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STUDIES ON HETEROSIS IN INTERSPECIFIC HYBRIDS OF *CUCUMIS*

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ABSTRACT

Interspecific hybridization is used to improve crops by transferring specific traits, such as yield, improve quality, pest and stress resistance to crops from their wild relatives. This approach is a very effective method of gene transfer. In experiment 36 hybrids and 15 parents were evaluated with three replications in complete rondamized design with Line x Tester method during *kharif*- 2014. The mean sum of squares were highly significant for all the characters indicated a wide genetic variation for characters studied and there is a possibility of genetic improvement using such genetic pools in future breeding programme. *Cucumis sativus* use as a testers and *Cucumis melo var. momordica* use as a line in the experiment. Five best hybrids (L_3xT_3, L_3xT_2, L_2xT_2, $L_{12}xT_1$ and L_3xT_1) identified on the basis of *per se* performance on pooled basis for total yield per vine. Appreciable heterosis was observed over better and top parent for most of the characters studied. Best three economic hybrid L_3 x T_3, L_7 xT_1 and L_6 x T_2 showing 10.75 %, 22.30% and 41.39% economic heterosis for total yield per vine, T.S.S and for fruit length respectively, may be exploited for commercial cultivation.

INTRODUCTION

Genera *Cucumis* includes many species like *Cucumis sativus* (cucumber), *Cucumis melo* (muskmelon),*Cucumis melo var. utilissimus* (kakri),*Cucumis melo var. momordica* (snap melon),*Cucumis melo var. agrestis* (weed melon) etc. All these species are monoecious and highly cross pollinated in nature, which provides ample scope for the utilization of heterosis breeding and has a great scope of improvement over its base population. Among many cucurbits grown across the world, cucumber is distinct with a unique sex mechanism and this feature can easily be manipulated for the production of F1 hybrid seeds (Airina *et al*., 2013).

The phenomenon of heterosis has provided the most important genetic tool improving yield potential of crop plant. Yield is a complex character and is associated with some yield contributing characters, which are simple inherited (Rao *et al*., 2004). This can be achieved through effective utilization of germplasm resources and integration of genomic tools to impart efficiency and pace of breeding processes (Banga, 2012). The aim of heterosis in the present investigation was identification of parents and their cross combinations capable of producing the highest level of transgressive segregates. The magnitude of heterosis depends on the extant of genetic diversity between parents and helps in choosing the parents for superior F_1's.

Interspecific crosses are an effective way to create new germplasms. Genetic variation is relatively limited in cucumber (Staub *et al*., 1987); thus, efforts to create interspecific hybrids become more critical and meaningful. In 1859, Naudin first tried to cross melon with cucumber and other species. Historically, various approaches (traditional and biotechnological) for interspecific hybridization have been used in *Cucumis* to overcome the fertilization barriers between cucumber, melon, and wild species, but with only limited success. The recent cross between cucumber and *C.hystrix* Chakr. (2n = 24) was the first repeatable cross between a cultivated *Cucumis* species and a wild relative (Chen *et al*., 1997), and represented a breakthrough in interspecific hybridization in *Cucumis*. The success of this cross was even more surprising because the parental species have different chromosome numbers (Chen and Adelberg, 2000).

Interspecific hybridization is used to improve crops by transferring specific traits, such as yield, improve quality, pest and stress resistance to crops from their wild relatives (Bowley and Taylor,1987). When applicable, this approach is a very effective method of gene transfer. Heterosis breeding can be exploited as most efficient tool to exploit the genetic diversity in many cucurbitaceous crops including pumpkin (Mohanty and Mishra, 1999).The first man-made interspecific hybrid was synthesized in 1717. Since then, thousands of interspecific crosses have been attempted, but success has been rather limited. Chromosomal, genetic, cytoplasmic or mechanical isolation barriers can handicap successful hybridization and utilization. Significant benefits and difficulties make interspecific hybridization an important objective for geneticists and plant breeders. Interspecific hybrids in the Cucurbitaceae have been produced in several genera, including *Cucumis* (Deakin *et al*., 1971), *Citrullus*

(Valvilov,1925), *Luffa* (Singh,1991), and *Cucurbita* (Weeden and Robinson, 1986).

