Research Article
doi.org/10.25081/jpc.2018.v46.i3.2095
Journal of Plantation Crops, 2018, 46(3): 151-155

Heterosis for economic traits in coconut (*Cocos nucifera* L.)

V.V. Shinde*, S.L. Ghavale, H.P. Maheswarappa[1], B.A. Jerard[2] and S. Sumitha[1]

ICAR-All India Coordinated Research Project on Palms, Regional Coconut Research Station, Bhatye, Ratnagiri Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli-415 712, Maharashtra, India
[1]AICRP on Palms, ICAR-Central Plantation Crops Research Institute, Kasaragod-671 124, Kerala, India
[2]ICAR-Central Island Agricultural Research Institute, Port Blair-744 101, Andaman and Nicobar Islands, India

(Manuscript Received: 20-07-2018, Revised: 03-10-2018, Accepted: 01-11-2018)

Abstract

Field studies conducted for a period of 12 years to assess the traits responsible for yield performance and heterosis of twelve coconut hybrids in comparison with three varieties showed that among the hybrids, GBGD x ECT recorded the highest mean yield of 127.6 nuts palm^{-1} year^{-1} and was on par with ECT x GBGD (106.9 nuts palm^{-1} year^{-1}), COD x LCT (108.0 nuts palm^{-1} year^{-1}) and WCT x MYD (107.6 nuts palm^{-1} year^{-1}). Hybrid GBGD x PHOT recorded the highest fruit length (23.9 cm) followed by ECT x GBGD (23.3 cm). The hybrid ECT x GBGD recorded the highest values for most of the fruit characteristics *viz.*, fruit breadth (17.3 cm), fruit weight (1180.0 g), husked fruit weight (758.0 g) and copra weight (231.1 g). The variety 'Laccadive Ordinary' recorded higher oil content (71.1%) compared to its hybrids, LCT x GBGD (70.8%), COD x LCT (70.0%) and LCT x COD (69.8%). Hybrids displayed substantial differences in their heterotic response for nut characters. The highest yielding hybrid, GBGD x ECT excelled its standard check by 40.8 per cent followed by LCT x COD (39.4%).

Keywords: Coconut hybrids, economic heterosis, nut yield, yield components

Introduction

Coconut (*Cocos nucifera* L.) is a cross pollinated plantation crop, showing great variation in its yield potential depending on growth conditions and cultivars (Iyer *et al*., 1981). India is the first country in the world to exploit hybrid vigour in coconut in a cross between West Coast Tall (female parent) and Chowghat Green Dwarf (male parent) (Patel, 1937). Subsequently during the 1950s, major emphasis was given for the production of tall x dwarf hybrids. The hybrids developed showed precocity in flowering, higher yield, quantity and better quality of copra and oil compared to the parents. However, considerable variation occurred in the progenies involving different parental combinations (Rajamony *et al.*, 1983). Heterosis is the superiority of the hybrid over the mid or better parent as standard variety and is the result of allelic or non-allelic interaction of genes under the influence of particular environments. Meredith and Bridge (1972) coined the term economic heterosis, which is defined as the superiority of a hybrid over a non–hybrid commercial cultivar. As the effect of heterosis of yield, in particular, can vary between sites (Chapman *et al*., 2000), it is more meaningful to characterize a particular hybrid as showing heterosis for yield at a specific locality or under certain environmental conditions. The present study was undertaken to identify better hybrids for yield and quality of copra, based on economic heterosis estimates over Pratap, the commercial coconut cultivar in Konkan region of Maharashtra state.

Materials and methods

Evaluation of 12 hybrids and three varieties (Table 1) developed by different centres of All India Coordinated Research Project on Palms (AICRPP) was undertaken at Regional Coconut Research Station, Bhatye, Ratnagiri (Dr. Balasaheb Sawant

