International Journal of Oil Palm, **6(1)** : 53-59, June 2009

RESEARCH PAPER

Application of Statistical Models in Selection of Promising Oil Palm Hybrids

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ABSTRACT

Data on Fresh Fruit Bunches weight (FFBW), number of bunches (BN) and average bunch weight (ABW) on 395 palms (23 Costa Rican and one Palode hybrids) for four years were subjected to different statistical models of Analysis of Variance (ANOVA). In first and second models, individual palm wise data and plot wise data, respectively were considered for studying the effects of hybrids, replication, years and hybrid X year interaction. In third model, plot wise data averaged over years were considered to study the effects of hybrids and replication. For above three characters scoring was done and promising hybrids were selected based on greater averages with lesser deviations within hybrid. The correlation between the scores of bunch weight and the total scores based on bunch weight, number of bunches and average bunch weight were found to be very high (r = 0.91), indicating the efficiency of scoring technique used in selecting promising hybrids.

Keywords: Statistical models, oil palm, scoring method, correlation

INTRODUCTION

Oil palm is the highest vegetable oil yielding crop introduced in India to meet the oil demand of the country. Farmers from different states of the country have started adopting oil palm and a huge acreage is going to be under oil palm within a limited time period. A number of oil palm hybrids are being introduced from different countries as well as developed in India, for cultivation under irrigated conditions in India. Performance of different hybrids are being studied by breeders for selection of mother palms for further breeding experiments as well as to identify the best hybrids which may be imported for commercial cultivation in the country. In most cases it becomes difficult to compare the observed performances of genotypes under field conditions primarily due to huge requirement of experimental area leading to high soil heterogeneity. With this view, the present study was undertaken by applying different Analysis of Variance (ANOVA) models and scoring method for identifying superior oil palm hybrid performances from an existing experiment.

MATERIALS AND METHODS

An experiment has been laid in a Randomized Complete Block Design with three replications and plots consisting of six palms with 23 ASD Costa Rican hybrids and one Palode hybrid as check variety (24 crosses) at the National Research Centre for Oil Palm, Pedavegi (A.P.) during October, 1995. Recommended agronomic and plant protections measures were followed to maintain good condition of palms. Because of high voltage electric lines in the experimental field few palms were discarded while recording the observations; this led to less than six palm plots in some cases. Data on Fresh Fruit Bunches weight (FFBW in Kg), number of bunches (BN) and average bunch weight (ABW in Kg) on 395 palms for four years (8-11th year after planting) were collected and subjected to different statistical models of ANOVA (Gomez and Gomez, 1983, Mathew *et al*., 1993, Panse and Sukhatme, 2000, Rangaswamy, 2005). Year wise data on FFBW and BN for each hybrid are summarized in Table 1.

In the present experiment, FFBW, BN and ABW are response variables and hybrids, replication, years are explanatory variables. Three different models are being used for interpreting the data from 24 hybrids. In first model, individual palm wise data were considered (unequal number of observations from each plot) for studying the effects of hybrids, replication, years and hybrid X year interaction. In the second model, plot wise data (averaged over palms) were