In view of the above facts the present investigation was carried out to develop high yielding and good quality (free from bitterness, possessing earliness) interspecific hybrids of cucumber and snapmelon for maximum exploitation of heterosis with the objectives to obtain mid parent heterosis, heterbeltiosis and economic heterosis for eighteen plant and fruit charcterstics.

MATERIALS AND METHODS

The present investigation was conducted during *Kharif*, 2014 at three different locations (Horticulture Farm, Department of Horticulture, Rajasthan College of Agriculture, Udaipur, Agricultural Research Station, Banswara and KVK Chittorgarh). Twelve inbred lines (female) of *Cucumis melo* were crossed with three testers of *Cucumis sativus* in line x tester mating design (Kempthorne,1957) to develop a total 36 hybrids at Hi-Tech Horticulture unit, Department of Horticulture, Rajasthan College of Agriculture,Udaipur. These 15 parents along with 36 hybrids and three standard checks (Mamta-5002, Sedona, Kakri surya prabha) were evaluated in randomized block design with three replications at three locations *viz*. Udaipur, Banswara and Chittorhgarh during *kharif* 2014. Lines and testers accessions were collected from NBPGR, New Delhi (Table 1). The observations were recorded for eighteen important characters namely vine length, number of branches per vine, days to anthesis of first female and male flower, number of male flower per vine, number of female flower per vine, sex ratio, number of fruits per vine, fruit weight fruit length, fruit volume, fruit diameter, pulp thickness, total yield per vine, pulp weight, seed weight (Table 2). Therefore, heterosis was calculated in favourable direction as percentage increase of F_1 performance over mid parent (MP), better parent (BP) and standard check or economic heterosis (EC) (Fonesca and Patterson,1968; Briggle,1963, respectively).

RESULTS AND DISCUSSION

There were highly significant amount of variability for parents in individual environment and pooled over the environments for all the characters in the experiment. This suggested that the parental lines selected were quite variable for most of the characters under study. The mean square due to crosses (F_1) were significant in individual environment and in pooled over the environments for all the characters. The results suggested that considerable amount of variability existed among the hybrids.

The *per se* performance was advocated by Genter and Alexander (1962) as one of the method useful in evaluating parents for heterosis breeding in cucumbers. The present study indicated that in general, the parents, hybrids and check varieties performed better in E_2 (Banswara) followed by E_1 (Udaipur) and E_3 (Chittorgarh).

In case of mean values for yield character along with quality traits on pooled basis in the experiment revealed that among the 12 parental lines L3 exhibited maximum value of total yield per vine (6.98 kg/vine) along with maximum value of fruit weight (1441.06 g), pulp weight (1656.37 g), and fruit length (24.26 cm). The parental line L7 exhibited maximum value of T.S.S. (6.68 %) along with maximum specific gravity (1.03 g/cc). Another parental line L11 exhibited maximum value of number of fruit per vine (11.98) with number of branches per vine (5.64), number of female flower per vine (31.49). Parental line L1exhibited maximum fruit diameter (14.89) along with maximum pulp thickness (23.84). Similarly among the testers, T_3 exhibited maximum values of total yield per vine (4.23 kg/vine), pulp weight (872.38 g), T.S.S (5.18 %), fruit volume (1354.22 g/cc), pulp thickness (20.12 mm), fruit diameter (8.00 cm), fruit weight(939.64 gm).while the tester T_2 exhibited minimum value of seed weight (128.77 g) and maximum number of fruit per vine (5.47). The range of mean performance of parents and heterotic crosses for all characters are presented in Table 2.

