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GENETIC ESTIMATES AND GENE ACTION FOR OBTAINING PROMISING HETEROTIC HYBRIDS IN BOTTLE GOURD [*LAGENARIA SICERARIA* (MOLINA) STANDL.]

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ABSTRACT

Gene action, magnitude of exploitable heterosis and combining ability variance and its effects were studied through half diallel analysis including 45 F_1 hybrids derived by crossing ten diverse bottle gourd parents for earliness and yield components. Data was recorded for twelve quantitative traits including 5 maturity traits for earliness. Ratio of GCA and SCA variance revealed preponderance of non- additive genetic variance for all studied traits except fruit length. The genetic ratio $H_2/4H_1$ revealed that the asymmetrical distribution of the positive and negative alleles at all loci for most of the traits. All traits exhibit below 50 per cent narrow sense heritability except fruit length (72%). The average degree of dominance $(H_1/D)^{1/2}$ revealed that over dominance gene action for most of the yield related traits except fruit length. The best performing F_1 hybrids regarding earliness, standard heterosis, SCA effects and mean performance of crosses were found in crosses Pusa Naveen x NDBG-603, NDBG-707-2 x NDBG-603 and NDBG-707-2 x NDBG-624. Based on earliness, desirable fruit shape and high fruit yield, elite hybrids were NDBG-707-2 x NDBG-624, NDBG-51 x NDBG-601 and NDBG-517 x NDBG-751.

INTRODUCTION

Bottle gourd [*Lagenaria siceraria* (Molina) Standl.] is widely grown cucurbits throughout India for its delicate and tender fruits. In recent, bottle gourd improvement programmes is mainly focus on heterosis breeding. Identification of suitable parents with good combining ability (GCA) and derivation of best F_1 hybrids having better specific combining ability (SCA) are prerequisite for full exploitation of heterosis in desirable direction. Out of several mating design, Diallel mating design is most frequently used to determine nature and magnitude of gene action by calculating genetic components, GCA and SCA variances and their effects in many self, often-cross and cross pollinated crops as similar reported by Pitchaimuthu and Sirohi (1994). Parvathi and Reddy (2005) reported that the ratio estimates of GCA and SCA variances revealed non-additive genetic variances for days to first male flowering, days to first female flowering, node number of first male flowering, node number of first female flowering, fruits per vine, sex ratio and fruit weight. Sit and Sirohi (2008) revealed that the gene distribution among the parents was found asymmetry as the proportion of dominant and recessive genes exceeds one for all the studied characters except vine length. It indicates ample scope of exploitation of hybrid vigour in bottle gourd. Considering aforesaid facts, the prime objective of present study is to analyze heterosis, combining ability and gene action through diallel mating design for earliness and yield components.

MATERIALS AND METHODS

The field experiment was conducted at main experiment station of Department of Vegetable Science, N.D. University of Agriculture and Technology (Narendra Nagar), Faizabad which geographically falls under humid sub-tropical climate (Gangetic alluvial plains of eastern Uttar Pradesh) and located in between 24.47º and 26.56º N latitude and 82.12º and 83.98ºE longitude at an altitude of 113 meters above the mean sea level during Zaid, 2011. The soil type of experimental site was clay with neutral reaction (soil pH 7.0-7.5).

The experiment materials consist of ten diverse parents who were procured from Department of Vegetable Science, N.D.U.A. &T., Faizabad. After selfing, crosses were attempted in half diallel fashion during summer 2010. Derived 45 F_1's were carried out in randomized complete block design (RCBD) in three replications. The crop was planted in rows spaced at 3.0 meters with plant to plant spacing of 0.5 meter apart during summer, 2011. All the recommended agronomic practices and protective measures were followed to raise a healthy crop. Twelve important polygenic traits were considered for present study. Observations were recorded on average mean

Table 1: ANOVA for 10 x 10 diallel set and its combining ability for twelve studied traits in bottle gourd

