Research Article

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Evaluation of interspecific oil palm hybrids for dwarfness

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Abstract

Inter-specific hybridization is taken up for introgression of desirable traits, mainly dwarfness, from *Elaeis oleifera* (HBK) Cortes into the cultivated species *Elaeis guineensis* Jacq. Two inter-specific hybrids ISH-1 (360Egx13Eo) and ISH-2 (361Egx11Eo) developed with *E. guneensis* as female parent and *E. oleifera* as male parent were evaluated along with normal Dura x Pisifera (Tenera). There was significant variation for vegetative growth and yield parameters between as well as within the hybrids. This indicated scope for selection within as well as between the hybrids. The shortest was palm 20 of ISH-1 with 210 cm height after 12 years. With respect to bunch characters, mean bunch weight, number of fruits and average fruit weight showed significant variation among the hybrids. Palm height as well as height increment was having high heritability, whereas bunch index showed low heritability. Subsequently, a selection index constructed based on discriminant function analysis by considering the most important traits of height increment and FFB yield. As a result, eight promising palms were shortlisted, five from ISH-1 and three from ISH-2. They are used for back crossing with recurrent parent to develop dwarf genotypes in oil palm.

Keywords: Breeding, bunch index, height increment, interspecific hybridization, oil palm

INTRODUCTION

The oil palm (*Elaeis guineensis* Jacq.), a perennial oil yielding crop, produces 4 to 6 MT of palm oil (mesocarp oil) and 0.4 to 0.6 MT of palm kernel oil per hectare per annum which is higher than any other oil seed crops. Realising the potential of the crop in bridging the shortage in edible oil requirement in India, the cultivation of oil palm has got considerable attention from planners, researchers and farmers. The country has got potential of 2 million ha for cultivation of the crop against the present area coverage of 2.03 lakh ha.

Palm height is an important criterion that decides the economic life of an oil palm plantation and hence, reduced height of palms has been a priority in oil palm breeding programme. Dwarf palms have always been of interest to oil palm industry because of the high cost involved in harvesting from tall palms (Bakoume and Louise, 2007). High yielding palms with slow stem elongation would help in prolonging commercial exploitation of oil palm crop (Escobar and Alvarado, 2004). Moreover, reduced height coupled with compact canopy is expected to accommodate more number of palms per ha for overall increase in yield per unit area (Nampoothiri, 1998). It was also suggested that short trunks would allow simplifying the design of oil palm harvesting machine.

The oil palm genus *Elaeis* consists of two species *viz*., *E. guineensis* Jacq and *E. oleifera* (HBK) Cortes. Both species have 16 haploid chromosomes. *E. guineensis* is generally regarded as originated from West Africa and hence known as African oil palm which is the commonly cultivated species. The *E. oleifera*, otherwise known as American oil palm is under-utilized and considered to have dwarfness, tolerance to several biotic and abiotic stresses, high iodine value, high carotene content, high vitamin E content *etc*. Inter-specific hybridization is being taken up in oil palm

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for introgression of desirable traits mainly dwarfness/compactness from *E. oleifera* into *E. guineensis*, the cultivated species. In interspecific hybrids the refining efficiency is reportedly higher leading to more recovery of liquid oil compared to the traditional *E. guineensis* varieties. Inheritance of growth and yield parameters in interspecific hybrids was reported by Haradon (1969) and Hardon and Tan (1969). Sterling *et al*. (1987) reported the phenotypic characteristics of an exceptional segregant from *E. oleifera* x *E. guineensis* hybrid open pollinated with *E. guineensis* known as the original compact palm. Commercial plantations are being developed in South American countries and the present interspecific sprout production is 2.5 million. The interspecific hybrids has gained importance due to the promising features like short palm height and the consequent advantages in plantation management and extending its economic life. The objectives of the present studyincluded evolving dwarf/compact palms which combine the high yield of *E. guineensis* with dwarfness of *E. oleifera* and transfer of superior oil quality and disease resistance of *E. oleifera* to cultivated genotypes.

Materials and methods

Two inter-specific hybrids ISH-1 (360 Eg x13 Eo) and ISH-2 (361 Eg x11 Eo) developed with *E. guneensis* as female and *E. oleifera* as male parent were evaluated along with Dura x Pisifera (Tenera) at the research farm of the Directorate of Oil Palm Research, Pedavegi, Andhra Pradesh. Growth parameters like palm height, annual height increment was recorded based on Breure and Powell (1987) at 12 years age. Girth of trunk and leaf characters was also recorded. The biomass parameters were estimated using the non-destructive method (Hardon and Tan 1969; Corely *et al.*, 1971). Yield traits such as number of bunches, average bunch weight and bunch yield were recorded for four years and averaged for analysis. Bunch analysis and oil estimation was carried out using the procedure suggested by Blaak *et al*. (1963) and later modified by Rao *et al.* (1983). Bunch index was calculated according to Corely *et al.* (1971). Specific leaf weight (SLW) is the ratio of leaf dry weight to leaf area. Statistical analysis of the data was carried out using SPSS version 17. Genetic analysis was carried out as per Singh (2007).