Table 1 : Year-wise Fresh Fruit Bunch Weight (Kg) and Number of Bunches

HYBRID	PN*	2003	2004	2005	2006	TOTAL
1	18	889 (73)^	1618 (125)	1339.7 (73)	2626 (164)	6472.7 (435)
2	18	903 (84)	1577 (101)	879.62 (49)	2222 (141)	5581.6 (375)
3	17	1247 (108)	1548 (101)	918 (52)	2380 (158)	6093.0 (419)
4	15	691 (65)	2036 (146)	995 (56)	1705 (138)	5427.0 (405)
5	16	788 (77)	1401 (107)	982.94 (61)	2292 (168)	5463.9 (413)
6	17	937 (76)	2190 (146)	1710.3 (93)	2497 (150)	7334.3 (465)
7	18	593 (57)	1758 (113)	1200.4 (64)	1765 (121)	5316.4 (355)
8	12	821 (75)	915 (63)	906.12 (49)	1445 (107)	4087.1 (294)
9	17	902 (87)	1313 (88)	1009.2 (55)	2121 (140)	5345.2 (370)
10	16	813 (54)	1688 (106)	1338.8 (72)	2030 (119)	5869.8 (351)
11	17	540 (55)	1133 (80)	1026.3 (58)	1402 (108)	4101.3 (301)
12	10	607 (62)	1110 (87)	743.7 (46)	1572 (110)	4032.7 (305)
13	13	601 (55)	1340 (86)	1075.3 (62)	1319 (82)	4335.3 (285)
14	18	921 (82)	1484 (94)	946.46 (65)	2209 (158)	5560.5 (399)
15	18	805 (67)	2254 (145)	933.1 (52)	1847 (125)	5839.1 (389)
16	18	637 (60)	1738 (118)	1504.7 (91)	1511 (110)	5390.7 (379)
17	18	832 (81)	1668 (119)	1367.3 (76)	1866 (134)	5733.3 (410)
18	16	787 (79)	1996 (133)	1125.8 (69)	2055 (146)	5963.8 (427)
19	18	889 (80)	1752 (121)	1033.1 (57)	2460 (143)	6134.1 (401)
20	18	1019 (80)	1924 (135)	1013.5 (55)	2738 (176)	6694.5 (446)
21	18	850 (73)	1822 (122)	1644 (94)	2093 (134)	6409.0 (423)
22	15	602 (62)	1117 (79)	1202.7 (77)	1506 (103)	4427.7 (321)
23	16	936 (90)	1778 (117)	998.7 (56)	1986 (131)	5698.7 (394)
24	18	1034 (87)	1521 (105)	857 (49)	2390 (163)	5802.0 (404)
TOTAL	**395**	**19644 (1769)**	**38681 (2637)**	**26751.7 (1531)**	**48037 (3229)**	**133113.7 (9166)**

* PN: NO. OF PALMS; ^ NUMBER OF BUNCHES IN BRACES;

considered and effects of the above four factors were studied (as the first model). In the third model, plot wise data averaged over years were considered to study the effects of hybrids and replication on the response variables.

Model 1:

$$Y_{ijkl} = \mu + \tau_i + \beta_j + \eta_k + (\tau\eta)_{ik} + \varepsilon_{ijkl}$$

where, Y_{ijkl} is the observation from l^{th} palm of i^{th} hybrid, j^{th} replication in k^{th} year; $1 \le i \le 24$; $1 \le j \le 3$; $1 \le k \le 4$; $1 \le l \le$ no. of palms in different plots ;

μ is general mean;

is effect due to i^{th} hybrid;

β_j is effect due to j^{th} replication;

η_k is effect due to k^{th} year;

$(\tau\eta)_{ik}$ is the interaction effect due to i^{th} hybrid and k^{th} year; ε_{ijkl} is the error component associated with (i, j, k, l)th observation and is identically independently normally distributed random variable with mean zero and variance σ^2.

Model 2:

$$Y_{ijk} = \mu + \tau_i + \beta_j + \eta_k + (\tau\eta)_{ik} + \varepsilon_{ijk}$$

(with similar notation as in Model 1)

Model 3 : $Y_{ij} = \mu + \tau_i + \beta_j + \varepsilon_{ij}$

(with similar notation as in Model 1 except for the year component [k^{th}] and interaction term has been removed)

High variation in FFB yield, BN and ABW for a single palm over years as well as among the palms within plot at a particular time is reported in literature (Corley and Tinker, 2007; Mathur *et al*., 2001). Situations, where palm to palm variation within a plot or variation within palm over years is very high, the first model may be optimum for comparisons. When only within palm variation over years is too high and palm to palm variation is either negligible or ignored, the second model may be appropriate. Further, it is also observed that for oil palm the production of bunches follows a cyclic trend of producing high FFB yield followed by low FFB yield in 3-4 years. In such situation, average/total of FFB yield over years for each plot (Model 3) may be useful ignoring within palm variation over years.

Means and standard deviations (S.D.) for FFBW, BN and ABW were computed for each hybrid and scores for above three characters were assigned to hybrid performance as 1, 2 and 3 (for low, medium and high average values) and 3, 2 and 1 (for low, medium and high deviations within hybrids pooled over the years). All the models were fitted on the same set of data using standard statistical software (SPSS 13.0, SAS 8.0).

