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Seasonal variation in fresh fruit bunch production in *dura* oil palm

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ABSTRACT

An attempt was made to study the temporal variation in the Fresh Fruit Bunche's (FFB) production in *dura* palms at Indian Institute of Oil Palm Research, Pedavegi, Andhra Pradesh. The performance of the two D × D cross combinations, viz. 240D × 281D (CC1 palms) and 80D × 281D (CC2 palms) planted in the year 2000 in terms of number and weight of fresh bunch produced during different months during 2005 – 2012 was analysed. The FFB production (in terms of number and weight) was maximum (seasonal maxima) during the four months from May to August in an year which accounted for almost 2/3rd of FFB production of the year. Seasonal minima in the FFB production was observed during the winter starting from October to March. FFB production exhibited a trend of alternate bearing that is good yield in one year (on year) and reduced or poor yield in the subsequent year (off year), the trend being consistent in respect of bunch weight. The average bunch weight continuously increased from the 6th to 13th year of the plantation. The difference in FFB production not significantly different whereas the duration of FFB production (*seasonal maxima*) was significantly different among crosses. In Andhra Pradesh, it could be the non-availability of short days or non-availability of pollen and or pollinating weevil during rainy season (June to October in Andhra Pradesh) resulting in reduced flowering and subsequently low harvest of FFB (after 5-6 months of flowering) during November to March (*Seasonal minima*).

Key words: Bunch number, Bunch weight, Calendar year, Cross combination, Dura, Season, Oil palm, Photoperiod

Oil palm (*Elaeis guineensis* Jacq) is the highest edible oil yielding crop giving up to 5-6 tonnes of oil per ha per year. It is a monoecious plant in which male and female flowers are produced on separate inflorescences, with each leaf subtending a single inflorescence. Flowering occurs throughout the year, with male and female inflorescences being produced in series of varying duration. Although the Fresh Fruit Bunches (FFBs), are produced round the year, in the commercial *tenera* plantations as well as in the *dura* palms of seed gardens, production peaks were observed during certain period of the year (Corley and Tinker 2003, Henson 2006). Studies on the physiology of flowering explaining the occurrence of production peaks, variation in the oil recovery during peak and off-peak season and sex differentiation would certainly help in regular production of FFBs with greater oil recovery.

The 'sex ratio' (ratio of female to total inflorescences in a given group of palms) in oil palm is influenced by both genetic and environmental factors. Corley (1976a) noted that in West Africa, the period of lowest sex ratio (high male inflorescence production) occurs during the rainy season and speculated that this character is an adaptation against the reduction in airborne pollen density caused by high atmospheric humidity. It is reported that in tropical humid climates with regular rainfall (*e.g*. Malaysia and Indonesia), inflorescence and fruit production is spread evenly throughout the year and the sex ratio tend to vary little throughout the year. 'The enhancement of male inflorescence production in response to water stress has been well documented (Adam *et al*. 2005). However, there is no information available about these variations under irrigated conditions. Hence, an attempt was made to study the FFB production of *dura* palms in different months of the calendar year to find out seasonal variation *vis-à-vis* presence or absence of seasonal maxima/minima in FFB production.

MATERIALS AND METHODS

The *dura* × *dura* crosses, 240D × 281D (cross combination 1 or CC1 palms) and 80D × 281D (cross combination 2 or CC2 palms), were planted at Indian

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Table 1 Rainfall data of IIOPR, Pedavegi during 2002 to 2013

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
2002	17	59	128	365	164	150	169	217	94	709	407	25	2504
2003	na	na	na	0	0	97	212	109	274	113	8	272	1085
2004	7	1	0	0	39	97	169	169	113	149	4	0	748
2006	0	0	0	156	409	189	306	203	399	666	299	15	2642
2007	6	42	208	255	218	442	404	238	351	408	196	21	2789
2008	74	80	85	246	91	142	431	186	213	422	208	61	2239
2009	26	19	90	24	167	235	355	2	153	137	13	3	1224
2010	41	3	24	164	139	270	267	267	468	92	184	96	2015
2011	na	na	na	2	0	25	160	165	34	17	0	3	406
2012	11	0	0	0	42	373	426	152	206	106	6	0	1322
2013	0	37	0	27	6	116	278	217	233	399	27	1	1341

na – not available; Values are in mm

Institute of Oil Palm Research (IIOPR), Pedavegi, Andhra Pradesh, India during the year 2000 and 45 palms of each cross were used in this experiment. Data on the number and weight of fresh fruit bunches (FFBs) was recorded month-wise in 15 palms per replication, during 2005-2012. The per cent FFB production (number and weight of fresh fruit bunch) during different months of the calendar year .