Results and discussion

Analysis of variance for growth and bunch components indicated that there was significant variation between hybrids as well as within the hybrids.

Growth and biomass partitioning

Of the growth parameters studied (Table 1), significant variation was observed with respect to height of palm, annual height increment, leaf dry weight, leaf area, specific leaf weight, vegetative dry matter and total dry matter. Girth of trunk, number of leaves, bunch dry matter or bunch index did not show any significant difference between hybrids.

There was significant variation for palm height among different genotypes.The palm height ranged from 210 to 557 cm in ISH-1 hybrid, 257 to 530 cm in ISH-2 and the same for DxP was 328 to 407 cm. The mean plant height ranged from 370.9 cm in hybrid 360 Eg x 13Eo (ISH-1) to 414.2 cm in 361 Eg x 11Eo (ISH-2) after 12 years where the population mean was 388.6 cm. Height increment showed similar trend and varied from 23.3 to 61.9 cm in ISH-1 and 28.6 to 65.4 cm in ISH-2. This was in conformity with earlier report by Hardon (1969) that palm height was substantially low in interspecific hybrids between *E. guineensis* x *E. oleifera*. This indicated scope of selection for palm height as well as height increment within each hybrid as well as among the hybrids. The hybrid ISH-1 recorded a leaf area of 8.5 m^2 which was less than that of normal D x P (9.1 m^2) where as it was significantly higher in ISH-2 which in turn agreed with findings of Hardon (1969). Similar trend was observed for leaf dry weight also with ISH-1 recording 5.8 kg, ISH-2 with 9.0 kg and D x P with 7.0 kg. Total dry matter also showed significant difference mainly due to the effect of vegetative dry mater. The mean total dry matter varied from 137.4 kg in ISH-1 to 206.9 kg in ISH-2 and 148.3 kg for normal D x P. Bunch index which is an indication of the biomass partitioning efficiency of palms between vegetative and yield parameters, did not vary significantly among hybrids. However, the bunch index of individual palms varied from 0.07 to 0.35 against the standard value of 0.3 in case of normal D x P.

Table 1. Variation in growth, biomass partitioning and bunch components of interspecific hybrids

	Cross ID	Range			SD
		Mean	Minimum	Maximum	
Height (cm)	ISH-1	370.9	210.0	557.0	84.6
	ISH-2	414.2	257.0	530.0	65.1
	D x P (control)	374.5	328.0	407.0	27.5
	Total	388.6	210.0	557.0	76.7
Height increment (cm)	ISH-1	41.5	23.3	61.9	9.3
	ISH-2	46.9	28.6	65.4	7.8
	D x P (control)	41.6	36.4	45.2	3.1
	Total	43.7	23.3	65.4	8.7
No of leaves	ISH-1	12.6	10.8	16.0	1.2
	ISH-2	12.0	11.0	18.0	1.2
	D x P (control)	12.0	11.6	13.0	0.5
	Total	12.4	10.8	18.0	1.3
Specific leaf weight (kg)	ISH-1	0.9	0.6	1.2	0.1
	ISH-2	0.9	0.8	1.1	0.1
	D x P (control)	0.9	0.9	1.0	0.0
	Total	0.9	0.6	1.2	0.1
Bunch index	ISH-1	0.2	0.1	0.4	0.0
	ISH-2	0.2	0.1	0.3	0.1
	D x P (control)	0.3	-	-	-
Number of bunches	ISH-1	5.1	1.3	9.3	2.2
	ISH-2	4.4	2.0	6.8	1.3
	DxP(control)	4.9	2.3	6.8	2.4
	Total	4.8	1.3	9.3	1.9
Bunch yield (kg palm^{-1})	ISH-1	83.5	16.3	166.0	42.4
	ISH-2	95.4	36.3	147.3	33.1
	DxP(control)	74.0	33.8	98.3	35.1
	Total	88.2	16.3	166.0	38.1
Sterile (parthenocarpic) fruits (%)	ISH-1	18.0	11.3	29.6	5.5
	ISH-2	18.3	6.7	54.4	12.0
	DxP(control)	14.2	12.3	17.1	2.6
	Total	17.9	6.7	54.4	8.8
Average fruit weight (g)	ISH-1	11.3	7.9	15.2	1.7
	ISH-2	14.2	7.7	23.0	4.0
	DxP(control)	17.3	13.3	19.2	3.4
	Total	12.9	7.7	23.0	3.5
Mesocarp /fruit (%)	ISH-1	65.7	43.8	77.3	9.6
	ISH-2	62.2	45.8	78.8	8.0
	DxP(control)	72.4	65.4	78.2	6.5
	Total	64.5	43.8	78.8	9.0
Oil yield potential (t ha^{-1})	ISH-1	2.0	0.4	4.8	1.2
	ISH-2	2.2	0.8	3.9	0.8
	D x P (control)	3.0	-	-	-

