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ISSN: 0975-928X

Volume: 10

Number:1

EJPB (2019) 10(1):256-263

DOI:10.5958/0975-928X.2019.00029.2

Electronic Journal of Plant Breeding, 10(1): 248 – 255(Mar 2019) DOI: 10.5958/0975-928X.2019.00029.2
ISSN 0975-928X

Research Article

Evaluation for heterosis in okra (*Abelmoschusesculentus* L. Moench)

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(Received:19 Aug 2018; Revised:06 Mar 2019; Accepted:08 Mar 2019)

Abstract
The present investigation was conducted in okra to study the magnitude of heterosis and to identify potential parents and superior cross combinations for twelve plant traits including fruit yield and its component traits. Forty five F_1s were developed by crossing 10 elite lines of okra in half diallel fashion during summer 2016. All 45 F_1s along with their 10 parents and one standard check (Nunhems hybrid Shakti) were evaluated in a randomized complete block design with three replications during late *kharif* (July to October) 2016 at ICAR- KrishiVigyan Kendra, Babbur Farm, Hiriyur, Chitradurga, Karnataka. The results revealed wide range of heterotic pattern for different traits. For first fruit producing node, heterosis over standard control ranged from -9.03 to 43.32, respectively. For days to 50% flowering, heterosis over standard control ranged from -8.70 to 0.72, respectively and for total yield per plant, heterosis over standard control ranged from -0.13 to 168.55,respectively.The overall maximum positive significant heterosis for total yield per plant was observed in cross IIHR-875 x IIHR-478 (168.55%) over standard heterosis. Negatively heterotic crosses like IIHR-562 x IIHR-444 for days to 50% flowering (-8.70%) and IIHR-567 x IIHR-107 for fruiting nodes (-9.03%) respectively, are important to exploit heterosis for earliness in okra. Out of 45 F_1s, 44 F_1s crosses exhibit significant standard heterosis in any given direction for total yield per plant except cross IIHR-604 x IIHR-107 (-0.13%). The F_1 hybrid IIHR-875 x IIHR-478 with high yield potential has the potential for commercial cultivation after further evaluation for late *kharif* season of Karnataka.

Keywords
Abelmoschusesculentus, Mean performance, Standard Heterosis, Half diallel

Introduction

Okra (*Abelmoschusesculentus*L. Moench), is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. It is quite popular in India because of easy cultivation, dependable yield and adaptability to varying moisture conditions. Tender okra fruits are used as vegetable in India, Brazil, West Africa and many other countries. It is also available in dehydrated and canned forms. Okra has tremendous export potential as fresh vegetable. The term heterosis refers to a phenomenon in which F_1 shows increase or decrease vigor over the parents. Shull, 1908 referred to this phenomenon as the stimulus of heterozygosity. The occurrence of heterosis is common in plant species, but its level of expression is highly variable. Hybrid vigor in okra has been first reported by Vijayaraghavan and Warier, 1946. A high yielding genotype may or may not transmit its superiority to its progenies. Therefore, the success of a breeding programme is determined by useful gene combinations in the form of high combining inbred. For exploitation of heterosis, choice of suitable parents is an important pre-requisite. Selection of parents on the basis of phenotypic performance alone is not a sound procedure. It is therefore essential that parents should be chosen on the basis of their combining ability. The half diallel mating design has been used in the present study to assess the genetic potentialities. The magnitude of heterosis provides a basis for genetical diversity and a guide for the choice of desirable parents for developing superior F_1 hybrids to exploit hybrid vigour and for building gene pools to be employed in future breeding programme. Keeping this in view, the present investigation was carried out to know the magnitude of heterosis for fruit yield and its component traits in okra.

