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Bunch Analysis of Oil Palm

National Research Centre for Oil Palm

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Introduction

Bunch analysis in oil palm is essential for evaluation of a palm for its oil yield. Oil palm being a cross pollinated crop, performance of individual palm varies from each other and hence, assessment of individual palm is utmost important. Evaluation of palms is needed for different purposes, like for selection of superior and elite *tenera* palms for *in vitro* micro-propagation, *dura* mother palms for hybrid seed production, specific hybrid combination (D X P) by analyzing the bunches of the progeny palms, or for comparison of palm(s) grown under any two or more treatments. Therefore, the evaluation of the performance of palms is a regular activity in oil palm R&D Laboratories and large number of palms needs to be evaluated every year.

Usually evaluation of palms is conducted by recording the fresh fruit bunch (FFB) yield / palm / year. But oil being the ultimate yield of oil palm, the evaluation of palms for oil yield needs to be carried out, which can be accomplished by 'Bunch Analysis' of palms.

Selection of palms

Usually, bunch analysis is conducted for the palms after they attain the stable yield and hence, the activity can be started only after the palms attain a age of 10 years. However, in most of the cases the comparative performance matters for a researcher and hence the juvenile palms of the same age can be selected for bunch analysis for a specific experiment. However, sampling of the bunches should be carried out during the same period or same season. Otherwise, the error due to seasonal variation should be taken into consideration.

Harvesting of FFB

Harvesting FFB for bunch analysis is a very crucial aspect. Since the oil formation during the last two weeks of bunch maturity is maximum, any premature harvesting would result in under performance of the palms. Collection of bunches for bunch analysis from the commercial harvesting lots are not advisable, because the process of harvesting in a garden takes places at a particular interval of 1-4 week depending upon the season (lean and peak season). Both over mature and under mature bunches are harvested along with the optimum mature bunches; hence collection from these harvested bunch would end up in error. Personal observation and selection of fully ripen bunches from individual palm is very important. Till

Harvesting of oil palm bunch

now the procedure followed for harvesting a fully ripen bunch is the day when around 10 fruits fall from the bunch to the ground.

Step by step procedure and observations to be recorded

- The FFB needs to be weighed immediately after harvesting and taken to the bunch analysis laboratory. To reduce unaccountable moisture loss from the bunch and also from the mesocarp, the bunch analysis should be started as early as possible after harvest. Loose fruits should be collected with the bunch and weighed along with the bunch. The bunch is then cut into 1/4th vertically with a sharp axe. While cutting the bunch, care should be taken to see that the entire portion of the bunch from the base to the bottom tip represents the 1/4th bunch.

1/4th bunch

- Spikelets should be removed from stalk, for both 1/4th portion and 3/4th portion of the bunch and total stalk and total spikelet weight should be recorded. The spikelets weight for 1/4th bunch should be recorded separately and kept aside for further analysis. In case of very small bunches, especially in case of juvenile palms, where the weight of the bunch is even less than 6-8 kg, the entire spikelets of the bunch should be considered.
- All the fruits from the 1/4th spikelets should be separated. Bruising or rupturing of fruits should be avoided during separation of fruits. After recording the total fruit weight, a representative sample of 500 g (representative fruits should be of all sizes and types) should be separated out for further analysis. Number of fruits present in 500 g fruits should be counted. In case of bunch analysis of interspecific hybrids it is recommended to separate all the fruits into parthenocarpic and seeded categories. Both the fruits should be proportionately sampled to 500 g for further analysis.

Scraping of mesocarp

- Mesocarp from each of the 500 g fruit sample should be scraped fully leaving the nuts alone. The number and weight of the nuts should be recorded. Mesocarp should be scraped manually with a sharp knife as thin flakes of 1-2 mm thickness for uniform drying during the subsequent step. Though the number of nuts and number of fruits are usually same

in case of *dura* and *tenera* palms, in case of interspecific hybrids *(Elaeis guineensis* X *Elaeis oleifera* and reciprocal crosses), *E. oleifera* palms, *pisifera* palms (though the bunch analysis is rarely done in *pisifera*) and in some other cases due to parthenocarpy, number of nuts would be lesser than number of fruits.