**Corresponding Author: vaibhavvilasshinde@yahoo.co.in*

Table 1. List of hybrids/varieties and parents included in the experiment

Hybrids/Varieties	Code	Name of the center	Parents
GBGD x ECT	H_1	Ambajipeta (A.P.)	COD (Chowghat Orange Dwarf)
ECT x GBGD	H_2	Ambajipeta (A.P.)	MYD (Malayan Yellow Dwarf)
PHOT x GBGD	H_3	Ambajipeta (A.P.)	PHOT (Philippine Ordinary Tall)
GBGD x PHOT	H_4	Ambajipeta (A.P.)	LCT (Laccadive Ordinary Tall)
LCT x COD	H_5	Kasaragod (Kerala)	GBGD (Gangabondam Green Dwarf)
COD x LCT	H_6	Kasaragod (Kerala)	ECT (East Coast Tall)
ECT x MYD	H_7	Veppankulam (TN)	WCT (West Coast Tall)
MYD x ECT	H_8	Veppankulam (TN)	
COD x WCT	H_9	Kasaragod (Kerala)	
WCT x MYD	H_{10}	Kasaragod (Kerala)	
LCT x GBGD	H_{11}	Kasaragod (Kerala)	
WCT x GBGD	H_{12}	Kasaragod (Kerala)	
ECT	V_1	Veppankulam (TN)	
LCT	V_2	Kasaragod (Kerala)	
Pratap	V_3	Bhatye (Maharastra)	

Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India). The hybrids and varieties were planted (five palms per replication) during 1992, in a randomized block design with three replications. The package of practice, including manuring and fertilization, weed control, irrigation during summer months, mulching, pest and disease management, were followed as per the standard recommendations (Maheswarappa and Rajkumar, 2014). The observations on height (m), girth (cm) and number of leaves on the crown were recorded during October 2016 (at the age of 24 years). The yield (nuts palm^{-1} year^{-1}) was recorded periodically during each harvest and pooled to get the yield palm^{-1} year^{-1}. The fruit characters *viz*., fruit length (cm), fruit breadth (cm), fruit weight (g), husk weight (g), husked fruit weight (g), shell weight (g), shell thickness (mm), copra weight (g), copra thickness (mm) and oil content (%) were recorded during 2014-15 and 2015-16 at quarterly interval by drawing samples from each replications and the mean was worked out. The data were subjected to statistical analysis as per the standard procedures (Panse and Sukhatme, 1985) and the economic heterosis of F_1 hybrids were calculated as per Meredith and Bridge (1972).

Results and discussion

Growth components

The observations on 24 year old palms with respect to height, girth and total number of leaves on the crown showed that there was no significant difference in the growth parameters like height and number of leaves on the crown. Whereas, significantly higher stem girth was observed in ECT (126.0 cm) (Table 2) which was on par with ECT x MYD (121.0 cm) and WCT x GBGD (116.2 cm). The girth was significantly lower in COD x WCT hybrid (91.8 cm), which might be due to dwarf female parent. Similar findings were also reported by Nagwekar *et al.* (2002) and Ramanandam *et al.* (2017).

Yield and yield components

The average yield for 12 years (Table 3) indicated that the hybrids GBGD x ECT recorded

Table 2. Growth characteristics of different hybrids and varieties of coconut (at the age of 24 years)

Hybrids/varieties	Height (m)	Girth (cm)	No. of leaves on the crown
H_1	4.45	101.3	28.2
H_2	4.26	102.8	30.2
H_3	4.17	111.5	29.2
H_4	4.03	101.3	29.2
H_5	4.30	109.7	27.0
H_6	4.62	100.8	26.8
H_7	3.47	121.0	26.2
H_8	3.44	99.0	27.5
H_9	4.20	91.8	26.3
H_{10}	5.34	100.8	28.0
H_{11}	4.11	101.5	26.7
H_{12}	5.56	116.2	28.5
V_1	4.78	126.0	29.7
V_2	5.26	105.8	27.0
V_3	4.73	104.3	27.7
S.E.±	-	**4.1**	-
C.D. (P=0.05)	**N.S.**	**12.6**	**N.S.**

Table 3. Nut yield of coconut hybrids and varieties over a period of twelve years

Hybrids/varieties	Nut yield palm^{-1} year^{-1}						
	2004-06	2006-08	2008-10	2010-12	2012-14	2014-16	Av. yield (2004-2016)
H_1	105.2	117.8	129.8	119.6	127.2	166.1	127.6
H_2	90.6	98.9	99.5	88.4	111.8	152.6	107.0
H_3	73.4	79.9	96.8	87.5	89.1	114.9	90.3
H_4	65.8	67.1	85.4	79.3	87.1	101.9	81.1
H_5	39.7	34.8	51.9	65.1	62.3	72.2	54.3
H_6	91.1	99.6	110.0	104.1	119.4	124.2	108.1
H_7	36.9	41.8	61.2	66.5	69.6	96.5	62.1
H_8	34.8	39.4	58.3	58.7	68.9	95.8	59.3
H_9	61.1	67.8	82.5	72.6	83.6	114.8	80.4
H_{10}	96.9	103.8	110.7	94.9	104.1	135.3	107.6
H_{11}	73.6	71.2	87.2	84.4	79.3	101.9	82.9
H_{12}	64.9	58.2	74.3	68.6	71.8	110.6	74.7
V_1	60.5	63.1	78.5	84.2	88.9	115.5	81.8
V_2	49.3	66.0	90.8	82.1	89.3	121.2	83.1
V_3	76.2	86.8	100.6	85.6	104.8	122.1	96.0
S.E.m±	12.1	12.1	12.9	7.6	11.7	11.4	12.7
C.D. (P=0.05)	35.1	35.0	37.3	21.9	34.0	33.0	30.8