RESULTS AND DISCUSSION

Analysis on FFBW: Data on FFBW were analyzed using Model 1, it was observed that six hybrids numbered 6, 12, 18, 20, 10 and 4 were best in terms of FFBW but palm to palm variation within plot was non significant. Therefore, Model 2 can be used to identify the best hybrids ignoring the palm to palm variation within plot. Though year component was found significant, to take care cyclic nature of bunch production the same data was subjected to Model 3 for analysis. From Table 2, it was seen that both the models (2 and 3) reflect the same set of hybrids numbered 6, 12, 18, 20, 10, 4, 23, 1, 3, 21 and 8 as promising hybrids for production of FFBW.

Analysis on BN : Data on BN were analyzed using Model 1 and five hybrids numbered 12, 6, 4, 18 and 5 were found to be best in terms of BN but here also palm to palm variation within replication was found to be non significant. Therefore, as in case of FFBW, analysis has been performed under both Model 2 and Model 3 to identify the promising hybrids ignoring the palm to palm variation within plot and the same set of hybrids numbered 12, 4, 6, 18, 5, 8, 23, 20, 3, 1 and 21 were found to be promising hybrids for production of maximum BN (Table 3).

Analysis on ABW : ABW is the ratio of FFBW and BN. In the present experiment, many palms were found to produce no bunches in a year resulting in 0 divisor for obtaining ABW in a number of cases. Therefore, only plot-wise data has been analyzed using Model 2 and hybrids numbered 10, 6, 20, 19, 15, 2 and 23 were found to be best hybrids for production of maximum average bunch weight (Table 4).

In oil palm, both palm to palm variation and within palm variation is observed for a number of parameters, the above said ANOVA models may be used to identify the best hybrids depending on the situation and objective of the experimenter. To study consistent performance of genotypes (hybrids) for all three characters over years correlation matrix for above three characters was computed; the correlations were found highly significant. Means and standard deviations (S.D.) for FFBW, BN and ABW were calculated for each hybrid and scores for above three characters were assigned to hybrid performance (Table 5) and finally total scores were calculated for each hybrid. The maximum score of 17 out of 18 was obtained by hybrid number 18 and the minimum score of 9 was scored by hybrids numbered 2, 7, 9 and 11. The average score is 11.83 (@12) and standard deviation of scores is 2.20. The average score has been obtained by Palode hybrid and the hybrids numbered 4, 20 and 23.

The hybrids numbered 18, 6, 10, 21, 3, 17 and 16 were found to be best hybrids (scored greater than the score 12 of Palode hybrid or the average of scores) having greater averages with lesser deviations within

Table 2 : Grouping of Hybrids based on Fresh Fruit Bunch Weight (Kg)

Hybrid	Mean (Kg)	Model 1						Hybrid	Mean (Kg)	Model 2			Hybrid	Mean (Kg)	Model 3		
6	107.86	A						6	107.34			A	6	107.34			A	
12	100.82	A	B					12	101.17	B		A	12	101.17	B		A	
18	93.18	A	B	C				18	93.90	B		A	C	18	93.90	B		A	C
20	92.98	A	B	C				20	92.98	B		A	C	20	92.98	B		A	C
10	91.72	A	B	C	D			10	92.32	B		A	C	10	92.32	B		A	C
4	90.45	A	B	C	D	E		4	92.15	B	D	A	C	4	92.15	B	D	A	C
1	89.90		B	C	D	E		23	90.96	B	D	A	C	23	90.96	B	D	A	C
3	89.60		B	C	D	E		1	89.90	B	D	A	C	1	89.90	B	D	A	C
23	89.04		B	C	D	E		3	89.39	B	D	A	C	3	89.39	B	D	A	C
21	89.01		B	C	D	E		21	89.01	B	D	A	C	21	89.01	B	D	A	C
5	85.37		B	C	D	E		8	87.10	B	D	A	C	8	87.10	B	D	A	C
19	85.20		B	C	D	E		5	86.12	B	D		C	5	86.12	B	D		C
8	85.15		B	C	D	E		19	85.20	B	D		C	19	85.20	B	D		C
13	83.37		B	C	D	E		15	81.10	B	D	E	C	15	81.10	B	D	E	C
15	81.10			C	D	E		24	80.58	B	D	E	C	24	80.58	B	D	E	C
24	80.58			C	D	E		17	79.63		D	E	C	17	79.63		D	E	C
17	79.63			C	D	E		2	77.52		D	E	C	2	77.52		D	E	C
9	78.61			C	D	E		9	77.43		D	E	C	9	77.43		D	E	C
2	77.52			C	D	E		14	77.23		D	E	C	14	77.23		D	E	C
14	77.23			C	D	E		22	76.07		D	E	C	22	76.07		D	E	C
16	74.87				D	E	F	16	74.87		D	E	C	16	74.87		D	E	C
7	73.84					E	F	7	73.84		D	E	C	7	73.84		D	E	C
22	73.80					E	F	13	71.25		D	E		13	71.25		D	E	
11	60.31						F	11	60.50			E		11	60.50			E	