Source of variation	DF	DAFSF	DAFPF	NAFSF	NAFPF	DFFH	VL (m)	PBP	FL (cm)	FC(cm)	FW (kg)	FP	FYP(kg)
Replications	2	0.12	1.06	0.22	0.11	3.50	0.01	0.56	2.47	3.33	0.00	0.26	0.02
Genotypes	54	67.62**	72.41**	4.36**	10.70**	48.25**	1.81**	60.27**	94.74**	22.08**	0.09**	3.07**	2.47**
Parents	9	78.43**	168.27**	2.01**	27.81**	97.06**	1.27**	166.13**	143.05**	77.77**	0.19**	4.70**	1.20**
Hybrids	44	65.98**	54.42**	4.24**	5.70**	35.80**	1.91**	36.80**	86.28**	9.33**	0.07**	2.78**	2.67**
Parents vs. Hybrids	1	42.16**	1.01	30.79**	76.99**	156.92**	2.76**	139.92**	31.84**	82.16**	0.00	1.07*	5.16**
Error	108	0.39	0.38	0.29	0.34	4.08	0.19	0.83	3.09	1.48	0.01	0.19	0.12
GCA	9	25.27**	35.65**	1.88**	7.80**	34.85**	1.25**	36.86**	143.36**	17.80**	0.05**	1.68**	1.09**
SCA	45	21.99**	21.83**	1.37**	2.72**	12.33**	0.48**	16.74**	9.22**	5.27**	0.03**	0.89**	0.77**
Vgca		2.10	2.96	0.15	0.64	2.79	0.10	3.05	11.86	1.44	0.00	0.14	0.09
Vsca		21.86	21.7	1.27	2.61	10.97	0.42	16.46	8.19	4.78	0.03	0.83	0.73
Vgca/Vsca		0.10	0.14	0.12	0.25	0.25	0.24	0.19	1.45	0.30	0.14	0.16	0.12
Error	108	0.13	0.13	0.10	0.11	1.36	0.06	0.28	1.03	0.49	0.00	0.06	0.04

*,** Significant at 5 % and 1%, respectively. Traits: Days to first staminate flower anthesis(DAFSF);Days to first pistillate flower anthesis (DAFPF);Node number to first staminate flower anthesis (NAFSF); Node number to first pistillate flower anthesis (NAFPF); Days to first fruit harvest (DFFH);Vine length (m) (VL);Primary branches per plant(PBP);Fruit length (cm)(FL); Fruit circumference (cm)(FC); Fruit weight (kg)(FW); Fruits per plant(FP);Fruit yield per plant (kg)(FYP); GCA variance (Vgca); SCA variance (Vsca).

performance of six plants of each replication of each treatment for ten polygenic traits viz. days to first staminate flower anthesis, days to first pistillate flower anthesis, node number to first staminate flower anthesis, node number to first pistillate flower anthesis, days to first fruit harvest, vine length (m), primary branches per plant, fruit weight (kg), fruits per plant and fruit yield per plant (kg). Out of ten, first five maturity traits are considered desirable for earliness however Dey *et al.* (2012) reported these traits earlier. Observation data on two another polygenic traits viz. fruit length (cm) and fruit circumference (cm) were recorded on average mean performance of five randomly selected edible fruits of each treatment in each replication.

Statistical and biometrical analysis

The ANOVA for the experiment (RCBD) was estimated according to Panse and Sukhatme procedure (1967). Heterosis over better parent (Heterobeltiosis) and standard/ check variety (Pusa Naveen) heterosis was estimated according to Hayes *et al.* (1955).

$$\text{Standard heterosis (\%)} = \frac{F_1 - SV}{SV} \times 100$$

$$\text{Heterosis (\%)} = \frac{F_1 - BP}{SV} \times 100$$

Where,

F_1= mean performance of cross, BP= mean performance of better parent and SV = mean performance of standard variety (Pusa Naveen) and significance of heterosis is tested with the help of standard error using't' test at 5 % and 1 % level of significance. Heritability (narrow sense) was calculated by using the formulae as per Hays *et al.* 1955.

$$h^2(ns) = \frac{2\sigma^2 g}{2\sigma^2 g + \sigma^2 s + \sigma^2 e} \times 100$$

Where, $\sigma^2 g$ = GCA variance, $\sigma^2 s$ = SCA variance and $\sigma^2 e$ = error variance.

