International Journal of Bio-resource and Stress Management 2016, 7(3):432-436 DOI: HTTPS://DOI.ORG/10.23910/IJBSM/2016.7.3.1342

Short Research Article

Studies of Heterosis in Cashew (*Anacardium occidentale* L.)

Kabita Sethi*, P. C. Lenka, P. Tripathy, S. K. Mukherjee and A. K. Dash

All India Coordinated Research Project on Cashew, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, India

Article History

Manuscript No. AR1342
Received in 11st August, 2015
Received in revised form 27th May, 2016
Accepted in final form 5th June, 2016

Correspondence to

E-mail: kabita2273@yahoo.com

Keywords

Nut weight, kernel weight, nut yield, relative heterosis, heterobeltiosis and standard heterosis

Abstract

Cashew (*Anacardium occidentale* L.) is one of the most important export earning crops of India occupying an area of 9.82 lakh h with a production of 7.28 lakh t. Although India is the largest producer and exporter of cashew in the world, but the productivity is very low, only 722 kg ha^{-1} as compared to other countries, which is primarily due to seedling progeny of poor genetic stock. Being a highly cross pollinated crop, developing hybrids exhibiting heterosis for important economic characters is one of the ways to enhance the productivity. The present investigation is an attempt to study the extent of heterosis exhibited by certain better promising hybrids which were under taken at All India Coordinated Research Project on Cashew operating under Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, India. The study was conducted to determine the extent of heterosis exhibited by twenty F_1 cashew hybrids of ten year old selected plants, based on their superior performance. The results indicated that the hybrid namely A-71, B-27, C-30 and C-41 exhibited better heterosis in terms of nut weight (-0.27 to 19.68%), kernel weight (18.89 to 32.26%) and overall nut yield (15.51 to 30.70%) than rest of the tested hybrids. The relative heterosis, heterobeltiosis and standard heterosis among these superior hybrids varied from 85.71 to 94.88%, 57.33 to 65.85% and 15.51 to 30.70%, respectively. Hence, these hybrids may be recommended for cultivation to increase production and productivity of cashew under coastal agro-climatic condition of East coast.

1. Introduction

Cashew (*Anacardium occidentale* L.) is an important export earning nut crop of tropical nature. Although the crop was introduced to India by Portuguese from Brazil as a crop for afforestation and soil conservation purpose, but due to multifarious uses by each part of the plant, it is now known as "wonder nut" of the world. Although our country enjoys largest area and production in the world but from productivity point of view, Indian cashew suffers a lot. The average productivity of Indian cashew is only 772 kg ha^{-1}, quite low as compared to other growing countries of the world (Saroj et al., 2014). Practically a number of factors contribute towards low production and productivity of Indian cashew, primary factor being cultivation of seedling progenies and old as well as senile plantation in majority of the cashew growing areas in India. Low productivity of cashew can be addressed by developing superior cashew types with desirable traits through crop breeding programme.

Basically, cashew is a highly cross pollinated crop and heterozygous in nature, as a result large variations exhibited in nut yield, nut characters and other tree growth characters (Nawale and Salvi, 1990). Due to presence of large variations in the population, crop improvement through breeding programme can be effectively done in cashew. There is also existence of high degree of relative heterosis, heterobeltiosis as well as standard heterosis in cashew indicating the effectiveness and possible improvement of the character which may ultimately lead to yield improvement in the crop (Manoj and George, 1993; Shankarnarayan, 1996).

Exploitation of heterosis and estimation of different aspects of heterosis play a very crucial role in the development of potential hybrid and subsequent popularization among the growers will make considerable head way in enhancing not only the production but also productivity and quality of cashew to a satisfactory level. The present investigation is an attempt to study the extent of heterosis exhibited by certain better performing hybrids of cashew.

