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Evaluation of *tenera* oil palm hybrids in western costal region of India

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ABSTRACT

Ten hybrid progenies of *tenera* oil palm (*dura* × *pisifera*) derived from 14 genetic origins as F_1 hybrid single generation were evaluated for yield and yield attributing traits during three consecutive years (2015-16 to 2017-18). Crossing programme with pedigree numbers 90 × 557 (*D* × *P*) having progeny code NRCOP 2 showed the highest bunch number (8.14) and fresh fruit bunch (221.8 kg palm^{-1} years^{-1}). There were significant difference among the hybrids in respect of mesocarp to fruit, which ranged from 48.1 to 75.7 per cent. Frond production had a positive correlation with number of inflorescence production (0.662 *), sex ratio (0.698 *), bunch number (0.654*) and fresh fruit bunch (FFB) yield (0.659*). Yield of FFB had a strong positive correlation with bunch number (0.773*). *Tenera* hybrid NRCOP 2 proved to be a promising hybrid for cultivation in western coastal regions of Indian with respect to growth and yield parameters.

Key words: *Elaeis guineensis* Jacq, *tenera*, mesocarp to fruit ratio, bunch, yield.

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq) originating from West Africa, is a relatively new crop in India, boasts the highest yield of vegetable oil per hectare. It produces two kind of oils namely palm oil and palm kernel oil, and both are used in cooking and cosmetic industries. Palm oil is extracted from the fruit's mesocarp, which contains 45-55% oil. The palm kernel oil is a good source of lauric oil. A well maintained oil palm can yield 20-25 MT fresh fruit bunches (FFBs) per ha after the attaining the age of commercial bearing (> 8 years after planting). In terms of yield, oil palm produces five times the amount of edible oil produced by oilseed crops. Superior planting materials (hybrids) could be a better option to meet worldwide demand for palm oil without increasing the acreage of plantations (Youmbi *et al*., 21). As a result of planting *dura* × *pisifera* progenies (Ishak *et al*., 7), oil palm yield has been reported to increase substantially in different agro climatic regions *viz*., Tungabhadra command area (Karnataka); West Godavari (Andhra Pradesh) and Konkan regions (Maharashtra) (Sanjeevi reddi *et al.,* 17) and Cauvery delta regions of Tamil Nadu (Tamil Selvan *et al.,* 19).

Growth and yield of oil palm are hampered by factors such as soil type or location, climate variability, crop management and unadaptable germplasm (Corley and Tinker, 5). Hybrid vigour is influenced by the environment (Chapman *et al.,* 6), hence hybrids must be evaluated through multilocational trials to determine their location specific suitability. As an outcome of a crop improvement programme, three high-yielding oil palm hybrids (*tenera)* have been developed and released (Maheswarappa *et al*., 11). An area of approximately 10,000 hectares has been identified as a potential area for oil palm cultivation in Maharashtra (Chadha, 3). In light of these factors, the current study was undertaken to identify a superior performing *tenera* hybrids (*dura* × *pisifera*) for the commercial cultivation in Konkan region of Maharashtra.

MATERIALS AND METHODS

A set of ten *tenera* hybrids were evaluated at AICRP on Palms (Oil Palm), Mulde, Sindhudurg (M.S.) which represents agro climatic zone No-12 *i.e.* Western coastal plains and Ghats covering the Konkan region of Maharashtra. The experimental site experiences a consistent and high annual rainfall (3000-3500 mm), which is confined between June and September (Fig. 1), high humidity, and a moderate environment with temperatures ranging 15^0 C to 35^0 C. The experimental materials consisted of ten *tenera* hybrid cross combinations developed at ICAR- IIOPR, Pedavagi (Table 1) were collected and planted in a triangular system with a spacing of 9 m x 9 m x 9 m in Randomized Block Design with three replications including nine palms per replications. The experiment was initiated in the year 2007 and

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Table 1. Genetic origins of *tenera* hybrids and their pedigree information.

S. No.	C/P	Code	Pedigree No. ♀ palm × ♂ palm
1.	D × P	NRCOP 1	78 × 435
2.	D × P	NRCOP 2	90 × 557
3.	D × P	NRCOP 3	158 × 116
4.	D × P	NRCOP 4	131 × 435
5.	D × P	NRCOP 5	5 × 577
6.	D ×P	NRCOP 6	173 × 435
7.	D × P	NRCOP 7	183 × 577
8.	D × P	NRCOP 8	70 × 557
9.	D × P	NRCOP 9	28 × 435
10.	D × P	NRCOP 10	345 × 577

NOTE: C/P = crossing program, D = *dura*, P = *pisifera*, NRCOP = National Research centre for oil Palm (IIOPR)

evaluated for yield performance till 2019 following recommended package of practices (ICAR-IIOPR, Pedavegi), and adopting fertigation facility. All the morphological traits were recorded as per the standard methods of Bhagya *et al.* (2). For the elite hybrid selection, three years of data were compiled. The bunch analysis was done as per the method of Mandal *et al*. (10). The oil content in dried mesocarp was determined in a Soxhlet apparatus using pooled samples from each hybrid over multiple replications, and the oil yield per palm was calculated. The sex ratio was calculated as the number of female inflorescence / total number of inflorescence × 100.