The combining ability analysis for studied traits was carried out using method 2 of model I of Griffing (1956), where parents and F_1's were included under the experiment excluding reciprocals. Thus the experimental material comprises of n (n+1)/2 genotypes through half diallel mating *i.e.* 55 genotypes (10 parents and 45 its F_1 hybrids). The genetic components of variation were calculated according to Griffing's numerical approach and graphical analysis (Wr-Vr graph) given by Jinks and Hayman (1953), Hayman (1954) and Askel and Johnson (1963).

RESULTS AND DISCUSSION

Analysis of Variance (ANOVA)

Analysis of variance (ANOVA) revealed that mean sum of squares due to genotypes, parents, hybrids and parents vs hybrids were found almost highly significant (Table 1) for all studied traits except for days to anthesis of first pistillate flower and fruit weight (kg) indicating significant differences among the traits under study as similar reported by Sharma and Sengupta (2013) and Ravishankar *et al.* (2014). It is evident from the table that mean sum of squares due to GCA and SCA were highly significant for all studied traits. Ratio of GCA and SCA variance revealed preponderance of non- additive genetic variance for all studied traits except fruit length in consonance with Quamruzzaman and Ahmad (2010).

Estimation of Heterosis and Combining ability

The GCA and SCA effects in negative direction were considered desirable for five maturity traits for earliness as previous said in consonance with Dey *et al.* (2012). The best performing F_1 hybrid regarding earliness based on maturity traits considering standard heterosis (Check, Pusa Naveen), SCA effects and mean performance of crosses was Pusa Naveen x NDBG-603, NDBG-707-2 x NDBG-603, NDBG-707-2 x NDBG-624 and NDBG-603 x NDBG-625 (Table 2 and 3) in consonance with Kumar *et al.* (2013), Makani *et al.* (2013) and Singh *et al.* 2013 (Table 2). Considering superior SCA effects and standard heterosis, the crosses NDBG-707-2 x NDBG-624, NDBG-51 x NDBG-601, NDBG-707-2 x NDBG-603 and NDBG-517 x NDBG-751 exhibit high fruit yield per plant (Table2 and 3) in consonance with Mendez-Natera *et al.* (2012), Singh, M. *et al.* (2013) and Yadav *et al.* (2013). Fruit characteristics are effective selection parameter in bottle gourd. Considering fruit characteristics, best ten F_1's hybrids are represented in Table 5.

Table 2: Identification of superior crosses in bottle gourd based on heterosis and mean performance of hybrids