Bunch components and yield

With respect to bunch characters, mean bunch weight, number of fruits and average fruit weight showed significant variation among the hybrids. The mean bunch weight was 15.8 kg in ISH-1 and 21.6 in ISH-2 where as normal D x P had 14.4 kg as mean bunch weight. This in turn, offers scope of selection for bunch weight. The mean number of fruits per bunch was 1563.8 in ISH-1 and 1997.1 in ISH-2 where the normal D x P had 1434.7 fruits. Average fruit weight showed significant difference for different hybrids where ISH-1 had 10.8 g, ISH-2 had 13.6 g and the normal D x P had 13.6 g fruit weight. Per cent of parthenocarpic fruits was slightly higher for interspecific hybrids. The character was more prominent in *E. oleifera* and could have been transmitted from that parent. In *E. oleifera* and its hybrids, the bract surrounding the inflorescence persists to cover the inflorescence to a large extent and this seemed to make them less accessible for airborn pollen and results in more parthenocarpic fruits. The reduced pollen fertility of some interspecific hybrids (Sunilkumar *et al.*, 2012) could also be attributed to higher proportion of parthenocarpic fruits. However, there was no significant variation in case of oil to bunch ratio. The mesocarp to fruit content varied from 43.8 to 77.3 per cent for interspecific hybrids. Some of the palms recorded mesocarp content on par with commercial D x P material. Corely and Tinker (2003) reported that interspecific crosses involving Dura (*E. guineensis* parent) had mesocarp to fruit per cent of 40 to 50 per cent and crosses involving Tenera/Pisifera, 58 to 74 per cent.

Genetic analysis

Genetic parameters were worked out and the results (Table 2) indicated that, among growth parameters, the maximum phenotypic coefficient of variation (PCV) was in vegetative dry matter followed by leaf dry matter and total dry matter. The genotypic coefficient of variation (GCV) was the highest for leaf dry weight and vegetative dry matter which were on par, followed by total dry matter production. With respect to yield parameters, phenotypic coefficient of variation as well as genotypic coefficient of variation was the maximum for bunch yield followed by number of fruits and average fruit weight. Okaye *et al*. (2009) observed high PCV and GCV for bunch number and FFB yield in Deli Dura x Tenera progenies. Wide deviation between PCV and GCV was observed for bunch dry matter, bunch index and vegetative dry matter, indicating that such characters are more influenced by the environment. Whereas for leaf area, specific leaf weight, palm height, bunch yield, and average fruit weight had least deviation between PCV and GCV and hence are more under genetic control.

Table 2. Genetic analysis

Character	GCV	PCV	Heritability (H^2)
Height	28.9	39.6	53.0
Height increment	33.9	43.5	60.8
Girth	8.0	15.8	25.4
No of leaves	10.6	16.7	40.2
Leaf dry weight	126.0	149.6	71.0
Leaf area	55.1	58.3	89.2
Specific leaf wt	17.5	23.9	53.4
Vegetative dry matter	127.0	159.1	63.7
Bunch dry matter	47.3	82.6	32.8
Total dry matter	115.8	141.5	67.0
Bunch index	12.6	46.3	7.5
Bunch yield	134.4	141.7	89.9
No of fruits	101.4	114.3	78.7
Fruit/bunch ratio	4.0	18.0	4.9
Av. fruit weight	92.9	100.0	86.4
Oil to bunch ratio	35.7	53.2	45.1

Heritability (broad sense) analysis indicated that among growth parameters the maximum value was for leaf area, leaf dry weight, vegetative dry matter and height increment whereas bunch index showed low heritability. Among yield parameters, heritability was high for bunch yield, average fruit weight and number of fruits in the inter-specific hybrids. Heritability (broad sense) was high for bunch number, average bunch weight and FFB yield in Deli D x T progenies (Okaye *et al*., 2009). The high heritability combined with least deviation between PCV and GCV for palm height, height increment, leaf area, bunch yield and average fruit weight indicated the possibility of improving these traits through selection from the population.

