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HETEROSIS AND INTER-RELATIONSHIP OF MAJOR PHYSIOMORPHIC FRUIT YIELD TRAITS IN CHILLI (*Capsicum annuum* L.)

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ABSTRACT: The seeds of nine hybrids along with national check Pusa Jwala were evaluated in a Randomized Block Design in three replications for M.P. plains. The highest positive and significant correlation coefficient of fresh fruit yield plant^{-1} was noted with dry fruit yield plant^{-1}, number of fruits plant^{-1}, 1000 seed weight, number of seed fruit^{-1}, plant height at maturity, days to maturity and fruit length. Variation was highest for fresh fruit yield plant^{-1} followed by number of fruits plant^{-1}. High heritability coupled with high genetic advance for traits like number of secondary branches plant^{-1} at 30 DAT followed by number of fruits plant^{-1}.An overall observation of standard heterosis the hybrids HPH-2024, NCH-913 and Ujjala were recorded the best hybrids for yield and its component characters.

Keywords : *Capsicum annuum, genetic variability, heritability, correlation.*

Chilli (*Capsicum annuam* L.) is an important spice cum vegetable crop for domestic as well as for export values. The crop was introduced in India by portugues and now cultivated all over India produces nearly 8.5 lakh tones followed by China and Pakistan.

The extent of genetic variation for different traits of economic values and their inheritance are pre requisite to breeder for further upgrading yield (Tembhurne *et al.,* 19). Genetic improvement for traits depends upon the nature and amount of genetic variability present in hybrids and their inheritance are pre-requisite for further upgrading yield. Heritability along with genetic advance gives the best picture of efficiency of selection. Genetic advance on the measure the expected gain from the selection applied in a population.

The scope for utilization of heterosis depends mainly upon the direction and magnitude of heterosis. The magnitude of heterosis provides a basis of genetic diversity and guides to choice of desirable parents for developing superior hybrids. Planning and execution of a breeding programme for the improvement of the various quantitative and quality attributes depends, to a great extent upon the magnitude of genetic variability existing in the population. Hence, studies on heterosis with the helpof suitable biometrical tools eg. Coefficient of variability, heritability and genetic advance has become indispensable in breeding programme for tangible results of desire values.

MATERIALS AND METHODS

A field experiment was conducted under at RAK College of Agriculture, Sehore during *Kharif* 2012-13.The experiment was laid out in randomized block design with three replications. Nine hybrids along with national check Pusa Jwala were evaluated under three different conditions. Each hybrid was sown in four rows plot of 3 meter^2 length with 60 cm row to row and 60 cm plant to plant distances. The fertilizer dose 20t FYM, 150 kg N, 80 kg P_2O_5 and 50 kg K_2O ha^{-1}was applied uniformly and recommended package of practices were adopted for optimum crop growth and plant protection under rainfed condition. Average data were subjected to analysis of variance following Steel (18). Broad sense heritability [h^2 (bs)] was estimated according to Lush (10) Johnson *et al.* (6) and Hanson (3). Heritability values were categorized as low (<30%), moderate (30-60%) and high (>60%). The expected genetic advance (GA %) on 5% selection intensity was estimated and classified as low (<10%), moderate (10-20%) and high (>20%) following the method given by Lush (10). Genotypic and phenotypic correlation coefficients were calculated by standard procedures (Johnson *et al.* 6) and Hanson (3).The analysis of variance was computed as per method given by Panse and Sukhatme (13).

RESULTS AND DISCUSSION

The analysis of variances for all the characters studied has been presented in (Table 1). Mean squares due to genotypes were highly significantly for all the characters, indicating that the presence of genetic diversity in the existing material. Highest value of mean sum of square were recorded for fresh fruit yield plant^{-1}, number of fruit plant^{-1}, dry fruit yield plant^{-1}, fresh fruit yield hectare^{-1}, number of seed plant^{-1}, plant

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Table 1a : Analysis of variance for various yield parameters of chilli (mean square).

Characters	Source of variation			
	Replications	Genotypes	Error	
	d.f. 2	d.f. 9	d.f. 18	
Plant height (cm)	30 DAT	3.841	5.430**	0.537
	60 DAT	1.209	162.398**	0.735
	90 DAT	8.737	228.776**	1.968
	120 DAT	25.257	259.398**	6.266
	150 DAT	32.777	271.443**	8.230
	At maturity	3.089	254.857**	3.260
No. of primary branches plant^{-1}	30 DAT	0.028	0.528**	0.001
	60 DAT	0.016	1.740**	0.106
	90 DAT	2.601	2.421**	0.085
	120 DAT	1.697	4.874**	0.386
	150 DAT	2.536	8.084**	0.083
	At maturity	6.646	12.151**	1.883
No. of secondary branches plant^{-1}	30 DAT	0.260	0.875**	0.013
	60 DAT	0.438	0.810**	0.003
	90 DAT	2.052	4.349**	0.075
	120 DAT	0.816	14.218**	0.252
	150 DAT	1.097	4.953**	0.005
	At maturity	1.586	6.984**	0.009

Table 1b : Analysis of variance for various yield parameters of chilli (mean square).