Trait	Range of heterosis % over BP	Range of heterosis % over SP	No.of significant heterotic crosses over BP	No.of significant heterotic crosses over SP	Three superior crosses based on heterobeltiosis	Mean performance of crosses	Three superior crosses based on Standard heterosis	Mean performance of crosses
DAFSF	-16.71 % ($P_3 \times P_6$) to 37.30% ($P_5 \times P_{10}$)	-0.29 % ($P_1 \times P_6$) to48.95 % ($P_2 \times P_8$)	10	0	P_3 x P_6 (-16.71)	41.64	P_1 x P_6 (-0.29)	39.88#
					P_6 x P_8 (-13.36)	40.58	P_6 x P_8 (1.46)	40.58
					P_3 x P_7 (-12.90)	42.67	P_8 x P_9 (3.76)	41.5
DAFPF	-19.29 % ($P_6 \times P_8$) to34.25 % ($P_5 \times P_{10}$)	0.68 % ($P_1 \times P_6$) to 47.32 % ($P_2 \times P_8$)	11	0	P_6 x P_8 (-19.29)	40.58	P_1 x P_6 (0.68)	41.01#
					P_2 x P_6 (-13.85)	44.7	P_6 x P_8 (1.73)	41.43
					P_7 x P_8 (-12.38)	44.98	P_8 x P_9 (1.96)	41.53
NAFSF	-25.28 % ($P_3 \times P_6$) to 19.26 % ($P_2 \times P_6$)	-24.34 % ($P_3 \times P_6$) to 28.66 % ($P_2 \times P_6$)	18	14	P_3 x P_6 (-25.28)	8.07#	P_3 x P_6 (-24.34)	8.07#
					P_6 x P_9 (-25.11)	9.59	P_4 x P_5 (-21.56)	8.37
					P_4 x P_9 (-24.38)	8.98	P_1x P_7 (-19.09)	8.63
NAFPF	36.04 % ($P_4 \times P_9$) to 48.14 % ($P_2 \times P_8$)	-21.52 % ($P_3 \times P_6$) to 32.05 % ($P_2 \times P_7$)	16	15	P_4 x P_9 (-36.04)	9.61	P_3 x P_6 (-21.52)	8.95#
					P_4 x P_6 (-28.05)	10.09	P_5x P_{10} (-14.52)	9.52
					P_2 x P_4 (-26.00)	11.47	P_4 x P_9 (-15.67)	9.61
DFFH	-11.85 % (P6 × P9) to 23.00 % (P2 × P3)	11.34 % (P3 × P7) to 16.26 % (P2 × P5)	12	1	P6 x P9 (-11.85)	62.11	P3 x P7 (-11.34)	55.50#
					P6 x P7 (-9.34)	66	P3 x P6 (-5.21)	59.34
					P7 x P10 (-9.06)	65.11	P7 x P8 (-4.33)	59.89
VL (m)	-43.88 % (P6 × P10) to 13.07 % (P4 × P5)	-28.04 % (P7 × P10) to 42.13 % (P2 × P6)	0	7	P4 x P5 (13.07)	6.11	P2 x P6 (42.13)	6.89
					P5 x P8 (11.10)	6.01	P6 x P8 (40.21)	6.8
					P2 x P7 (9.53)	6.01	P4 x P5 (26.05)	6.11
PBP	-66.11 % (P6 × P10) to 108.85 % (P1 × P2)	4.85 % (P9 × P10) to 166.09 % (P2 × P6)	22	43	P1 x P2 (108.85)	19.58	P2 x P6 (166.09)	23.75*
					P3 x P4 (99.08)	20.31	P2 x P5 (16.32)	23.42
					P2 x P3 (98.55)	19.59	P4 x P8 (151.05)	22.41
FL (cm)	-28.02 % (P4 × P9) to 25.44 % (P1 × P2)	-14.82 % (P1 × P9) to 52.70 % (P4 × P8)	6	34	P1 x P2 (25.44)	44.63	P4 x P8 (52.70)	51.44*
					P1 x P7(16.88)	43.84	P2 x P8 (49.94)	50.51
					P4 x P8 (9.14)	51.44*	P3 x P7 (44.35)	48.63
FC(cm)	-44.69 % (P8 × P9) to 10.16 % (P2 × P8)	-12.24 % (P1 × P6) to 30.35 % (P3 × P6)	0	6	P2 x P8 (10.16)	21.39	P3 x P6 (30.35)	25.84*
					P4 x P5 (8.73)	22.82	P3 x P7 (20.99)	23.98
					P5 x P6 (6.10)	22.27	P5 x P9 (17.15)	23.22
FW (kg)	-36.26 % (P5 × P7) to 65.45 % (P2 × P10)	-7.02 % (P5 × P7) to 89.26 % (P2 × P9)	3	41	P2 x P10 (65.45)	1.36	P2 x P9 (89.26)	1.53*
					P1 x P10 (21.95)	1	P6 x P8 (69.83)	1.37
					P4 x P6 (15.08)	1.25	P7 x P9 (69.83)	1.37
FP	-42.32 % (P1 × P8) to 60.65 % (P3 × P7)	-46.07 % (P6 × P8) to 14.70 % (P4 × P10)	11	1	P3 x P7 (60.65)	7.12	P4 x P10 (14.70)	7.54*
					P3 x P6 (46.82)	5.93	P4 x P5 (10.04)	7.24
					P4 x P5 (45.70)	7.24	P3x P7 (8.21)	7.12
FYP(kg)	-24.59 % (P1 × P2) to 46.34 % (P3 × P6)	-24.59 % (P1 × P2) to 42.83 % (P3 × P7)	11	11	P3 x P6 (46.34)	7.2	P3 x P7 (42.83)	7.57*
					P3 x P7 (45.76)	7.57*	P4 x P5 (39.81)	7.41
					P4 x P10 (36.49)	7.26*	P4 x P10 (36.92)	7.26

