monoecious nature hence it is the quickest way of improving important economic traits and an easy way of introducing disease resistance governed by dominant genes. In India, the hybrids developed by public sector or private seed companies lack stable disease resistance and these hybrids succumb to the attack of fusarium wilt. There is an urgent need to develop hybrids with inbuilt fusarium wilt resistance. In this study, the efforts were made to identify genotypes and their utilization for development of hybrids superior in horticultural traits along with fusarium wilt resistance.

Keeping the above points in view, the present study objectives were to estimate GCA and SCA effects using ten *C. melo* inbred lines including one male sterile line and one snap melon line; and to identify promising hybrid combination for commercial exploitation.

MATERIAL AND METHODS

Location

The present experiment was conducted at Department of Vegetable Science, Punjab Agricultural University, Ludhiana, India. An Indo-Gangetic plain has major melon growing area in India and being one of the largest fluvial plain, so the experiment was conducted over here.

Climate and soil of experimental field

The climate of Ludhiana is characterized as sub-tropical with an average annual rainfall of 755 mm. The rainfall was monsoonal in nature with around 70% received during July-September. The soil of the experimental field was loamy sand in texture, low in available nitrogen and organic matter, medium in available phosphorus and high in available potassium.

Plant material and experimental design

The study comprised of ten inbred lines which includes one male sterile line and a snapmelon (*C melo* var*momordica*L.) line. The genetic male sterile line (MS-1) was controlled by single nuclear recessive gene (ms_1ms_1) and expressed only under recessive homozygous condition (MISHRA and KUMARI, 2018). The anthers are indehiscent with shriveled empty pollen at tetrad stage. MS-1 line has been introduced during 1970s from Canada by Department of Vegetable Science, Punjab Agricultural University, Ludhiana. The other nine inbred lines (Table 1) were male fertile and selected on *per se* basis. MS-1 and Punjab Sunheri was found to be susceptible whereas rest of the parental lines was resistant to fusarium wilt (PATEL *et al*., 2016). The crosses were attempted in diallel mating design without reciprocal cross.

Table 1. Description of parental lines of muskmelon

Sr	Genotype	Botanical group	Important characters	
1	MS-1	*cantalupensis*	Genetic male sterile line (ms_1ms_1) having intense netting along with small seed cavity, average fruit weight is 700-800 g with 10% TSS and susceptible to fusarium wilt	
2	MM-321	*reticulatus*	Inbred line developed from pedigree of *reticulatus* × *momordica* line with netting, Fruit weight 500 g, 6-7% TSS.	
3	NDM-21	*cantalupensis*	Oval shape, suture present, smooth fruit surface, fruit weight 900 g with greenish orange flesh and 10% TSS.	
4	Punjab Sunehri	*reticulatus*	Fruits are oval round, golden yellow, non-sutured, intensely netted with thick rind weighing 600-700 g. Fruit flesh is of medium thickness, salmon orange with 12% TSS.	
5	MM-314	*reticulatus*	Greenish white flesh, no suture, 8 % TSS, 600 g fruit weight, medium seed cavity	
6	IC-267375	*cantalupensis*	Fruits are round, light yellow, sutured and netted weighing about 900 g. Fruit flesh is medium thick, light green with 9% TSS	
7	KP$_4$HM-15	*cantalupensis*	An inbred line developed from *cantalupensis* (Hara Madhu) × *momordica*, fruit are sutured with green flesh colour having average fruit weight 700 g, 10% TSS, resistant to fusarium wilt	
8	Kajri Sel-1	*cantalupensis*	Round fruit with red fruit and green colour suture. Average fruit weight is 900 g TSS 10% along with small seed cavity and highly resistant to fusarium wilt	
9	MM-202	*cantalupensis*	An inbred line developed from cross between *cantalupensis* × *momordica*, small fruit with 500 g fruit weight, sutured and netted and have 11% TSS	
10	SM-2012-12	*momordica*	A snapmelon line with oval fruit shape without netting and suture, resistant to fusarium wilt.	

Nursery was sown with F_1 hybrid seeds and parents. Ten plants of each genotype were transplanted on edges of raised beds at a distance of 0.60m whereas the water channels were spaced at 3.0m. Observations were recorded on eight plants. The experiment was laid out in a Completely Randomized Block Design (CRBD) with two replications.

Evaluated traits

Fifteen horticultural traits include fruit yield, number of fruit vine^{-1}, average fruit weight, days to first fruit ripening, seed cavity area, flesh&rind thickness and fusarium wilt incidence while biochemical traits include TSS, firmness, pH, titrable acidity, ascorbic acid content, dry matter and β carotene content were recorded. Fruit firmness was calculated by using hand-held penetrometer (Model FT-327, USA). Titrable acidity was measured as anhydrous citric acid mg 100^{-1} ml of juice and was estimated by the method suggested by SRIVASTAVA and KUMAR (2006) and ascorbic acid and β-carotene content was estimated by the method as described by KAUR *et al*. (2022). All parent and hybrids were transplanted in wilt sick plot of fusarium wilt (*Fusarium oxysporum* f. sp*melonis* race 1.2) and the disease incidence was recorded as per the disease rating scale given by PATEL *et al*. (2016).

Statistical analyses

The data were subjected to analysis for general and specific combining ability variance, effects and components analysis. The experimental data were subjected to Windostat software programme. The general combining ability and the specific combining ability analysis was carried out by Method II (parents and one set of F_1's were included, but not reciprocal F_1's) and Model I (Fixed effect model) as suggested by GRIFFING (1956). Heterobeltosis (H_{BP}) was expressed as per cent deviation of hybrid performance from the better parent (KAUR *et al*., 2022).

RESULTS AND DISCUSSION

There is always a great demand of hybrids in muskmelon due to earliness, higher yield, better quality, higher adaptability and resistance against various stresses. Being a andromonoecious (dominant) sex form, muskmelon is highly cross pollinated crop (KOUONON *et al*., 2009). Even though, hybrid seeds were costly because of hand emasculation and pollination. At present, male sterility is being used to reduce the cost of hybrid seed and increase the purity (DHALL, 2010). Five male sterile genes were identified but out of them, only *ms-1* gene is being commercially utilized in India.

Analysis of variance for the experimental design

The pertaining to the pooled analysis of variance for experimental design has been given for various traits (Table 2). The mean square due to environment were non-significant for all the traits except β carotene content and TSS juice which depicts that environment in 2 years were almost similar. Mean squares due to treatment were significant for all the studied traits denotes potential genetic variability among treatments i.e. parents and their hybrids. DEHGHANI *et al.*(2012) similarly reported significant difference for fruit number, average weight, yield whereas, JAGTAP and MUSMADE (2014) found a significant difference for days to first fruit ripening, flesh thickness, TSS, titrable acidity and ascorbic acid content irrespective of their parental lines. The mean square due to treatment × environment, variance due to parent × environment and hybrid × environment was non-significant for all the traits except for fruit shape index and TSS juice. Contrarily, MOHAMMADI *et al.* (2014) found significant interaction for all the studied traits except TSS and suggested that genotypes were influenced by year. Some researchers suggested that fruit development can be modified with genotype × environment interaction (KULTUR *et al*., 2001; ZALAPA *et al*., 2006).

Table 2. Pooled analysis of variance for the experimental design, mean values and range of 15 horticultural traits of melon evaluated in half-diallel for two consecutive year at PAU, Ludhiana, India

Source of variation	d.f.	Fruit yield (kg)	Number of fruit vine^{-1}	Average fruit weight (kg)	Days to first fruit ripening	Seed cavity area (cm^2)	Flesh thickness (cm)	Rind thickness (mm)	TSS (%)
		Mean sum of squares							
Environments	1	1.05	0.02	0.004	0.77	8.39	0.01	0.01	0.03
Replication within environments	2	1.56	15.39	0.004	34.42*	746.39**	0.03	0.23	0.70
Genotype	54	184.73**	157.34**	0.08**	54.80**	1199.77**	0.41**	1.71**	17.87**
Genotype ×environment	54	0.61	3.57	0.002	2.22	1.15	0.06	0.05	0.42
Parents ×environment	9	1.29	1.25	0.001	1.25	1.98	0.04	0.02	0.22
Hybrids ×environment	44	0.49	4.13	0.002	2.38	1.00	0.06	0.06	0.45
Parents vs Hybrids × environment	1	0.06	0.06	0.002	3.95	0.06	0.01	0.07	0.80
Error	108	2.80	6.23	0.002	10.76	52.47	0.05	0.08	0.40
		Mean and range values							
Parent mean		22.02	33.42	0.67	94.02	32.42	2.54	2.96	8.85
General mean		24.40	35.18	0.70	93.26	32.68	2.68	2.83	9.26
Hybrid mean		25.02	36.22	0.69	93.21	32.53	2.69	2.73	9.31
Range Minimum value		12.22	19.00	0.39	88.25	13.00	2.08	1.22	4.57
Maximum value		40.03	48.75	1.03	108.50	101.16	4.07	4.77	13.56

Source of variation	d.f.	Firmness (Ib/inch^2)	pH	Titrable Acidity (mg 100^{-1} ml)	Ascorbic acid content (mg 100^{-1} ml)	Dry matter (%)	β carotene content (mg 100^{-1} g)	Fusarium wilt incidence
		Mean sum of squares						
Environments	1	0.03	0.02	21.11	16.57	1.70	0.062*	0.55
Replication within environments	2	0.02	0.15**	61.99**	5.27	17.68**	0.008*	0.05
Genotype	54	3.71**	1.46**	298.35**	344.04**	11.58**	2.784**	8.23**
Genotype ×environment	54	0.01	0.01	2.44	1.10	0.04	0.001	0.04
Parents ×environment	9	0.01	0.00	5.15	1.21	0.10	0.002	0.04
Hybrids ×environment	44	0.01	0.01	1.92	1.07	0.03	0.001	0.03
Parents vs Hybrids × environment	1	0.00	0.00	0.75	1.56	0.10	0.000	0.03
Error	108	0.01	0.02	3.09	2.01	0.63	0.002	0.20
		Mean and range values						
Parent mean		3.57	5.85	18.53	17.85	8.93	0.71	2.05
General mean		3.02	5.97	20.19	18.45	8.96	0.95	1.92
Hybrid mean		2.94	5.97	20.68	18.09	8.89	1.01	1.77
Range Minimum value		1.35	4.26	5.25	2.90	4.51	0.07	0.00
Maximum value		5.67	6.73	40.50	37.17	12.46	2.98	4.87

Analysis of variance for combining ability

The pooled analysis of variance for combining ability of studied traits was presented in Table 3. The mean sum of squares due to GCA and SCA were highly significant for all the traits under study. The mean sum of squares due to GCA*E and SCA*E was non-significant for all the traits except fruit shape index and TSS juice. Quadratic component of variance was presented in Table 3. The ratio of variance due to GCA and SCA (σ^2_g / σ^2_s) was less than unity. It was unity or more for the traits i.e. seed cavity area (1.02), fruit shape index (1.00) and pH (1.88). In present study, dominance variance was higher for the traits fruit yield, number of fruits vine^{-1}, average fruit weight, days to first pistillate flowering, days to first fruit ripening, flesh thickness, firmness, titrable acidity, ascorbic acid content and dry matter content.

