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Heterosis in ridge gourd (*Luffa acutangula* Roxb.) using hermaphrodite lines

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ABSTRACT

Seven parental lines, including two hermaphrodite lines and 28 F_1 hybrids of ridge gourd obtained from half diallel mating, were studied to investigate the extent of heterosis for yield and its contributing characters during spring summer and rainy season for two years. The three top performing parents, *viz.* P_1 (DRG-2), P_2 (Pusa Nasdar) and P_7 (Satputia Small) were observed for total yield per plant. Appreciable heterosis was observed over better parents and top parent for all the characters studied. In order of merit, $P_1 \times P_7$, $P_1 \times P_6$ and $P_2 \times P_7$ were found to be best heterotic combinations as they exhibited significant heterosis percentage for yield per plant over the top parent. The high yielding F_1 hybrids $P_1 \times P_7$ (DRG-2 × Satputia Small), $P_1 \times P_6$ (DRG-2 × Satputia Long) and $P_2 \times P_7$ (Pusa Nasdar × Satputia Small) were early in maturity, had high number of fruits per plant and showed 91.36, 84.84 and 73.11% heterosis for yield over top parent and may be recommended for commercial exploitation.

Key words: F_1 hybrids, heterosis, ridge gourd, hermaphrodite line.

INTRODUCTION

Luffa acutangula (ridge gourd) is very popular vegetable in the tropical and subtropical regions. In India, they are eaten boiled or in curry (mixed with potato or sole). The tender fruits along with *khus* seeds make an excellent dish. In Japan, the young fruits are sliced and dried and kept for future use. The young insipid leaves are consumed in Malaysia (Porterfield, 11). In African countries, leaves are used as leafy vegetable and seeds are used in several soup and sauce preparations (Adebooye, 2).

It is an important component of crop rotation during pre-*kharif* and *kharif* season in North India and is cultivated both on commercial scale and in kitchen gardens. Ridge gourd is generally monoecious in nature with pistillate flowers borne in leaf axil and staminate flowers in raceme. Monoecious ridge gourd generally produces solitary long fruits of 15-30 cm in length with prominent ribbed and rough fruit skin, but it has an ancestral form "Satputia" found in Bihar, which is hermaphrodite in nature and was given a separate taxonomic status *L. hermaphrodita,* having cluster bearing habit. Though, Ram *et al*. (12) studied variability and correlation coefficients among the ridge gourd hermaphrodite lines, but the breeding potentiality of hermaphrodite sex form in combination with monoecious ridge gourd is yet to be explored for different economically important traits. Despite its importance and diversified use, attention to the improvement on yielding ability and other characters has been very limited, which is prominent from the presence of very few varieties for commercial cultivation. Being monoecious and essentially cross-pollinated, it provides ample scope for successful exploitation of hybrid vigour. Abhusaleha and Dutta (1) and Hedau and Sirohi (7) reported earliness, higher number of fruits, bigger fruit size and higher total yield per plant over better and top parent in monoecious × monoecious cross combination, but till now no information is available about the potentiality of hermaphrodite lines in ridge gourd improvement and heterotic effect of monoecious × hermaphrodite cross combination for earliness, yield, its attributing characters and different fruit quality parameters. Hence, the present study was undertaken to evaluate the performance of hybrids of ridge gourd along with their parents for yield and related traits.

MATERIALS AND METHODS

The present investigation was carried out during spring summer of 2007-08 and rainy season of 2008-09 at Research Farm of Division of Vegetable Science, IARI, New Delhi. Seven genetically diverse inbreds of ridge gourd including two hermaphrodite lines, *viz.*, DRG-2 (P_1), Pusa Nasdar (P_2), Utkal Tripti (P_3), Arka Sumeet (P_4), HARG-110 (P_5), Satputia Long (P_6) and Satputia Small (P_7) were crossed in 7 × 7 half-diallel (excluding reciprocals) mating scheme (Hayman, 6) to obtain 21 F_1 hybrid combinations. Twenty one F_1 hybrids along with seven parents were evaluated in field for heterosis under randomized block design with three replications. The crops were sown in rows