# indicates lowest mean performance; * indicates highest mean performance. Parents: Pusa Naveen (P_1); NDBG-202 LF (P_2); NDBG-707-2 (P_3); NDBG-517 (P_4); NDBG-60 (P_5); NDBG-603 (P_6); NDBG-62 (P_7); NDBG-625 (P_8); NDBG-749-2 (P_9) and NDBG-751 (P10)

Table 3: Promosing general combiner based on GCA effects and promising specific combiner based on SCA effects for studied traits

Trait	Best General combiner based on GCA effects		Best Specific combiner based on SCA effects		Total no. of important specific combiner
DAFSF	1.Pusa Naveen (P_1) (-2.95) 2.NDBG-603 (P_6)(-0.74)	3.NDBG-624 (P_7)(-0.65) 4.NDBG-601 (P_5)(-0.63)	1. $P_3 \times P_6$ (-6.75) 2.$P_6 \times P_8$ (-6.41)	3.P_8 x P_9 (-6.22)	18
DAFPF	1.Pusa Naveen (P_1) (-3.15) 2.NDBG-601 (P_5) (-2.18)	3. NDBG-749-2 (P_9) (-0.42) 4. NDBG-625 (P_8) (-0.29)	1.P_6 x P_8 (-7.62) 2.P_8 x P_9 (-7.31)	3.P_2 x P_6 (-6.24)	22
NAFSF	1.Pusa Naveen (P_1) (-0.56) 2. NDBG-517 (P4)(-0.37)	3. NDBG-70-2 (P_3) (-0.19)	1.P_3 x P_6 (-2.38) 2.P_4 x P_5 (-1.76)	3.P_7 x P_8 (-1.69)	15
NAFPF	1. Pusa Naveen (P_1) (-0.77) 2. NDBG-70-2 (P_3) (-0.49)	3. NDBG-625 (P_8) (-0.46) 4.NDBG-751(P_{10}) (-0.43)	1.P_1 x P_2 (-2.66) 2.P_3 x P_6 (-2.15)	3.P_2 x P_4 (-2.20)	18
DFFH	1. NDBG-707-2(P_3) (-3.38)	2. NDBG-625 (P_8) (-1.23)	1.P_3 x P_7 (-6.85) 2.P_6 x P_9 (-4.74)	3.P_2 x P_{10} (-5.41)	14
VL (m)	1. NDBG-603 (P_6) (0.55) 2. NDBG-625 (P_8) (0.32))	3. NDBG-601 (P_5)(0.14	1.P_2 x P_6 (1.34) 2.$P_4 \times P_5$ (1.15)	3.P_6 x P_8 (1.05)	11
PBP	1.NDBG-603 (P_6) (3.21) 2. NDBG-202 L (P_2) (1.42)	3.NDBG-601 (P_5) (1.19) 4.NDBG-517 (P4) (0.88)	1.P_1 x P_9 (7.27) 2.P_3 x P_{10} (5.05)	3.P_4 x P_8 (4.99)	18
FL (cm)	1. NDBG-625 (P_8) (4.89) 2. NDBG-517 (P4) (2.88)	3.NDBG-70-2 (P_3) (2.80) 4.NDBG-624 (P_7) (1.58)	1.P_7 x P_9 (6.29) 2.P_1 x P_2 (6.14)	3.P_2 x P_8 (6.11)	11
FC(cm)	1. NDBG-749-2 (P_9) (2.76)	2. NDBG-70-2 (P_3) (1.36)	1.P_3 x P_6 (4.36) 2.P_3 x P_7 (3.79)	3.P_4 x P_5 (2.63)	6
FW (kg)	1. NDBG-625 (P_8) (0.11) 2. NDBG-749-2 (P_9) (0.10)	3.NDBG-603 (P_6) (0.04) 4.NDBG-70-2 (P_3) (0.03)	1.P_2 x P_9 (0.38) 2.P_2 x P_{10} (0.36)	3.$P_1 \times P_3$ (0.28)	11
FP	1. NDBG-601 (P_5) (0.49) 2. NDBG-751(P_{10}) (0.42)	3.NDBG-517 (P4) (0.36) 4.NDBG-624 (P_7) (0.16)	1.P_3 x P_7 (2.14) 2.P_4 x P_{10} (1.77)	3.P_3 x P_6 (1.59)	13
FYP(kg)	1. NDBG-601 (P_5) (0.42) 2. NDBG-749-2 (P_9) (0.38)	3.NDBG-751(P_{10}) (0.25) 4.NDBG-517 (P4) (0.12)	1.P_3 x P_6 (2.13) 2.P_3 x P_7 (2.12)	3.P_4 x P_{10} (1.53)	14