Salient features of promising palms

Palms were shortlisted based on annual height increment and seven were having less than 30 cm

Table 3. Promising palms selected based on height increment

Cross ID	Palm No.	Height after 12 years (cm)	Height increment (cm)	Girth (cm)	Number of leaves	Number of bunches	Bunch yield (kg palm^{-1})
ISH-1	20	210	23.3	271.0	12.5	8.0	96.0
ISH-1	73	212	23.6	267.7	14.7	3.0	39.5
ISH-1	2	217	24.1	303.3	11.6	4.8	79.3
ISH-1	11	240	26.7	312.7	15.3	5.0	57.3
ISH-1	10	246	27.3	249.3	15.3	1.0	6.0
ISH-2	43	257	28.6	273.5	18.0	3.0	22.3
ISH-1	3	264	29.3	232.0	11.6	2.5	60.0

(Table 3). Six palms belonged to ISH-1 and only one palm belonged to ISH-2. However, the yield parameters were moderate in these palms.

Subsequent upon variance and heritability analysis of various growth and bunch components, a selection index was constructed by considering the most important traits of height increment, FFB yield and oil yield. As a result, eight palms were shortlisted; five from ISH-1 and three from ISH-2 and the growth and yield parameters are presented in Tables 4 and 5. Of the five promising palms from ISH-1, four were having annual height increment between 30 and 33 cm. Number of leaves produced by interspecific hybrid is lower compared to *E. guineensis* and this was earlier reported by Hartley (1988). Palm number 28 recorded a bunch yield of 148.3 kg, height increment of 33.1 cm and had a bunch index of 0.29 which is on par with normal D x P. Though ranked low, palm numbers 2 and 3 were promising with respect to height increment and had moderate yield.

Palm 28 of ISH-1 showed potential of the maximum oil yield of 4.8 tonnes per ha resulting from the high mesocarp content and oil to bunch ratio. This was followedby 3.8 tonnes per ha in palm 25, also from ISH-1. Among promising palms from ISH-2, palm 34 recorded the highest oil yield of 3.4 tonnes per ha. Hardon (1969) and Meunier *et al*. (1975) quoted low oil to bunch ratio in interspecific hybrids compared to *E. guineensis* (Tenera) material. The kernel size was the maximum for palm number 34, which in turn would be useful in the development of genotypes for high kernel oil. The shortlisted palms would be used for back crossing with better parent for development of dwarf genotypes. Back crosses are generally reported to have better fruit set and oil /bunch ratio with oil composition close to that of *E. guineensis* (Corley and Tinker, 2003)

Conclusion

In the present study, two interspecific hybrids were evaluated for palm height and height increment. Among the two crosses compared, ISH-1 (360*Eg* x 13*Eo*) performed better both for height increment and multiple trait selection. Based

Table 4. Growth and biomass partitioning in inter specific palms selected based on multiple traits

Cross ID	Palm No	Height (cm)	Height Increment (cm)	Girth (cm)	Number of leaves	Specific leaf weight	Bunch index
ISH-1 (360Eg x 13Eo)	12	314	31.4	293.3	11.8	0.9	0.25
	25	381	38.1	323.8	11.8	0.8	0.23
	28	331	33.1	298.3	12.2	0.9	0.29
	13	318	35.3	243.8	12.8	0.7	0.22
	14	374	41.6	332.3	12.6	0.8	0.29
ISH-2 (361Eg x 11Eo)	34	302	30.2	283.8	12.0	1.0	0.28
	57	324	32.4	266.8	11.6	0.9	0.19
	42	404	44.9	285.5	11.0	1.0	0.16

Table 5. Bunch components and yield in inter specific palms selected based on multiple traits

Cross ID	Palm No.	BN	ABW (kg)	Sterile fruit (%)	Av. fruit wt (g)	Mesocarp (%)	Kernel (%)	Oil/wet mesocarp (%)	Oil yield potential (t ha^{-1})
ISH-1 (360Eg x 13Eo)	12	7.5	17.9	26.1	15.2	57.2	5.8	47.6	3.4
	25	8.5	17.4	12.4	12.6	63.8	8.4	38.9	3.8
	28	6.8	22.0	13.2	12.3	75.8	7.5	47.1	4.8
	13	6.8	13.3	19.9	9.3	70.9	11.9	45.6	2.3
	14	6.5	16.1	18.3	11.4	43.8	10.9	43.0	1.7
ISH-2 (361Eg x 11Eo)	34	6.8	21.6	13.7	15.2	45.8	13.6	52.0	3.4
	57	6.0	22.5	12.8	11.9	59.6	4.2	39.1	2.8
	42	5.5	19.6	26.9	10.5	63.9	11.9	46.7	2.7

BN: Bunch number, ABW: average bunch weight

on height, two palms *viz.,* Palm 2 and 3 and based on multiple traits, three *viz.,* Palm 12, 28 and 34 were selected. More palms were shortlisted in F-1considering the chance of segregation in subsequent generation and these palms would be used for back crossing with recurrent parent for development of dwarf varieties with better oil yield.

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