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of 2.5 m with 75 cm spacing between the plants. All the recommended package of practices was followed to grow a successful crop. Out of 20 plants, 10 were randomly marked for taking observations. Observations on individual plant basis were recorded on nine quantitative characters, *viz.* node number of first female flower, days to first productive flower, *i.e.*, female or hermaphrodite flower anthesis, days to first fruit harvest, fruit length (cm), fruit diameter (cm), average fruit weight (g), number of fruits per plant, vine length (m) and total fruit yield per plant (kg). Heterosis was calculated in the favorable direction over mid parent (MP), better parent (BP) and top parent (TP).

RESULTS AND DISCUSSION

The analysis of variance revealed that there was highly significant difference among the parental lines with respect to different characters studied including total yield per plant (data not presented). The mean performance of the 7 parental lines together with their 21 F_1 hybrids is given in Tables 1 & 2, respectively. Range of mean values of parents, F_1 hybrids and heterosis percentage are presented in Table 3. In the present study, it was evident that among 7 parents, Satputia Small (P_7) had shortest vine length, lowest node number of first productive flower, lowest days to first productive flower opening, minimum days to first fruit harvest and maximum number of fruits per plant. Pusa Nasdar (P_2) and HARG-110 (P_5) had the highest fruit length and diameter. While DRG-2 reported maximum individual fruit weight and yield per plant. The study of heterosis revealed that range of mean values in F_1 hybrids was higher than that of parents for all the characters studied, except vine length, node to first productive flower, days to anthesis of first productive flower and first harvest.

Earliness, which is one of the most important parameter in hybrids is indicated by node to first productive flower, number of days for first productive flower anthesis and first harvest. In order of merit the best 3 F_1 hybrids, which gave highest performance over top parent in relation to earliness includes Pusa Nasdar × Satputia Small (-22.55%), Arka Sumeet × Satputia Small (-19.57%) and Satputia Long × Satputia Small (-15.75%) for vine length; Satputia Long × Satputia Small (-44.31%), DRG-2 × Satputia Small (-32.16) and Pusa Nasdar × Satputia Small (-29.80%) for node number for first productive flower opening; Satputia Long × Satputia Small (-21.05%), DRG-2 × Satputia Long (-14.47%) and DRG-2 × Satputia Small (-10.79%) for days to first productive flower anthesis, while crosses like Satputia Long × Satputia Small (-19.62%), DRG-2 × Satputia Small (-16.20%) and

Table 1. Mean performance of parents for different quantitative traits including yield per plant in ridge gourd.

Parent	Denomination used for parents	Vine length (m)	Node to first productive flower appearance	Days to first productive flower anthesis	Days to first harvest	Fruit length (cm)	Fruit dia. (cm)	No. of fruits per plant	Av. fruit weight (g)	Yield per plant (g)
DRG-2 (P_1)	DG	5.23	13.28	47.52	53.77	25.92	5.40	18.09	115.60	2092.17
Pusa Nasdar (P_2)	PN	4.76	14.23	51.87	56.20	30.60	5.57	11.87	109.80	1303.93
Utkal Tripti (P_3)	UT	5.35	16.25	64.14	70.07	17.41	5.33	9.82	101.35	996.03
Arka Sumeet (P_4)	AS	4.57	15.26	55.54	61.83	21.80	5.15	9.90	107.25	1062.07
HARG-110 (P_5)	HG	4.91	16.42	52.30	59.13	16.19	6.28	8.85	105.90	937.97
Satputia Long (P_6)	SPL	3.12	9.00	40.60	45.61	10.72	4.10	31.20	40.09	1250.93
Satputia Small (P_7)	SPS	2.79	8.50	38.00	43.63	8.55	4.43	37.15	33.02	1227.07
Mean		4.39	13.28	50.00	55.75	18.74	5.18	18.13	87.57	1267.17
Range		2.79-	8.50-	38.00-	43.63-	8.55-	4.10-	8.85-	33.02-	937.97-
		5.35	16.42	64.14	70.07	30.60	6.28	37.15	115.60	2092.17
CD at 5%		0.065	0.547	0.784	0.580	0.561	0.297	1.624	1.203	37.150

Table 2. Mean performance of hybrids for different quantitative traits including yield per plant in ridge gourd.