Materials and Methods

The experimental materials comprised of ten elite and nearly homozygous lines of okra namely,IIHR -875, IIHR -478, IIHR- 604, IIHR- 567, IIHR- 182, IIHR- 595, IIHR- 562, IIHR- 347, IIHR- 444, IIHR-107 selected from the germplasm collected by ICAR-Indian Institute of Horticulture Research Institute, Bengaluru, Karnataka and were crossed inhalf diallel fashion i.e., n(n - 1)/2 possible combinations during summer 2016 to generate the breeding material. The resulting 45 one way crosses along with their 10 counterpart parental lines and one standard check (Nunhems Hybrid Shakti) were evaluated in a randomized complete block design with three replicates. The experiment was conducted at the Experimental Farm, ICAR-KrishiVigyan Kendra, Babbur Farm, Hiriyur, Chitradurga, Karnataka. The experiment was conducted during late *kharif*(July-October) 2016. The experimental site is situated in Central dry zone (Zone-4) 13°57'32" North latitude and 70°37'38" East longitude at 606 meters above Mean Sea Level (MSL). Among the agro-climatic zones of Karnataka, Hiriyur benefits of both South-West and North- East monsoons. The annual average rainfall for last 35 years is 567 mm per year. The maximum and minimum temperature in a year ranges between 31.49 °C and 20.91 °C, respectively. The annual relative humidity of location is 77.76 per cent and 61.74 per cent in morning and evening, respectively. The soil type of the experimental block was sandy clay loamy (montmorillonite) with a uniform fertility having soil pH range of 7.0 to 8.0. The experimental plots were ploughed repeatedly and land was brought to a fine tilth. Raised beds with inline drip and plastic mulching developed at 90 x 10 x 30 cm. Two to three seeds of each genotype per hill were dibbled at a distance of 15 cm apart and 60 cm between rows on the beds. Biometric data were recorded for 12 quantitative characters. The following observations were recorded on the five plants chosen at random in each genotype and in each replication on the characters like plant height (cm), number of branches per plant, internodal length (cm), stem girth (mm), first fruit producing node, fruit length (cm), fruit diameter (mm), number of ridges per fruit and average fruit weight (g) were recorded on five randomly selected competitive plants, while the observations on the characters like days to 50% flowering, total number of fruits per plant and total yield per plant (g) were recorded on whole plot basis in each entry in each replicate.Standardheterosis was determined as percent increase (+) or decrease (-) of F1 over standard control (SC) using the formula (F1-SC/SC × 100). The statistical significance of standard heterosis was assessed by t-test.

Results and Discussion

From the present investigation the mean performance of the genotypes, it is evident that, in general, the mean values of crosses were desirably higher than those of the parents (Table 1) for internodal length number of branches per plant, first fruit producing node, days to 50% flowering fruit length, fruit diameter, average fruit weight, total number of fruits per plant and total yield per plant. On other hand, the mean values of crosses were desirably lower than those of the parents for plant height and stem girth. In general, the range of mean values of parents as a whole was highest for total yield per plant (357.53 to 536.50 g) followed by plant height (103.93 to 166.30 cm), number of fruits per plant (24.00 to 30.66). Similarly, the range of mean values of crosses as a group was highest for total yield per plant (336.33 to 904.40) followed by plant height (96.27 to 164.43 cm), number of fruits per plant (22.00 to 45.67). The range of mean performance of 10 parental lines and their 45 cross combinations are presented in Table 1. Plant height among the parents and crosses varied from 103.93 to 166.30 and 96.27 to 164.43cm, respectively. Internodal length varied from 9.20 to 12.39 and 9.23-13.33 cm among the parents and crosses, respectively. Number of branches per plant among the parents and crosses varied from 2.20 to 4.21 and 2.20 to 4.35, respectively. Stem girth varied from 18.55 to 24.33and 17.92 to 26.89 mm among the parents and crosses, respectively. First fruit producing node among the parents and crosses varied from 4.53 to 6.99 and 5.10 to 8.04, respectively. Days to 50% flowering varied from 44.00 to 45.66 and 42.00 to 46.33 among the parents and crosses, respectively. Fruit length among the parents and crosses varied from 11.78 to15.05 and 11.07 to 16.81 cm, respectively. Fruit diameter varied from 17.54 to 21.59 and 16.31 to 21.33 mm among the parents and crosses, respectively. Average fruit weight among the parents and crosses varied from 13.10 to18.83 and 13.06 to 21.66 g, respectively. No. of ridges per fruit varied from 5.03 to 5.86 and 5.00 to 6.10 among the parents and crosses, respectively.No. of fruits per plant among the parents and crosses varied from 24.0 to 30.66 and 22.00 to 45.67, respectively. Yield per plant varied from 357.53 to 536.50and 336.33 to 904.40 g among the parents and crosses, respectively.