RESULTS AND DISCUSSION

In Andhra Pradesh, oil palm, although, grown under irrigated conditions, the rainfall data of Indian Institute of Oil Palm Research (IIOPR), Pedavegi is mentioned in Table 1. The south-west monsoon starts during June and the effect extends up to October. It is dry season from December to February and the temperatures start rising from end of March peaking in May (summer season).

Seasonal variation

Dura FFB production in terms of bunch number (BN) during 2005-12 is presented in the Table 2. In CC1 palms, total FFB production (BN) increased from the month of May and reached maximum during June (160) and declined in August (149) which was insignificant. Mean BN was maximum in June (26.67) and August (24.83) and declined in July (20.50) and Sept (19.33). Whereas in CC2, total BN increased from the month of May (101), reached maximum during August (160). Average BN was the maximum during August (26.67) and declined during June to Sept which was insignificant.

Dura FFB production in terms of bunch weight (BW) also had similar trend (Table 3). In CC1 palms, from April (772 kg) to May (1408 kg) and during May to June (2882 kg) there was a sharp increase in FFB production which continued up to July – August. The FFB production declined

Table 2 FFB Production (Bunch Number) in 240D × 281D (CC1) and 80D × 281D (CC2) during 2005-2012

	2005		2007		2008		2009		2011		2012		Total		Mean	
	CC1	CC2	CC1	CC2	CC1	CC2	CC1	CC2	CC1	CC2	CC1	CC2	CC1	CC2	CC1	CC2
Jan	4	9	0	1	0	0	8	1	0	0	1	3	13	14	2.17	2.33
Feb	12	22	1	3	7	1	6	5	10	2	3	0	39	33	6.50	5.50
March	5	8	0	0	7	6	7	9	0	2	7	1	26	26	4.33	4.33
April	8	11	2	5	12	13	13	13	9	14	6	7	50	63	8.33	10.50
May	17	22	16	5	15	20	13	16	13	17	16	21	90	101	15.00	16.83
June	20	35	52	20	15	7	13	19	31	15	29	49	160	145	26.67	24.17
July	21	20	26	48	19	13	19	15	22	26	16	5	123	127	20.50	21.17
Aug	44	42	19	18	21	14	26	28	14	21	25	37	149	160	24.83	26.67
Sept	38	33	13	19	18	24	16	25	7	11	24	21	116	133	19.33	22.17
Oct	8	6	25	15	9	4	13	19	9	8	22	10	86	62	14.33	10.33
Nov	0	0	5	6	1	12	3	6	1	2	2	2	12	28	2.00	4.67
Dec	0	0	1	1	0	0	3	1	0	2	0	3	4	7	0.67	1.17
Total	177	208	160	141	124	114	140	157	116	120	151	159	868	899		
CD (P=0.05)															7.91	9.44

Table 3 FFB production (Bunch weight in kg) in 240D × 281D (CC1) and 80D × 281D (CC2) during 2005-2012

	2005		2007		2008		2009		2011		2012		Total		Mean	
	CC1	CC2	CC1	CC2	CC1	CC2	CC1	CC2	CC1	CC2	CC1	CC2	CC1	CC2	CC1	CC2
Jan	23	37	0	10	0	0	115	19	0	0	17	27	155	93	25.83	15.50
Feb	58	141	8	25	71	15	54	98	176	13	42	0	409	292	68.17	48.67
March	22	83	0	0	78	105	81	149	0	63	137	8	318	408	53.00	68.00
April	50	101	24	80	197	213	188	224	196	271	117	189	772	1078	128.67	179.67
May	158	265	151	64	225	358	252	366	276	463	346	464	1408	1980	234.67	330.00
June	228	352	870	263	218	140	288	390	695	408	583	1001	2882	2554	480.33	425.67
July	207	240	350	677	245	253	331	294	425	525	314	110	1872	2099	312.00	349.83
Aug	307	409	195	228	234	155	419	518	206	341	409	648	1770	2299	295.00	383.17
Sept	311	276	138	275	194	279	234	392	70	182	351	306	1298	1710	216.33	285.00
Oct	44	29	291	132	90	32	161	272	122	117	327	103	1035	685	172.50	114.17
Nov	0	0	50	60	5	145	29	48	14	26	20	15	118	294	19.67	49.00
Dec	0	0	11	6	0	0	39	11	0	34	0	46	50	97	8.33	16.17
Total	1408	1933	2088	1820	1557	1695	2191	2781	2180	2443	2663	2916	12087	13589		
CD (P=0.05)															119.90	153.75