Days to first flower initiation	62.533	8.651**	1.274
Days to first fruit initiation	48.533	10.448**	1.348
Days to first picking	14.933	153.170**	23.748
Number of flower clusters^{-1}	2.105	7.773**	0.073
Number of fruits clusters^{-1}	1.242	3.058**	0.045
Days to maturity	48.533	142.759**	1.348
Number of fruits plant^{-1}	1597.38	71832.84**	944.43
Fruit length (cm)	0.910	9.328**	0.056
Number of seed fruit^{-1}	2.884	1022.42**	2.484
1000 seed weight (g)	0.045	1.844**	0.115
Fruit and seed ratio	0.196	6.051**	0.003
Fresh fruit yield plant^{-1} (g)	308.23	89532.96**	2.677
Fresh fruit yield plot^{-1} (kg)	13.058	10.237**	0.597
Fresh fruit yield ha^{-1} (q)	1611.55	1263.63**	73.79
Dry fruit yield plant^{-1} (g)	10.228	3181.31**	0.088
Dry fruit yield plot^{-1} (kg)	0.440	0.363**	0.020
Dry fruit yield ha^{-1} (q)	54.364	44.830**	2.562

height at 150, 120 DAT, at maturity and 90 DAT (Table 2a, 2b and 2c). Variability is the most important characteristic feature of any population. Estimation of variability is an important prerequisite for realizing response to selection as the progress in the breeding depends upon its amount, nature and magnitude. The genetic proportion of this variability measured in terms of genotypic coefficient of variation (GCV) alone represents the heritable component of total variability (Kumar *et al.,* 7; and Jabeen *et al.* (5).

Genotypic (GCV) and phenotypic (PCV) coefficient of variation

Estimation of components of genetic parameters of variation for yield and its attributes exhibited a wide range of variation for the characters studies ((Table 3a and 3b). High genotypic coefficient of variation was noted for number of secondary branches plant^{-1} (48.36%), number of fruits plant^{-1} (44.60%), number of fruits cluster^{-1} (35.74%) and number of flower cluster^{-1} (34.13%) Results are in line of Datta and Jana (2) for number of fruits plant^{-1} , Ukkund (20) for number of secondary branches plant^{-1}. While it was found to be lowest in the characters *i.e.,* days to maturity (3.22%) followed by days to first fruit initiation (3.92%), plant height at 30 DAT (4.15%), days to 1st flower initiation (4.36%), number of secondary branches plant^{-1} at maturity (7.01%), at 150 DAT (7.61%), and at 60 DAT (8.41%), plant height at maturity (10.13%), days to first picking (9.11%), number of secondary branches plant^{-1} at 90 DAT (11.62%), plant height at 150 DAT (11.41%), plant height at 120 DAT (11.58%), number of primary branches plant^{-1} at 90 DAT (11.71%), plant height at 90 DAT (12.43%), 1000 seed weight (11.61%), plant height at 60 DAT (13.56%), number of primary branches plant^{-1} at 120 DAT (12.17%), number of primary branches plant^{-1} at 150 DAT (14.55%) and number of

Table 2a : Mean performance of morphological parameters of chilli.

Genotypes	Plant height (cm)						No. of primary branches plant^{-}					
	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	At maturity	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	At maturity
T_1-NCH-913	32.47	62.33	79.93	87.47	91.47	100.15	1.85	5.33	8.24	11.40	13.15	15.20
T_2-GEN-445	30.00	52.13	62.47	72.67	75.13	86.25	1.10	4.27	7.44	9.93	10.27	11.90
T_3-MHCP-317	31.33	54.47	70.20	83.07	86.20	93.85	1.60	5.07	7.85	10.33	11.78	13.70
T_4-US-642	29.47	50.47	62.13	71.67	73.60	81.75	1.01	4.20	7.15	9.80	10.05	11.43
T_5-Sitara	31.47	57.40	74.87	85.60	89.87	96.45	1.77	5.20	8.02	10.60	12.02	14.37
T_6-Ujjala	31.60	59.53	79.53	85.73	90.07	98.05	1.83	5.20	8.12	10.93	12.35	14.87
T_7-HPH-2024	32.67	64.40	83.20	95.20	95.47	103.35	1.86	5.47	8.5	11.53	13.55	15.53
T_8-DCx-3160	30.80	53.47	64.93	75.87	78.13	86.98	1.31	4.87	7.74	10.13	10.99	12.87
T_9-Indam Jwala	29.00	39.53	60.60	68.07	70.20	76.40	0.78	3.13	5.4	7.67	8.30	9.80
T_{10}-Pusa Jwala (Check)	29.07	47.53	61.87	68.20	70.73	80.65	0.98	3.87	6.9	8.13	9.80	10.67
C.D. (P=0.05)	1.25	1.47	2.40	4.29	4.92	3.09	0.07	0.55	0.50	1.06	0.49	2.35

Table 2b: Mean performance morphological traits of chilli.