significantly higher yield (127.6 nuts palm^{-1} year^{-1}) and was at par with COD x LCT (108.0 nuts), WCT x MYD (107.6 nuts) and ECT x GBGD (106.9 nuts). Among the hybrids, LCT x COD recorded significantly the lower yield (54.3 nuts palm^{-1} year^{-1}) and was on par with MYD x WCT (59.3 nuts palm^{-1} year^{-1}) and ECT x MYD (62.1 nuts palm^{-1} year^{-1}). The variation in fruit set percentage among coconut hybrids were earlier reported by Nair *et al*. (2003) and Thomas *et al*. (2012). In coconut, inter-spadix overlapping of female and male phase is an important factor affecting fruit set along with cross-pollination, where the pollen from nearby palms are transferred by agents like wind, insect *etc*. (Henderson, 1988; Nagwekar *et al*., 2002). The highest values for all the morphological and yield attributing characters were observed in the hybrid GBGD x ECT, which can be attributed to the heterotic effect of the hybrid (Rao and Koyamu 1955; Ramanandam *et al.,* 2017).

The hybrids exhibited wide variation for different fruit characters (Table 4). The length of the fruit was significant and the highest in (H_4) GBGD x PHOT (23.9 cm) and at par with H_1, H_2, H_7, H_{10} and H_{11}. The variety Pratap recorded the minimum fruit length (18.3 cm) compared to other varieties. The hybrid ECT x GBGD recorded significantly maximum fruit breadth (17.3 cm) and was at par with other varieties except ECT (14.6 cm), LCT x GBGD (13.6 cm) and LCT x COD (12.2 cm). The fruit weight was significantly higher in ECT x GBGD (1180 g) and was on par with COD x LCT (1083.0 g) and WCT x MYD (1077.0 g). The husk weight was significantly higher in WCT x MYD (430.0 g) whereas, the hybrid LCT x COD recorded significantly lower husk weight (220.0 g). The hybrid ECT x GBGD recorded significantly higher dehusked fruit weight (787.0 g) and the lowest dehusked fruit weight (270.0 g) was recorded in COD x LCT combination. The shell weight, thickness of copra and oil content did not differ significantly among the varieties studied. The copra content and oil per cent of different hybrids (Table 4) showed that the hybrid ECT x GBGD recorded the highest copra content (231.1 g nut^{-1}) and was at par with MYD x ECT (204.1 g) and LCT (227.3 g) whereas, it was significantly lower in LCT x COD (92.1 g). The better performance of the hybrid GBGD x ECT might be attributed to the ECT's performance as a pollen parent or specific combining ability of GBGD (Ramanandam *et al*., 2017). An earlier report had indicated GBGD as a good general combiner (Nampoothiri *et al*., 1999). The hybrid palms exhibited desirable fruit characters for fruit weight, fruit yield, kernel weight and copra content besides many morphological traits such as earliness of flowering, shorter petiole length and higher number of female flowers. Similar reports