during September (commencement of winter/low temp) to March which was insignificant. Mean BW was significantly the maximum in June (480.33 kg) which declined in July (312) and August (295). CC2 palms also had maximum BW in June (425.67 kg) which insignificantly declined in August (383.17) and July (349.83 kg). The FFB production was the lowest during winter months (from December to March) in terms of both number and weight of the bunch. Corley and Tinker (2003) and Henson (2007) reported that although the vegetative growth and development are continuous and constant under favourable conditions there were strong seasonal variations of reproductive growth in oil palm. Henson (2006) also reported that annual production is continuous but generally shows marked seasonal peaks which can neither be explained by carbon assimilation nor by phenology alone.

In oil palm owing to the thickness of shell in the fruit, there are three fruit forms, dura (thick shell), pisifera (no/ rudimentary shell) and tenera (thin shell and this is the hybrid of Dura and Pisifera). Commercial planting material (Tenera) is produced by crossing the Dura (mother palm) with Pisifera (pollen parent). Dura improvement consists of making selections among the Dura population, selfing and inter se crossing of selected dura palms for taking them to next breeding cycle. Oil palm being a cross-pollinated crop, variation among the progeny of D × D crosses is expected. Peak FFB production was observed in four months (June to September) in the case of CC1 palms, whereas in CC2 palms it was the maximum during five months (from May to September). Thus varietal variation among CC1 and CC2 palms was apparent both for mean annual yield and duration of maxium yield. Variation in the performance of different Dura crosses was reported by Seng *et al.* (2011) and Mohd *et al.* (2014). Differences among various Dura crosses as influenced by season is not reported.

Trend of 'on' and 'off' years

Comparison of annual yield data (Table 4) of both CC1 and CC2 palms for the years 2005 (6^{th} year of plantation) to 2012 (13^{th} year of plantation) indicated a trend of *on* (high production) and *off* (low production) years which is comparable to that of alternate bearing in mango (Litz 2009), and other fruit crops like apple (Ebert and Bangerth 1981), citrus (Shalom *et al*. 2012), mandarin (Natalia *et al*. 2011), olive (Rallo *et al*. 1994) and pistachio (Crane and Iwakiri 1981).

Alternate bearing (AB) is the process by which cycles of heavy yield (ON crop) in one year are followed by a light yield (OFF crop). The data from 6^{th} to 13^{th} year of the *dura* plantation (consisting of CC1 and CC2 palms) exhibited decrease in FFB production every alternate year. The trend was consistent in CC1 palms (Fig 1) compared to CC2 palms. The bunch weight (Fig 2) has shown consistent

Table 4 The FFB production of dura palms in successive years during 2005 to 2012.

Year	Age	240D × 281D			80D × 281D		
		BN	BW (kg)	Ave. BW(kg)	BN	BW (kg)	Ave. BW(kg)
2005	6^{th}	177	1408	7.96	208	1933	9.29
2006	7^{th}	148	1617	10.93	154	1582	10.27
2007	8^{th}	160	2088	13.01	141	1820	12.91
2008	9^{th}	124	1557	12.55	114	1695	14.87
2009	10^{th}	140	2191	15.64	157	2781	17.71
2011	12^{th}	116	2180	18.79	120	2443	20.36
2012	13^{th}	151	2663	17.64	159	2916	18.34
Mean		144.67	2014.50		149.83	2264.67	
CD		NS	NS		NS	NS	

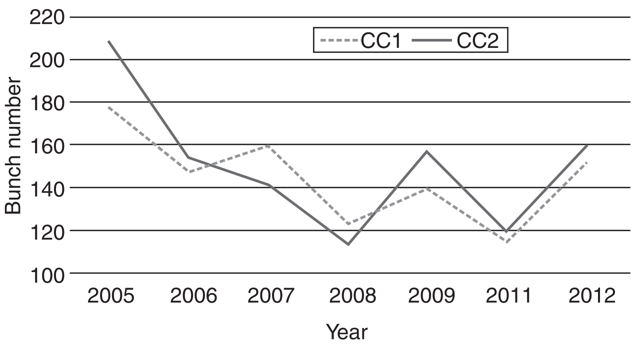

Fig 1 Trend of FFB production (Bunch number) in 240D × 281D (CC1) and 80D × 281D (CC2) palms during 2005-2012