2. Materials and Methods

Ten year old, twenty F_1 cashew hybrids (one plant from each

hybrid) were selected based on their superior phenotypic performance, planted at Cashew Research Station of All India Coordinated Research Project on Cashew operating under Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, India for the present study. The hybrids along with their parents were planted at a spacing of 4×4 m^2 by adopting the recommended package of practices uniformly to raise a good crop. The selected hybrids were evaluated based on heterosis over mid parent (Relative heterosis), better parent (Heterobeltiosis) and standard variety (Standard heterosis) for the yield attributing characters like nut yield $tree^{-1}$, nut weight (g) and kernel weight (g) using the following formulae suggested by Hayes et al. (1963).

$$\text{Relative heterosis} = \frac{\text{F1-MP}}{\text{MP}} \chi\ 100$$

$$\text{Heterobeltiosis} = \frac{\text{F1-BP}}{\text{BP}} \chi\ 100$$

$$\text{Standard heterosis} = \frac{\text{F1-CV}}{\text{CV}} \chi\ 100$$

Where F_1, BP and CV denote average performance of F_1 hybrid, better parent and check/standard variety (BPP-8, as standard variety in the present study), respectively while MP denote as mid parent value. Data on yield and yield attributing traits for the year 2011 and 2012 were analyzed following

Table 1: Details of sources of parents used in study

Sl. no.	Name of the parents	Source of collection	Hybrids	Parents combinations
1.		Ranasinghpur	A series	RP1×Kalyanpur
	RP-1 and RP-2	Bhubaneswar,Odisha		bold nut
2.	Kalyanpur	Kalyanpur, Khurda, Odisha	B series	RP1×VTH 711/4
				bold nut
3.	Kankady	RFRS, Vengurla, Maharastra	C series	RP2×Kankady
4.		RRS, Vridhachalam, Tamil Nadu	D series	M44/3×VTH 711/4
5.		DCR, Puttur, Karnataka		

Table 2: Heterosis for nut yield (kg $tree^{-1}$) of cashew hybrids

Sl. no.	Hybrid no.	Nut yield $tree^{-1}$ (kg)					Relative heterosis (%)	Heterobeltiosis (%)	Standard heterosis (%)
		Hybrid	Parent	Parent	Mid parent	Standard variety			
1.	A-33	3.42	2.49	1.85	2.17	3.16	57.60	37.35	8.23
2.	A-48	3.80	2.49	1.85	2.17	3.16	75.12	52.61	20.25
3.	A-62	3.57	2.49	1.85	2.17	3.16	64.52	43.37	12.97
4.	A-71	4.03	2.49	1.85	2.17	3.16	85.71	61.85	27.53
5.	A-95	3.09	2.49	1.85	2.17	3.16	42.40	24.10	-2.22
6.	A-99	2.46	2.49	1.85	2.17	3.16	13.36	-1.20	-22.15
7.	B-5	2.99	2.49	1.77	2.13	3.16	40.38	20.08	-5.38
8.	B-6	2.39	2.49	1.77	2.13	3.16	12.21	-4.02	-24.37
9.	B-27	4.13	2.49	1.77	2.13	3.16	93.90	65.86	30.70
10.	B-31	3.08	2.49	1.77	2.13	3.16	44.60	23.69	-2.53
11.	B-35	2.41	2.49	1.77	2.13	3.16	13.15	-3.21	-23.73
12.	B-58	2.38	2.49	1.77	2.13	3.16	11.74	-4.42	-24.68
13.	C-7	2.08	2.32	1.59	1.95	3.16	6.39	-10.34	-34.18
14.	C-14	2.55	2.32	1.59	1.95	3.16	30.43	9.91	-19.30
15.	C-30	3.81	2.32	1.59	1.95	3.16	94.88	64.22	20.57
16.	C-41	3.65	2.32	1.59	1.95	3.16	86.70	57.33	15.51
17.	C-44	1.88	2.32	1.59	1.95	3.16	-3.84	-18.97	-40.51
18.	C-52	2.00	2.32	1.59	1.95	3.16	2.30	-13.79	-36.71
19.	D-9	2.15	2.57	1.77	2.17	3.16	-0.92	-16.34	-31.96
20.	D-10	2.47	2.57	1.77	2.17	3.16	13.82	-3.89	-21.84

Augmented Design (Petersen, 1985) and the adjusted mean values were used to calculate the heterosis.

The details of the parents as well as hybrids used for developing the twenty hybrids for the present study are depicted in Table 1.

3. Results and Discussion

Magnitude of heterosis for nut yield (kg tree^{-1}), individual average nut weight (g) as well as kernel weight (g) in terms of relative heterosis, heterobeltiosis and standard heterosis are presented in Table 2 to 3.