The range of heterosis and the number of crosses displaying significantly positive and negative heterosis over standard control (Nunhems hybrid Shakti) are presented in Table 1. There was huge amount of variation in heterotic effects as they varied differently for different characters. For plant height, heterosis over standard control ranged from -23.82 to 30.12. For this trait, 36 cross over standard control manifested significantly positive heterosis. Heterosis over standard control ranged from -19.79 to 15.91 for internodal length. For internodal length 11 cross over standard control manifested significantly negative heterosis. For number of branches per plant, standard control ranged from -35.64 to 26.97. For this trait, four cross over standard control manifested significantly positive heterosis. For stem girth, heterosis over standard control ranged from -14.57 to 28.23. For this trait, 18 cross over standard control manifested significantly positive heterosis. For first fruit producing node, heterosis overstandard control ranged from-9.03 to 43.32. For this trait, six cross over standard control manifested significant heterosis in desirable direction (negative). For days to 50% flowering, heterosisover standard control

Electronic Journal of Plant Breeding, 10(1): 248 – 255(Mar 2019) DOI: 10.5958/0975-928X.2019.00029.2
ISSN 0975-928X

ranged from -8.70 to 0.72. For this trait, nine cross over standard control manifested significantly negative heterosis. For fruit length, heterosisoverstandard control ranged from-25.24 to 13.53. For this trait, five cross over standard control manifested significantly positive heterosis. For fruit diameter, heterosis over standard control ranged from -16.77 to 11.90. For this trait, four cross over standard control manifested positively significant heterosis. For average fruit weight, heterosis over standard control ranged from -15.39 to 42.25. For this trait,26 cross over standard control manifested significantly positive heterosis. For number of ridges per fruit, heterosisover standard control ranged from -3.85 to 17.31 respectively. For this trait, eight cross over standard control manifested significantly positive heterosis.

For number of fruits per plant, heterosisover standard control ranged from -4.35 to 98.55 respectively. For this trait, 42 cross over standard control manifested significantly positive heterosis. For total yield per plant, heterosisover standard control ranged from -0.13 to 168.55. For this trait, 44 cross over standard control manifested positively significant heterosis. From the results of the heterosis studies, it is evident that none of the 45 F_1 hybrids of okra showed consistency in direction and degree of heterosis over three bases for all the characters studied. Some of them manifested positive heterosis while others exhibited negative heterosis, mainly due to varying extent of genetic diversity between parents of different cross combinations for the component characters. Significant heterosis was observed for all the growth, earliness and yield attributes. It is inferred that the magnitude of economic heterosis was higher for most of the growth and earliness characters under study. In the present study, the estimates standard heterosiswas found to be highly variable in direction and magnitude among crosses for all the characters under study. Weerasekara *et al*. (2007) and Jindal *et al*. (2009) also reported such a variation in heterosis for different characters. The manifestation of negative heterosis observed in some of the crosses for different traits may be due to the combination of the unfavorable genes of the parents.

Of the 12 characters under study, plant height, number of branches per plant and internodal length largely determine the fruit bearing surface and thus considered as growth attributes. Okra bears pods at almost all nodes on main stem and primary branches. Higher the plant height with more number of branches on the main stem, higher is the number of fruits per plant because of accommodation of more number of nodes for a given internodal length. Shorter distance between nodes accommodates more number of nodes on main stem, which will ultimately lead to higher fruit number and higher fruit production. Hence, positive heterosis is desirable for plant height and number of branches, while negative heterosis is desirable for internodal length to accommodate more number of nodes and to get higher fruit yield in okra. Appreciable amount of the crosses displayed positive standard heterosis for plant height (up to 30.12%), no. of branches per plant (up to 26.97%), internodal length (up to -19.79%). Ahmed *et al*. (1999), Dhankar and Dhankar (2001) and Rewale*et al*. (2003), Singh *et al*. (2004), Weerasekara*et al*. (2007) and Jindal *et al*. (2009) also reported the similar projections for number of branches in okra. For internodal length, similar projections were also made by Rewale*et al*. (2003), Singh *et al*. (2004), and Jindal *et al*. (2009).