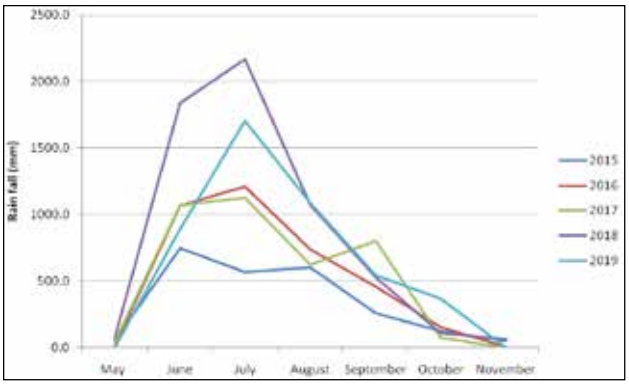

Fig. 1. Time series of rainfall in mm for the months of May to November.

The mean value of all the traits was statistically analysed adopting Panse and Sukhatme's methods (13). The pooled data were statistically analyzed at 0.05 probability using WASP 2.0 software of ICAR-CCARI, Goa.

RESULTS AND DISCUSSION

Oil palm is a cross-pollinated crop, and *tenera* is the progeny of the fertile *Dura* and the sterile *Pisifera*. In the stabilized phase (12 years), the palm height and stem girth of the ten *tenera* hybrids differed significantly (Table 2). The palm hybrid NRCOP 10 showed the lowest palm height (4.48 m), but proved statistically at par with NRCOP 5 hybrids, whereas it was highest in NRCOP 8 (5.45 m). The stem girth at 60 cm height ranged from 3.40m (NRCOP 1) to 3.79 m (NRCOP 5). In the Cauvery delta zones, Tamil

Table 2. Performance of *tenera* hybrids for vegetative traits.

Tenera Hybrids	Palm Height (m)	Palm girth (m)	No of frond (palm^{-1} year^{-1})	Reproductive traits (palm^{-1} year^{-1})		
				Female	Male	Total inflorescence
NRCOP 1	5.13	3.40	24.9	8.3	4.2	12.5
NRCOP 2	4.92	3.52	25.8	9.6	4.0	13.6
NRCOP 3	5.16	3.48	25.0	7.0	4.9	11.9
NRCOP 4	4.89	3.45	24.8	7.0	4.8	11.8
NRCOP 5	4.56	3.79	25.1	7.3	4.6	11.9
NRCOP 6	4.83	3.42	24.7	8.1	4.0	12.0
NRCOP 7	4.93	3.35	25.4	8.0	4.5	12.5
NRCOP 8	5.45	3.67	24.6	7.5	4.4	11.9
NRCOP 9	5.25	3.60	25.1	8.5	4.5	13.0
NRCOP 10	4.48	3.48	23.9	5.8	7.1	12.9
S.Em ±	0.06	0.04	0.29	0.13	0.08	0.19
CD (P=0.05)	0.17	0.11	0.85	0.38	0.24	0.56
CV (%)	2.06	2.06	2.07	2.85	3.00	2.04