Genotypes	No. of secondary branches plant^{-1}						Days to first flower initiation	Days to first fruit initiation	Days to first picking	No. of flowers cluster^{-1}	No. of fruits cluster^{-1}	Days to maturity
	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	At maturity						
T_1-NCH-913	1.80	6.80	11.20	16.87	18.17	23.57	34.33	43.00	71.00	6.47	3.53	220.67
T_2-GEN-445	0.82	5.93	10.27	15.40	16.23	20.87	36.33	44.67	75.67	4.43	2.63	209.33
T_3-MHCP-317	1.00	6.27	10.63	15.93	16.93	21.97	35.67	43.67	72.67	4.93	3.23	212.67
T_4-US-642	0.70	5.75	9.60	13.47	15.80	20.42	36.67	45.33	76.33	7.60	4.73	207.33
T_5-Sitara	1.20	6.36	10.93	16.07	17.40	22.50	35.33	43.33	72.33	3.57	2.87	216.67
T_6-Ujjala	1.50	6.55	11.20	16.33	17.87	22.90	35.33	43.33	71.33	3.30	2.30	218.33
T_7-HPH-2024	2.10	6.93	11.70	17.47	19.17	24.13	33.33	41.67	69.67	6.47	3.60	224.00
T_8-DCx-3160	0.90	6.12	10.43	15.53	16.57	21.47	35.67	44.67	73.67	3.13	2.10	210.67
T_9-IndamJwala	0.40	5.30	7.67	10.97	15.13	19.67	39.67	48.00	79.00	3.67	1.57	202.67
T_{10}-PusaJwala (C)	0.67	5.65	9.07	11.80	15.47	20.00	37.00	46.67	77.67	3.37	1.47	206.00
C.D. (P=0.05)	0.20	0.10	0.47	0.86	0.12	0.17	1.93	1.99	8.35	0.46	0.36	1.99

Table2c : Mean performance of yield parameters of chilli.

Genotypes	No. of fruits plant^{-1}	Fruit length (cm)	No. of seeds fruit^{-1}	1000 seed weight (g)	Fruit and seed ratio	Fresh fruit yield plant^{-1} (g)	Fresh fruit yield plot^{-1} (kg)	Fresh fruit yield ha^{-1} (q)	Dry fruit yield plant^{-1} (g)	Dry fruit yield plot^{-1} (kg)	Dry fruit yield ha^{-1} (q)
T_1-NCH-913	523.33	10.19	86.47	7.23	9.04	916.00	9.23	102.58	168.07	1.69	18.81
T_2-GEN-445	239.80	7.45	75.60	6.11	7.85	647.67	6.27	69.62	117.54	1.14	12.63
T_3-MHCP-317	335.53	8.47	76.27	5.56	8.50	719.67	7.30	81.10	133.03	1.33	14.78
T_4-US-642	238.33	6.39	61.33	5.39	6.85	645.00	6.15	68.33	116.85	1.11	12.37
T_5-Sitara	353.33	10.36	93.20	7.03	8.90	812.33	8.80	97.77	147.97	1.61	17.85
T_6-Ujjala	458.33	9.91	63.80	7.17	9.00	870.67	9.22	102.40	158.59	1.68	18.67
T_7-HPH-2024	653.33	9.46	74.47	7.48	9.95	970.33	9.64	107.06	181.03	1.80	20.00
T_8-DCx-3160	252.67	10.46	118.53	6.92	8.10	730.33	6.74	74.88	130.85	1.22	13.59
T_9-IndamJwala	193.00	6.12	58.33	5.64	5.50	380.00	4.72	52.40	68.47	0.85	9.44
T_{10}-PusaJwala (C)	198.20	6.59	62.40	6.87	6.10	615.67	4.81	53.40	111.53	0.87	9.67
C.D. (P=0.05)	52.71	0.40	2.70	0.58	0.09	2.80	1.32	14.73	0.50	0.24	2.74

secondary branches plant^{-1} at 120 DAT (14.40%) confirming to reports of Tembhurne (19). Rest of the characters viz., number of primary branches plant^{-1} at 30 DAT (29.74%) followed by fresh fruit yield plot

Table 3a : Genetic parameters in different characters in chilli

Traits	Stages	Grand Mean	Range		Coefficient of variations		Heritability % (BS	Genetic Advance	GA as % of mean
			Min.	Max.	Phe.	Gen.			
Plant height	30 DAT	30.78	29.00	32.67	4.78	4.15	75.21	2.28	7.41
	60 DAT	54.12	39.53	64.40	13.65	13.56	98.65	15.02	27.75
	90 DAT	69.97	60.60	83.20	12.59	12.43	97.46	17.68	25.27
	120 DAT	79.35	68.07	95.20	12.00	11.58	93.09	18.26	23.01
	150 DAT	82.09	70.20	95.47	11.93	11.41	91.42	18.45	22.47
	Maturity	90.39	76.40	103.35	10.33	10.13	96.26	18.51	20.48
No. of primary branches plant^{-1}	30 DAT	1.40	0.78	1.86	29.89	29.74	99.02	0.86	61.39
	60 DAT	4.66	3.13	5.46	17.32	15.84	83.66	1.39	29.84
	90 DAT	7.53	5.40	8.50	12.34	11.71	90.11	1.73	22.92
	120 DAT	10.04	7.66	11.53	13.66	12.17	79.48	2.25	22.37
	150 DAT	11.22	8.30	13.55	14.77	14.55	96.97	3.31	29.53
	Maturity	13.03	9.80	15.53	17.67	14.19	64.50	3.06	23.49
No. of secondary branches plant^{-1}	30 DAT	1.10	0.40	2.10	49.51	48.36	95.42	1.08	98.06
	60 DAT	6.16	5.30	6.93	8.47	8.41	98.67	1.06	17.23
	90 DAT	10.27	7.67	11.70	11.93	11.62	94.98	2.40	23.33
	120 DAT	14.98	10.97	17.47	14.79	14.40	94.86	4.33	28.90
	150 DAT	16.87	15.13	19.17	7.62	7.61	99.67	2.64	15.66
	Maturity	21.74	19.67	24.13	7.03	7.01	99.57	3.13	14.42