In present investigation 45 F_1 hybrids were evaluated using half diallel analyses with one commercial check hybrid (Nunhems hybrid Shakti). Significant variation has been observed among treatments. The interaction like parents vs. hybrids showed significant differences for most of the characters except for indicated that the selected material was appropriate for the study of manifestation of heterosis and gene effects involved in inheritance of different traits and presented in Table 2 and Fig.1.

However, days to 50% flowering and first fruit producing node are the indicators of earliness in okra. Early flowering not only gives early pickings and better returns but also widens fruiting period of the plant. Fruiting at lower nodes is helpful in increasing the number of fruits per plant as well as getting early yields. Negative heterosis is highly desirable for all these three attributes of earliness. In the present study, cross IIHR-562 x IIHR-444 exhibiting high negative heterosis over standard control for days to 50% flowering (-8.70%) out of 45 hybrids, 9 hybrids showed significant heterosis in desirable direction (negative) over standard parent.The cross IIHR-567 x IIHR-107 (Table-2) displaying high negative heterosis over standard control for first fruit producing node (-9.03%) among the 45 hybrids developed, 6 hybrids over standard parent showed significantly negative heterosistherefore, it is important to exploit heterosis for earliness in okra. Weerasekara*et al*. (2007) and Jaiprakashnarayan*et al*. (2008) also noticed heterosis in desirable direction for days to 50% flowering in okra. The negative estimates of heterobeltiosis and economic heterosis for earliness revealed the presence of genes for the development of earliness in okra. Singh *et al*., 2012, Mandal and Das (1991), Tippeswamy*et al*. (2005) and Jindal *et* *al*. (2009) also noticed desirable heterosis for first fruit producing node in okra.

Total number of fruits per plant and fruit length, width, and weight are considered to be associated directly with total yield per plant, for which positive heterosis is desirable. The trait fruit length exhibit high magnitude significant heterosis in both the direction of standard parent. Maximum positive and significant heterosis over standard parent (13.53%) was observed in crosses IIHR-478 x IIHR-567. Among 45 hybrids developed, 5 hybrids over standard parent exhibited positive and significant heterosis. The trait fruit diameter exhibit high magnitude significant heterosis in standard parent. The cross IIHR-478 x IIHR-444 exhibited maximum positively significant heterosis over standard parent (11.90%). Out of 45 hybrids, 4 hybrids showed positive and significant heterosis over standard parent. The trait average fruit weight exhibit high magnitude significant heterosis in both the direction of standard parent. Positively significant heterosis is preferred for this trait. The cross IIHR-478 x IIHR-567 showed maximum significant heterosis over standard parent (42.25%). Among 45 hybrids, 26 hybrids over standard parent exhibited significant positive heterosis (Table-2). Similar results were also reported by Ahmed *et al*. (1999), Weerasekara*et al*. (2007) and Jaiprakashnarayan*et al*. (2008) in okra.

The magnitude of heterosis for number of fruits per plant was significant in both the direction, where only positive direction was seen in standard parent. Maximum positive significant heterosis was observed in cross IIHR-875 x IIHR-478 (98.55%) over standard parent. Majority of crosses exhibits positive and significant heterosis. Out of 45 hybrids, 42 hybrids over standard parent exhibited positive and significant heterosis. The magnitude of heterosis for total yield per plant was significant in both the direction, where maximum positive direction was seen in standard parent. Maximum positive significant heterosis was observed in cross IIHR-875 x IIHR-478 (168.55%) over standard parent. Majority of crosses exhibits positive and significant heterosis. Out of the 45 hybrids, 44 hybrids over standard parent exhibited positive and significant heterosis. Similar results were also reported by Singh *et al*. (2012),Solankey and Singh, (2010), Sheela*et al*. (1998), Kumbhani*et al*. (1993) and Shukla and Gautam, (1990). The heterosis observed for total yield per plant was attributed to the heterosis exhibited for growth, earliness and yield parameters. As there is significant genotypic association between yield and yield parameters like fruit length, average fruit weight and number of fruits per plant. Heterosis observed for these component characters have greatly contributed for higher magnitude of heterosis observed for total yield. However, for exploitation of heterosis the information on gca should be supplemented with sca and hybrid performance.