Selvan *et al.* (19) observed *tenera* hybrids of different heights (4.93 to 6.20 m). *Elaeis* stems are relatively constant in diameter, but their height is unpredictable due to the presence of phytomers (support leaves and fruit bunches) at stem top. As the apical bud develops, new phytomers generate, resulting in stem elongation that increases palm height (Legros *et al.,*8). Physiological processes that occur throughout the juvenile period are probably responsible for the increase in palm height as also seen in the present study. Frond production (FP) ranged from 23.9 to 25.8 fronds palm^{-1} year^{-1}, with a mean of 26.49 fronds palm^{-1} year^{-1}. This finding was similar to that of Rafii *et al.* (14), who noticed that at the age of 12 to 14 years (after planting), palms generated 20 to 25 leaves annually. There were substantial differences between hybrids with respect to the reproductive characters *viz.*, male, female and total number of inflorescences production, whereas the hybrid NRCOP 2 bore significantly higher number inflorescences (13.6), female inflorescence (9.6) with the least number of male inflorescence (4.0) compared to other hybrids. In oil palm, the leaf initiation rate directly impacts the potential number of inflorescence, and each leaf axis produces a single inflorescence either a male or female (Woittiez, 20). This phenomenon justified the findings in Table 2, which revealed that the number of open leaves increased in parallel with the number of inflorescences. Sex ratio percentage of oil palm was observed to be an important trait influencing the yield and in the present study, it was within the range from 52 to 72, and the maximum sex ratio (72 %) was obtained in NRCOP 6 followed by NRCOP 2 (70 %) and the lowest sex ratio (52 %) was observed in NRCOP 10 (Fig 2). A study conducted in the Cauvery delta region documented heterogeneity among *tenera* hybrids based on sex ratio (Tamil Selvan *et al.,* 19). During South West monsoon, Konkan regions receive 60-70 rainy days (daily rainfall >=2.5mm) on average out of 122 days. In present study, oil palm sex ratios are less fluctuating in coastal regions in Fig. 2 (three consecutive years) due to humid weather and high rainfall throughout the year (Fig. 1).

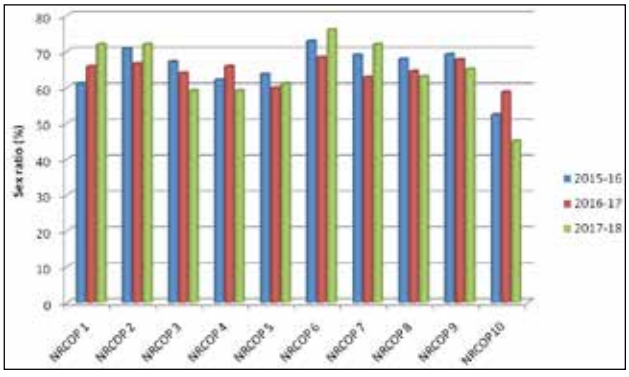

Fig. 2. Sex ratio percentage of oil palm hybrids.

Oil palm yield is influenced by many factors. Different genetic materials (*dura* × *pisifera)* that have been utilised as parents to generate hybrids (NRCOP 1 to 10) and G×E interaction could influence bunch yield and oil output. An analysis of variance revealed a significant difference (P * 0.05) in fruit bunch number, weight, and yield across ten *tenera* hybrids (Table 3). As water is a critical factor for frond and inflorescence productions, it is equally important in bunch number and yield. The highest number of harvested fruit bunches (BNO) were recorded in NRCOP 2 (8.14) followed by NRCOP 6 and NRCOP 7, and it was least in NRCOP 10 (5.33). Palms with larger diameters influence an increase in frond production with an increase in bunch number (Swaray *et al.,* 16). Hence, improved growth attributing parameters of NRCOP 2 such as stem girth (3.52 m), which increased in high frond production (25.8) and bunch numbers (8.14). Bunch quality components are crucial in determining bunch weight because they were the most vital economic component of the oil palm bunch. The main contributing features in determining oil to bunch were mesocarp to fruit, oil-to-wet mesocarp to fruit, and fruit to bunch. According to Corley (4), mesocarp to fruit (MTF) was one of the most important aspects of bunch quality, because 95 per cent of palm oil yield (POY) was always found inside MTF of the palm fruit.

Table 3. Performance of *tenera* hybrids for yield and yield traits.

Tenera Hybrids	BNO (bunch palm^{-1} yr^{-1})	ABW (kg bunch^{-1})	FFB (kg palm^{-1} yr^{-1})	FFB yield (t ha^{-1})
NRCOP 1	6.44	16.95	188.3	15.63
NRCOP 2	8.14	19.22	221.8	22.14
NRCOP 3	6.50	15.25	137.5	14.38
NRCOP 4	6.13	15.91	150.5	13.95
NRCOP 5	6.26	15.46	109.6	14.01
NRCOP 6	8.04	15.89	168.4	18.19
NRCOP 7	7.49	15.60	153.2	16.63
NRCOP 8	6.94	16.19	140.7	16.07
NRCOP 9	7.43	16.02	178.9	16.88
NRCOP 10	5.53	15.68	102.7	12.35
S.Em±	0.11	0.80	14.28	0.18
CD(P=0.05)	0.33	0.26	41.30	0.53
CV (%)	2.84	2.58	2.05	1.96

BNO = number of harvested bunch, ABW= Average bunch weight, FFB= Fresh fruit bunch