Table 3b: Genetic parameters in different characters in chilli

Characters	Grand Mean	Range		Coefficient of variations		Heritability % (BS)	Genetic Advance	GA as % of mean
		Min.	Max.	Phe.	Gen.			
Days to 1st flower initiation	35.93	33.33	39.67	5.38	4.36	65.87	2.62	7.30
Days to first fruit initiation	44.43	41.67	48.00	4.71	3.92	69.23	2.99	6.72
Days to first picking	73.93	69.67	79.00	11.35	9.11	64.50	10.87	14.70
Number of flower clusters^{-1}	4.69	3.13	7.60	34.62	34.13	97.21	3.25	69.38
Number of fruits clusters^{-1}	2.80	1.47	4.73	36.54	35.74	95.65	200.94	71.76
Days to maturity	212.83	202.67	224.00	3.27	3.22	97.22	13.95	6.55
Number of fruits plant^{-1}	344.58	193.00	653.33	45.49	44.60	96.16	310.52	90.11
Fruit length (cm)	8.53	6.12	10.46	20.77	20.58	98.21	3.59	42.07
Number of seed fruit^{-1}	77.04	58.33	118.53	24.02	23.93	99.27	37.85	49.12
1000 seed weight (g)	6.54	5.39	7.48	12.72	11.61	83.33	1.43	21.83
Fruit and seed ratio	7.97	5.50	9.95	17.81	17.80	99.84	2.92	36.67
Fresh fruit yield plant^{-1} (g)	730.76	380.00	970.33	23.64	23.64	99.99	355.85	48.70
Fresh fruit yield plot^{-1} (kg)	7.28	4.72	9.64	26.79	24.60	84.31	3.39	46.58
Fresh fruit yield ha^{-1} (q)	80.95	52.40	107.06	26.79	24.60	84.31	37.67	46.54
Dry fruit yield plant^{-1} (g)	133.39	68.47	181.03	24.41	24.41	99.99	67.08	50.29
Dry fruit yield plot^{-1} (kg)	1.33	0.85	1.80	27.61	25.40	84.60	0.64	48.12

$^{-1}$ (24.60%), fresh fruit yield ha^{-1} (24.60%), dry fruit yield plot^{-1} (25.40%), dry fruit yield ha^{-1} (25.40%), dry fruit yield plant^{-1} (24.41%), number of seeds fruit^{-1} (23.93%), fresh fruit yield plant^{-1} (23.64%), fruit length (20.58%), fruit and seed ratio (17.80%). Results are in agreement with Sharma *et al.* (16) for fruit and seed ratio, number of primary branches plant^{-1} at 60 DAT (15.84%) and number of primary branches plant^{-1} at maturity (14.19%) were showed moderate genotypic coefficient of variation confirming to Lakhare *et al.* (9) and Singh and Singh (17).

The phenotypic coefficien6t of variation ranges from 3.27% for days to maturity to 49.51% for number of secondary branches plant^{-1} at 30DAT. The highest phenotypic coefficient of variation was observed for

Table 3c: Mean performance of yield parameters of chilli

.Genotypes	No. of fruits plant^{-1}	Fruit length (cm)	No. of seeds fruit^{-1}	1000 seed weight (g)	Fruit and seed ratio	Fresh fruit yield plant^{-1} (g)	Fresh fruit yield plot^{-1} (kg)	Fresh fruit yield ha^{-1} (q)	Dry fruit yield plant^{-1} (g)	Dry fruit yield plot^{-1} (kg)	Dry fruit yield ha^{-1} (q)
T_1–NCH-913	523.33	10.19	86.47	7.23	9.04	916.00	9.23	102.58	168.07	1.69	18.81
T_2–GEN-445	239.80	7.45	75.60	6.11	7.85	647.67	6.27	69.62	117.54	1.14	12.63
T_3–MHCP-317	335.53	8.47	76.27	5.56	8.50	719.67	7.30	81.10	133.03	1.33	14.78
T_4–US-642	238.33	6.39	61.33	5.39	6.85	645.00	6.15	68.33	116.85	1.11	12.37
T_5–Sitara	353.33	10.36	93.20	7.03	8.90	812.33	8.80	97.77	147.97	1.61	17.85
T_6–Ujjala	458.33	9.91	63.80	7.17	9.00	870.67	9.22	102.40	158.59	1.68	18.67
T_7–HPH-2024	653.33	9.46	74.47	7.48	9.95	970.33	9.64	107.06	181.03	1.80	20.00
T_8–DCx-3160	252.67	10.46	118.53	6.92	8.10	730.33	6.74	74.88	130.85	1.22	13.59
T_9–Indam Jwala	193.00	6.12	58.33	5.64	5.50	380.00	4.72	52.40	68.47	0.85	9.44
T_{10}–Pusa Jwala (C)	198.20	6.59	62.40	6.87	6.10	615.67	4.81	53.40	111.53	0.87	9.67
C.D. (P=0.05)	52.71	0.40	2.70	0.58	0.09	2.80	1.32	14.73	0.50	0.24	2.74