Table 3. Pooled analysis of variance for combining ability of 15 horticultural traits of melon evaluated in half-diallel for two consecutive year

Character	Source of variation (df)					
	GCA (9)	SCA (45)	E (1)	GCA*E (9)	SCA*E (45)	Error (108)
Fruit yield (kg)	187.39**	73.36**	1.40	0.43	0.28	1.40
Number of fruit vine^{-1}	109.62**	72.48**	3.12	1.84	1.78	3.12
Average fruit weight (kg)	0.11**	0.03**	0.01	0.00	0.00	0.00
Days to first fruit ripening	51.53**	22.58**	5.38	0.32	1.27	5.38
Seed cavity area (cm^2)	2473.18**	225.22**	26.24	0.50	0.59	26.24
Flesh thickness (cm)	0.23**	0.20**	0.02	0.02	0.03	0.02
Rind thickness (mm)	2.81**	0.47**	0.04	0.02	0.03	0.04
TSS (%)	33.01**	4.12**	0.20	0.22	0.21	0.20
Firmness (Ib/inch^2)	5.92**	1.04**	0.01	0.00	0.00	0.01
pH	3.57**	0.16**	0.01	0.00	0.00	0.01
Titrable acidity (mg 100^{-1} ml)	408.69**	97.27**	1.54	1.58	1.15	1.54
Ascorbic acid content (mg 100^{-1} ml)	195.53**	167.32**	1.01	0.41	0.58	1.01
Dry matter (%)	10.82**	4.78**	0.31	0.03	0.02	0.31
β carotene content (mg 100^{-1} g)	5.48**	0.57**	0.00	0.00	0.00	0.00
Fusarium wilt incidence	15.62**	1.82**	0.10	0.01	0.02	0.10

Character	Genetic components						
	σ^2_{GCA}	σ^2_{SCA}	σ^2_{GCA}/ σ^2_{SCA}	σ_e^2	σ^2_A	σ^2_D	h^2_{bs} (%)
Fruit yield (kg)	7.75	35.98	0.22	1.4	15.5	35.98	30.00
Number of fruit vine^{-1}	4.44	34.68	0.13	3.12	8.88	34.68	19.62
Average fruit weight (kg)	0.00	0.01	0.33	0.00	0.01	0.01	38.27
Days to first fruit ripening	1.92	8.60	0.22	5.38	3.85	8.60	28.93
Seed cavity area (cm^2)	101.96	99.49	1.02	26.24	203.91	99.49	67.55
Flesh thickness (cm)	0.01	0.09	0.10	0.02	0.02	0.09	12.49
Rind thickness (mm)	0.12	0.21	0.55	0.04	0.23	0.21	49.24
TSS (%)	1.37	1.96	0.70	0.2	2.73	1.96	55.79
Firmness (Ib/inch^2)	0.25	0.52	0.48	0.01	0.49	0.52	48.60
Ph	0.15	0.08	1.94	0.01	0.3	0.08	79.03
Titrable acidity (mg 100^{-1} ml)	16.96	47.86	0.35	1.54	33.93	47.86	40.91
Ascorbic acid content (mg 100^{-1} ml)	8.11	83.16	0.10	1.01	16.21	83.16	16.23
Dry matter (%)	0.44	2.24	0.20	0.31	0.88	2.24	28.18
β carotene content (mg 100^{-1} g)	0.23	0.29	0.80	0.00	0.46	0.29	61.41
Fusarium wilt incidence	0.65	0.86	0.75	0.10	1.29	0.86	59.79

Mean performance of parents and hybrids with their combining ability and heterobeltosis

The mean performance and GCA of parental lines (Table 4) and mean performance, SCA affects and heterobeltosis (%) of F_1 hybrids for studied traits were presented in Table 5.

Table 4. Pooled mean performance, GCA effects, GCA variance and SCA variance of 15 horticultural traits of melon evaluated in half-diallel for two consecutive year.

Parental Line	Fruit yield (kg)				Number of fruit vine^{-1}				Average fruit weight (kg)			
	Mean[a]	g_i	σ^2_{gi}	σ^2_{si}	Mean[a]	g_i	σ^2_{gi}	σ^2_{si}	Mean[a]	g_i	σ^2_{gi}	σ^2_{si}
MS-1	17.98 e	-1.34**	1.64	73.40	30.00 e	-2.67**	6.79	42.91	0.59 de	0.01*	0.000	0.03
MM-321	16.54 ef	-1.47**	1.99	84.16	39.25 b	0.79	0.27	58.12	0.42 f	-0.05**	0.003	0.03
NDM-21	24.65 c	2.07**	4.12	94.10	25.25 f	-1.90**	3.26	61.79	0.97 a	0.11**	0.011	0.04
PS	12.22 g	-5.29**	27.80	58.30	32.00 d	-2.05**	3.84	82.38	0.39 f	-0.12**	0.014	0.02
MM-314	21.38 d	-0.48	0.08	18.56	34.50 c	2.66**	6.74	76.65	0.63 cd	-0.06**	0.003	0.01
IC-267375	28.51 b	0.88**	0.61	60.85	35.50 c	1.52**	1.95	60.13	0.79 b	-0.01**	0.000	0.02
KP$_4$HM-15	15.93 f	-0.96**	0.77	63.46	23.75 f	-2.03**	3.75	74.40	0.68 c	0.01*	0.000	0.02
Kajri Sel-1	24.24 c	2.93**	8.42	63.69	30.00 e	0.48	-0.12	60.12	0.82 b	0.07**	0.004	0.01
MM-202	22.26 d	-1.07**	0.99	16.12	40.25 b	-0.23	-0.29	48.95	0.56 e	-0.02**	0.000	0.01
SM-2012-12	36.56 a	4.74**	22.28	67.55	43.75 a	3.43**	11.44	27.56	0.84 b	0.06**	0.004	0.03
CD (g_i) (p= 0.05)		**0.68**				**1.01**				**0.02**		
CD (g_i - g_{ij}) (p= 0.01)		**0.89**				**1.34**				**0.03**		

Parental Line	Days to first fruit ripening				Seed cavity area (cm^2)				Flesh thickness (cm)			
	Mean[a]	g_i	σ^2_{gi}	σ^2_{si}	Mean[a]	g_i	σ^2_{gi}	σ^2_{si}	Mean[a]	g_i	σ^2_{gi}	σ^2_{si}
MS-1	95.50 a	-0.81	0.06	9.73	13.75 gh	-6.50**	39.38	173.79	2.56 ab	0.09*	0.01	0.12
MM-321	92.25 c	-0.68	-0.13	10.26	19.60 f	-3.53**	9.55	189.88	2.32 bc	-0.10*	0.01	0.11
NDM-21	93.75 bc	-0.35	-0.47	7.30	48.20 b	5.82**	31.00	92.98	2.65 a	-0.02	-0.00	0.04
PS	92.00 c	1.48*	1.60	60.30	13.00 h	-8.80**	74.61	121.73	2.78 a	0.12**	0.01	0.41
MM-314	98.75 a	1.57*	1.86	15.70	23.52 e	-7.42**	52.20	84.97	2.11 c	-0.07	0.00	0.16
IC-267375	93.50 bc	0.55	-0.30	35.54	28.87 d	-3.35**	8.30	162.03	2.76 a	0.10*	0.00	0.38
KP$_4$HM-15	92.25 c	-2.31**	4.73	8.37	43.16 c	2.76*	4.71	95.96	2.67 a	0.05	0.00	0.06
Kajri Sel-1	95.00 a	1.25	0.97	12.44	15.33 g	-3.51**	9.42	223.89	2.74 a	0.04	-0.01	0.23
MM-202	98.75 a	1.38*	1.30	8.62	17.60 f	-1.40	-0.95	226.66	2.58 ab	-0.04	-0.01	0.04
SM-2012-12	88.50 d	-2.08**	3.72	16.46	101.16 a	25.94**	670.08	470.84	2.29 bc	-0.17**	0.03	0.10
CD (g_i) (p= 0.05)		**1.33**				**2.93**				**0.09**		
CD (g_i - g_{ij}) (p= 0.01)		**1.76**				**3.88**				**0.12**		

Parental Line	Rind thickness (mm)				TSS (%)				Firmness (Ib/inch^2)			
	Mean[a]	g_i	σ^2_{gi}	σ^2_{si}	Mean[a]	g_i	σ^2_{gi}	σ^2_{si}	Mean[a]	g_i	σ^2_{gi}	σ^2_{si}
MS-1	3.68 ab	0.50**	0.25	0.31	9.88 c	0.07	-0.02	3.50	2.44 h	-0.30**	0.09	0.70
MM-321	2.58 d	-0.07	0.00	0.16	6.40 f	-0.70**	0.46	1.82	3.33 f	-0.20**	0.04	0.73
NDM-21	2.25 e	-0.23**	0.05	0.20	9.39 cd	0.68**	0.44	2.83	4.65 b	0.18**	0.03	0.95
PS	3.53 b	0.42**	0.17	0.68	11.63 a	1.01**	1.00	3.57	4.44 c	0.61**	0.38	1.31
MM-314	2.28 e	-0.24**	0.05	0.04	7.63 e	-0.43**	0.16	2.83	3.33 f	0.07**	0.01	1.09
IC-267375	3.20 c	0.12*	0.01	0.31	8.76 d	-0.27*	0.05	2.82	5.43 a	0.57**	0.32	1.28
KP$_4$HM-15	2.62 d	0.01	-0.01	0.16	9.75 c	1.21**	1.44	3.92	3.50 e	-0.02	0.00	0.54
Kajri Sel-1	3.88 a	-0.11*	0.01	1.09	9.53 cd	0.33**	0.08	6.26	2.98 g	-0.10**	0.01	0.47
MM-202	3.26 c	0.25**	0.06	0.07	10.79 b	0.89**	0.77	2.30	4.26 d	0.30**	0.09	0.96
SM-2012-12	2.35 e	-0.66**	0.42	0.79	4.73 g	-2.79**	7.77	3.86	1.35 i	-1.12**	1.25	0.48
CD (g_i) (p= 0.05)		**0.12**				**0.26**				**0.05**		
CD (g_i - g_{ij}) (p= 0.01)		**0.16**				**0.34**				**0.06**		

Parental Line	pH				Titrable acidity (mg 100^{-1} ml)				Ascorbic acid content (mg 100^{-1} ml)			
	Mean[a]	g_i	σ^2_{gi}	σ^2_{si}	Mean[a]	g_i	σ^2_{gi}	σ^2_{si}	Mean[a]	g_i	σ^2_{gi}	σ^2_{si}
MS-1	5.95 e	0.06*	0.00	0.04	12.38 c	-0.93**	0.69	58.62	14.90 e	-2.15**	4.50	68.28
MM-321	6.05 cd	0.06*	0.00	0.14	13.45 c	0.73*	0.37	55.13	28.78 c	3.05**	9.17	95.27
NDM-21	5.98 de	0.12**	0.01	0.16	31.78 a	-0.03	-0.17	106.08	5.39 h	-0.85**	0.61	180.69
PS	5.51 g	0.05*	0.00	0.22	28.86 a	1.31**	1.54	114.89	16.93 d	0.49	0.13	130.63
MM-314	6.18 b	0.24**	0.06	0.07	7.26 d	-3.26**	10.47	73.44	8.25 g	-0.96**	0.80	116.44
IC-267375	6.08 c	0.16**	0.03	0.16	21.28 b	1.79**	3.02	57.84	11.71 f	-2.65**	6.92	120.26