On an average, okra displays heterosis for yield and its component traits studied. However, for each trait important differences exist among hybrids for the individual values of heterosis. Yield components should be considered to increase the yield through selections. The overall maximum positive significant heterosis for total yield per plant was observed in cross IIHR-875 x IIHR-478 (168.55%) over standard heterosis. Negatively heterotic crosses like IIHR-562 x IIHR-444 for days to 50% flowering (-8.70%) and IIHR-567 x IIHR-107 for fruiting nodes (-9.03%) respectively, are important to exploit heterosis for earliness in okra. The F_1 hybrid IIHR-875 x IIHR-478 with high yield potential has the potential for commercial cultivation after further evaluation for late *kharif* season of Karnataka.

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Electronic Journal of Plant Breeding, 10(1): 248 – 255(Mar 2019) DOI: 10.5958/0975-928X.2019.00029.2
ISSN 0975-928X

Table 1.Range, mean of parents, crosses and range of standard heterosisin okra

	Parents		Crosses		Control mean	Range of Standard Heterosis (%)	No. of positive heterotics
	Range	Mean	Range	Mean			
Plant height (cm)	103.93-166.30	144.13	96.27-164.43	140.50	129.67	-23.82 to 30.12	36
Inter nodal length (cm)	9.20-12.39	11.18	9.23-13.33	11.21	12.33	-19.79 to 15.91	5
No. of branches per plant	2.20- 4.21	2.88	2.20-4.35	3.06	3.00	-35.64 to 26.97	4
Stem girth (mm)	18.55- 24.33	21.41	17.92- 26.89	21.27	20.94	-14.57 to 28.23	18
First fruit producing node	4.53- 6.99	5.78	5.10- 8.04	6.05	5.67	-9.03 to 43.32	26
Days to 50% flowering	44.00- 45.66	44.80	42.00- 46.33	44.87	45.00	-8.70 to 0.72	-
Fruit length (cm)	11.78- 15.05	13.25	11.07- 16.81	13.71	14.84	-25.24 to 13.53	5
Fruit diameter (mm)	17.54- 21.59	18.55	16.31- 21.33	18.57	19.67	-16.77 to 11.90	4
Average fruit weight (g)	13.10- 18.83	15.79	13.06- 21.66	16.88	19.40	-15.39 to 42.25	26
No. of ridges per fruit	5.03-5.86	5.22	5.00- 6.10	5.22	5.00	-3.85 to 17.31	8
No. of fruits per plant	24.00- 30.66	28.27	22.00- 45.67	31.50	34.00	-4.35 to 98.55	42
Yield per plant (g)	357.53- 536.50	452.99	336.33- 904.40	543.74	564.40	-0.13 to 168.55	44

*, **Significant at 5 % and 1 % levels probability, respectively.

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ISSN 0975-928X

Table 2.Estimation of standard heterosis of 10 X 10 half diallel crosses in okra for different characters