- Scraped mesocarp should be mixed thoroughly and a representative sample of 50-100 g should be dried either in a hot air oven at a temperature of 105°C for 24 hours, or in a microwave oven in full power for 10 min. In case of hot air oven, long duration of heating may degrade the minor nutritional ingredients like carotenoids, tocopherols and tocotrienol etc. and also the mesocarp samples may get charred. Hence, the mesocarp samples should be uniformly spread on a petriplate and put in the microwave for drying. The drying is usually done in three splits of 4 min., 4 min. and 2 min. with a gap of 2 min. between every interval. Number of petriplates that can be placed in the micro oven at a time depends upon the capacity of the oven. The split is recommended instead of continuous 10 min. to avoid overheating and malfunctioning of many of the equipments, which are usually manufactured for home cooking purpose. However, this timing can be adjusted depending upon the make and capacity of microwave oven.
- Representative mesocarp samples should be weighed as early as possible to avoid moisture loss. If the entire mesocarp from 500 g fruits is dried at a time, delay is not a factor. If the delay is inevitable and the drying needs to be done by sub-sampling, the weight of the whole mesocarp from 500 g fruits may be measured before sub-sampling to record the moisture loss. This loss may be accounted during calculation of moisture content in the subsamples.
- The fresh and dried mesocarp should be weighed for estimating the moisture percentage. Three to five grams of the dried mesocarp should be subjected to oil estimation by any of the standard methods. When the samples are less, ordinary Soxhlet apparatus with a 200 ml extractor, or automated Soxhlet apparatus with microprocessor control can be used. In case of large samples, indirect methods of oil estimation developed by NRCOP can be adopted. In both the cases a period of 14 hours extraction process should be continued for complete extraction of the oil. The process can be completed in shorter duration of 2 hours in automated machine like SOXTHERM (Gerhardt, Germany). It is recommended to use three replications for oil estimation from dry mesocarp.

Extraction of oil in Soxhlet apparatus

- Nuts should be kept for air drying for 1-2 weeks depending upon the atmospheric temperature and

relative humidity. Drying should be continued till the kernel gets separated from the shells easily. As the shell does not contain any moisture (even there is any moisture, it would be negligible and usually ignored), the fresh kernel weight is obtained by deducting the weight of the shell from the nut weight. Hence the duration of drying and extent of drying of the kernel does not matter much.

- Kernel should be dried fully in hot air oven or in microwave oven. Since the breaking of kernel is not advisable (as some pieces may get lost during breaking them), drying of the whole kernel should be carried out. Hence the drying time of the kernel depends on the size of the kernel and it may vary from 24 hours to 48 hours in hot air oven at 100^{O}C or 10 – 30 min. in microwave oven. Depending upon the material the time needs to be standardized.
- Measuring kernel oil is an optional step. Mostly the kernel weight is only recorded and 50% of the weight is considered as oil content. However, in case kernel oil need to be measured, measured kernel should be ground in a mixie/grinder or in pestle and mortar. Oil would ooze out while grinding, which should be wiped with little cotton/tissue paper, and should also be placed in the thimble along with ground kernel. Indirect method of oil estimation can be adopted by standardization. However, 18-20 hours of extraction would be sufficient to extract oil from kernel. Programme for three hours is sufficient in SOXHTHERM.