KP_4HM-15	5.86 f	0.13**	0.02	0.15	13.38 c	-3.13**	9.64	38.07	32.55 b	5.89**	34.54	101.18
Kajri Sel-1	6.19 b	0.19**	0.03	0.04	13.38 c	-1.75**	2.90	105.53	15.53 de	-3.24**	10.41	173.55
MM-202	6.40 a	0.06*	0.00	0.21	12.76 c	-4.76**	22.50	24.67	7.25 g	-1.41**	1.87	133.41
SM-2012-12	4.26 h	-1.08**	1.17	0.12	30.75 a	10.04**	100.59	161.61	37.18 a	1.83**	3.25	249.24
CD (g_i) (p= 0.05)		**0.05**				**0.71**				**0.57**		
CD (g_i - g_{ij}) (p= 0.01)		**0.07**				**0.94**				**0.76**		

Parental Line	Dry matter (%)				β carotene content (mg 100^{-1} g)				Fusarium wilt incidence			
	Mean[a]	g_i	σ^2_{gi}	σ^2_{si}	Mean[a]	g_i	σ^2_{gi}	σ^2_{si}	Mean[a]	g_i	σ^2_{gi}	σ^2_{si}
MS-1	9.73 c	0.72**	0.48	5.29	1.14 c	0.28**	0.08	0.55	4.88 a	1.69**	2.84	1.62
MM-321	7.72 ef	-0.38*	0.11	5.12	0.24 d	-0.30**	0.09	0.26	0.00f	-0.70**	0.48	0.99
NDM-21	6.96 g	-0.34*	0.08	3.75	0.12 ef	-0.32**	0.10	0.35	2.63 b	0.34**	0.11	2.10
PS	12.01 a	1.02**	1.00	1.39	2.73 a	0.80**	0.64	0.47	4.50 a	0.80**	0.63	2.10
MM-314	9.89 c	-0.27	0.04	5.65	0.12 ef	-0.21**	0.05	0.26	2.63 b	0.14	0.01	1.50
IC-267375	8.61 d	-0.13	-0.02	1.76	0.21 de	-0.31**	0.10	0.28	1.63 c	0.13	0.00	1.50
KP_4HM-15	8.19 de	-0.12	-0.02	2.36	0.12 ef	0.06**	0.00	1.04	1.25 cd	-0.34**	0.11	1.24
Kajri Sel-1	7.42 fg	-0.20	0.01	8.55	0.11 ef	-0.43**	0.19	0.48	1.63 c	-0.42**	0.17	0.88
MM-202	11.04 b	0.87**	0.72	3.96	2.20 b	0.82**	0.67	0.54	0.88 de	-0.60**	0.35	0.96
SM-2012-12	7.81 ef	-1.16**	1.31	1.33	0.08 f	-0.38**	0.15	0.47	0.50 e	-0.51**	1.05	1.96
CD (g_i) (p= 0.05)		**0.32**				**0.02**				**0.18**		
CD (g_i - g_{ij}) (p= 0.01)		**0.42**				**0.03**				**0.24**		

Fruit yield (kg)

The fruit yield of parent ranged from 12.22-36.56 kg (mean 22.03) (Table 2 and 4) as compared to 13.07-40.04 kg (mean 25.02) by F_1 hybrids (Table 2 and 5). The maximum fruit yield was observed by SM-2012-12 (36.56 kg) while minimum fruit yield was shown by PS (12.22 kg). The best GCA effect was observed for SM-2012-12 (4.74). In present investigation, all the parents have lower GCA variance than SCA variance which was desirable to obtain superior hybrids (Table 4). These results were in accordance with SINGH *et al.* (2014). Out of 45 hybrids, 13 and 18 hybrids showed significant positive and negative heterosis over respective better parent whilst, 18 and 17 hybrids were observed to have significant positive and negative SCA effects respectively (Table 5). Heterosis over better parent ranged from -53.88 to 80.42%. The superior hybrid combinations with respect to fruit yield were PS × KP_4HM-15 (80.42%) followed by MS-1 × KP_4HM-15 (66.49%) and MM-321× KP_4HM-15 (59.87%).

Number of fruit vine^{-1}

In muskmelon, number of fruit vine^{-1} is important component contributing fruit yield. The number of fruit produced by the parental genotypes and F_1 hybrids varied from 2.35-4.37 (mean 3.34) and 2.15-4.90 (mean 3.62), respectively (Table 2, 4 and 5). The maximum number of fruit vine^{-1}was found in SM-2012-12 (4.37) while the minimum was possessed by KP_4HM-15 (2.37)which was *at par* with NDM-21 (2.52). The best general combiner was SM-2012-12 (3.43). The parental line SM-2012-12 has high GCA and SCA variance while rest nine parents have low GCA and high SCA variance (Table 4). Out of 45 hybrids, 14 and 10 hybrids have significant positive and negative SCA value whereas, 10 and 14 hybrids have showed significant positive and negative heterosis over better parent. The heterobeltosis was ranged from -45.22 to 41.41%. PS × KP_4HM-15 (41.41%) followed by IC-267375 × Kajri Sel. 1 (37.32%) were observed to have highest heterosis over respective better parent. The heterobeltosis for number of fruit vine^{-1} has been observed from -57.89 to 83.02 % by GURAV *et al.*(2000), up to 15.96 % by CHAUDHARY *et al.*(2003) and up to 30% by TOMAR and BHALALA (2006b).

Table 5.Pooled mean, specific combining ability (SCA) effects (S_{ij}) and heterobeltosis (H_{BP}) exhibited by 45 F_1 hybrids for 15 horticultural and biochemical traits in melon evaluated in half-diallel for two consecutive seasons at Ludhiana, India.

F_1 hybrid	Fruit yield (kg)			Number of fruit vine^{-1}			Average Fruit weight (kg)		
	Mean[a]	S_{ij}	H_{BP}	Mean[a]	S_{ij}	H_{BP}	Mean[a]	S_{ij}	H_{BP}
MS-1 × MM-321	13.07 q	-8.60**	-27.32**	21.50 r	-12.33**	-45.22**	0.628 lmnopq	-0.012	6.40
MS-1 × NDM-21	19.26 m	-5.94**	-21.88**	32.50 klmn	0.86	6.67	0.602 opq	-0.197**	-37.74**
MS-1 × PS	16.76 o	-1.09	-6.80	37.00 fghi	5.51**	14.06	0.459 t	-0.118**	-22.19**
MS-1 × MM-314	26.17 gh	3.52**	22.40**	35.50 hijk	-0.45	2.17	0.749 fgh	0.111**	19.59*
MS-1 × IC-267375	28.63 e	4.62**	0.40	36.50 fghi	1.95	2.82	0.797 efg	0.111**	0.28
MS-1 × KP$_4$HM-15	29.94 d	7.76**	66.49**	36.00 ghij	4.74**	19.17*	0.827 de	0.121**	21.51**
MS-1 × Kajri Sel. 1	25.98 h	-0.08	7.19	31.00 mno	-2.51	3.33	0.849 cde	0.089**	3.38
MS-1 × MM-202	17.34 no	-4.73**	-22.12**	31.50 lmno	-1.31	-21.74**	0.560 qrs	-0.118**	-5.17
MS-1 × SM-2012-12	40.04 a	12.16**	9.51*	41.00 de	4.28**	-6.86	0.988 a	0.233**	17.95**
MM-321 × NDM-21	38.33 b	13.25**	55.45**	41.50 de	6.65**	5.10	0.931 ab	0.191**	-3.75
MM-321 × PS	23.36 jkl	5.64**	41.26**	39.00 efg	4.55**	-0.64	0.591 pq	0.073*	39.19**
MM-321 × MM-314	27.16 fg	4.63**	27.04**	47.00 ab	7.59**	19.11**	0.590 pq	0.011	-5.87
MM-321 × IC-267375	15.47 p	-8.42**	-45.76**	32.50 klmn	-5.51**	-17.20**	0.481 t	-0.145**	-39.50**
MM-321 × KP$_4$HM-15	26.44 gh	4.39**	59.87**	34.00 ijklm	-0.72	-14.01*	0.796 efg	0.149**	16.81*
MM-321 × Kajri Sel. 1	22.34 l	-3.60**	-7.84	35.50 hijk	-1.97	-10.83	0.633 lmnopq	-0.067*	-22.87**
MM-321 × MM-202	24.58 i	2.64**	10.40	36.00 ghij	-0.76	-11.80	0.697 hijkl	0.078**	25.03**
MM-321 × SM-2012-12	27.84 ef	0.09	-23.87**	38.50 efgh	-1.43	-12.00*	0.730 ghij	0.035	-12.90*
NDM-21 × PS	29.83 d	8.57**	20.97**	34.00 ijklm	1.74	4.69	0.893 bcd	0.217**	-7.68
NDM-21 × MM-314	26.91 fgh	0.85	9.16	47.50 ab	10.53**	36.23**	0.569 qr	-0.169**	-41.17**
NDM-21 × IC-267375	24.55 i	-2.87**	-13.91*	31.00 mno	-4.58**	-13.38	0.804 ef	0.019	-16.96**
NDM-21 × KP$_4$HM-15	18.19 n	-7.39**	-26.22**	30.50 nop	-1.28	20.79*	0.588 pq	-0.217**	-39.21**
NDM-21 × Kajri Sel. 1	36.99 c	7.52**	50.03**	41.00 de	6.47**	35.83**	0.906 bc	0.047	-6.33
NDM-21 × MM-202	28.07 ef	2.60*	13.86*	31.50 lmno	-2.33	-22.36**	0.891 bcd	0.114**	-7.91
NDM-21 × SM-2012-12	22.62 kl	-8.67**	-38.15**	33.00 jklmn	-4.74**	-25.71**	0.714 hijk	-0.140**	-26.21**
PS × MM-314	15.44 p	-3.27**	-27.82**	26.00 q	-10.33**	-24.64**	0.616 nopq	0.100**	-1.72
PS × IC-267375	13.15 q	-6.92**	-53.88**	27.50 pq	-8.18**	-23.94**	0.498 st	-0.064*	-37.30**
PS × KP$_4$HM-15	28.74 e	10.51**	80.42**	45.50 bc	13.61**	41.41**	0.631 lmnopq	0.048	-7.34
PS× Kajri Sel. 1	17.96 n	-4.17**	-25.93**	29.00 opq	-5.39**	-10.16	0.620 mnopq	-0.017	-24.54**
PS × MM-202	16.72 o	-1.41	-24.93**	30.50 nop	-3.18*	-24.84**	0.564 qrs	0.008	1.08
PS × SM-2012-12	19.42 m	-4.51**	-46.90**	38.50 efgh	0.90	-13.14*	0.504 rst	-0.128**	-39.86**
MM-314 × IC-267375	23.54 ijk	-1.33	-17.46**	41.00 de	0.86	14.79*	0.583 pq	-0.041	-26.66**
MM-314 × KP$_4$HM-15	23.50 ijk	0.47	9.91	34.00 ijklm	-2.35	-1.45	0.689 hijklm	0.044	1.17
MM-314 × Kajri Sel. 1	27.11 fgh	0.19	11.86	39.50 ef	0.40	13.77	0.683 hijklmn	-0.015	-16.78**
MM-314 × MM-202	27.28 fg	4.36**	22.55**	46.00 abc	7.36**	13.04*	0.596 pq	-0.021	-4.95
MM-314 × SM-2012-12	23.57 ijk	-5.17**	-35.55**	41.50 de	-0.56	-5.71	0.573 q	-0.120**	-31.53**
IC-267375 × KP$_4$HM-15	26.43 gh	2.03*	-7.32	40.50 de	5.05**	13.38	0.668 jklmno	-0.024	-15.96*
IC-267375 × Kajri Sel. 1	39.30 ab	11.01**	37.83**	49.00 a	11.05**	37.32**	0.797 efg	0.052	-2.95
IC-267375 × MM-202	27.69 ef	3.41**	-2.88	43.50 cd	6.26**	7.45	0.646 klmnop	-0.017	-18.63**
IC-267375× SM-2012-12	24.00 ij	-6.09**	-34.37**	40.50 de	-0.41	-8.00	0.603 opq	-0.137**	-28.04**
KP$_4$HM-15 × Kajri Sel. 1	24.22 ij	-2.22*	-0.07	35.50 hijk	1.09	17.50*	0.673 jklmno	-0.093**	-18.09**
KP$_4$HM-15 × MM-202	19.77 m	-2.67**	-11.20	27.50 pq	-6.20**	-32.30**	0.736 fghij	0.052	8.11
KP$_4$HM-15× SM-2012-12	28.65 e	0.39	-21.64**	39.50 ef	1.88	-10.86	0.743 fghi	-0.018	-11.29
KajriSel 1 × MM-202	22.79 kl	-3.55**	-5.97	34.50 ijkL	-1.70	-14.91*	0.681 hijklmn	-0.057	-17.08**
KajriSel 1 × SM-2012-12	39.23 ab	7.09**	7.32	46.00 abc	5.88**	4.00	0.872 bcd	0.058*	4.17
MM-202 × SM-2012-12	27.64 ef	-0.51	-24.42**	31.00 mno	-8.16**	-29.71**	0.890 bcd	0.158**	6.27
CD (S_{ij}) (p= 0.05)	-	**2.244**	**3.31**	-	**3.35**	**4.949**	-	**0.066**	**0.097**
CD (S_{ij}) (p= 0.01)	-	**2.969**	**4.38**	-	**4.43**	**6.547**	-	**0.087**	**0.129**