Table 4. Nut characters of coconut hybrids/varieties

Hybrids/ varieties	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g nut^{-1})	Weight of husk (g nut^{-1})	Dehusked fruit weight (g nut^{-1})	Shell weight (g)	Shell thickness (mm)	Copra content (g nut^{-1})	Copra thickness (mm)	Oil content (%)
H_1	21.9	16.0	1003	328	675	134	5.0	169.1	9.8	67.1
H_2	23.3	17.3	1180	393	787	151	4.0	231.0	10.6	64.1
H_3	21.0	16.1	937	377	560	132	5.3	177.1	10.6	68.4
H_4	23.9	16.6	1128	407	721	161	4.7	192.3	9.4	68.2
H_5	19.2	12.2	490	220	270	80	4.2	92.1	9.0	69.8
H_6	21.5	16.5	1083	338	745	149	4.8	195.1	10.4	70.0
H_7	22.4	17.0	1050	365	685	135	4.5	187.3	9.4	64.0
H_8	20.1	16.7	1027	338	689	142	5.1	204.1	11.5	64.8
H_9	19.7	16.6	985	377	608	150	5.0	184.5	10.3	67.3
H_{10}	22.0	17.0	1077	430	647	151	5.5	196.2	10.0	66.2
H_{11}	22.0	13.6	693	333	360	105	4.1	179.1	9.5	70.8
H_{12}	20.8	15.8	838	371	467	130	5.0	157.3	10.0	69.2
V_1	19.5	14.5	722	275	447	153	4.5	196.2	9.3	65.6
V_2	20.7	17.2	1137	388	749	168	4.5	227.3	11.0	71.1
V_3	18.3	17.1	935	365	570	109	4.0	130.5	9.8	68.8
S.E.±	0.8	0.8	39.2	23.8	31.5	17.5	0.3	10.3	0.8	3.0
C.D. (P=0.05)	2.3	2.3	113.6	69.0	91.7	NS	0.9	29.9	NS	NS

were also found by Jerard *et al*. (2015), Nagwekar *et al*. (2002) and Ramanandam *et al*. (2017) for morphological and yield traits of coconut hybrids.

Economic heterosis

In the present study, four hybrids showed yield superiority over standard check wherein heterosis of the hybrids for yield ranged from 21.4 to 40.8 per cent over the check. A wide variation for yield was observed in the study and the hybrid ECT x GBGD was found to be a good performer for yield. The hybrids COD x LCT, WCT x MYD and ECT x GBGD either as male or as female parent were observed to be high yielding. Among the varieties, Pratap (standard check) was found to be the best yielding variety, which performed better in terms of the number of female flowers and other inflorescence characters among the different parents. Eleven hybrids (except H_5) showed positive economic heterosis for copra weight which varied from 20.5 to 77.1 per cent over the standard check. Significant variation in copra weight shown by the five hybrids *viz*., H_2, H_8, H_{10}, H_6 and H_4 indicate the scope for selection of these hybrids as better option over the ruling variety Pratap. James *et al*. (2003) reported that when two different alleles of various genes are brought together, there is a combined allelic expression. Besides, the complementation of alleles in different genes has cumulative effect in phenotype resulting in heterosis (Jayabose *et al.*, 2008). In a similar way, in the present study, well pronounced heterosis was exhibited by the hybrid GBGD x ECT. Heterosis for oil content in various crosses between high and low oil yielding parents was also studied to identify a hybrid/variety with distinct improvement in oil percentage. But the lack of pronounced heterosis for this character was observed in the present study. There was no indication of any marked maternal influence on character expression for this trait and hence this is unlikely to impose any serious restriction on the choice of parents as females or males in developing of hybrids for high oil content.

Table 5. Economic heterosis (%) for selected characters in coconut hybrids

Hybrids/ varieties	Nut Yield	Copra weight	Thickness of copra	Oil content
H_1	40.8*	29.6*	0.0	-2.5*
H_2	22.5*	77.1*	8.2*	-6.9*
H_3	-2.9	35.7*	8.7*	-0.6
H_4	-9.8	47.4*	-3.6*	-0.9
H_5	-39.4*	-29.4*	-7.7*	1.5*
H_6	21.4*	49.5*	6.7*	1.7*
H_7	-38.7*	43.6*	-3.6*	-6.9*
H_8	-34.1*	56.4*	17.4*	-5.8*
H_9	-10.4*	41.4*	5.6*	-2.2*
H_{10}	21.8*	50.4*	2.6	-3.8*
H_{11}	-10.2*	37.3*	-2.6	2.9*
H_{12}	-19.4*	20.5*	2.6	0.6

*Significant at 5% level

Natarajan *et al*. (2006) and Jayabose *et al.* (2008) also noticed heterosis for yield, kernel thickness and copra yield in similar pattern. In coconut growing areas, farmers generally prefer local ecotypes of that region and it is essential to prove the better performance of new hybrids over the traditional cultivars (local ecotypes) to gain farmers' acceptance.

Conclusion

Thus, from the present study, it can be concluded that the two hybrids *viz*, GBGD x ECT and COD x LCT are superior with respect to nut production followed by WCT x MYD, ECT x GBGD and standard variety 'Pratap'. Furthermore, a varying pattern of heterotic behaviour was observed among the hybrids/varieties for four economically important traits (nut yield, copra weight, thickness of copra and oil content). The negative heterosis noticed in crosses studied may be attributed to non-allelic interaction which can either increase or decrease the expression of heterosis. Among the hybrids studied, five hybrids expressed economic heterosis for commercially important traits. Therefore, coconut hybrids showing well pronounced heterotic expression could be further utilized for commercial cultivation.