Traits: Days to first staminate flower anthesis (DAFSF);Days to first pistillate flower anthesis (DAFPF);Node number to first staminate flower anthesis (NAFSF); Node number to first pistillate flower anthesis (NAFPF); Days to first fruit harvest (DFFH);Vine length (m) (VL);Primary branches per plant(PBP);Fruit length (cm)(FL); Fruit circumference (cm)(FC); Fruit weight (kg)(FW); Fruits per plant(FP);Fruit yield per plant (kg)(FYP). Parents: Pusa Naveen (P_1); NDBG-202 LF (P_2); NDBG-707-2 (P_3); NDBG-517 (P_4); NDBG-60 (P_5); NDBG-603 (P_6); NDBG-62 (P_7); NDBG-625 (P_8); NDBG-749-2 (P_9) and NDBG-751 (P_{10})

Table 4: Genetic components of variation and its proportions for studied traits in bottle gourd.

Components/ proportions	DAFSF	DAFPF	NAFSF	NAFPF	DFFH	VL (m)
$\hat{D}$	26.02**±8.18	55.96**±8.65	0.57±0.43	9.16**±0.57	31.00**±3.58	0.36*±0.15
$\hat{H}1$	114.73**±17.41	121.85**±18.40	5.69**±0.92	13.04**±1.22	54.81**±7.63	1.94**±0.32
$\hat{H}2$	73.31**±14.79	69.61**±15.64	4.41**±0.78	7.90**±1.04	38.84**±6.48	1.63**±0.27
$\hat{F}$	55.66**±18.87	96.46**±19.95	1.03±0.99	12.19**±1.32	36.93**±8.27	0.21±0.35
$\hat{h}2$	5.52±9.90	0.09±10.47	4.03**±0.52	10.12**±0.69	20.22**±4.34	0.34±0.18
$\hat{E}$	0.13±2.47	0.13±2.61	0.10±0.13	0.11±0.17	1.36±1.08	0.06±0.05
$(\hat{H}1/\hat{D})1/2$	2.1	1.48	3.15	1.19	1.33	2.32
$\hat{H}2/4\hat{H}1$	0.16	0.14	0.19	0.15	0.18	0.21
$\frac{(4\ \hat{D}\hat{H}1)1/2+F}{(4\hat{D}\hat{H}1)1/2\ F}$	3.07	3.81	1.8	3.52	2.62	1.28
$\hat{h}2/\hat{H}2$	0.08	0	0.91	1.28	0.52	0.21
t2	0.89	0.01	13.36*	3.1	0.01	1.45
h^2 (N. S.)	16	21.3	17.8	32	31	29