F_1 hybrid	Days to first fruit ripening			Seed Cavity (cm^2)			Flesh Thickness (cm)	
	Mean[a]	S_{ij}	H_{BP}	Mean[a]	S_{ij}	H_{BP}	Mean[a]	S_{ij}
MS-1 × MM-321	90.50 lmno	-1.867	-5.76	44.69 g	22.208**	127.93**	2.63 efghijk	-0.035
MS-1 × NDM-21	91.50 klmn	-1.201	-4.71	17.05 uv	-14.784**	-64.63**	2.61 efghijk	-0.140
MS-1 × PS	93.00 ijkl	-1.034	-2.62	13.55 w	-3.654	-1.49	2.69 cdefghi	-0.195
MS-1 × MM-314	93.00 ijkl	-1.367	-6.08	16.05 uv	-2.544	-31.82	2.89 cdef	0.198
MS-1 × IC-267375	92.00 jklmnn	-1.347	-3.93	20.09 t	-2.572	-30.42	3.37 b	0.505
MS-1 × KP$_4$HM-15	90.00 mno	-0.242	-5.76	35.85 i	7.078	-16.95	2.82 cdefg	0.002
MS-1 × Kajri Sel. 1	97.00 efg	2.945	1.31	16.73 uv	-5.769	9.14	2.89 cdef	0.084
MS-1 × MM-202	91.50 klmn	-2.430	-7.34*	31.27 n	6.668	77.68	2.64 defghijk	-0.087
MS-1 × SM-2012-12	90.00 mno	-0.972	-6.28	56.82 d	4.870	-43.83**	2.84 cdefg	0.247
MM-321 × NDM-21	95.50 fghi	2.924	1.60	28.93 op	-5.873	-39.98**	2.51 fghijk	-0.038

MM-321 × PS	91.00 klmno	-3.409	-1.63	25.13 r	4.954	28.18	2.58 fghijk	-0.108
MM-321 × MM-314	99.50 bcd	4.758*	0.25	24.65 r	3.090	4.77	2.45 ghijkl	-0.050
MM-321 × IC-267375	91.50 klmn	-1.722	-2.14	22.51 s	-3.119	-22.01	2.28 ijkl	-0.386
MM-321 × KP$_4$HM-15	88.50 o	-2.117	-4.34	39.26 jk	7.518*	-9.04	3.03 bcde	0.419
MM-321 × Kajri Sel. 1	93.50 hijk	-0.680	-1.84	15.36 v	-10.110**	-21.67	2.53 fghijk	-0.081
MM-321 × MM-202	96.00 fgh	1.445	-3.29	34.62 i	7.036	76.55*	2.63 efghijk	0.102
MM-321 × SM-2012-12	91.00 klmno	0.153	-1.63	40.92 hi	-14.011**	-59.56**	2.85 cdefg	0.452
NDM-21 × PS	91.00 klmno	-3.492	-2.93	34.38 i	4.843	-28.68	3.07 bc	0.290
NDM-21 × MM-314	92.00 jklmnn	-2.826	-7.09*	31.60 n	0.688	-34.45*	2.52 fghijk	-0.067
NDM-21 × IC-267375	92.00 jklmnn	-1.555	-1.87	39.01 jk	4.021	-19.07	2.59 fghijk	-0.160
NDM-21 × KP$_4$HM-15	91.00 klmno	0.049	-3.20	35.06 i	-6.032	-27.25	2.81 cdefgh	0.102
NDM-21 × Kajri Sel. 1	96.00 fgh	1.487	0.79	37.89 k	3.065	-21.40	2.82 cdefg	0.129
NDM-21 × MM-202	95.50 fghi	1.112	-3.29	47.73 f	10.797**	-0.98	2.70 cdefghi	0.085
NDM-21 × SM-2012-12	92.50 jklm	1.320	-1.60	59.46 c	-4.814	-41.22**	2.26 jkl	-0.228
PS × MM-314	97.50 def	0.841	-1.52	16.42 uv	0.130	-30.23	2.79 cdefgh	0.068
PS × IC-267375	109.00 a	13.112**	16.04**	29.44 no	9.078*	1.97	4.08 a	1.185**
PS × KP$_4$HM-15	93.00 ijkl	0.216	0.54	26.94 q	0.473	-37.58*	2.66 cdefghijk	-0.183
PS× Kajri Sel. 1	91.00 klmno	-5.347*	-4.47	31.91 n	11.711**	108.19*	2.09 l	-0.746**
PS × MM-202	96.00 fgh	-0.472	-3.04	17.50 u	-4.808	-0.60	2.54 fghijk	-0.213
PS × SM-2012-12	101.00 b	8.237**	9.78**	30.73 mn	-18.920**	-69.63**	2.80 cdefgh	0.177
MM-314 × IC-267375	93.00 ijkl	-2.722	-6.08	27.75 pq	6.010	-3.87	2.60 fghijk	-0.097
MM-314 × KP$_4$HM-15	89.50 no	-3.367	-9.62**	31.56 n	3.713	-26.88	2.74 cdefgh	0.090
MM-314 × Kajri Sel. 1	100.50 bc	4.070	1.52	22.66 s	1.083	-3.69	3.29 b	0.652**
MM-314 × MM-202	94.50 ghij	-2.055	-4.56	16.52 uv	-7.171	-29.81	2.50 fghijk	-0.057
MM-314 × SM-2012-12	91.50 klmn	-1.847	-7.85*	34.31 i	-16.721**	-66.09**	2.53 fghijk	0.102
IC-267375 × KP$_4$HM-15	91.50 klmn	-0.347	-2.41	21.99 s	-9.938**	-49.06**	2.57 fghijk	-0.251
IC-267375 × Kajri Sel. 1	93.50 hijk	-1.909	-1.84	42.19 h	16.538**	46.15	2.68 cdefghij	-0.129
IC-267375 × MM-202	96.00 fgh	0.216	-3.29	16.68 uv	-11.081**	-42.22	2.64 defghijk	-0.093
IC-267375× SM-2012-12	90.50 lmno	-1.826	-3.74	40.06 ij	-15.045**	-60.40**	2.24 kl	-0.358*
KP$_4$HM-15 × Kajri Sel. 1	92.50 jklm	0.195	-2.63	22.15 s	-9.619*	-48.71**	2.76 cdefgh	0.004
KP$_4$HM-15 × MM-202	90.50 lmno	-2.180	-8.61*	39.93 ij	6.053	-7.51	2.66 cdefghijk	-0.023
KP$_4$HM-15× SM-2012-12	90.00 mno	0.778	-2.71	51.72 e	-9.499*	-48.88**	2.58 fghijk	0.029
KajriSel 1 × MM-202	98.50 cde	2.258	-0.51	22.36 s	-5.236	27.05	3.06 bcd	0.384*
KajriSel 1 × SM-2012-12	91.50 klmn	-1.284	-3.95	73.61 b	18.659**	-27.25**	2.25 jkl	-0.284
MM-202 × SM-2012-12	90.00 mno	-3.159	-9.37**	79.00 a	21.949**	-21.91**	2.39 hijkl	-0.073
CD (S_{ij}) (p= 0.05)	-	**4.401**	**6.501**	-	**9.721**	**14.358**	-	**0.299**
CD (S_{ij}) (p= 0.01)	-	**5.822**	**8.600**	-	**12.859**	**18.994**	-	**0.396**