The data presented in Table 2 revealed that all the tested hybrids showed relative heterosis for nut yield tree^{-1} which ranged from minimum (-) 3.84 to maximum 94.88%. Among the twenty tested hybrids, C-30 (94.88%), B-27 (93.90%), C-41 (86.70%), A-71 (85.71%) and A-48 (75.12%), exhibited a relative heterosis more than 70.00% for nut yield tree^{-1}. Similarly, all these hybrids exhibited heterosis over better parent, i.e. heterobeltiosis for nut yield; of course the magnitude is relatively less as compared to relative heterosis which ranged from minimum 52.61% (A-48) to maximum 65.86% (B-27). However, F_1 hybrids namely B-27 (65.86%), C-30 (64.22%), A-71(61.85%), and C-41(57.33%), recorded higher magnitude of heterobeltiosis over 50% for nut yield as compared to the respective better parents. On the other hand, very low magnitude of standard heterosis was observed in the present study for nut yield tree^{-1} when compared with standard check variety, BPP-8. The standard heterosis varied from minimum (-) 36.71% (C-52) to maximum 30.70% (B-27) among the twenty hybrids. The hybrids which exhibited higher % of standard heterosis in the present study identified were B-27(30.70%), A-71(27.53%), C-30(20.57%) and C-41 (15.51%).

As a whole, the hybrids such as A-71, B-27, C-30 and C-41in the present study exhibited higher magnitude of heterosis for nut yield tree^{-1} over their respective mid parents, better parents as well as standard check, BPP-8 indicating the effectiveness of hybridization in crop improvement of cashew. The results are in conformity with Manoj and Gorge (1993).

From the Table 3, it is revealed that none of the hybrids recorded positive relative heterosis or heterobeltiosis for nut weight during the study. The mid parent and better parent values recorded for nut weight were found to be superior to

Table 3: Heterosis for individual nut weight (g) of cashew hybrids

Sl. no.	Hybrid no.	Individual Nut weight (g)					Relative heterosis (%)	Heterobeltiosis (%)	Standard heterosis (%)
		Hybrid	Parent	Parent	Mid parent	Standard variety			
1.	A-33	6.62	6.17	9.31	7.74	7.52	-14.47	-28.89	-11.97
2.	A-48	6.75	6.17	9.31	7.74	7.52	-12.79	-27.50	-10.24
3.	A-62	6.29	6.17	9.31	7.74	7.52	-18.73	-32.44	-16.36
4.	A-71	7.50	6.17	9.31	7.74	7.52	-3.10	-19.44	-0.27
5.	A-95	6.36	6.17	9.31	7.74	7.52	-17.83	-31.69	-15.43
6.	A-99	6.41	6.17	9.31	7.74	7.52	-17.18	-31.15	-14.76
7.	B-5	8.18	6.17	12.84	9.51	7.52	-13.94	-36.29	8.78
8.	B-6	8.15	6.17	12.84	9.51	7.52	-14.26	-36.53	8.38
9.	B-27	8.6	6.17	12.84	9.51	7.52	-9.52	-33.02	14.36
10.	B-31	8.47	6.17	12.84	9.51	7.52	-10.89	-34.03	12.63
11.	B-35	8.06	6.17	12.84	9.505	7.52	-15.20	-37.23	7.18
12.	B-58	8.43	6.17	12.84	9.505	7.52	-11.31	-34.35	12.10
13.	C-7	8.06	6.44	11.76	9.10	7.52	-11.43	-31.46	7.18
14.	C-14	8.00	6.44	11.76	9.10	7.52	-12.09	-31.97	6.38
15.	C-30	9.00	6.44	11.76	9.10	7.52	-1.10	-23.47	19.68
16.	C-41	8.80	6.44	11.76	9.10	7.52	-3.30	-25.17	17.02
17.	C-44	8.19	6.44	11.76	9.10	7.52	-10.00	-30.36	8.91
18.	C-52	8.37	6.44	11.76	9.10	7.52	-8.02	-28.83	11.30
19.	D-9	8.15	5.32	12.84	9.08	7.52	-10.24	-36.53	8.38
20.	D-10	8.65	5.32	12.84	9.08	7.52	-4.74	-32.63	15.03

the tested hybrids. Regarding standard heterosis, the hybrids of 'B', 'C' and 'D' crosses recorded positive values for the character studied. Maximum standard heterosis was recorded in hybrid C-30(19.68%) followed by C-41(17.02%), D-10 (15.03%) and B-27 (14.36%), while minimum was recorded in hybrid A-95 (-15.43%) among the twenty tested hybrids.