Genetic components of variation and its proportions

The results of genetic component analysis revealed over dominance for most of the traits except fruit length representing partial dominance. Sit and Sirohi (2008) found that the gene distribution among the parents was asymmetry as the proportion of dominant and recessive genes exceeds one for all studied traits except vine length. In all the traits except fruit length, the dominance component of genetic variation (H_1) was higher than additive component (D). Heritability in narrow sense (h^2) was found highest for fruit length (72%). All remain traits had narrow sense heritability less than 50 % which is sign of preponderance of non-additive gene action for most of the traits under study as similar reported by Quamruzzaman and Ahmad (2010) (Table 4). Sit and Sirohi (2008) reported that predominance of non-additive gene action and below 50 % narrow-sense heritability for all studied traits except fruit length emphasize that the heterosis breeding has prime importance to acquire high-yielding bottle gourd hybrid. The proportion of genes with positive and negative effect in the parents ($H_2/4H_1$) was found to be less than 0.25 for all the traits under study indicating asymmetry distribution of dominant genes with positive and negative alleles at loci as similar reported by Dubey and Ram (2006). Positive F value indicates dominant gene control (Hayman, 1954). The average degree of dominance $(H_1/D)^{1/2}$ was found to be more than one for all the traits under study except fruit length. It confirmed over

Table 4: Cont............

Components/ proportions	PBP	FL (cm)	FC(cm)	FW (kg)	FP	FYP(kg)
$\hat{D}$	55.10**±6.14	46.66**±4.12	25.42**±1.93	0.06**±0.01	1.50**±0.36	0.36±0.31
$\hat{H}1$	94.64**±13.06	41.11**±8.76	26.03**±4.11	0.12**±0.02	4.36**±0.76	3.18**±0.65
$\hat{H}2$	49.36**±11.10	30.66**±7.44	15.26**±3.49	0.09**±0.02	2.93**±0.64	2.78**±0.55
$\hat{F}$	89.18**±14.16	7.63±9.49	32.49**±4.45	0.08**±0.02	2.35**±0.82	0.33±0.71
$\hat{h}2$	18.37*±7.43	3.83±4.98	10.66**±2.34	0.00±0.01	0.12±0.43	0.67±0.37
$\hat{E}$	0.27±1.85	1.03±1.24	0.50±0.58	0.00±0.00	0.06±0.11	0.04±0.09
$(\hat{H}1/\hat{D})1/2$	1.31	0.94	1.01	1.41	1.7	2.98
$\hat{H}2/4\hat{H}1$	0.13	0.19	0.15	0.18	0.17	0.22
$\frac{(4\ \hat{D}\hat{H}1)1/2+F}{(4\hat{D}\hat{H}1)1/2\ F}$	4.23	1.19	4.43	2.8	2.69	1.37
$\hat{h}2/\hat{H}2$	0.37	0.13	0.7	0	0.04	0.24
t2	1.82	0.11	0.02	0.06	0.38	2.33
h² (N. S.)	27	72	35	25	23	19

*,** Significant at 5% and 1%, respectively. Traits: Days to first staminate flower anthesis(DAFSF);Days to first pistillate flower anthesis (DAFPF);Node number to first staminate flower anthesis (NAFSF); Node number to first pistillate flower anthesis (NAFPF); Days to first fruit harvest (DFFH);Vine length (m) (VL);Primary branches per plant(PBP);Fruit length (cm)(FL); Fruit circumference (cm)(FC); Fruit weight (kg)(FW); Fruits per plant(FP);Fruit yield per plant (kg)(FYP).

Table 5: Visual observations on fruit characteristics for promising ten F_1's hybrids

Genotypes	Fruit shape	Presence of neck	Fruit surface	Fruit colour	General rating
P_1 x P_2	Small Cylindrical	Without neck	Smooth	Green	Very good
P_1 x P_{10}	Small Cylindrical	With neck	Smooth	Light green	Very Good
P_2 x P_3	Medium Cylindrical	Without neck	Smooth	Pale green	Very good
P_2 x P_5	Medium Cylindrical	Without neck	Smooth	Pale green	Very Good
P_2 x P_6	Small thin Cylindrical	Without neck	Smooth	Pale green	Very Good
P_2 x P_{10}	Small Cylindrical slight curve	Without neck	Smooth	Pale green	Very Good
P_4 x P_5	Long thin slight curve	With neck	Smooth	Pale green	Very good
P_4 x P_9	Small Cylindrical	Without neck	Smooth	Pale green	Very good
P_6 x P_7	Small thin Cylindrical	Without neck	Smooth	Pale green	Very good
P_6 x P_{10}	Small thin Cylindrical	Without neck	Smooth	Pale green	Very good

Parents: Pusa Naveen (P_1);NDBG-202 LF (P_2); NDBG-707-2 (P_3); NDBG-517 (P_4); NDBG-601 (P_5); NDBG-603 (P_6); NDBG-624 (P_7); NDBG-625 (P_8); NDBG-749-2 (P_9); NDBG-751 (P_{10}).