F_1 hybrid	Rind Thickness (mm)			TSS (°Brix)			Firmness (Ib/inch^2)		
	Mean[a]	S_{ij}	H_{BP}	Mean[a]	S_{ij}	H_{BP}	Mean[a]	S_{ij}	H_{BP}
MS-1 × MM-321	2.72 hijkl	-0.498**	-26.34**	7.71 qr	-0.893*	-21.97**	2.80 ij	0.245**	-15.79**
MS-1 × NDM-21	3.36 cde	0.309	-8.83	11.14 defg	1.156**	12.73	2.78 ij	-0.162*	-40.32**
MS-1 × PS	3.15 efg	-0.549**	-14.46	9.49 klmno	-0.821*	-18.46**	2.82 ij	-0.555**	-36.62**
MS-1 × MM-314	3.04 efgh	0.003	-17.52*	6.10 tu	-2.764**	-38.23**	2.32 mn	-0.513**	-30.45**
MS-1 × IC-267375	4.14 a	0.746**	12.42	11.08 defg	2.046**	12.15	2.29 n	-1.034**	-57.83**
MS-1 × KP$_4$HM-15	3.77 b	0.473*	2.17	11.85 bcd	1.338**	19.92**	2.48 kl	-0.255**	-29.29**
MS-1 × Kajri Sel. 1	2.74 hijk	-0.426*	-29.49**	10.38 ghijkl	0.752	5.06	3.12 h	0.456**	4.62
MS-1 × MM-202	3.74 bcd	0.213	1.49	9.09 mno	-1.097**	-15.76**	4.23 cd	1.176**	-0.88
MS-1 × SM-2012-12	2.55 ijkl	-0.079	-30.75**	5.78 u	-0.730	-41.52**	2.30 mn	0.666**	-5.64
MM-321 × NDM-21	2.52 jklm	0.032	-2.52	10.63 efghij	1.419**	13.18	2.93 i	-0.117	-37.10**
MM-321 × PS	3.15 efg	0.020	-10.64	10.75 defghi	1.214**	-7.59	2.39 lmn	-1.085**	-46.20**
MM-321 × MM-314	2.30 lmn	-0.171	-10.96	8.45 opq	0.356	10.71	3.52 fg	0.582**	5.64
MM-321 × IC-267375	3.29 def	0.462*	2.73	7.95 pqr	-0.309	-9.22	2.48 kl	-0.952**	-54.38**
MM-321 × KP$_4$HM-15	3.15 efg	0.429*	20.23	9.44 lmno	-0.294	-3.18	2.53 kl	-0.310**	-27.86**
MM-321 × Kajri Sel. 1	2.54 ijklm	-0.062	-34.77**	8.82 nop	-0.040	-7.55	2.57 k	-0.199*	-22.93**
MM-321 × MM-202	3.22 efg	0.257	-1.53	9.68 ijklmn	0.261	-10.31	3.84 e	0.684**	-9.97**
MM-321 × SM-2012-12	1.72 pq	-0.343	-33.37**	6.88 rst	1.140**	7.42	1.57 s	-0.177*	-53.01**
NDM-21 × PS	3.67 bcd	0.699**	4.04	10.46 ghijkl	-0.461	-10.14	3.56 fg	-0.305**	-23.66**
NDM-21 × MM-314	2.58 ijkl	0.270	13.19	9.90 hijklmn	0.423	5.41	3.62 f	0.299**	-22.31**
NDM-21 × IC-267375	2.34 klmn	-0.332	-27.11**	9.57 jklmno	-0.075	1.86	3.48 fg	-0.334**	-35.94**
NDM-21 × KP$_4$HM-15	2.46 jklm	-0.102	-6.20	10.60 fghijk	-0.513	8.72	2.75 j	-0.467**	-40.86**
NDM-21 × Kajri Sel. 1	2.39 klmn	-0.046	-38.51**	12.73 ab	2.494**	33.49**	2.57 k	-0.582**	-44.89**
NDM-21 × MM-202	2.66 hijkl	-0.137	-18.54*	9.35 lmno	-1.450**	-13.40*	2.43 klmn	-1.111**	-47.85**
NDM-21 × SM-2012-12	1.35 qr	-0.556**	-42.87**	6.52 stu	-0.600	-30.63**	2.45 klm	0.328**	-47.31**
PS × MM-314	3.02 efgh	0.058	-14.54	8.83 nop	-0.977*	-24.13**	5.67 a	1.919**	27.61**
PS × IC-267375	3.38 cde	0.061	-4.26	10.43 ghijkl	0.458	-10.38	5.09 b	0.848**	-6.22**
PS × KP$_4$HM-15	3.36 cde	0.151	-4.68	11.71 bcde	0.265	0.64	3.19 h	-0.460**	-28.17**
PS× Kajri Sel. 1	1.84 op	-1.250**	-52.80**	7.19 rs	-3.371**	-38.19**	3.45 g	-0.124	-22.25**
PS × MM-202	3.29 def	-0.157	-6.74	12.33 bc	1.202**	5.95	4.34 c	0.371**	-2.25
PS × SM-2012-12	3.70 bcd	1.152**	4.96	9.16 mno	1.714**	-21.28**	1.64 s	-0.914**	-63.10**
MM-314 × IC-267375	2.60 ijkl	-0.055	-18.91*	9.19 mno	0.658	4.85	3.40 g	-0.298**	-37.33**
MM-314 × KP$_4$HM-15	2.53 jklm	-0.020	-3.63	10.84 defgh	0.837*	11.15	2.52 kl	-0.593**	-28.21**
MM-314 × Kajri Sel. 1	2.30 lmn	-0.119	-40.76**	10.20 ghijklm	1.081**	7.00	2.11 o	-0.933**	-36.84**
MM-314 × MM-202	3.01 efgh	0.228	-7.82	9.70 ijklmn	0.019	-10.08	2.92 i	-0.512**	-31.67**
MM-314 × SM-2012-12	1.72 pq	-0.164	-26.81*	7.83 pqr	1.824**	2.52	1.82 qr	-0.198*	-45.49**
IC-267375 × KP$_4$HM-15	2.38 klmn	-0.529**	-25.78**	8.52 opq	-1.648**	-12.64	4.15 d	0.549**	-23.50**

IC-267375 × Kajri Sel. 1	2.94 fghi	0.159	-24.34**	7.83 pqr	-1.459**	-17.91**	3.53 fg	-0.003	-35.02**
IC-267375 × MM-202	2.84 ghij	-0.302	-13.03	11.64 cdef	1.787**	7.83	3.19 h	-0.733**	-41.24**
IC-267375× SM-2012-12	1.66 pq	-0.594**	-48.44**	4.58 v	-1.591**	-47.76**	2.01 op	-0.506**	-63.13**
KP_4HM-15 × Kajri Sel. 1	2.58 ijkl	-0.099	-33.68**	13.57 a	2.801**	39.08**	3.95 e	1.009**	12.71**
KP_4HM-15 × MM-202	3.23 efg	0.190	-1.15	12.29 bc	0.961*	13.86*	2.87 ij	-0.466**	-32.79**
KP_4HM-15× SM-2012-12	2.01 nop	-0.134	-23.47*	7.68 qr	0.034	-21.28**	1.93 pq	0.011	-45.00**
KajriSel 1 × MM-202	2.87 ghij	-0.041	-26.14**	11.01 defgh	0.568	2.04	3.15 h	-0.106	-26.10**
KajriSel 1 × SM-2012-12	1.23 r	-0.788**	-68.45**	4.63 v	-2.135**	-51.48**	2.11 o	0.259**	-29.41**
MM-202 × SM-2012-12	2.14 mno	-0.237	-34.48**	5.50 uv	-1.822**	-49.02**	1.71 rs	-0.533**	-60.12**
CD (S_{ij}) (p= 0.05)	-	**0.389**	**0.575**	-	**0.852**	**1.259**	-	**0.156**	**0.230**
CD (S_{ij}) (p= 0.01)	-	**0.515**	**0.761**	-	**1.127**	**1.665**	-	**0.206**	**0.304**

F_1 hybrid	pH			Titrable acidity (mg 100^{-1} ml)			Ascorbic acid content (mg 100^{-1} ml)		
	Mean[a]	S_{ij}	H_{BP}	Mean[a]	S_{ij}	H_{BP}	Mean[a]	S_{ij}	H_{BP}
MS-1 × MM-321	6.03 op	-0.049	-0.41	24.59 ef	4.494**	82.81**	29.94 bc	10.992**	4.03
MS-1 × NDM-21	6.10 lmnop	-0.032	2.09	17.99 kl	-1.343	-43.39**	14.73 op	-0.322	-1.17
MS-1 × PS	6.41 cdef	0.337**	7.56**	18.83 jk	-1.843	-34.78**	16.18 no	-0.219	-4.46
MS-1 × MM-314	6.18 ijklm	-0.078	0.00	9.25 s	-6.849**	-24.25	10.44 rs	-4.511**	-29.98**
MS-1 × IC-267375	5.98 p	-0.195*	-1.65	17.22 klm	-3.934**	-19.10*	2.90 w	-10.348**	-80.54**
MS-1 × KP_4HM-15	6.29 efghij	0.145	5.67*	20.35 ij	4.122**	52.15**	14.39 op	-7.398**	-55.81**
MS-1 × Kajri Sel. 1	6.28 fghijk	0.073	1.37	21.40 hi	3.791**	60.00**	11.43 rs	-1.231	-26.41**
MS-1 × MM-202	6.18 ijklm	0.114	-3.40	17.18 klm	2.576*	34.57*	22.16 hij	7.670**	48.72**
MS-1 × SM-2012-12	4.85 tuv	-0.076	-18.49**	40.50 a	11.101**	31.71**	20.80 jk	3.068**	-44.05**
MM-321 × NDM-21	6.73 a	0.590**	11.20**	29.13 d	8.134**	-8.34	9.94 s	-10.304**	-65.47**
MM-321 × PS	6.39 def	0.320**	5.58*	22.08 ghi	-0.254	-23.52**	23.18 ghi	1.587	-19.47**
MM-321 × MM-314	6.37 defg	0.104	3.04	21.73 hi	3.966**	61.52**	14.33 op	-5.813**	-50.22**
MM-321 × IC-267375	6.04 nop	-0.137	-0.62	24.33 efg	1.518	14.34	20.95 j	2.507**	-27.20**
MM-321 × KP_4HM-15	5.85 q	-0.304**	-3.43	15.73 lmn	-2.163	16.91	33.54 a	6.557**	3.03
MM-321 × Kajri Sel. 1	6.22 hijkl	0.011	0.44	14.85 mnop	-4.419**	10.41	5.81 uv	-12.040**	-79.81**
MM-321 × MM-202	5.62 r	-0.457**	-12.27**	15.58 lmno	-0.684	15.80	15.17 nop	-4.514**	-47.29**
MM-321 × SM-2012-12	4.92 stu	-0.017	-18.76**	37.08 b	6.016**	20.57**	24.68 fg	1.753	-33.61**
NDM-21 × PS	6.17 jklmn	0.037	3.14	21.40 hi	-0.166	-32.65**	16.05 no	-1.647	-5.24
NDM-21 × MM-314	6.42 cde	0.097	3.85	14.83 mnop	-2.172	-53.34**	14.56 op	-1.679	76.48**
NDM-21 × IC-267375	6.64 ab	0.400**	9.18**	16.95 klm	-5.094	-46.66**	31.43 b	16.881**	168.30**
NDM-21 × KP_4HM-15	6.15 klmno	-0.060	2.85	16.83 klm	-0.301	-47.05**	27.75 de	4.661**	-14.77**
NDM-21 × Kajri Sel. 1	6.31 efghi	0.038	1.82	5.25 t	-13.257**	-83.48**	21.41 ij	7.459**	37.91**
NDM-21 × MM-202	5.63 r	-0.505**	-12.11**	12.23 qr	-3.272**	-61.53**	30.54 bc	14.747**	321.14**
NDM-21 × SM-2012-12	4.87 tuv	-0.123	-18.54**	24.68 ef	-5.622**	-22.34**	11.15 rs	-7.883**	-70.02**
PS × MM-314	6.41 cdef	0.154	3.64	23.08 fgh	4.741**	-20.05**	18.54 lm	0.952	9.49
PS × IC-267375	6.66 ab	0.494**	9.59**	24.82 ef	1.431	-14.03*	16.95 mn	1.052	0.07
PS × KP_4HM-15	6.08 mnop	-0.066	3.54	11.18 rs	-7.288**	-61.28**	16.88 mn	-7.551**	-48.15**
PS× Kajri Sel. 1	6.29 efghij	0.095	1.62	32.53 c	12.681**	12.69*	34.17 a	18.872**	101.83**
PS × MM-202	5.74 qr	-0.330**	-10.47**	13.08 opqr	-3.759**	-54.70**	23.90 gh	6.768**	41.17**
PS × SM-2012-12	4.97 st	0.048	-9.89**	14.18 nopq	-17.459**	-53.90**	4.78 v	-15.600**	-87.16**
MM-314 × IC-267375	6.65 ab	0.289**	7.57**	13.28 nopqr	-5.537**	-37.60**	6.38 tuv	-8.065**	-45.57**
MM-314 × KP_4HM-15	6.35 defgh	0.022	2.79	23.38 efgh	9.482**	74.77**	26.51 e	3.528**	-18.57**
MM-314 × Kajri Sel. 1	6.47 cd	0.085	4.53*	13.38 nopqr	-1.900	0.00	19.13 kl	5.278**	23.19**
MM-314 × MM-202	6.43 cde	0.172	0.35	13.33 nopqr	1.061	4.41	26.20 ef	10.511**	217.48**
MM-314 × SM-2012-12	4.79 uv	-0.322**	-22.47**	37.28 b	10.211**	21.22**	34.50 a	15.569**	-7.22
IC-267375 × KP_4HM-15	6.54 bc	0.290**	7.53**	23.50 efgh	4.559**	10.46	31.48 b	10.190**	-3.31
IC-267375 × Kajri Sel. 1	6.03 op	-0.275**	-2.63	32.63 c	12.303**	53.35**	13.30 pq	1.145	-14.35
IC-267375 × MM-202	5.97 p	-0.207*	-6.88**	11.98 qr	-5.337**	-43.71**	11.94 qr	-2.049*	1.92
IC-267375× SM-2012-12	4.76 v	-0.269**	-21.69**	37.38 b	5.263**	21.54**	7.99 t	-9.247**	-78.53**
KP_4HM-15 × Kajri Sel. 1	6.54 bc	0.258**	5.54*	11.03 rs	-4.379**	-17.57	5.65 uv	-15.045**	-82.66**
KP_4HM-15 × MM-202	6.67 a	0.532**	4.26*	11.18 rs	-1.218	-16.45	18.98 l	-3.549**	-41.71**
KP_4HM-15× SM-2012-12	4.89 stuv	-0.113	-16.64**	25.68 e	-1.518	-16.50**	28.92 cd	3.146**	-22.23**
KajriSel 1 × MM-202	6.25 ghijk	0.048	-2.38	12.48 pqr	-1.300	-6.73	11.27 rs	-2.132*	-27.46**
KajriSel 1 × SM-2012-12	5.02 s	-0.046	-19.03**	31.88 c	3.300**	3.66	6.40 tuv	-10.236**	-82.78**
MM-202 × SM-2012-12	4.89 stuv	-0.038	-23.63**	33.50 c	7.936**	8.94	6.98 tu	-11.496**	-81.24**
CD (S_{ij}) (p= 0.05)	-	**0.183**	**0.270**	-	**2.358**	**3.483**	-	**1.903**	**2.811**
CD (S_{ij}) (p= 0.01)	-	**0.242**	**0.357**	-	**3.120**	**4.608**	-	**2.517**	**3.719**