number of secondary branches plant^{-1} at 30DAT (49.51%), number of fruits plant^{-1} (45.49%), number of fruits clusters^{-1} (36.54%) and number of flower cluster^{-1} (34.62%) confirming to the results of Datta and Jana (2) for number of fruits plant^{-1} and Ukkund (20) for number of secondary branches plant^{-1}. However, it was found lowest for days to maturity (3.27%) followed by days to first fruit initiation (4.71%), plant height at 30 DAT (4.78%), days to 1st flower initiation (5.38%), number of secondary branches plant^{-1} at maturity (7.03%), at 150 DAT (7.62%), and at 60 DAT (8.47%), plant height at maturity (10.33%), days to first picking (11.35%), number of secondary branches plant-1 at 90 DAT (11.93%), plant height at 150 DAT (11.93%), plant height at 120 DAT (12.00%), number of primary branches plant^{-1} at 90 DAT (12.34%), plant height at 90 DAT (12.59%), 1000 seed weight (12.72%), plant height at 60 DAT (13.65%), number of primary branches plant^{-1} at 120 DAT (13.66%), number of primary branches plant^{-1} at 150 DAT (14.77%) and number of secondary branches plant^{-1} at 120 DAT (14.79%). The remaining characters such as number of primary branches plant^{-1} at 30 DAT (29.89%) followed by dry fruit yield plot^{-1} (27.61%), dry fruit yield ha^{-1} (27.61%), fresh fruit yield plot-1 (26.79%), fresh fruit yield ha^{-1} (26.79%), dry fruit yield plant^{-1} (24.41%), number of seed fruit^{-1} (24.02%), fresh fruit yield plant^{-1} (23.64%), fruit length (20.77%), fruit and seed ratio (17.81%), number of primary branches plant-1 at maturity (17.67%) and number of primary branches plant^{-1} at 60 DAT (17.32%) were showed moderate phenotypic coefficient of variation by confirming results of Sharma *et al.* (16).

Heritability

Heritability (broad sense) was recorded very high for fresh fruit yield plant^{-1} (99.99%) followed by dry fruit yield plant^{-1} (99.99%), fruit and seed ratio (99.84%) and number of secondary branches plant^{-1} at 150 DAT (99.67%) (Table 3a and 3b). However, it was recorded high for dry fruit yield plot^{-1} (84.60%) followed by dry fruit yield ha^{-1} (84.60%), fresh fruit yield plot^{-1} (84.31%) and fresh fruit yield ha^{-1} (84.31%). Medium estimate of heritability was recorded for days to first fruit initiation (69.23%), days to 1st flower initiation (65.87%), number of primary branches plant^{-1} at maturity (64.50%) and days to first picking (64.50%) for plant height, fruit length, number of fruits plant-1and fresh fruit yield. Findings are in consonance with Ukkund, (20).

Table 4: Estimates of genotypic and phenotypic correlation coefficients among yield and its contributing traits in chilli.

Characters		No. of primary branches plant^{-1} at maturity	No. of secondary branches plant^{-1} at maturity	Days to 1st flower initiation	Days to first fruit initiation	Days to first picking	No. of flower cluster^{-1}	No. of fruits cluster^{-1}	Days to maturity	Number of fruits plant^{-1}	Fruit length (cm)	No. of seed fruit^{-1}	1000 seed wt. (g)	Fruit and seed ratio	Dry fruit yield plant^{-1} (g)	Fresh fruit yield plant^{-1} (g)
Plant height at maturity	G	0.127	0.252	0.434	0.640	0.460	0.530	0.693	0.660	-0.118	0.284	0.343	-0.496	-0.252	0.470	0.473
	P	0.138	0.246	0.342*	0.534**	0.372*	0.521**	0.664**	0.642**	-0.117	0.286	0.327	-0.434**	-0.244	0.460**	0.463**
No. of primary branches plant^{-1} at maturity	G		0.729	0.487	0.194	-0.312	0.142	0.352	0.172	-0.159	0.660	0.330	-0.191	0.531	-0.403	-0.394
	P		0.587**	0.396**	0.234	-0.160	0.140	0.290	0.168	-0.157	0.541**	0.263	-0.157	0.437**	-0.322	-0.315
No. of secondary branches plant^{-1} at maturity	G			0.630	0.575	0.380	-0.122	0.137	0.436	0.009	0.453	-0.205	0.150	0.060	-0.104	-0.092
	P			0.504**	0.466**	0.317	-0.117	0.136	0.425*	0.009	0.445**	-0.201	0.132	0.059	-0.103	-0.092
Days to 1st flower initiation	G				0.933	0.506	0.321	0.345	0.893	-0.610	0.041	0.160	-0.597	0.220	-0.651	-0.641
	P				0.861**	0.277	0.268	0.303	0.784**	-0.457**	0.055	0.115	-0.308	0.175	-0.526**	-0.518**
Days to first fruit initiation	G					0.705	0.430	0.530	0.939	-0.453	-0.078	0.136	-0.600	-0.179	-0.508	-0.498
	P					0.441**	0.350*	0.416*	0.920**	-0.394*	-0.049	0.099	-0.386*	-0.150	-0.421*	-0.413*
Days to first picking	G						0.128	0.103	0.637	0.139	-0.012	-0.644	0.150	-0.366	-0.005	-0.004
	P						0.145	0.090	0.496**	0.134	0.004	-0.512**	0.093	-0.294	-0.004	-0.003
No. of flower cluster^{-1}	G							0.914	0.406	-0.342	-0.131	0.582	-0.780	0.116	-0.425	-0.422
	P							0.888**	0.394*	-0.322	-0.129	0.571**	-0.693**	0.116	0.419*	0.416*
No. of fruits cluster^{-1}	G								0.509	-0.289	0.101	0.649	-0.730	-0.020	-0.437	-0.429
	P								0.486**	-0.260	0.101	0.630**	-0.665**	-0.021	0.427**	0.420*
Days to maturity	G									0.353	-0.024	0.136	0.565	-0.267	0.476	0.469
	P									0.349*	-0.019	0.130	0.488**	-0.263	0.469**	0.462**
No. of fruits plant^{-1}	G										0.069	-0.542	0.654	-0.507	0.834	0.829
	P										0.065	-0.530**	0.609**	-0.497**	0.818**	0.813**
Fruit length (cm)	G											-0.050	0.251	0.350	0.374	0.372
	P											-0.057	0.240	0.349*	0.370*	0.368*