Sl. No.	Crosses	Plant height (cm)	Inter nodal length (cm)	No. of branches per plant	Stem girth (mm)	First fruit producing node	Days to 50% flowering	Fruit length (cm)	Fruit diameter (mm)	Average fruit weight (g)	No. of ridges per fruit	No. of fruits per plant	Yield per plant (g)
1	875 x 478	15.83 **	-10.55 *	20.06 **	3.16	21.33 **	-0.72	-0.88	-3.52	25.88 **	-1.92	98.55 **	168.55 **
2	875 x 604	30.12 **	-14.72 **	21.32 **	10.71 **	43.32 **	-0.72	-0.79	-3.21	16.02 **	7.05 **	52.17 **	80.14 **
3	875 x 567	28.81 **	15.91 **	2.92	10.78 **	17.05 **	-1.45	-13.94 **	5.68 *	23.69 **	-1.28	34.78 **	73.80 **
4	875 x 182	24.27 **	-1.48	-2.82	1.49	13.07 **	-1.45	-14.90 **	-4.73*	1.14	8.33 **	30.43 **	38.12 **
5	875 x 595	27.20 **	-11.10 **	-9.15	4.72 *	13.78 **	-0.72	0.83	6.19 **	20.18 **	3.85 *	39.13 **	82.04 **
6	875 x 562	23.45 **	10.40 *	19.08 **	5.45 *	27.99 **	-1.45	-1.22	-4.39	16.68 **	16.67 **	20.29 **	49.99 **
7	875 x 347	25.72 **	-4.46	-9.15	5.79 *	38.03 **	-1.45	-17.60 **	-9.93 **	-11.78 **	-1.92	95.65 **	77.61 **
8	875 x 444	8.34 **	-6.49	-20.35 **	3.50	9.09 **	-6.52 **	-14.48 **	-3.16	2.89	1.28	36.23 **	46.70 **
9	875 x 107	11.69 **	14.00 **	-14.61 *	2.48	-4.16	-0.72	5.27	-2.87	8.14 **	* 0.64	43.48 **	61.55 **
10	478 x 604	23.08 **	3.94	-33.79 **	14.78 **	-4.58	-2.17	-1.96	-16.77 **	13.94 **	-0.64	37.68 **	71.23 **
11	478 x 567	12.90 **	5.27	-8.57	-2.07	13.07 **	-1.45	13.53 **	10.94 **	42.25 **	-1.92	78.26 **	159.53 **
12	478 x 182	20.26 **	-8.35	-1.27	5.63 *	7.55 *	-1.45	-1.19	-3.44	28.11 **	-1.28	34.78 **	83.45 **
13	478 x 595	15.88 **	14.00 **	-29.60 **	-0.60	-1.96	0.00	1.33	-7.62 **	26.53 **	-0.64	36.23 **	83.56 **
14	478 x 562	19.15 **	7.74	-8.57	15.27 **	8.50 **	-2.17	-2.43	-3.64	10.11 **	* 0.64	73.91 **	95.62 **
15	478 x 347	22.32 **	14.81 **	-26.29 **	-1.59	15.81 **	-2.17	9.21 **	-7.35 **	22.18 **	-3.21	26.09 **	58.77 **
16	478 x 444	-0.58	-13.74 **	-27.26 **	3.10	-4.10	-2.17	-11.21 **	11.90 **	25.04 **	17.31 **	13.04 **	50.76 **
17	478 x 107	23.56 **	6.26	-18.70 **	4.96 *	-1.37	-0.72	6.71 *	-2.94	20.05 **	0.00	33.33 **	74.18 **
18	604 x 567	14.19 **	3.97	-24.44 **	14.35 **	8.97 **	0.00	-8.31 **	-7.35 **	15.61 **	-3.21	36.23 **	59.16 **
19	604 x 182	10.13 **	-10.32 *	-16.16 **	-6.99 **	15.39 **	-0.72	6.10 *	0.37	36.14 **	-1.28	8.70 **	58.43 **
20	604 x 595	-6.38 **	2.32	-20.25 **	-14.57 **	-5.29	-5.80 **	-12.27 **	-15.34 **	13.70 **	-1.92	17.39 **	43.83 **
21	604 x 562	2.22 **	-4.72	-20.35 **	-5.91 *	13.19 **	0.00	0.14	-3.95	2.45	3.21	26.09 **	30.38 **
22	604 x 347	17.30 **	4.23	-19.86 **	1.35	9.69 **	-1.45	-0.23	-8.28 **	20.45 **	-1.92	85.51 **	133.05 **
23	604 x 444	-23.82 **	0.49	-32.42 **	4.72 *	-1.96	-2.9	-16.21 **	-14.35 **	-3.02	0.00	14.49 **	7.28 *