F_1 hybrid	Dry matter (%)			β carotene content (mg 100^{-1} g)			Fusarium wilt incidence		
	Mean[a]	S_{ij}	H_{BP}	Mean[a]	S_{ij}	H_{BP}	Mean[a]	S_{ij}	H_{BP}
MS-1 × MM-321	10.38 ef	1.141*	6.65	0.800 n	-0.140**	-29.98**	4.63 a	1.817**	-5.13
MS-1 × NDM-21	10.32 efg	1.039*	6.01	0.555 pq	-0.364**	-51.42**	3.00 de	-0.849**	-38.46**
MS-1 × PS	10.58 def	-0.059	-11.91	1.460 i	-0.573**	-46.48**	3.63 c	0.567	0.00
MS-1 × MM-314	5.14 u	-4.215**	-48.07**	1.145 k	0.122**	0.14	4.13 b	-0.021	-25.64**
MS-1 × IC-267375	10.39 ef	0.895	6.73	1.240 j	0.317**	8.32*	3.63 c	0.494	-15.38
MS-1 × KP_4HM-15	10.42 ef	0.921	7.04	2.035 d	0.740**	77.90**	3.13 d	0.463	-25.64**
MS-1 × Kajri Sel. 1	11.76 b	2.341**	20.81*	2.015 d	1.210**	76.15**	3.00 de	0.041	-35.90**
MS-1 × MM-202	10.67 de	0.177	-3.37	1.730 fg	-0.445**	-21.45**	0.50 opq	0.099	-38.46**
MS-1 × SM-2012-12	7.42 qr	-1.034*	-23.72**	0.605 p	-0.123**	-46.83**	1.50 ij	-1.974**	-89.74**
MM-321 × NDM-21	10.28 efg	2.098**	33.18**	0.190 stu	-0.153**	-21.05	0.88 lmn	0.036	-42.86*
MM-321 × PS	9.42 ij	-0.120	-21.57**	1.030 l	-0.427**	-62.31**	1.50 ij	-1.047**	-80.56**
MM-321 × MM-314	9.74 hi	1.483**	-1.54	0.250 s	-0.195**	4.21	1.38 jk	0.239	-42.86*

MM-321 × IC-267375	7.16 rs	-1.232*	-16.82	0.385 r	0.044	63.16**	1.00 lm	0.130	-15.38
MM-321 × KP$_4$HM-15	8.35 no	-0.045	1.98	1.770 f	1.055**	645.26**	0.00 r	0.224	-20.00
MM-321 × Kajri Sel. 1	4.52 v	-3.800**	-41.48**	0.100 v	-0.131**	-60.00**	0.75 mno	-0.698*	-100.00**
MM-321 × MM-202	11.28 c	1.895**	2.22	1.555 h	0.078**	-29.51**	0.00 r	0.234	-14.29
MM-321 × SM-2012-12	6.78 st	-0.578	-13.13	0.390 r	0.115**	65.21**	1.63 hij	-0.089	-100.00
NDM-21 × PS	8.18 no	-1.398**	-31.90**	1.925 e	0.484**	-29.64**	3.19 d	-1.339**	-63.89**
NDM-21 × MM-314	9.40 ij	1.105*	-4.98	0.205 st	-0.223**	68.75	0.75 mno	0.885**	21.43
NDM-21 × IC-267375	8.98 kl	0.554	4.36	0.100 v	-0.222**	-51.19*	3.75 c	-1.537**	-71.43**
NDM-21 × KP$_4$HM-15	7.30 r	-1.133*	-10.84	0.250 s	-0.448**	108.33**	3.07 de	1.932**	42.86*
NDM-21 × Kajri Sel. 1	10.45 ef	2.100**	40.96**	0.120 uv	-0.087**	1.25	1.50 ij	1.322**	16.67
NDM-21 × MM-202	7.76 pq	-1.672**	-29.74**	1.900 e	0.441**	-13.85**	0.50 opq	-0.058	-42.86*
NDM-21 × SM-2012-12	7.21 r	-0.192	-7.69	1.235 j	0.978**	927.08**	2.00 fg	-0.631*	-80.95**
PS × MM-314	9.56 hij	-0.093	-20.41*	1.690 g	0.149**	-38.24**	1.75 ghi	-0.761*	-55.56**
PS × IC-267375	10.95 cd	1.162*	-8.75	2.245 c	0.806**	-17.93**	2.00 fg	-0.995**	-61.11**
PS × KP$_4$HM-15	9.94 gh	0.144	-17.24*	2.200 c	0.388**	-19.49**	1.75 ghi	-0.277	-55.56**
PS× Kajri Sel. 1	8.46 n	-1.257*	-29.57**	0.505 q	-0.819**	-81.61**	2.13 f	-0.448	-61.11**
PS × MM-202	10.16 fg	-0.631	-15.41*	2.710 b	0.138**	-0.91	3.63 c	0.109	-52.78**
PS × SM-2012-12	8.86 lm	0.100	-26.24**	0.860 mn	-0.512**	-68.62**	3.50 c	2.036**	-19.44
MM-314 × IC-267375	7.47 qr	-1.039*	-24.50**	0.135 tuv	-0.291**	-35.71	0.50 opq	1.416**	33.33
MM-314 × KP$_4$HM-15	8.48 mn	-0.024	-14.21	0.895 m	0.096**	645.83**	2.13 f	-1.115**	-80.95**
MM-314 × Kajri Sel. 1	6.69 t	-1.743**	-32.39**	0.205 st	-0.107**	76.09	0.00 r	0.588*	-19.05
MM-314 × MM-202	10.28 efg	0.773	-6.91	2.065 d	0.503**	-6.47**	0.00 r	-1.355**	-100.00**
MM-314 × SM-2012-12	8.17 no	0.702	-17.35*	1.130 k	0.770**	880.43**	1.88 fgh	-0.928**	-100.00**
IC-267375 × KP$_4$HM-15	9.27 jk	0.617	7.64	0.135 tuv	-0.564**	-35.71	1.13 kl	0.276	15.38
IC-267375 × Kajri Sel. 1	8.87 klm	0.302	3.05	0.680 o	0.470**	222.62**	2.75 e	-0.396	-30.77
IC-267375 × MM-202	7.74 pq	-1.902**	-29.88**	1.180 jk	-0.276**	-46.42**	1.00 lm	1.411**	69.23*
IC-267375× SM-2012-12	8.32 no	0.712	-3.31	0.200 st	-0.056	-4.76	0.25 qr	0.088	-38.46
KP$_4$HM-15 × Kajri Sel. 1	11.21 c	2.633**	36.85**	0.105 v	-0.481**	-16.67	0.00 r	-0.803**	-84.62**
KP$_4$HM-15 × MM-202	7.98 op	-1.665**	-27.70**	2.985 a	1.151**	35.41**	0.38 pq	-0.870**	-100.00**
KP$_4$HM-15× SM-2012-12	7.09 rs	-0.525	-13.40	0.590 p	-0.040	389.58**	0.25 qr	-0.068	-70.00
KajriSel 1 × MM-202	12.29 a	2.719**	11.30	1.235 j	-0.110**	-44.04**	0.00 r	-0.542	-84.62**
KajriSel 1 × SM-2012-12	6.39 t	-1.147*	-18.16	0.165 tuv	0.025	54.49	0.63 nop	-0.365	-100.00**
MM-202 × SM-2012-12	8.12 nop	-0.494	-26.48**	0.570 pq	-0.821**	-74.23**	4.63 a	0.442	-28.57
CD (S_{ij}) (p= 0.05)	-	**1.062**	**1.568**	-	**0.064**	**0.095**	-	**0.602**	**0.889**
CD (S_{ij}) (p= 0.01)	-	**1.404**	**2.074**	-	**0.085**	**0.125**	-	**0.796**	**1.176**