Among the hybrids, L3× T3 exhibited maximum value of yield per vine (7.73 kg) along with higher fruit weight (1385.67 g). The hybrid L3× T1 exhibited maximum value of pulp weight (1474.43 g) along with maximum value of pulp thickness (24.28 mm). Another hybrid L7× T1 exhibited maximum value of T.S.S (8.17 %), while the hybrid L11× T1

Table 1: description of parents

S.No	Symbol	Species Name	IC Number
A.	Lines (Female Parents)		
1.	L1	*C.melo var. momoradica*	IC-415539
2.	L2	*C.melo var. momoradica*	IC-415521
3.	L3	*C.melo var. momoradica*	IC-433621
4.	L4	*C.melo var. utilissimus*	IC-315294
5.	L5	*C.melo var. utilissimus*	IC-258163
6.	L6	*C.melo var. utilissimus*	IC-313031
7.	L7	*C.melo var. momoradica*	VRSM-44
8.	L8	*C.melo var. agrertris*	IC-258165
9.	L9	*C.melo var. momoradica*	VRSM-32
10.	L10	*C.melo var. momoradica*	DR/KPS/26
11.	L11	*C.melo*	BS-41
12.	L12	*C.melo var. momoradica*	VRSM-58
B.	Tester (Male Parent)		
1.	T1	*C.sativus*	SKY/DR/RS
2.	T2	*C.sativus*	SPP-58
3.	T3	*C.sativus*	SPP-56

Table 2: Grand Mean, Mean ± SE(m) and range of eighteen characters in parents and F1

Characters	GM	Parents		F_1s	
		Mean ± SE(m)	Range	Mean ± SE(m)	Range
Vine length	2.39	2.68 ± 0.09	1.53 – 3.66	2.31 ± 0.09	1.30 - 3.78
Number of branches	4.31	4.01 ± 0.20	3.04 - 5.64	4.41 ± 0.20	2.69 – 5.89
Days to anthesis of first male flower	37.28	35.40 ± 0.67	31.80 – 39.09	38.11 ± 0.67	34.31 – 42.47
Days to anthesis of first female flower	43.49	41.63 ± 0.81	38.73 – 46.56	44.37 ± 0.81	39.42 – 52.18
No. of male flower/vine	132.90	137.56 ± 2.27	92.38 – 197.93	131.31 ± 2.27	94.29 – 157.89
No. of female flower/vine	16.52	16.32 ± 0.70	7.78 – 31.49	16.54 ± 0.70	8.36 – 29.27
Sex ratio	9.17	9.67 ± 0.37	4.86 – 14.44	9.06 ± 0.37	5.10 – 16.72
Number of fruit/vine	5.45	5.47 ± 0.24	3.18 – 11.98	5.52± 0.24	2.96 – 11.98
Fruit weight	611.30	558.99 ± 26.63	140.61 – 1441.06	653.74 ± 26.63	133.47 – 1385.67
Fruit diameter	7.53	7.87 ± 0.28	3.28 – 14.89	7.66± 0.28	4.40 – 11.82
Fruit length	18.15	16.34± 0.58	6.94 – 24.26	18.64± 0.58	7.91 – 34.30
Pulp thickness	14.79	14.63 ± 0.49	5.79 – 23.84	15.13 ± 0.49	8.00 – 24.28
T.S.S	5.14	4.81 ± 0.11	3.73 – 6.68	5.26 ± 0.11	3.76 – 8.17
Fruit volume	736.03	688.04 ± 20.40	204.22 – 1675.33	779.07 ± 20.40	146.22 – 1935.11
Specific gravity	0.86	0.84 ± 0.03	0.72 -1.03	0.88 ± 0.03	0.71 – 1.03
Total yield/vine	3.26	2.93 ± 0.12	0.46 – 6.98	3.54 ± 0.12	1.04 – 7.73
Pulp weight	491.06	535.25 ± 16.62	158.61- 1656.37	495.07 ± 16.62	120.65 – 1474.43
Seed weight	120.16	126.18 ± 4.03	38.30 – 195.46	123.71 ± 4.03	34.96 – 226.91

Table 3: First five best hybrids identified on the basis of *per se* performance and economic heterosis on pooled basis for total yield per vine

S.No.	Hybrids	*Per se* performance for yield per vine (kg)	Economic heterosis (%)
1	L3× T3	7.73	10.75**
2	L3× T2	6.81	-
3	L2× T2	6.19	-
4	L12× T1	5.72	-
5	L3× T1	5.41	-
	Best check ' Mamta-5002'	2.60	-

exhibited minimum seed weight (34.96 g). On the basis of yield per vine five best highest yielding identified hybrids are *viz*., L3× T3, L3× T2, L2× T2, L12× T1, L3× T1 (Table 3).