Hybrid	Vine length (m)	Node to first productive flower appearance	Days to first productive flower anthesis	Day to first harvest	Fruit length (cm)	Fruit dia. (cm)	No. of fruits per plant	Av. fruit weight (g)	Yield per plant (g)
DG × PN	5.30	11.83	45.85	52.57	36.13	6.09	23.95	125.45	3005.32
DG × UT	5.18	14.65	50.27	55.97	27.13	5.77	18.64	121.50	2265.73
DG × AS	5.22	13.00	46.94	52.94	30.17	5.62	22.26	123.09	2740.03
DG × HG	5.11	15.48	46.33	52.33	24.47	5.61	17.93	113.20	2030.33
DG × SPL	2.99	6.41	33.90	38.50	16.72	5.65	41.80	92.50	3867.07
DG × SPS	2.36	5.77	32.50	36.57	14.20	5.09	47.71	83.90	4003.48
PN × UT	4.94	13.83	52.23	55.04	25.30	5.76	13.43	114.75	1541.63
PN × AS	4.50	13.65	51.03	55.54	32.38	5.62	16.06	117.35	1884.92
PN × HG	5.18	15.00	50.20	54.37	21.77	6.06	12.94	115.30	1492.13
PN × SPL	2.77	6.90	35.44	41.11	17.12	5.72	37.73	93.10	3512.83
PN × SPS	2.16	5.97	34.13	38.63	14.74	6.92	41.88	86.47	3621.85
UT × AS	4.46	15.00	54.47	60.51	27.00	5.50	12.01	110.50	1327.63
UT × HG	4.75	15.58	53.30	61.68	22.40	6.04	12.10	107.67	1303.83
UT × SPL	3.04	7.23	40.12	45.04	15.05	5.39	33.06	90.65	2997.18
UT × SPS	2.46	6.57	35.10	40.54	13.94	5.89	37.26	75.20	2802.03
AS × HG	5.05	15.10	50.52	58.33	20.21	5.63	10.76	111.45	1200.00
AS × SPL	2.89	8.33	36.18	42.72	16.25	4.81	35.12	91.30	3207.02
AS × SPS	2.25	6.83	36.00	42.17	14.62	7.02	42.13	77.65	3272.03
HG × SPL	2.86	8.33	35.67	42.44	15.03	5.42	31.95	87.85	2806.87
HG × SPS	2.64	8.00	34.08	39.00	14.33	6.32	35.66	76.50	2728.43
SPL × SPS	2.35	4.73	30.00	35.07	11.17	4.71	37.05	42.10	1560.00
Mean	3.74	10.39	42.11	47.67	20.48	5.74	27.69	97.98	2531.92
Range	2.16 - 5.30	4.73 - 15.58	30.00 - 54.47	35.07 - 61.68	11.17 - 36.13	4.71 - 7.02	10.76 - 47.71	42.10 - 125.45	1200.00 - 4003.48
CD at 5%	0.143	0.495	16.186	0.639	0.882	0.215	1.616	1.584	57.892

DRG-2 × Satputia Long (-11.76%) for days to first fruit harvest. From the above findings it was quite clear that, monoecious × hermaphrodite hybrids manifested appreciable amount of heterosis for earliness as compared to monoecious × monoecious hybrids. Yield is the foremost character for any breeding programme. It is a complex trait resulting from the interaction of its component characters of a crop. Moll and Stuber (9) pointed out that heterosis estimates should indicate whether heterozygotes or homozygotes represent the more ideal genotype.