[a] Means in a column followed by the same letter are not statistically different at 5% level by Duncan test according to Duncan (1955)

*,** Denote significance at p= 0.05 and p=0.01 respectively

Average fruit weight (kg)

Being a most important trait which contributes to total yield, it plays a key role in acceptanceby the consumer. The mean of average fruit weight of parents (0.669 kg) was lower than hybrids (0.692 kg) (Table 2). The range of parents was 0.39 to 0.97 kg while 0.46 to 0.99 kg was observed in F$_1$ hybrids (Table 4 and 5). The maximum average fruit weight was observed in NDM-21 (0.97 kg) trailed by SM-2012-12 (0.84 kg) which was statistically *at par* with Kajri Sel. 1 (0.82 kg). Among parental lines, NDM-21 (0.11) was observed to have highest GCA effect. None of the parent has higher GCA variance then the respective SCA variance (Table 4). Fourteen crosses showed positive significant SCA effects for average fruit weight while 13 crosses have negative significant SCA effects. The cross MS-1 × SM-2012-12 (0.23) observed to be the best specific combiner for this trait. Out of 45 hybrids, only six hybrids were found to have significant positive heterosis over respective better parent. SINGH *et al.*(2013) reported positive significant heterosis for average fruit weight in cross P-5 × P-8 (60.67) followed by P-2 × P-8 (57.51) and P-5 × P-7 (55.65) over the better parent.Favorable heterosis over better parent was documented by CHAUDHARY *et al.* (2003), NERSON (2012), FEYZIAN *et al.* (2009) and MOHAMMADI *et al.*(2014) also.

Days to first fruit ripening

Among the parents, the minimum days required for first fruit ripening (88.5) were taken by SM-2012-12 while the maximum were observed in MM-314 (98.75) and MM-202 (98.75) (Table 4). The days to first fruit ripening for parents and F$_1$ hybrids varied from 88.50-98.75

days (Table 4) to 88.50-109.00 days (Table 5) with an average of 94.02 and 93.21 days (Table 2). The parentKP$_4$HM-15 was the best general combiner having GCA value of -2.31 followed by SM-201-12 (-2.08) whereas MM-314 (1.57) was poor general combiner (Table 4). The GCA variance was lower than SCA variance for this trait for all the parents. The cross combination PS ×KajriSel 1 (-5.35) was the only best specific combiner having significant negative effect while, three crosses were observed to have positive significant SCA effects. Among 45 F$_1$ hybrids, 6 and 2 hybrids exhibited significant negative and positive heterosis over respective better parent. The magnitude of heterosis over better parent ranged from -9.62 to 16.04 % (Table 5).Evidently, dominance and additive gene effects were more important and heterosis breeding will be of immense help in improving this trait. ARAVINDAKUMAR *et al.* (2005) and several other research workers have confirmed pronounced earliness and high productivity in muskmelon. Heterosis for days to first fruit ripening was reported by MOHAMMADHI *et al.* (2014) also.

Seed cavity area (cm^2)

The seed cavity area of hybrids varied from 15.26-79.00 cm^2 (mean 32.53) (Table 2 and 5) whereas that of parents from 13.00 to 101.16 cm^2 (mean 32.42) (Table 2 and 4). The minimum seed cavity area was shown by PS (13.00 cm^2) trailed by MS-1 (13.75 cm^2) and Kajri Sel. 1 (15.33 cm^2) while maximum was shown by SM-2012-12 (101.16 cm^2). The parent PS had best GCA effects (-8.80) and all the parents have higher SCA variance as compared to GCA variance (Table 4). Of 45 hybrids, 15 and 3 showed significant negative and positive heterosis over respective better parent, while 10 and 8 exhibited significant negative and positive SCA effects, respectively (Table 5). The magnitude of heterobeltosis varied from -69.63 to 127.93%. The best cross combinations were PS × SM-2012-12 (-69.63%), MM-314 × SM-2012-12 (-66.09%) and MS-1 × NDM-21 (-64.63%). NERSON (2012) found smaller seed cavity area as compared to their mid-parent values. Similar results were in harmony with the finding of GURAV *et al.* (2000) and LAL and KAUR (2002)**.** The dominance variance was less than additive variance (Table 4). This states that seed cavity area was more governed by additive gene action and can be improved by selection too. In melon, positive heterobeltosis were reported by SELIM (2019) and MOHAMMADHI *et al.* (2014).

Flesh thickness (cm)

The flesh thickness of parental lines varied from 2.11-2.78 cm (mean 2.55 cm) (Table 2 and 4) whereas that of hybrids from 2.09 to 4.08 cm (mean 2.69) (Table 2 and 5). Among parents, the maximum flesh thickness was observed in PS (2.78cm) while lowest was in MM-314 (2.11cm) (Table 4). A positive significant GCA effects was observed for PS (0.12), IC-2672375 (0.10) and MS-1 (0.09). These parents were shown to have positive GCA and SCA variance. Among hybrids, PS × IC-267375 (4.08cm) exhibited maximum flesh thickness followed by MS-1 × IC-267375 (3.37cm) which was *at par* with MM-314 × Kajri Sel. 1 (3.29 cm) (Table 5). Only three hybrid combinations were found to have significant positive SCA value while four were observed to have heterosis over better parent, respectively. The magnitude of heterobeltosis ranged from -24.95 to 46.76%.

Rind thickness (mm)

Among the parental genotypes, the maximum rind thickness was recorded by Kajri Sel. 1 (3.88 mm) which was *at par* with MS-1 (3.68 mm) while the minimum was observed in NDM-21 (2.25 mm) (Table 4). The rind thickness of parental genotypes and hybrids varied from 2.25-3.88 to 1.23-4.14 mm, with an average of 2.96 and 2.73 mm, respectively (Table 2, 4 and 5). MS-1 was found to have highest GCA effect (0.50) followed by PS (0.42) and these parents have higher SCA variance than respective GCA variance (Table 4).Out of 45 hybrids, none of the hybrid has significant heterotic effect over better parent while six and eight hybrid combinations were found to have significant positive and negative SCA value. The range of heterosis was -68.45 to 20.23%. The best crosses were MS-1 × IC-267375 (4.14 mm), MS-1 × KP_4HM-15 (3.77 mm) and MS-1 × MM-202 (3.74 mm) (Table 5). A similar trend of results was reported by VASHISHT *et al.* (2010). SARI *et al.*(2012) reported heterosis over mid parent for this trait in hybrids and backcross generation.

TSS (%)

An average TSS of parental lines and hybrids was 8.85 and 9.31% (Table 2). The range for parental genotype was 4.73 to 11.63 (Table 4) while hybrid was 4.58 to 13.57 (Table 5). PS was found to have highest TSS content (11.63). On the other hand, KP_4HM-15 have highest GCA value (1.21) trailed by PS (1.01) and MM-202 (0.89). All the parental genotypes have higher SCA variance as compared to respective GCA variance (Table 4). Among F_1 hybrids, KP_4HM-15 × Kajri Sel. 1 (13.57%) was observed to have highest TSS content which was *at par* with NDM-21 × Kajri Sel. 1 (12.73%). Out of 45 hybrids, 15 and 12 have significant positive and negative SCA value whereas, only three i.e. KP_4HM-15 × Kajri Sel. 1 (39.08%), NDM-21 × Kajri Sel. 1 (33.49%) and KP_4HM-15 × MM-202 (13.86%) have significant positive heterosis over better parent and 15 cross combinations were observed to have negative heterosis over respective better parent (Table 5). MONFORTE *et al.* (2005) found no heterosis for trait soluble solid concentration among the hybrids developed from 12 exotic accessions and Piel de Sapo. Here, only four hybrids were found to have desirable heterosis over respective better parent ranging from 39.08 to 13.86 %. Similarly, positive significant results were in agreement with the findings of MOON *et al.* (2006), TOMAR and BHALALA (2006b) and MOHAMMADI *et al.* (2014) reported heterosis for this trait.

Firmness (Ib/inch^2)

The fruit firmness of hybrids was in between 1.57-5.67Ib/inch^2 (mean 2.94) while parents was1.35-5.43 Ib/inch^2 (mean 3.57) (Table 2, 4 and 5). The parental line IC-267375 was observed to have maximum firmness (5.43). Contrarily, the GCA value was higher for PS (0.61) tracked by IC-267375 (0.57). Except SM-2012-12, the GCA variance of all parents was lower than SCA variance (Table 4). Cross combination PS × MM-314 was found to have maximum firmness i.e 5.67 Ib/inch^2 with 27.61% heterosis over better parent while the lowest heterobeltosis was observed in cross IC-267375 × SM-2012-12 (-63.13%). Significant positive heterosis was also observed in KP_4HM-15 × Kajri Sel.1 (12.71%) (Table 5).The selection for the desired texture and transportability coupled with flesh thickness can be achieved from the above cross combination (KAUR *et al.* 2022).

pH

In present study, a general range of pH was 4.26-6.73. The parental lines varied from 4.26 to 6.40 (mean 5.85) while hybrids were 4.76 to 6.73 (mean 5.97) (Table 2, 4 and 5). As mentioned in Table 4, the maximum pH was spotted in parental line MM-202 (6.40) while lowest was observed in SM-2012-12 (4.26). The GCA value was highest in MM-314 (0.24) followed by Kajri Sel. 1 (0.19). All parents were found to have lower GCA variance as compared to respective SCA variance except SM-2012-12 (Table 4). Among 45 hybrids, MM-321× NDM-21 (6.73) was scored at apex which was *at par* with KP_4HM-15 × MM-202 (6.67), PS × IC-267375 (6.66) and NDM-21 × IC-267375 (6.64). The SCA effects was significantly positive and negative in 9 hybrids each while 11 hybrids were found significantly positive and 13 significantly negative for heterosis over respective better parent with a range of heterobeltosis -23.63 to 11.20% (Table 5).

Titrable acidity (mg 100^{-1} ml)

The titrable acidity of parental genotypes were scattered in between 7.26- 31.78 mg 100^{-1}ml. The minimum acidity was observed for parent MM-314 (7.26). The GCA value depicts that MM-202 (-4.76) was the best general combiner among all parents. The SCA variance of parents was higher than their respective GCA variance (Table 4). Among hybrids, the range varied from 5.25-40.50 mg 100^{-1} ml. Out of 45 hybrids, 12 and 17 showed significant negative and positive SCA effects while 19 and 12 showed significant negative and positive heterosis over better parent, respectively (Table 5). The range of heterosis over better parent varied from -83.48 to 82.81% among which NDM-21 × Kajri Sel. 1 (-83.48%) and NDM-21 × MM-202 (-61.53%) were the best heterotic hybrids. Similar results were reported by GURAV *et al.* (2000).