The lowest value of days to anthesis, sex ratio and seed weight indicated better parents and hybrids having early flowering, higher female flowering and good fruit quality respectively.In the study of relative heterosis number of hybrids depicting significant negative heterosis for flowering related traits ranged from 18 (sex ratio) to 20 (number of male flower). For total yield per vine 17 hybrids showed positive significant heterosis. In case of plant type traits number of hybrids exhibited significant positive relative heterosis ranged from 5 (vine length) to 21 (number of branches). For quality traits number of hybrids exhibited significant positive relative heterosis ranged from 9 (pulp thickness) to 22 (T.S.S).

The majority of the hybrids exhibited positive significant relative heterosis, thereby indicating that for these traits the genes with positive effect were dominant. While for flowering characters and seed weight majority of the hybrids exhibited negative significant relative heterosis thereby indicating that for these traits the genes with negative effect were dominant. For other remaining traits variable number of hybrids depicted relative heterosis in both positive and negative direction, thereby indicating that the genes with negative as well as positive effects were dominant. The highest range of relative heterosis on pooled basis for eighteen characters presented in Table 4.The heterotic response over mid parent (relative heterosis) in cucumber was reported by Cramer and Wehner (1999), Airina *et al*. (2013) for yield and yield contributing characters as well as maturity traits. This was also reported by Sarkar and Sirohi (2010) in cucumber, Singh *et al*. (2013) in bitter gourd, Ramesh *et al*. (2014) in sesame, Pali and Mehta (2014) in Linseed and Spaldon *et al*. (2015) in chilli.

In the present study number of hybrids which exhibited significant positive heterobeltiosis over the environment for plant related traits ranged from 2 (vine length) to 11 (number of branches per vine). In case of yield related traits only 9 hybrids exhibited significant positive heterobeltiosis. For flowering traits only one hybrid gave significant negative heterobeltiosis for days to anthesis of first male flower and one hybrid for days to anthesis of first female flower. For quality traits, hybrids showing significant positive heterobeltiosis ranged from 2 (pulp thickness) to 13 (T.S.S). The highest range of significant heterobeltiosis on pooled basis for all the characters are presented in Table 4.

Significant heterobeltiosis in cucumber was observed for number of fruits per vine, yield per vine, fruit length and fruit girth by Airina *et al*. (2013). Significant heterobeltiosis over mid parent was observed by Behera *et al*. (2009) in bittergourd.

In case of economic heterosis for yield characters along with quality traits revealed that hybrid L3 × T3 exhibited maximum estimates of significant positive economic heterosis for total yield per vine (10.75 %) and hybrid L7× T1 for T.S.S (22.30 %) (Table 4).On the analysis of individual environment, it was found that highest estimates of positive significant economic heterosis for total yield per vine were exhibited by hybrid L2 × T2 in E_3 (29.87%),for number of fruits per vine by hybrid L11 × T3 in E_2 (29.80 %). Similarly the hybrid L7 × T1 exhibited economic heterosis in E_1 (20.59 %), in E_2 (20.59 %), in E_3 (25.26 %) and on pooled basis (22.30 %) for T.S.S. In case of fruit length maximum positive significant economic

Table 4: Highest heterosis, heterbeltiosis and economic heterosis identified in different crosses for eighteen traits on pooled basis