Table 6: Parental distribution considering dominant and recessive alleles based on graphical analysis (Wr-Vr graph).

Trait	Parents with maximumfrequency of dominant alleles	Parents with intermediate proportion of dominant and recessive alleles	Parents with maximum frequency of recessive alleles
DAFSF	P2, P4, P7	P1, P3, P5, P9, P10	P6, P8
DAFPF	P3, P4	P1, P2, P5, P7, P9, P10	P6, P8
NAFSF	P1, P5	P3, P4, P6, P8, P9, P10	P2, P7
NAFPF	P1, P3, P7, P10	P4, P5, P6, P8, P9	P2
DFFH	P1, P4,P8, P9, P10	P2, P3, P5, P6	P7
VL (m)	P1, P3, P10	P4, P5, P7, P9	P2, P6, P8
PBP	P1, P3, P5, P7, P8, P9, P10	P2, P4	P6
FL (cm)	P3, P7, P9	P5,P6,P8,P10	P1, P2, P4
FC(cm)	P1, P2, P3, P4, P5, P6, P7, P8, P10	Nil	P9
FW (kg)	P3, P4, P5, P6	P1, P7, P8, P9, P10	P2
FP	Nil	P1, P2, P8, P9	P3, P4, P5, P6, P7, P10
FYP(kg)	Nil	P1, P2, P8, P9, P10	P3, P4, P5, P6, P7

Traits: Days to first staminate flower anthesis(DAFSF);Days to first pistillate flower anthesis (DAFPF);Node number to first staminate flower anthesis (NAFSF); Node number to first pistillate flower anthesis (NAFPF); Days to first fruit harvest (DFFH);Vine length (m) (VL);Primary branches per plant(PBP);Fruit length (cm)(FL); Fruit circumference (cm)(FC); Fruit weight (kg)(FW); Fruits per plant(FP);Fruit yield per plant (kg)(FYP). Parents: Pusa Naveen (P_1);NDBG-202 LF (P_2); NDBG-707-2 (P_3); NDBG-517 (P_4); NDBG-601 (P_5); NDBG-603 (P_6); NDBG-624 (P_7); NDBG-625 (P_8); NDBG-749-2 (P_9); NDBG-751 (P_{10}).

dominance gene action for all studied traits as similar reported by Dubey and Ram (2006). Ratio of dominant and recessive alleles $(4DH1)^{1/2}+F/\ (4DH1)^{1/2}-F$ was more than unity for all studied traits indicating presence excess of dominant alleles. The higher proportions of dominant genes observed in most of the traits are in agreement with the findings of Pandey *et al.* (2004) and Dey *et al.*(2012) (Table 4).

Graphical analysis of recorded data was done in order to get information about allelic constitution of the parents used in the diallel cross. In the present study, F value indicates preponderance of non-additive genetic variance and absence of epistasis as similar to GCA to SCA variance ratio (Table 1 and 4) in consonance with Quamruzzaman .and Ahmad (2010). It represent over dominance for all studied traits. D is less than H_1 when intercept is negative. It indicated the fulfillment of the assumption that epistasis is absent for these traits. Parental distribution considering dominant and recessive alleles based on graphical analysis are represented in Table 6. The Wr (offspring covariance)/Vr (parental variance) graph analysis revealed that most of parents having maximum frequency of dominant alleles for all studied traits except fruit per plant and fruit yield per plant exhibiting maximum frequency of recessive alleles as similar reported by Dubey and Ram (2006). However, Sit and Sirohi (2008) elaborate that the dominant alleles were more comman in parents than recessive alleles for all the traits except vine length.

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