For MTF, there were significant effects between the genetic origin materials of their progenies, ranged from 48.1 to 75.7 per cent (Table 4), resulting in considerable differences in oil to bunch ratio (OTB). MTF varied from 47.90 to 73.81 per cent in Thailand (Krualee *et al.,* 9) and 74.26 per cent on Hainan Island (Shi *et al.,* 18). Amiruddin *et al.* (1) reported that hybrids generally manifest low MTF and low total OTB but high STF. The Average bunch weight (ABW) was significantly higher in NRCOP 2 (19.22 kg) followed by NRCOP 1 (16.95 kg). In the same way, FFB yield in NRCOP 2 (22.14 t ha $^{-1}$) was higher than other hybrids (Table 3). These findings were in line with Sapey *et al.* (15), who suggested that high ABW paired with moderate BNO should be explored for higher FFB production. Tamil selvan *et al.*(19) reported that rate of inflorescences production and sex ratio increases the FFB yield of *tenera* hybrid NRCOP 17 (28.37 t ha $^{-1}$).

In the present study, NRCOP 2 had the maximum oil to bunch ratio (21.2 per cent), followed by NRCOP 7 and NRCOP 9 (Table 4). Different genetic materials used as parents to generate oil palm hybrids could influence fruit set and oil yield (Swaray *et al*.,16). Shell thickness has a significant impact on oil content, with *teneras* in bunches having 30 per cent more mesocarp and 30 per cent more oil than *duras* (Corley, 4). Among the genetic factors controlling yield, Amiruddin *et al.* (1) found that either the dominant gene, additive gene, or a combination of both were responsible for controlling yield, based on the type of planting materials and its growing environment.

A correlation study was done in these oil palm hybrids for six traits (Table 5), and it was reported that the number of frond produced per year was positively correlated with the number of inflorescence production, sex ratio, number of bunches and FFB yield. The number of inflorescences produced and the sex ratio were significantly and positively correlated with the number of bunches and FFB productivity and FFB yield. The number of bunches and the weight of the bunches had a significant and positive correlation with FFB productivity and yield. FFB productivity was significantly and positively correlated with FFB yield per palm**.** In this correlation study, we found out that an increase in the number of leaves of the palm will increase the number of inflorescence, bunch number, and FFB yield. These results agreed with previous report (Mathur and Kumar, 12).

This hybrids evaluation study conclude that, among the ten *tenera* hybrids, NRCOP-2 was considered the superior hybrid based on morphological traits and FFB yield performance for three consecutive years following yield stability. NRCOP- 2 produces more FFB (22.14 t ha^{-1}), has a higher sex ratio (70%), a higher number of bunches per palm (8.14) and a higher oil to bunch ratio (21.2%) than other hybrids.

Table 4. Performance of *tenera* hybrids for bunch yield components.

Tenera Hybrids	MTF (%)	KTF (%)	STF (%)	OTB (%)
NRCOP 1	68.7	6.65	13.68	19.9
NRCOP 2	75.7	7.73	10.9	21.2
NRCOP 3	60.9	6.6	28.61	19.8
NRCOP 4	47.0	7.4	13.5	18.0
NRCOP 5	60.2	6.9	26.3	17.1
NRCOP 6	56.7	7.8	27.7	16.1
NRCOP 7	55.6	7.8	27.4	21.3
NRCOP 8	48.1	9.3	32.9	18.1
NRCOP 9	57.6	8.1	25.9	20.6
NRCOP 10	53.5	8.6	33.0	12.6
S.Em±	0.97	0.12	0.42	0.22
CD (P=0.05)	2.19	0.35	1.28	0.62
CV (%)	2.88	2.82	3.10	2.07

MTF = mesocarp to fruit (%), KTF = kernel to fruit (%), STF = shell to fruit (%), OTB = oil to bunch (%)

Table 5. Correlation coefficient of vegetative and yield traits in oil palm hybrids

Trait	FP	INFL	SR	BNO	FFB P	FFBY
FP	1					
INFL	0.662*	1				
SR	0.698*	0.614	1			
BNO	0.654*	0.839**	0.911**	1		
FFBP	0.659*	0.686*	0.760**	0.733*	1	
FFBY	0.711*	0.847**	0.816**	0.919**	0.860**	1

FP- Frond Production, INFL- No. of Inflorescence production, SR - Sex Ratio, BNO- number of harvested bunch, FFB- Fresh fruit bunch (kg palm^{-1} yr^{-1}), FFBY- FFB yield (t ha^{-1})

AUTHORS' CONTRIBUTION

Conceptualization of research (HPM, RKM, PMH); Designing of the experiments (RKM,MSG,SS); Contribution of experimental materials (RKM); Execution of field/lab experiments and data collection (MSG, PPD); Analysis of data and interpretation (MSG, SS); Preparation of the manuscript (SS, MSG).

DECLARATION

There were no conflicts of interest to declare by the authors.

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