Characters	Het.	Hb.	EH.
Vine length (m)	L12xT3 (39.63**)	L12xT3 (26.39**)	-
No. of branches/vine	L5 xT3 (55.20**)	L5 xT3 (47.63**)	-
Days to anthesis of first male flower	-	-	-
Days to anthesis of first female flower	L9 xT3 (-5.44*)	-	-
Number of male flower per vine	L6 xT3 (19.09**)	-	-
Number of female flower per vine	L12x T3 (141.67**)	L12x T3 (132.52**)	-
Sex ratio (Male flower per female flower)	L10 xT3 (-13.31**)	L10 xT3 (-8.95*)	-
Number of fruit per vine	L2 x T2 (41.51**)	L2 x T2 (33.74**)	-
Fruit weight (g)	L5 x T2 (119.42**)	L5 x T2 (102.73**)	-
Fruit diameter (cm)	L5xT2 (46.49**)	L5x T2 (39.07**)	
Fruit length (cm)	L6 x T2 (117.22**)	L6 x T2 (90.47**)	L6 x T2 (41.39**)
Pulp thickness (mm)	L6 x T1 (48.13**)	L9x T1 (18.06**)	-
T.S.S (%)	L7 x T1 (46.85**)	L7 x T1 (22.30**)	L7 x T1 (22.30**)
Fruit volume (cc)	L5 x T1 (131.33**)	L5 x T1 (115.85**)	L3 x T3 (15.51**)
SG (W/V)g/cc	L12 x T3 (33.09**)	L12 x T3 (24.66**)	-
Total yield/ vine	L2 x T2 (89.78**)	L2 x T2 (81.96**)	L3 x T3 (10.75**)
Pulp weight(gm)	L5 x T2 (70.01**)	L5 x T2 (25.88**)	-
Seed weight (gm)	L11x T2 (-64.11**)	-	-

Table 5: Best three economic hybrids and parents identified on the basis of SCA/GCA effects, *per se* performance, heterosis and heterobeltiosis for total yield per vine, T.S.S and fruit length

Hybrid/Parent	SCA/GCA effects	*Per se* performance	Economic heterosis (%)	Heterosis (%)	Heterobeltiosis (%)	Traits
L3xT3	0.97**	7.73	10.75**	37.85**	10.75**	Total yield/vine
L7XT1	2.02**	8.17	22.30**	46.85**	22.30**	T.S.S
L6xT2	6.64**	34.30	41.39**	117.22**	90.47**	Fruit length
L3	3.11**	6.98				
L7	0.90**	6.68				
L6	8.78**	13.57				
T1	-0.01	4.44				
T2	0.23	18.01				
T3	0.11**	4.23				

heterosis was exhibited by hybrid L6 × T2 in E_1 (42.67 %), in E_2 (13.65 %), in E_3 (26.29 %) and on pooled basis (41.39 %) (Table 4).In case of fruit weight maximum positive significant economic heterosis was exhibited by hybrid L3× T3 in E_3 (15.07 %). This hybrid on pooled basis possessed 10.75 % economic heterosis for total yield per vine.for plant type trait hybrid L12× T3 showed highest positive significant economic heterosis for vine length (13.27 %) in E3 environment. This hybrid in E3 environment possessed 21.13 % economic heterosis for number of branches per vine.Similarly hybrid L5× T3 (30.99 %) exhibited economic heterosis for number of branches per vine E_3 environment.

Heterosis has been utilized in many crops, including cucurbits, to exploit dominance variance through the production of hybrids. In cucumber, Hayes & Jones (1916) first observed heterosis for fruit size and fruit number per plant. Others have reported heterosis for fruit yield in particular crosses of cucumbers (Rubino & Wehner, 1986; Hormuzdi & More, 1989). Ghaderi & Lower (1979a; 1979b) reported heterosis for fruit number per plot, fruit weight per plot, and average fruit weight for several crosses of cucumber.

Interspecific crosses between major *Cucurbita* species reported by Korakot *et al.*(2010) and Karaagac and Balkayab (2013). Traditional approaches for interspecific hybridization in *Cucumis* was reported by Fellner and Lebeda (1996), Bordas *et al.* (1998). Successful cross between cucumber and melon has been reported by Ruiter, (1973). Such hybridization would be important for transferring several resistance from *C.melo* or other wild *Cucumis* sp. to *C. sativus* (Lebeda, *et al.* 1996 and Lebeda *et al.* (1999).For developing hybrids with high yield potential, selection of desirable parents is essential. From the whole present work three superior hybrids L3x T3, L7x T1, L6x T2 were found which showes heterosis over mid parent over better parent and over standard check or economic heterosis on the basis of total yield per vine ,T.S.S and fruit length respectively (Table 5).

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