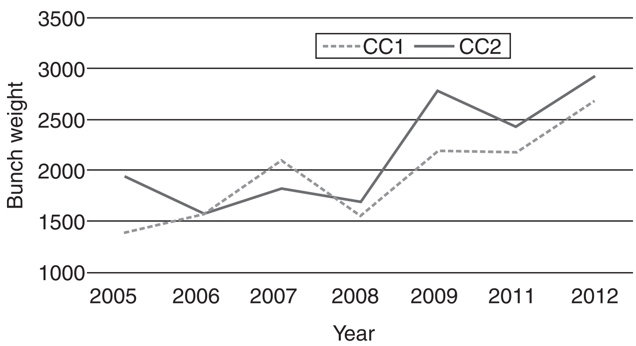

Fig 2 Trend of FFB production (Bunch weight) in 240D × 281D and 80D × 281D palms during 2005-2012

trend of on and off in successive years than bunch number. In both cases, the average bunch weight, however, increased steadily from 6th to 12th year of the crop.

Per cent FFB production in different months of calendar year

Analysis of data on per cent of FFB production during different months of the calendar year reveals that CC1 palms had the maximum FFB production in June which decreased during July and August (Fig 3) whereas in CC2 palms, it was maximum in June as well as in August which decreased during September (Fig 4). The FFB production during four months, viz. May to August of the calendar year was 65.62 and 65.74% of total FFB production in CC1 and CC2 palms respectively. Whereas, FFB production during five months from May to September was 76.36 and 78.32% of the total FFB production in CC1 and CC2 palms respectively during that year. These five months could be termed as *Seasonal Maxima,* whereas the months, November to March which recorded lowest (10.83 and 8.68% in CC1 and 12.01 and 8.71 in CC2 of BN and BW, respectively) may be termed as *Seasonal Minima* as reported by Henson (1999) and Legros *et al.* (2009). Henson (2006) reported that annual FFB production is continuous but generally shows marked seasonal peaks which can neither be explained by carbon assimilation nor by phenology alone.

The occurrence of seasonal maxima (about four months) and seasonal minima (2 -3 months during winter) under irrigated conditions may not be ascribed to a single factor. Seasonal variation in the production of FFBs may be attributed to day-length (photoperiod) requirement of the crop (Legros *et al*. 2009), allocation of available photosynthates (adaptive flexibility) (Korpelainen 1998), changes in endogenous hormone levels (Corley 1976), and or poor activity of pollinating weevil during rainy season, June to August (Corley 1976a). It was assumed that oil palm is a short-day plant like most tropical plants (Rivera and Borchert 2001, and Kouressy *et al*. 2008) but would also have obtained significant correlations with the opposite assumption which would result in a stimulus occurring 6 months earlier (the time taken from flowering to harvesting of FFBs is about 6 months). Legros *et al* (2009) reported regular seasonal peaks (two in number) at Kandista (a place in Indonesia without a drought) and irregular production peaks in Batu Mulia (Indonesia). The two annual minima of photoperiod observed at Kandista (where drought was considered to

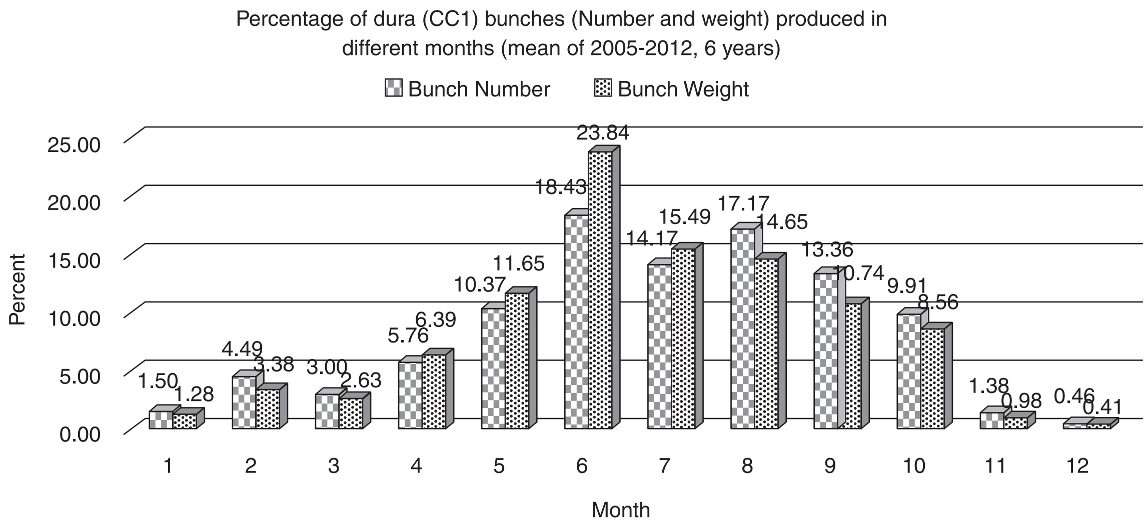

Fig 3 Per cent FFB (Bunch number and bunch weight) production of 240D × 281D (CC1) in different months of calendar year (mean of 2005, 2007, 2008, 2009, 2011 and 2012, 6 years)