Important Notes

- Minimum three bunches per palm should be analyzed for compiling the data.
- It is not recommended to estimate the nutritional quality of oil extracted from these mesocarp samples, because the factory level processing principle is entirely different from this method. For estimation of oil quality, it is better to extract the oil after sterilizing the fresh fruits at 15 psi pressure at 121^{O}C for one hour and oil should be extracted by a screw press (hand operated screw press is developed by NRCOP, Pedavegi).
- Fresh kernel weight is the basis for estimating the kernel oil, because many of the processing mills sell the kernel itself. Kernel oil content is also estimated roughly as 50% of the kernel weight. However, for specific purposes where the kernel oil content from palm to palm is an important factor, drying of the kernel should be carried out thoroughly.
- It is observed in case of irrigated oil palm under the coastal Andhra Pradesh conditions, the oil content in the fruits from different portions of the bunch varies. Similarly the oil content in the inner layer and outer layer fruits of a bunch also may vary. However, if the bunch analysis is to be done

considering these factors, then all the fruits from each bunch need to be separated and proportionate quantity of fruits are to be taken in 500 g fruit samples for further analysis. However, it is extremely time consuming and found practically not possible. It can be done for the smaller bunches, where the full bunch analysis is carried out, but not recommended in case

SAMPLE PROFORMA FOR BUNCH ANALYSIS

OBSERVATIONS TO BE RECORDED			
Parameters to be recorded		Code	Values
Experiment No.			
Palm No.			
Bunch No. (replication)			
Date of harvest			
Bunch weight (kg)		A	
Stalk weight (kg)		B	
Spikelet weight in 1/4th Bunch (kg)		C	
Fruit weight in 1/4th bunch (kg)		D	
No. of fruits in 500 g fruits		E	
Weight of nuts in 500 g fruits (g)		F	
Drying of mesocarp for estimating moisture content in mesocarp	Weight of container/petriplate (g)	G_1	
	Initial weight (mesocarp + container) (g)	G_2	
	Dry weight of (mesocarp+ container) (g)	G_3	
Weight of shell in 500 g fruits (g)		H	
Drying of kernel for estimating moisture content in mesocarp	Weight of container (g)	I_1	
	Initial Weight of container+ kernel (g)	I_2	
	Dry Weight of Container + kernel (g)	I_3	
Mesocarp Oil estimation	Weight of R.B. flask (g)	J_1	
	Weight of mesocarp (g)	J_2	
	Weight R.B.flask + oil (g)	J_3	
Average FFB Yield / Palm /year (kg)		Y	

CALCULATION FOR OTHER PARAMETERS			
Parameters to be calculated	Code	Formula	Values
Total Spikelet Weight (kg)	K	= A-B	
Spikelet/ Bunch (%)	L	= (K /A) x 100	
Fruit / Spikelet (%)	M	= (D /C) x 100	
Fruit /Bunch (%)	N	= (L x M)/ 100	
Average fruit weight (g)	Not required	= 500/E	
Mesocarp/Fruit (%)	O	= [(500-F)/500] x 100	
Mesocarp/Bunch (%)	P	= (O x N)/ 100	
Moisture in mesocarp (%)	Q	= $[(G_2-G_3)/(G_2-G_1)]$ x100	
Moisture in kernel (%)	R	= $[(I_2-I_3)/(I_2-I_1)]$ x 100	
Oil/Dry mesocarp (%)	S	= $[(J_3-J_1)/J_2]$ x 100	
Oil/fresh mesocarp (%)	T	= [S x (100-Q)]/100	
Oil/Bunch (%)	U	= (T x P) /100	
Oil Yield/Palm/Year (kg)	Not required	= U X Y	
Kernel/ Fruit (%)	V	= [(F – H)/500] x 100	
Kernel/ bunch (%)	W	= (V x N)/ 100	
Kernel Yield / Palm /Year (kg)	Not required	= W x Y	

Note : Average FFB yield of the palm is required for calculating the Oil yield, which is not actually a part of bunch analysis

of larger bunches. Many laboratories where equal amount of inner and outer layer of fruits are sampled, or equal amount of fruits from different portion of bunch are sampled, end up in error, since the proportion of different so called categories of fruits are not present in equal proportion in the bunch. Careful cutting of the bunch to 1/4th portion vertically from the base of the bunch to the tip portion, as mentioned earlier, takes care of both the factors – portion of bunch and inner and outer layer of fruits.