In ridge gourd, number of fruits per plant, fruit weight and fruit size are the direct component of yield. Crosses DRG-2 × Pusa Nasdar (18.08%) and Pusa Nasdar × Arka Sumeet (5.83%) were found to be best heterotic combinations for fruit length. For fruit diameter Arka Sumeet × Satputia Small (11.78%) and Pusa Nasdar × Satputia Small (10.14%) had highest top parent heterosis. F_1 hybrids DRG-2 × Satputia Small (28.43%), Arka Sumeet × Satputia Small (13.41%) and Pusa Nasdar × Satputia Small (12.73%) exhibited higher top parent heterosis for number of fruits per plant. For total yield per plant, F_1 hybrids DRG-2 × Satputia Small (91.36%), DRG-2 × Satputia Long (84.84%) and Pusa Nasdar × Satputia Sma (73.11%) recorded higher heterosis over top parent.

The above result also indicated that maximum yield per plant in the above mentioned hybrids was attributed by maximum number of fruits per plant. Therefore, monoecious × hermaphrodite hybrids were found to have maximum heterosis for earliness

Table 3. Range of mean values of parents, F_1 hybrids and heterosis percentage (over mid, better and top parents) for different quantitative traits.

Parameter	Vine length (m)	Node to first productive flower appearance	Days to first productive flower anthesis	Day to first harvest	Fruit length (cm)
Range of mean values					
Parents	2.79 to 5.35	8.5 to 16.42	38 to 64.14	43.63 to 70.07	8.55 to 30.60
F_1	2.16 to 5.30	4.73 to 15.58	30.00 to 54.57	35.07 to 61.68	11.17 to 36.13
Range of heterosis (%)					
M.P.	-2.17 to -42.74	-0.79 to -47.51	-3.62 to -31.27	-3.55 to -28.69	5.39 to 37.71
B.P.	-1.08 to -22.55	-1.05 to -44.31	-1.17 to -21.05	-1.24 to -19.62	4.20 to 28.64
T.P.	-0.84 to -22.55	-1.96 to -44.31	-4.78 to -21.05	-2.08 to -19.62	5.83 to 18.08
No. of heterotic crosses over					
M.P.	16	20	21	21	14
B.P.	15	18	18	19	7
T.P.	7	11	10	10	2
Three top parents					
	SPS (2.79)	SPS (8.5)	SPS (38.0)	SPS (43.63)	PN (30.60)
	SPL (3.12)	SPL (9.0)	SPL (40.6)	SPL (45.61)	DG (25.92)
	AS (4.50)	DG (13.2)	DG (47.52)	DG (53.77)	AS (21.80)
Three top F_1s with heterosis (%)					
M.P	PN × SPS (-42.74)	PN × SPS (-47.51)	UT × SPS (-31.27)	UT × SPS (-28.69)	UT × AS (37.71)
	DG × SPS (-41.11)	DG × SPS (-47.05)	AS × SPL (-24.73)	DG × SPS (-24.91)	UT × HG (33.31)
	UT × SPS (-39.66)	UT × SPS (-46.94)	HG × SPS (-24.51)	HG × SPS (-24.10)	DG × PN (27.87)
B.P.	PN × SPS (-22.55)	SPL × SPS (-44.31)	SPL × SPS (-21.05)	SPL × SPS (-19.62)	UT × HG (28.64)
	AS × SPS (-19.57)	DG × SPS (-32.16)	DG × SPL (-16.5)	DG × SPS (-16.20)	UT × AS (23.85)
	SPL × SPS (-15.75)	PN × SPS (-29.80)	DG × SPS (-14.47)	DG × SPL (-11.76)	DG × PN (18.08)
T.P.	PN × SPS (-22.55)	SPL × SPS (-44.31)	SPL × SPS (-21.05)	SPL × SPS (-19.62)	DG × PN (18.08)
	AS × SPS (-19.57)	DG × SPS (-32.16)	DG × SPL (-14.47)	DG × SPS (-16.20)	PN × AS (5.83)
	SPL × SPS (-15.75)	PN × SPS (-29.80)	DG × SPS (-10.79)	DG × SPL (-11.76)	–
Best F_1 hybrid	PN × SPS	SPL × SPS DG × SPS	SPL × SPS DG × SPL	SPL × SPS DG × SPS	DG × PN