Genetic advance

Genetic advance as percentage of mean ranged from 6.55% for days to maturity to 98.06% number of secondary branches plant^{-1} at 30 DAT. The highest estimate of genetic advance as percentage of mean was recorded for number of secondary branches plant^{-1} at 30 DAT (98.06%), followed by number of fruits plant^{-1} (90.11%) (Table 3a and 3b). Whereas, low estimates were recorded for days to maturity (6.55%), days to first fruit initiation (6.72%), days to 1st flower initiation (7.30%) and plant height at 30 DAT (7.41%) High heritability coupled with low genetic advance as percentage of mean was observed for days to maturity, plant height at 30 DAT, number of secondary branches plant^{-1} at maturity, number of secondary branches plant^{-1} at 150 DAT and number of secondary branches plant^{-1} at 60 DAT. Revealed that the predominance of non-additive gene action in the expression of these characters The results are in line of Jabeen *et al.* (5) and Singh and Singh (17).

Correlation Coefficient analysis

Genotypic correlation coefficients, in general, were of higher magnitude than the corresponding phenotypic correlation coefficient for all the characters.

The results of phenotypic correlation coefficients have been discussed only as the genotypic and environmental correlation were mostly influenced by the environmental conditions, hence phenotypic correlation will give the correct idea about the association between two variables (Table 4).

Correlation coefficient of fresh fruit yield plant^{-1} was recorded strong positive and significant with dry fruit yield plant^{-1} (0.999), number of fruits plant^{-1} (0.813), 1000 seed weight (0.594) and number of seed fruit^{-1} (0.510) . Plant height expressed significant and positive correlation with number of fruits cluster^{-1} (0.664), days to maturity (0.642) and days to first fruit initiation (0.534). Number of primary branches plant^{-1} at maturity was observed significant and positive with number of secondary branches plant^{-1} at maturity (0.587) and fruit length (0.541).Number of secondary branches plant^{-1} at maturity was observed significant and positive with days to 1st flower initiation (0.504) and days to first fruit initiation (0.466). Days to 1st flower initiation was exhibited significant and positive with days to 1st flower initiation (0.861) and days to maturity (0.784). Significant and negative association of this character was recorded with dry fruit yield plant-1 (-0.526), fresh fruit yield plant^{-1} (-0.518) and number of fruits plant^{-1} (-0.457). Days to 1st fruit initiation was found positive and significant with days to maturity (0.920) and days to first picking (0.441).Significant and negative association of this character was recorded with dry fruit yield plant^{-1} (-0.421) and fresh fruit yield plant-1 (-0.413). Days to first picking was observed significant and positive with days to maturity (0.496) and it was significant and negative with number of seed fruit^{-1} (-0.512). Number of flowers cluster^{-1} was observed significant and positive with number of fruits cluster^{-1} (0.888) and number of seed fruit^{-1} (0.571) and it was significant and negative with 1000 seeds weight (-0.693). Number of fruits cluster^{-1} was observed significant and positive with number of seed fruit^{-1} (0.630) and days to maturity (0.486) and it was significant and negative with 1000 seed weight (-0.665). Days to maturity expressed a significant and positive association with and 1000 seed weight (0.488) and dry fruit yield plant^{-1} (0.469). Number of fruits plant^{-1} was recorded positive and significant with dry fruit yield plant^{-1} (0.818), fresh fruit yield plant-1 (0.813) and 1000 seed weight (0.609). Results are in agreement with Chaudhary *et al.* (1), Kumar *et al.,* (7), Manna and Paul (12) and Sharma *et al.* (16) Significant and negative association of this character was recorded with number of seeds fruit^{-1} (-0.530) and fruit and seed ratio (-0.497). Fruit length expressed a significant and positive association with dry fruit yield plant^{-1} (0.370) and fresh fruit yield plant^{-1} (0.368). Number of seed fruit^{-1} showed positive and significant association with dry fruit yield plant^{-1} (0.511), fresh fruit yield plant^{-1} (0.510) and it was observed significant and negative association with 1000 seed weight (-0.746).1000 seed weight exhibited positive and significant with dry fruit yield plant^{-1} (0.590) and fresh fruit yield plant^{-1} (0.594).Fruit and seed ratio exhibited negative and significant with dry fruit yield plant^{-1} (-0.524) and fresh fruit yield plant^{-1} (-0.518). Dry fruit yield plant^{-1} exhibited positive and significant with fresh fruit yield plant^{-1} (0.999) Chaudhary *et. al.* (1), Padhar and Zaveri (14) and Singh and Singh (17) had also reported similar findings.