Ascorbic acid content (mg 100^{-1} ml)

Among the parental genotypes (mean 17.85), the highest ascorbic acid content was recorded in SM-2012-12 (37.18 mg 100^{-1} ml). In case of hybrids, it ranged from 2.90-34.50 (mean 18.09) (Table 2, 4 and 5).Among parents, KP_4HM-15 (5.89), MM-321 (3.05) and SM-2012-12 (1.83) were good general combiner (Table 4). Of 45 hybrids, MM-314 × SM-2012-12 (34.50) was *at par* with PS × Kajri Sel. 1 (34.17) and MM-321 × KP_4HM-15 (33.54). All these three hybrids were good specific combiner since at least one of the parent have good GCA value except in cross PS × Kajri Sel. 1. The best heterotic hybrid over better parent was NDM-21 × MM-202 (321.14%) and lowest in cross PS × SM-2012-12 (-87.16%) (Table 5). MOON *et al.* (2002, 2006) documented heterotic hybrids over better parent. SINGH *et al.* (2013) reported significant positive heterosis for ascorbic acid content in cross P-2 × P-8 (318.23) followed by P-2 × P-7 (223.51) and P-3 × P-8 (219.15) over the better parent.

Dry matter content (%)

The general range of experimental material for dry matter was 4.51-12.46 with general mean of 8.96%. The parental mean was 8.94 while hybrid mean was 8.89 (Table 2). The parental genotypes ranged between 6.96-12.01. The maximum dry matter content was observed in PS (12.01%) trailed by MM-202 (11.04%). Both these parents have high GCA value. The SCA variance was higher than respective GCA variance (Table 4). The dry matter of hybrid ranged from 4.52-12.29%. Among 45 hybrids, Kajri Sel. 1 × MM-202 (12.29) followed by MS-1 × Kajri Sel. 1 (11.76) and MM-321 × MM-202 (11.28) were the top three hybrids. Among them, Kajri Sel. 1 × MM-202 have highest significantly positive SCA value 2.72. Eleven cross combinations were found to have significant positive SCA effects. For heterosis over better parent, 4 crosses were observed to have significant positive effect and among them NDM-21 × Kajri Sel. 1 (40.96%) showed highest heterobeltosis whereas, MS-1 × MM-314 (-48.07) showed lowest heterobeltosis (Table 5).Contrarily, MONFORTE *et al.*(2005) observed no significant heterosis over mid or better parent in a desirable direction.

β carotene content (mg 100^{-1} g)

The β carotene content of hybrids varied from 0.100-2.985 mg 100^{-1} g (mean 1.009) (Table 2 and 5) while that of parental genotypes from 0.080-2.730 mg 100^{-1} g (mean 0.706) (Table 2 and 4). Among parental lines, the maximum β carotene content was shown by PS (2.730 mg 100^{-1} g) while minimum was shown by SM-2012-12 (0.08 mg 100^{-1} g). The best GCA combiner was MM-202 (0.82) followed by PS (0.80). Only these two parents were observed to have higher GCA variance than respective SCA variance (Table 4). Among hybrids, KP_4HM-15 × MM-202 (2.985 mg 100^{-1} g) was the best hybrid on per se basis. Of 45 hybrids, 19 and 13 cross combinations were observed to have significant positive SCA and heterobeltosis, respectively (Table 5). The highest heterosis over better parent was found in NDM-21 × SM-2012-12 (927.08%; 1.235 mg 100^{-1} g) followed by MM-314 × SM-2012-12 (880.43%; 1.130 mg 100^{-1} g). PITRAT (2008) reported that in melon between two different parental lines, heterosis can be clearly observed in hybrids

Fusarium wilt incidence

The mean performance of parent and hybrids for fusarium wilt incidence was 2.05 and 1.77 with general range of studied material i.e. 0.00 to 4.87 (Table 2). The maximum mean performance and GCA value was observed for MS-1 i.e. 4.88 and 1.69 and the GCA variance was also higher than SCA variance. MS-1 was *at par* with PS (4.50) with GCA value of 0.80. Among parents, the minimum disease incidence was observed in MM-321 followed by SM-2012-12 and MM-202. The GCA of these three parents was lowest among all (Table 4). Out of 45 hybrids, six hybrids were observed to have no disease incidence (0.00) throughout the seasons while two hybrids have minimum plant stand with maximum disease incidence (4.63). Fourteen and twenty-six cross combination were found to have significant negative SCA and heterosis over better parent in desirable direction, respectively (Table 5).

ZALAPA *et al.* (2006) reported the maximum SCA value of the cross having good × good GCA combination suggesting additive effects for number of fruit vine^{-1}. For the trait average fruit weight, SINGH *et al.* (2013) reported that cross P1× P2 followed by P5 × P8 have highest SCA effects. The results for flesh thickness and rind thickness were in accordance with the finding of PARIS *et al.* (2008) and VASHISHT *et al.* (2010) respectively. Some controversies were documented for the trait TSS against its genetic control. Some researchers (PAL *et al*. 2020) found a predominance of additive and non-additive effects, while ZALAPA *et al.* (2006) and PARIS *et al.*(2008) found no significant SCA effects. MONFORTE *et al.* (2004) studied these contradictory results in melon for this trait with Pele de Sapo melon and found non-additive gene effects and suggested that inheritance was specific for specific cross. SHASHIKUMAR *et al.* (2011) found ten hybrids which showed significant negative SCA effect for fusarium wilt incidence. A dominance or epistatic gene action was predominant since these hybrids have at least one parent with good combining ability. Whereas, additive gene effect with duplicate gene action was observed due to positive SCA effects in four hybrid combinations which were involved parents with negatively significant GCA value.

In the present investigation, some of the crosses that showed significant SCA effects involve either good or poor general combiners. The crosses which show significant SCA effects may involve good × good, good × poor or even poor × poor general combiners (GLALA *et al.*, 2011). Such crosses were likely to produce best segregants only when allelic systems were present in favorable combination and epistatic effects in crosses perform in a parallel direction which maximizes desirable traits (EL-ZAHAB *et al.*, 2008). Thus, suggesting additive and non-additive gene actions in the expression of particular traits. These results were also reported by GURAV *et al.* (2000). The crosses which involve both the parents with high GCA effects could be used as a source population for developing inbred lines (NAPOLITANO *et al.* 2020).

The present study has a good correlation between GCA and per se performance of parents depicting per se performance that may indicate the GCA of the parents. Similarly, DOSHI and SHUKLA (2000) and SINGH and HUNDAL (2001) documented positive correlation between per se and GCA. FEYZIAN *et al.* (2009) revealed that to predict yield potential of a cross, the parents with good GCA and high mean value could be effective. Hence selection should be based on their GCA and mean performance. Nevertheless, GRIFFING (1956) mentioned that combining ability and per se performance did not always come up with similar outcome. Thus, parental selection should be upon its combining ability effects along with some emphasis on mean performance for development of superior hybrids.

CONCLUSION

Generally, the hybrids were preferred due to its higher early yield, quality traits and resistant to various biotic and abiotic stresses. The ratio of variance due to GCA and SCA (σ^2_g /σ^2_s) was less than unity; it predicts that there was greater role of non-additive gene effects in the inheritance for most of the studied traits, which is considered important for heterosis breeding. The parental line MS-1, KP_4HM-15, PS and MM-202 were good combiners for 8 traits followed by Kajri Sel-1 and IC-267375 for 7 and SM-2012-12 for 6 traits. Hence for economic hybrid seed production, male sterility can be transferred into these good combiners. SM-2012-12 (*C. melo*var.*momordica*) line was found to be highly resistant to fusarium wilt which can be transferred into these good combiner along with male sterility. The desirable heterobeltosis in direction was observed maximum forβ carotene content (927.08%) followed by ascorbic acid content (321.14%), titrable acidity (-83.43%), fruit yield (80.42%) and seed cavity area (-69.63%). Among 45 hybrids, maximum significant desirable heterobeltosis was recorded for fusarium wilt incidence (26) followed by titrable acidity (19), seed cavity area (15), number of fruit vine^{-1} (14) and fruit yield and β carotene content (13). Among the tested hybrids, KP_4HM-15 × Kajri Sel. 1, Kajri Sel. 1× MM-202 and MM-314 ×KP_4HM-15 were found promising based on yield and quality traits along with fusarium wilt incidence and thus can further be tested at multilocation for commercial exploitation. The traits *viz.*, seed cavity area, pH and β carotene content were predominantly governed by additive gene action and thus improved by selection or pedigree method of breeding while other were controlled by dominance gene action and hence may be improved by heterosis breeding. Therefore, heterosis and selection or pedigree method along with population improvement method (recurrent selection) would assist concurrent exploitation of genetic variation in melon improvement program.

ACKNOWLEDGMENT

The authors are thankful to University Grants Commission (UGC) New Delhi for providing fellowship (Grant No. F1-17.1/2013-14/MANF-2013-14-MUS-MAH-23366) and facilities created under PURSE (SR/PURSE Phase 2/25(G), 28.09.2017) and FIST programme for conduct of research study.

Received January 30, 2023
Accepted October 18, 2023

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ANALIZA HETEROZE I KOMBINOVANJA SVOJSTVA VOĆA DINJE (*Cucumis melo* L.) UKLJUČUJUĆI MUŠKE STERILNE I SNAPMELON LINE

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Izvod

Deset uzoraka dinje uključujući osam rezistentnih linija gde spade i jedna linija *Cucumismelo* var. *momordica* i dve osetljive linije su ukrštene sa jednom muški sterilnom linijom da bi se dobilo 45 F1 kroz poludijalelni dizajn. Ovi genotipovi su ocenjeni za osobine prinosa, kvaliteta i otpornosti na bolesti u randomiziranom blok dizajnu sa tri ponavljanja. Objedinjena ANOVA za eksperimentalni dizajn otkrila je značajnost sredina kvadrata, osim za β -karoten i TSS soka, i tretman × sredina, osim za indeks oblika ploda i TSS soka. Procene GCA su pokazale da je roditelj Punjab Sunehri bio dobar kombinator za površinu šupljine semena (-8,80), debljinu mesa (0,12), debljinu kore (0,42), čvrstinu (0,61), suvu materiju (1,02) i β karoten (0,80), dok je SM-2012-12 bio dobar roditelj za prinos ploda (4,74), broj plodova vinove loze-1 (3,43), prosečnu masu ploda (0,06) i incidencu fuzarioznog uvenuća (-0,51), a KP4HM-15 je bio dobar za prosečnu masu ploda (0,01), broj dana do prvog sazrevanja ploda (-2,31), TSS (1,21), pH (0,13), titrabilnu kiselost (-3,13), sadržaj askorbinske kiseline (5,89) i β -karotena (0,06). Heterobeltoza se kretala od -87,2 do 927,08% za osobine prinosa i kvaliteta, dok je za fuzarioznu incidencu imala vrednost -100 do 69,23%. Studija ukazuje na mogućnost prenošenja incidence fuzarioznog uvenuća u superiorni hortikulturni genotip. Hibridi KP4HM-15 × Kajri Sel. 1, Kajri Sel.1 × MM-202 i MM-314 × KP4HM-15 su identifikovani kao obećavajući na osnovu fenotipskih performansi, efekata SCA i otpornosti na bolest fuzarioznog uvenuća. Ovi hibridi se mogu dalje ocenjivati na više lokacija kako bi se procenila njihova pogodnost za komercijalno puštanje u promet.

Primljeno 30.I.2023.
Odobreno 18 X.2023.