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Parameter	Fruit dia. (cm)	No. of fruits per plant	Av.fruit weight (g)	Yield per plant (g)
Range of mean values				
Parents	4.10 to 6.28	8.85 to 37.15	33.02 to 115.60	937.97 to 2092.17
F_1	4.71 to 7.02	10.76 to 47.71	42.10 to 125.45	1200.00 to 4003.48
Range of heterosis (%)				
M.P.	2.34 to 46.50	8.41 to 79.09	2.20 to 28.18	20.00 to 186.2
B.P.	0.74 to 36.31	0.30 to 35.30	1.67 to 8.52	8.30 to 177.76
T.P.	0.69 to 11.78	0.30 to 28.43	1.51 to 8.52	8.30 to 91.36
No. of heterotic crosses over				
M.P.	19	21	21	21
B.P.	14	18	10	20
T.P.	3	6	4	13
Three top parents	HG (6.28)	SPS (37.15)	DG (115.60)	DG (2092.17)
	PN (5.57)	SPL (31.20)	PN (109.80)	PN (1303.93)
	DG (5.40)	DG (18.09)	AS (107.25)	SPS (1250.93)
Three top F_1s with heterosis (%)				
M.P.	AS × SPS (46.50)	AS × SPS (79.09)	UT × SPL (28.18)	PN × SPS (186.20)
	PN × SPS (38.33)	PN × SPL (75.20)	PN × SPL (24.33)	AS × SPS (185.88)
	UT × SPS (26.11)	DG × SPS (72.74)	AS × SPL (23.91)	AS × SPL (177.33)
B.P.	AS × SPS (36.31)	PN × AS (35.30)	DG× PN (8.52)	PN × SPL (177.76)
	PN × SPS (24.25)	DG × SPL (33.97)	PN × AS (6.86)	PN × SPS (169.4)
	UT × SPS (10.44)	DG × PN (32.39)	DG × AS (6.46)	AS × SPS (166.65)
T.P.	AS × SPS (11.78)	DG × SPS (28.43)	DG × PN (8.52)	DG × SPS (91.36)
	PN × SPS (10.14)	AS × SPS (13.41)	DG × AS (6.48)	DG × SPL (84.84)
	HG × SPS (0.69)	PN × SPS (12.73)	DG × UT (5.10)	PN × SPS (73.11)
Best F_1 hybrid	AS × SPS	DG × SPS	DG × PN	DG × SPS

and total yield. Hayes and Jones (5) reported the first generation crosses in cucumber frequently exhibit high parent heterosis due to increased fruit size and fruit number per plant. Therefore, yield can more accurately be estimated by the number of fruits per plant, and it would be possible to achieve yield improvement in this crop by manipulating this particular trait. Hence, breeders should concentrate mainly on fruit number rather than fruit size, in their efforts to increase yield. Naliyadhara *et al.* (10) reported heterosis for high yield and earliness in sponge gourd, while Mole *et al.* (8) and Shaha and Kale (13) also observed heterotic effect for earliness, yield and fruit characters in the heterotic combinations in ridge gourd. Ahmed *et al*. (3) observed positive and significant standard heterosis for yield in ridge gourd. In accordance to the present findings, Grafius (4) was of the opinion that hybrid vigour of even small magnitude of individual yield components may have additive or synergistic effect on the end product, as had mentioned that heterosis for yield is the result of interaction of simultaneous increase in the expression of heterosis for yield components.

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