Standard Heterosis

Heterosis estimates over standard parent have been done the superiority of hybrid over the standard parent is of practical value for the plant breeder. Therefore, only heterosis over standard parents will be discussed. The heterosis for most of the characters was observed in either directions (*i.e.* positive and

Table 5a : Standard heterosis of morphological parameters of chilli.

Genotypes	Plant height (cm) at						No. of primary branches plant^{-1} at					
	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	At maturity	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	At maturity
T_1–NCH-913	11.70**	31.14**	29.19**	28.26**	29.32**	24.18**	88.78**	37.73**	19.42**	40.22**	34.18**	42.46
T_2–GEN-445	3.20	9.68**	0.97	6.55	6.22	6.94	12.24	10.34	7.83	22.14	4.80	11.53
T_3–MHCP-317	7.77	14.60**	13.46**	21.80**	21.87**	16.37**	63.27**	31.01*	13.77	27.06	20.20**	28.40
T_4–US-642	1.38	6.19	0.42	5.09	4.06	1.36	3.06	8.53	3.62	20.54	2.55	7.12
T_5–Sitara	8.26	20.77**	21.01**	25.51**	27.06**	19.59**	80.61**	34.37*	16.23*	30.38*	22.65**	34.68
T_6–Ujjala	8.70	25.25**	28.54**	25.70**	27.34**	21.57**	86.73**	34.37*	17.68*	34.44*	26.02**	39.36
T_7–HPH-2024	12.38*	35.49**	34.48**	39.59**	34.98**	28.15**	89.80**	41.34*	23.19**	41.82**	38.27**	45.55
T_8–DCx-3160	5.95	12.50**	4.95	11.25	10.46	7.85	33.67**	25.84	12.17	24.60	12.14*	20.62
T_9–IndamJwala	-0.24	-16.83**	-2.05	-0.19	-0.75	-5.27	-20.41**	-19.12	-21.74**	-5.66	-15.31**	-8.15
T_{10}–Mean of Standard Parent (Pusa Jwala)	29.07	47.53	61.87	68.20	70.73	80.65	0.98	3.87	6.9	8.13	9.8	10.67

Table 5b : Standard heterosis of chilli.

Genotypes	No. of secondary branches plant^{-1} at						Days to first flower initiation	Days to first fruit initiation	Days to first picking	Number of flower clusters^{-1}	Number of fruits clusters^{-1}	Days to maturity
	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	At maturity						
T_1–NCH-913	168.66**	20.35**	23.48**	42.97**	17.45**	17.85**	-7.22	-7.86	-8.59	91.99**	140.14**	7.12**
T_2–GEN-445	22.39	4.96*	13.23*	30.51**	4.91**	4.35**	-1.81	-4.29	-2.57	31.45**	78.91**	1.62
T_3–MHCP-317	49.25	10.97**	17.20**	35.00**	9.44**	9.85**	-3.59	-6.43	-6.44	46.29**	119.73**	3.24**
T_4–US-642	4.48	1.77	5.84	14.15	2.13*	2.10*	-0.89	-2.87	-1.73	125.52**	221.77**	0.65
T_5–Sitara	79.10*	12.57**	20.51**	36.19**	12.48**	12.50**	-4.51	-7.16	-6.88	5.93*	95.24**	5.18**
T_6–Ujjala	123.88**	15.93**	23.48**	38.39**	15.51**	14.50**	-4.51	-7.16	-8.16	-2.08	56.46**	5.99**
T_7–HPH-2024	213.43**	22.65**	29.00**	48.05**	23.92**	20.65**	-9.92	-10.71*	-10.30	91.99**	144.90**	8.74**
T_8–DCx-3160	34.33	8.32**	14.99*	31.61**	7.11**	7.35**	-3.59	-4.29	-5.15	-7.12**	42.86**	2.27*
T_9–IndamJwala	-40.30	-6.19**	-15.44**	-7.03	-2.20*	-1.65	7.22	2.85	1.71	8.90**	6.80*	-1.62
T_{10}– Mean of Standard Parent (Pusa Jwala)	0.67	5.65	9.07	11.8	15.47	20.00	37.00	46.67	77.67	3.37	1.47	206

negative). Fresh fruit yield plant^{-1} (g). Highest significant and positive heterotic effect was recorded in hybrid HPH-2024 (57.61%) followed by NCH-913 (48.78%) and Ujjala (41.42%). While, it was recorded maximum significant and negative heterotic value -38.28% in hybrid IndamJwala. Fresh fruit yield per plot and per hectare yield performance hybrid HPH-2024 was significantly superior over standard check it exhibit 100.42 and 100.49% for plot^{-1} and ha^{-1}, respectively heterotic effect followed by NCH-913 (91.89 and 92.10% for plot^{-1} and ha^{-1}, respectively), Ujjala (91.68 and 91.76% for plot^{-1} and ha^{-1}, respectively) and Sitara (82.95 and 83.09% for plot^{-1} and ha^{-1}, respectively). Dry fruit yield plant-1 (g) Highest significant and positive heterotic effect was recorded in hybrid HPH-2024 (62.32%) followed by NCH-913 (50.69%) and Ujjala (42.19%). While, it was recorded maximum significant and negative heterotic value