- Bunch analysis data and values may vary from laboratory to laboratory and they are not absolute values. But since in most of the cases, it is only the evaluation of comparative performance of palms; analysis of all the palms of a single experiment conducted in the same laboratory would not matter for the researchers.
- Bunch analysis data of oil/bunch (%) predicts the actual oil content in the bunch and hence it would not be the OER in a factory. Moreover since bunch analysis is for evaluation of experimental palms, in any case this data should not be extrapolated for factory level OER.
- It is recommended to use three replications for oil estimation from dry mesocarp.
- It is recommended to complete the bunch analysis of all the palms of an experiment within the same season (without any drastic variation in climatic conditions like, temperature, humidity and rainfall). However, when it is not possible, seasonal variation should be taken into consideration.
- Several parameters can be calculated from the recorded data. Which depending upon the individual research. However, estimation of oil/ bunch(%), kernal/bunch(%) and there by oil yield / palm/ year and kernel yield / palm /year are the most important parameters for selection of palms based on bunch analysis.

A FEW EXAMPLES OF BUNCH ANALYSIS RESULTS FROM INDIA

Example 1: Bunch analysis of the progeny of 11 different D X P crosses for selection of best hybrid combination under rainfed condition of Kerala

Cross Combination	B.Wt.	Fr/B	Meso/B	Oil/Meso	K/B	Oil/B	KO/B	OY/Y/P	KO/Y/P	Av.FFBY/P/Y
	(kg)	(%)	(%)	(%)	(%)	(%)	(%)	(kg)	(kg)	(kg)
210D Self	25.97	59.33	33.57	54.71	5.86	18.38	2.92	19.04	3.04	103.80
65D X 30.103P	24.40	55.89	41.24	51.77	6.28	21.38	3.17	27.83	4.16	129.70
271D X 30.4336P	24.27	52.72	42.41	51.82	4.19	21.91	2.16	22.58	2.29	102.50
139D X 24.3087P	26.37	55.35	36.90	53.53	8.13	19.77	4.05	15.60	3.25	80.26
156D X 30.4336P	23.07	56.88	45.00	54.20	4.40	24.45	2.29	13.82	1.29	56.09
61D X 30.4336P	30.67	54.99	40.91	47.83	4.30	19.37	2.19	18.46	2.06	94.73
125D X 30.103P	24.87	57.24	42.81	54.47	5.27	23.17	2.68	27.74	3.21	119.80
108D X 30.4336P	17.43	48.24	38.04	61.20	3.66	23.25	1.92	22.52	1.85	96.96
92D X 30.3154P	18.37	48.72	38.51	59.77	4.10	23.03	2.10	25.95	2.36	112.80
269D X 30.4336P	25.10	46.27	37.76	50.63	3.27	19.14	1.59	13.71	1.14	72.13
187D X 24.3087P	24.03	42.46	36.94	57.23	2.83	21.18	1.38	14.50	0.95	67.35
120D X 30.103P	29.50	62.35	48.59	54.50	5.36	26.49	2.67	31.33	3.14	118.50
LSD at 5%	5.45	7.60	6.20	5.45	0.89	2.99	0.46	5.09	0.73	16.22

Example 2: Bunch analysis of *dura* palms for selection of superior mother palms to be used for hybrid seed production under rainfed condition of Kerala, (performance of best 20 *dura* palms based on Mesocarp oil yield/year/palm)