24	604 x 107	3.51 **	-5.07	-35.64 **	-8.07 **	-6.12	0.00	-10.42 **	-4.42 *	3.46	3.21	-4.35	-0.13
25	567 x 182	2.61 **	-12.05 **	-8.47	0.17	9.27 **	-0.72	-11.55 **	-4.52 *	3.42	* 0.64	13.04 **	20.40 **
26	567 x 595	24.82 **	2.09	-11.78 *	4.78 *	28.10 **	0.72	-14.52 **	-1.87	5.58	* 0.64	23.19 **	33.14 **
27	567 x 562	15.67 **	-11.71 **	-6.52	1.45	12.54 **	-5.80 **	-21.52 **	-13.37 **	-13.44 **	-1.28	47.83 **	37.91 **
28	567 x 347	14.59 **	-9.10 *	-1.27	6.01 *	16.58 **	-7.97 **	-8.58 **	-12.76 **	10.99 **	-1.28	26.09 **	46.96 **
29	567 x 444	1.58 *	-4.93	-20.06 **	14.02 **	10.04 **	-7.97 **	-10.60 **	-6.36 **	15.78 **	-1.92	47.83 **	77.46 **
30	567 x 107	-2.16 **	-7.27	-27.65 **	4.93 *	-9.03 **	-8.70 **	-11.37 **	0.48	-4.93	-1.92	50.72 **	57.39 **
31	182 x 595	7.41 **	5.51	-25.22 **	-12.32 **	-8.38 **	-2.17	8.69 **	-8.03 **	28.61 **	-0.64	2.90	36.65 **
32	182 x 562	14.03 **	0.23	9.35	-1.51	11.88 **	-2.90	-25.24 **	-11.58 **	-14.23 **	-1.92	44.93 **	23.87 **
33	182 x 347	6.25 **	-5.33	26.97 **	4.42	16.52 **	-1.45	-13.67 **	-9.61 **	0.48	0.00	73.91 **	86.90 **
34	182 x 444	-11.98 **	-7.39	-13.34 *	-13.11 **	2.50	-2.90	-12.76 **	-3.78	-13.49 **	-1.28	21.74 **	17.28 **
35	182 x 107	15.88 **	-2.52	-2.34	-0.68	11.11 **	-1.45	-15.33 **	-7.24 **	10.18 **	-1.92	26.09 **	47.25 **
36	595 x 562	14.64 **	-15.71 **	-1.66	14.08 **	14.85 **	-0.72	-10.36 **	-7.47 **	3.35	0.00	30.43 **	37.34 **
37	595 x 347	18.04 **	-1.01	10.03	28.23 **	12.60 **	-8.70 **	-5.18	-0.70	1.38	-2.56	37.68 **	45.90 **
38	595 x 444	0.90	-7.48	-29.60 **	-8.06 **	-4.16	0.72	-8.17 **	-1.38	16.86 **	-0.64	30.43 **	54.30 **
39	595 x 107	22.63 **	-0.49	-13.34 *	5.36 *	-6.36 *	-2.17	-10.83 **	-0.10	3.06	-1.92	56.52 **	64.25 **
40	562 x 347	15.06 **	2.03	-7.50	-7.49 **	2.26	0.00	-18.21 **	-14.29 **	-15.39 **	-1.28	43.48 **	22.21 **
41	562 x 444	-9.81 **	-19.79 **	-16.55 **	-14.02 **	-7.01 *	-8.70 **	-7.00 *	-8.20 **	-9.04 **	-1.28	52.17 **	38.32 **
42	562 x 107	11.92 **	-7.62	1.95	0.11	10.22 **	-4.35 *	-9.88 **	-6.14 **	-0.53	0.00	31.88 **	30.08 **
43	347 x 444	-3.30 **	-3.51	1.95	-12.79 **	-7.13 *	-2.90	-4.73	-4.68 *	37.39 **	-3.85 *	18.84 **	58.32 **
44	347 x 107	6.33 **	-5.82	-0.39	-9.44 **	1.01	-1.45	-24.18 **	-16.63 **	15.85 **	-1.92	4.35	25.55 **
45	444 x 107	-11.13 **	-15.01 **	-27.17 **	-13.54 **	-8.32 **	-2.90	-13.26 **	-5.29 *	25.37 **	-3.21	10.14 **	46.29 **
	S.E.D	**0.92**	**0.48**	**0.20**	**0.49**	**0.17**	**0.79**	**0.42**	**0.43**	**0.44**	**0.10**	**0.76**	**10.28**
	C.D. 0.05	**1.86**	**0.97**	**0.39**	**0.99**	**0.35**	**1.60**	**0.85**	**0.86**	**0.89**	**0.20**	**1.52**	**20.71**
	C.D. 0.01	**2.42**	**1.28**	**0.51**	**1.29**	**0.45**	**2.08**	**1.11**	**1.12**	**1.15**	**0.26**	**1.99**	**26.95**