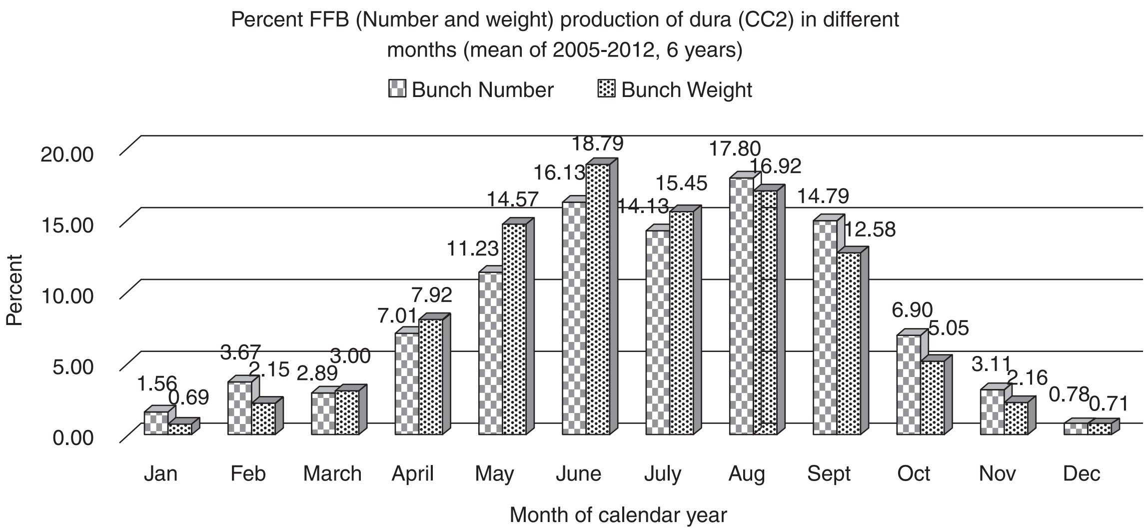

Fig 4 Per cent FFB (Bunch number and bunch weight) production of 80D × 281D (CC2) in different months of calendar year (mean of 2005, 2007, 2008, 2009, 2011 and 2012, 6 years)

be a negligible factor) were associated with these peaks of FFB production, whereas at Batu Mulia (experiences dry spells/drought) each dry season was associated with a depression in mature bunch number. In Andhra Pradesh, oil palm is mainly grown under irrigation conditions, hence, the drought or moisture deficit playing a role in intra or inter annual yield variation (seasonal variation) may be ruled out. Similarly, the concept of adaptive flexibility as proposed by Korpelainen (1998) may not be playing a role as the plantation was maintained following recommended cultural practices. Hence, it could be the non-availability of short days (may not able to synthesize the flowering stimulus adequately) or non-availability of pollen and or pollinating weevil during rainy season (June to October in Andhra Pradesh, Please refer to Table 1) resulting in reduced flowering and subsequently low harvest of FFB (after 5-6 months of flowering) during November to March (*Seasonal minima*).

The duration of extended seasonal maxima of FFB production could be used as one of the selection criteria in the oil palm breeding program as it would certainly enhance the overall yield. Variation in cross combinations may be exploited and steps may be taken to reduce the duration of seasonal minima in the direction of improving the yield.

In the cross combinations (240D × 281D and 80D × 281D palms), FFB production increased from the month of May, reached maximum during August and decreased during October. The lowest number of fresh fruit bunches were recorded during winter months, December – January. The FFB production during four months, viz. May to August of the calendar year was 65.62 and 65.74% of total FFB production in CC1 and CC2 palms respectively. Per cent FFB production of CC1 palms was the highest in June which decreased during July and August whereas in CC2 palms, FFB production was the maximum in August.

The FFB production exhibited a trend of on and off year (comparable to that of alternate bearing in mango and other temperate fruit crops), the trend being consistent in respect of bunch weight. Average bunch weight has shown continuous increase from 6th year to 13th year of the plantation.

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