	B.Wt.	Fr/B	Fr.Wt(Av)	Meso/B	Oil/B	K/Fr	K/B	OY/Y/P	KO/Y/P
P No.	(kg)	(%)	(g)	(%)	(%)	(%)	(%)	(kg)	(kg)
157	9.00	73.42	10.09	49.39	25.27	4.61	3.38	58.88	7.87
20	15.50	81.70	10.23	48.01	17.13	5.26	4.30	55.50	13.94
21	15.50	73.28	10.01	49.91	22.59	5.14	3.76	53.09	8.84
342	31.50	81.20	13.56	45.00	20.16	10.49	8.50	40.92	17.26
39	13.75	80.19	11.46	41.89	21.34	8.08	6.47	40.76	12.36
55	11.67	79.90	13.98	47.30	20.71	6.94	5.54	38.31	10.25
28	14.00	77.50	9.10	42.73	19.10	6.63	5.14	37.44	10.07
341	19.00	79.35	11.27	40.06	21.00	9.53	7.57	31.50	11.36
181	13.33	80.69	13.03	48.79	20.06	7.16	5.78	31.09	8.96
72	14.50	80.02	10.80	49.20	23.04	6.97	5.58	30.87	7.48
136	8.60	77.26	11.41	43.62	18.09	7.01	5.38	30.39	9.03
281	17.33	78.83	10.65	44.53	22.70	7.15	5.63	29.06	7.21
172	15.00	80.69	13.94	46.47	21.41	7.53	6.07	28.69	8.14
288	12.67	79.97	12.49	43.88	18.99	6.31	5.06	27.73	7.39
177	12.33	80.01	12.76	44.45	18.01	6.74	5.40	25.75	7.72
191	13.00	82.57	9.44	44.92	20.67	8.39	6.94	24.80	8.32
280	19.67	77.67	11.72	41.64	14.37	7.33	5.70	24.14	9.58
188	15.67	79.81	15.63	42.71	17.74	6.81	5.48	23.95	7.40
183	11.40	74.74	13.10	56.54	23.50	4.06	3.03	23.50	3.03
346	20.00	83.44	18.98	38.86	14.98	8.24	6.87	21.72	9.97
LSD at 5%	**3.80**	**5.56**	**1.96**	**5.57**	**4.47**	**1.55**	**1.36**	**NA**	**NA**

Example 3: Bunch analysis of the progeny of 11 different D X P crosses (juvenile palms) for selection of best hybrid combination under irrigated condition of Peadvegi

Cross Combination	Source	B.Wt	Fr.Wt(Av)	Fr/B	Meso/Fr.	Oil/B	K/B	OY/P/Y	K/P/Y
		(kg)	(g)	(%)	(%)	(%)	(%)	(kg)	(kg)
Deli X Avros	ASD Costa Rica	9.04	5.97	66.48	76.23	22.80	4.40	5.64	1.14
Deli X Ekona	ASD Costa Rica	8.26	5.61	67.41	81.49	24.56	4.06	3.25	0.55
Deli X Ghana	ASD Costa Rica	8.47	5.38	62.79	74.75	25.93	3.73	4.78	0.72
Deli X Lame	ASD Costa Rica	6.99	5.00	71.66	64.27	22.30	7.18	10.50	3.70
65D X 111P	Palode	9.84	6.53	65.68	76.31	23.66	5.27	4.57	1.01
12D X 313	Palode	13.05	8.59	65.45	68.98	22.66	4.86	4.83	1.07
12D x 266	Palode	8.91	5.17	60.34	76.71	22.15	7.33	4.17	1.25
128D X 313	Palode	10.11	6.84	67.32	77.54	23.67	7.38	2.69	0.87
18C X 5201	Ivory Coast	8.06	5.35	66.47	69.42	23.04	9.06	12.05	4.54
9C X 1001	Ivory Coast	7.73	5.32	68.82	76.94	22.10	4.10	10.62	2.39
1M0069D	PNG	9.71	6.07	70.02	80.85	29.54	4.83	8.33	1.35
LSD at 5%		**2.79**	**1.92**	**74.38**	**7.43**	**5.26**	**5.25**	**4.78**	**2.11**

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