Table 5c : Standard heterosis of yield parameters of chilli

Genotypes	Number of fruits plant^{-1}	Fruit length (cm)	Number of seed fruit^{-1}	1000 seed weight (g)	Fruit and seed ratio	Fresh fruit yield plant^{-1} (g)	Fresh fruit yield plot^{-1} (kg)	Fresh fruit yield ha^{-1} (q)	Dry fruit yield plant^{-1} (g)	Dry fruit yield plot^{-1} (kg)	Dry fruit yield ha^{-1} (q)
T_1–NCH-913	164.04**	54.63**	38.57**	5.24	48.20**	48.78**	91.89**	92.10**	50.69**	94.25**	94.52**
T_2–GEN-445	20.99	13.05	21.15**	-11.06	28.69**	5.20**	30.35	30.37	5.39**	31.03	30.61
T_3–MHCP-317	69.29*	28.53**	22.23**	-19.07*	39.34**	16.89**	51.77	51.87	19.28**	52.87	52.84
T_4–US-642	20.25	-3.03	-1.71	-21.54*	12.30**	4.76**	27.86	27.96	4.77**	27.59	27.92
T_5–Sitara	78.27**	57.21**	49.36**	2.33	45.90**	31.94**	82.95**	83.09**	32.67**	85.06**	84.59**
T_6–Ujjala	131.25**	50.38**	2.24	4.37	47.54**	41.42**	91.68**	91.76**	42.19**	93.10**	93.07**
T_7–HPH-2024	229.63**	43.55**	19.34**	8.88	63.11**	57.61**	100.42**	100.49**	62.32**	106.90**	106.83**
T_8–DCx-3160	27.48	58.73**	89.95**	0.73	32.79**	18.62**	40.12	40.22	17.32**	40.23	40.54
T_9–Indam Jwala	-2.62	-7.13	-6.52	-17.90	-9.84**	-38.28**	-1.87	-1.87	-38.61**	-2.30	-2.38

Table 6 : Categorization of chilli hybrids based on quality parameter.

Genotypes	Shape of fruits	Size of fruits	Flowers colour	Fruits colour	Breaing habit
T_1–NCH-913	Straight	Long	White	Dark green	Pendent
T_2–GEN-445	Straight	Medium	White	Green	Pendent
T_3–MHCP-317	Straight	Medium	White	Dark green	Pendent
T_4–US-642	Straight	Medium	White	Dark green	Pendent
T_5–Sitara	Straight	Long	White	Green	Pendent
T_6–Ujjala	Straight	Long	White	Dark green	Pendent
T_7–HPH-2024	Straight	Long	White	Green	Pendent
T_8–DCx-3160	Straight	Long	White	Green	Pendent
T_9–IndamJwala	Straight	Medium	White	Dark green	Pendent
T_{10}–PusaJwala (C)	Indefinitely curved	Long	White	Light green	Upright

-38.61% in hybrid IndamJwala. Hybrid HPH-2024 was recorded maximum positive heterotic effect 106.90 and 106.83% for plot^{-1} and ha^{-1}, respectively followed by NCH-913 (94.25 and 94.52% for plot^{-1} and ha^{-1}, respectively) and Ujjala (93.10 and 93.07% for plot^{-1} and ha^{-1}, respectively). Whereas hybrid Indam Jwala was recorded negative hetrotic effect -2.30 and -2.38% for plot^{-1} and ha^{-1}, respectively. Similar findings have also been reported by Prajapati and Agalodia (15), Singh and Singh (17), Krishnamurthy *et al.* (8), Chaudhary *et al.* (1) and Hasanuzzaman (4).

An overall observation of standard heterosis the hybrids HPH-2024, NCH-913 and Ujjala were recorded the best hybrids for yield and its component characters. Hybrid HPH-2024 exhibited tall plant, more primary and secondary branches, early flower, fruit initiation and picking, late maturity, more number of fruits plant^{-1}, high seed weight, higher fruit and seed ratio, fresh and dry fruit yield plant^{-1}, plot^{-1} and hectare^{-1}. While hybrid DCx-3160 was recorded long fruit and higher number of seeds fruit^{-1} (Table 5a, 5b and 5c).

Quality parameters

Considerable variability was observed for fruit shape i.e. straight, slightly curved and indefinitely curved. All the genotypes showed straight fruit shape except Pusa Jwala (C) which recorded indefinitely curved fruit shape. Variation was observed among the genotypes for size of fruits i.e. big, medium and small. Size of fruits was observed to be medium in the genotypes GEN-445, MHCP-317, US-642 and Indam Jwala. Rest of the genotypes were found long sized fruits.The colour of flower was observed to be light purple, purple and white. All the genotypes had white flower.Colour of fruits was observed to be dark green, green, light green, purple and yellowish green. Genotypes NCH-913, MHCP-317, US-642, Ujjala and Indam Jwala exhibited dark green fruits. Pusa Jwala (C) was observed light green fruits (Table 6).

Remaining genotypes exhibited green fruits. In all the genotypes bearing of fruits was pendent type except PusaJwala (C) which bears upright fruits (Manju and Sreelathakumary, 11).

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