References

Chapman, S.C., Cooper, M., Butler, D.G. and Henzell, R.G. 2000. Genotype by environment interactions affecting grain sorghum: I. Characteristics that confound interpretation of hybrid yield. *Australian Journal of Agricultural Research* **51**: 197-207.

Henderson, A. 1988. Pollination biology of economically important palms. *Advances in Economic Botany* **6**: 36-41.

Iyer, R.D., Rao, E.V.V.B., Sukumaran, C.K. and Jacob, P.M. 1981. Towards an ideal plant type concept in coconut. In: *Proceedings of Plantation Crops Symposium* (*PLACROSYM-IV*) (Eds.) Vishveshwara, S. and Sreenivasan M.S. CFTRI, Mysore, pp. 29-37.

James, A.B., Donald, L.A. and Nicole, C.R. 2003. In search of the molecular basis of heterosis. *The Plant Cell* **15**: 2236-2239.

Jayabose, C., Ganesh, S., Mohanan, K.V. and Arulraj, S. 2008. Estimation of heterosis of economical important character of coconut (*Cocos nucifera* L.) hybrids. *Journal of Plantation Crops* **36**(3): 151-154.

Jerard, B.A., Niral, V., Samsudeen, K., Nair, R.V., Jayabose, C. and Thomas, G.V. 2015. Development of a Dwarf x Tall coconut hybrid 'Kalpa Samrudhi'. *Journal of Plantation Crops* **43**(1): 46-52.

Maheswarappa, H.P. and Rajkumar. 2014. Research accomplishments of AICRP on Palms. *Technical Bulletin No. 85*. CPCRI, Kasaragod. 54 p.

Meredith, W.R. and Bridge, R.R. 1972. Heterosis and gene action in cotton, *Gossypium hirsutum* L. *Crop Science* **12**: 304-310.

Nagwekar, D.D., Sawant, V.S., Joshi, G.D., Jamhbale, N.D. and Khan, H.H. 2002. Performance of coconut hybrids under Konkan conditions of Maharashtra. In: *Proceedings of Plantation Crops Symposium* (*PLACROSYM* XV), (Eds.) Sridharan, K., Vinod Kumar, P.K., Jayarama and Chulak, B.M., CCRI, Balehonnur, Karnataka, pp. 476-480.

Nair, R.V., Jacob, P.M., Sasikala, M., Thomas, R.J. and Mathews, C. 2003. Studies on nut setting in artificial pollination of coconut. *Journal of Plantation Crops* **3**1: 53-54.

Nampoothiri, K.U.K., Kumaran, P.M., Jerard, B.A. and Ratnambal, M.J. 1999. Combining ability in coconut (*Cocos nucifera* L). *CORD* **15**(2): 68-75.

Natarajan, C., Yuvaraja, A., Vaithilingam, R., Ganesamurthy, K. and Arulraj, S. 2006. Performance of T x T coconut (*Cocos nucifera* L.) hybrids in Tamil Nadu. *Journal of Plantation Crops* **34**(3): 250-253.

Panse, V.G. and Sukhatme, P.V. 1985. *Statistical Methods for Agricultural Workers*, ICAR, New Delhi. 381 p.

Patel, J.S. 1937. Coconut breeding. *Proceedings of Association of Economic Biology* **5**: 1-6.

Rajamony, L., Kannan, K. and Balakrishnan, P.C. 1983. Comparative performance of coconut hybrids in the laterite soils under rainfed conditions - A preliminary study. *Indian Coconut Journal* **14**(8): 1-5.

Ramanandam, G., Ravindra Kumar, Padma, E., Kalpana, M. and Maheswarappa, H.P. 2017. Potential coconut (*Coconut nucifera*) hybrids for yield and quality for coastal region of Andhra Pradesh (India). *Indian Journal of Agricultural Sciences* **87**(8): 1073-1076.

Rao, M.B.S. and Koyamu, K. 1955. The dwarf coconut. *Indian Coconut Journal* **8**(3): 106-112.

Thomas, R.J., Nair, R.V., Mathews, C., Ajitkumar, R., Sasikala, M. and Nampoothiri, C.K. 2012. Studies on fruit set in coconut upon artificial pollination in various cross combinations. *Indian Journal of Horticulture* **69**(1): 7-12.