*, **Significant at 5 % and 1 % levels probability, respectively.

Electronic Journal of Plant Breeding, 10(1): 248 – 255(Mar 2019) DOI: 10.5958/0975-928X.2019.00029.2
ISSN 0975-928X

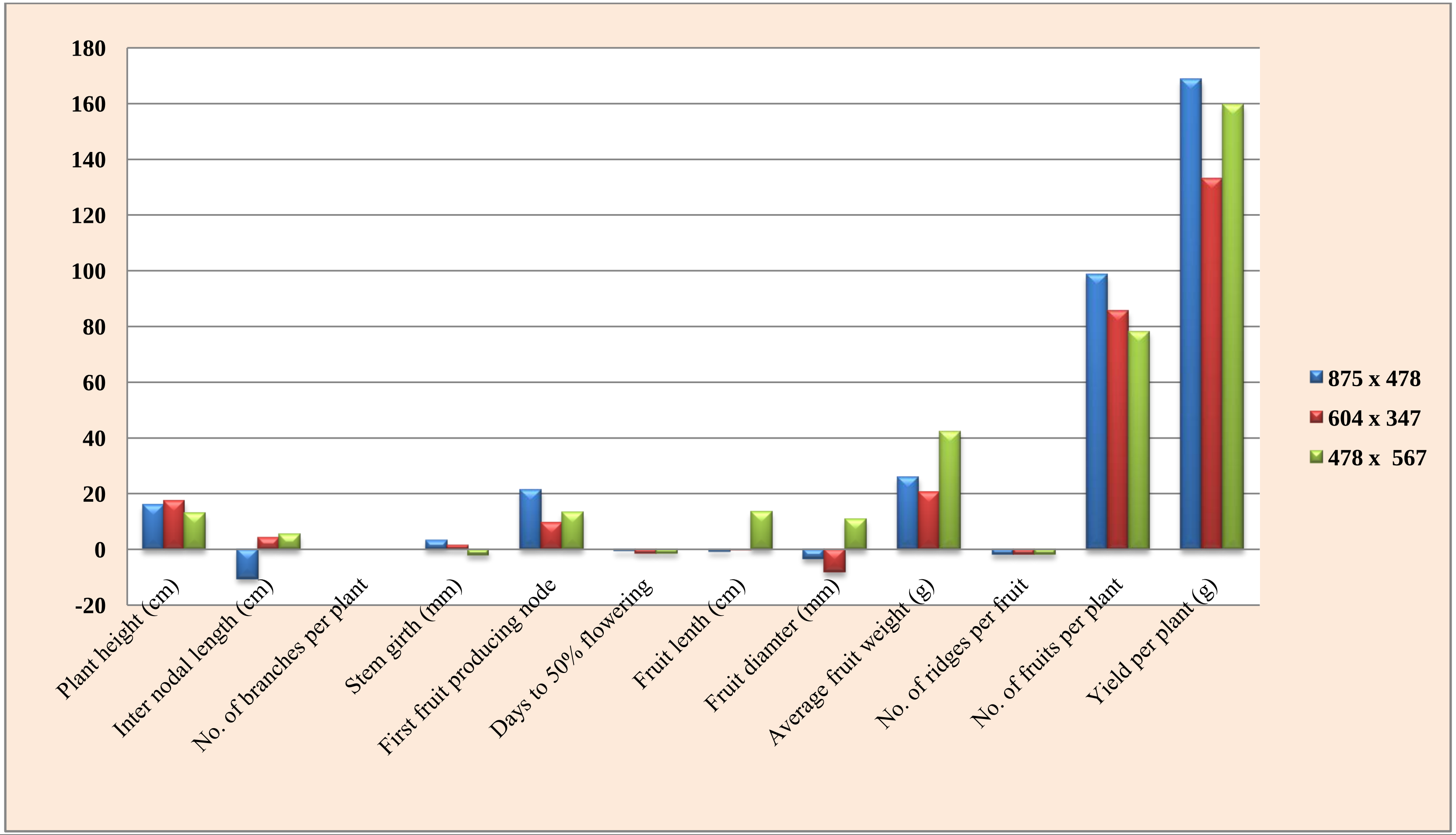

Fig. 1.*Per cent* standard heterosis of top three hybrids IIHR-875 x IIHR-478, IIHR-604 x IIHR-347 and IIHR-478 x IIHR-567 for 12 characters studied

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