Exploitation of hybrid vigour for kernel weight is also considered as important factors contributing high yield and export quality in cashew. It is one of the important parameter for developing new hybrids. The results of kernel weight (Table 4) indicated similar trend as that of nut weight. All the hybrids exhibited negative relative heterosis as well as

Table 4: Heterosis for kernel weight (g) of cashew hybrids

Sl. no.	Hybrid no.	Kernel weight (g)					Relative heterosis (%)	Heterobeltiosis (%)	Standard heterosis (%)
		Hybrid	Parent	Parent	Mid parent	Standard variety			
1.	A-33	2.01	2.00	2.53	2.265	2.17	-11.26	-20.55	-7.37
2.	A-48	2.24	2.00	2.53	2.265	2.17	-1.10	-11.46	3.23
3.	A-62	1.98	2.00	2.53	2.265	2.17	-12.58	-21.74	-8.76
4.	A-71	2.58	2.00	2.53	2.265	2.17	13.91	1.98	18.89
5.	A-95	1.97	2.00	2.53	2.265	2.17	-13.02	-22.13	-9.22
6.	A-99	1.9	2.00	2.53	2.265	2.17	-16.11	-24.90	-12.44
7.	B-5	2.62	2.00	3.88	2.94	2.17	-10.88	-32.47	20.74
8.	B-6	2.5	2.00	3.88	2.94	2.17	-14.97	-35.57	15.21
9.	B-27	2.87	2.00	3.88	2.94	2.17	-2.38	-26.03	32.26
10.	B-31	2.73	2.00	3.88	2.94	2.17	-7.14	-29.64	25.81
11.	B-35	2.45	2.00	3.88	2.94	2.17	-16.67	-36.86	12.90
12.	B-58	2.7	2.00	3.88	2.94	2.17	-8.16	-30.41	24.42
13.	C-7	2.46	2.17	3.01	2.59	2.17	-5.02	-18.27	13.36
14.	C-14	2.53	2.17	3.01	2.59	2.17	-2.32	-15.95	16.59
15.	C-30	2.85	2.17	3.01	2.59	2.17	10.04	-5.32	31.34
16.	C-41	2.78	2.17	3.01	2.59	2.17	7.34	-7.64	28.11
17.	C-44	2.5	2.17	3.01	2.59	2.17	-3.47	-16.94	15.21
18.	C-52	2.62	2.17	3.01	2.59	2.17	1.16	-12.96	20.74
19.	D-9	2.46	2.17	3.01	2.59	2.17	-5.02	-18.27	13.36
20.	D-10	2.53	2.17	3.01	2.59	2.17	-2.32	-15.95	16.59

heterobeltiosis for kernel weight. Hybrids such as B-27, C-30 and C-41 recorded maximum standard heterosis of 32.26%, 31.34%, and 28.11%, respectively. All the hybrids of 'A' cross showed negative standard heterosis suggesting that the kernel weight of standard check (BPP-8) was superior to hybrids studied. Rest fourteen hybrids of 'B', 'C' and 'D' cross exhibited heterosis over the standard variety with values ranging from 12.90% (B-35) to 32.26% (B-27).

Similar positive heterosis was also observed for nut yield and number of nuts in cashew by Manivannan et al. (1989) as well as Manoj and George (1993). The higher magnitude of heterosis for nut weight and kernel weight has also been suggested for cashew improvement programme (Chipojola et al., 2009).

4. Conclusion

Hybrids namely A-71, B-27, C-30, and C-41 exhibited better heterosis with respect to nut weight (g), kernel weight (g) and overall the total nut yield (kg tree^{-1}) as compared to the other tested hybrids. Hence, may be recommended for cultivation to increase the production and productivity of cashew. It is suggested that further studies should be undertaken for exhaustive evaluation of the selected hybrids for commercialization with different traits.

6. Acknowledgement

We gratefully acknowledge the Orissa University of Agriculture and Technology, Odisha, India for the research facilities provided and to the Director, Directorate of Cashew

Research (ICAR), Puttur, Karnataka, India for providing the financial and other facilities to carry out the study under All India Coordinated Research Project on Cashew.

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