Table 3 : Grouping of Hybrids based on Number of Bunches

Hybrid	Mean	Model 1							
12	7.63	A							
6	6.84	A	B						
4	6.75	A	B	C					
18	6.67	A	B	C	D				
5	6.45	A	B	C	D	E			
20	6.19		B	C	D	E	F		
3	6.16		B	C	D	E	F		
23	6.16		B	C	D	E	F		
8	6.13		B	C	D	E	F		
1	6.04		B	C	D	E	F		
21	5.88		B	C	D	E	F	G	
17	5.69			C	D	E	F	G	
24	5.61				D	E	F	G	
19	5.57					E	F	G	
14	5.54					E	F	G	
10	5.48					E	F	G	H
13	5.48					E	F	G	H
9	5.44					E	F	G	H
15	5.40					E	F	G	H
22	5.35					E	F	G	H
16	5.26						F	G	H
2	5.21						F	G	H
7	4.93							G	H
11	4.43								H

Hybrid	Mean	Model 2						
12	7.18				A			
4	6.88		B		A			
6	6.81		B		A	C		
18	6.76		B		A	C		
5	6.46		B	D	A	C		
8	6.42		B	D	A	C		
23	6.33		B	D	A	C		
20	6.19	E	B	D	A	C		
3	6.14	E	B	D	A	C		
1	6.04	E	B	D	A	C		
21	5.88	E	B	D	A	C	F	
17	5.69	E	B	D	G	C	F	
24	5.61	E	B	D	G	C	F	
19	5.57	E	B	D	G	C	F	
14	5.54	E		D	G	C	F	
10	5.51	E		D	G	C	F	
9	5.41	E		D	G		F	
15	5.40	E		D	G		F	
22	5.29	E		D	G		F	
16	5.26	E		D	G		F	
2	5.21	E		D	G		F	
7	4.93	E			G		F	
13	4.65				G		F	
11	4.43				G			

Hybrid	Mean	Model 3						
12	7.18				A			
4	6.88		B		A			
6	6.81		B		A		C	
18	6.76		B	D	A		C	
5	6.46	E	B	D	A		C	
8	6.42	E	B	D	A		C	
23	6.33	E	B	D	A		C	
20	6.19	E	B	D	A		C	F
3	6.14	E	B	D	A		C	F
1	6.04	E	B	D	A		C	F
21	5.88	E	B	D	A	G	C	F
17	5.69	E	B	D	H	G	C	F
24	5.61	E	B	D	H	G	C	F
19	5.57	E	B	D	H	G	C	F
14	5.54	E	B	D	H	G	C	F
10	5.51	E		D	H	G	C	F
9	5.41	E		D	H	G		F
15	5.40	E			H	G		F
22	5.29	E			H	G		F
16	5.26	E			H	G		F
2	5.21	E			H	G		F
7	4.93				H	G		F
13	4.65				H	G		
11	4.43				H			

Table 4 : Grouping of Hybrids based on Average Bunch Weight (Kg)

Hybrid	Mean (Kg)	Model 2				
10	16.59	A				
6	15.66	A	B			
20	15.40	A	B	C		
19	15.25	A	B	C		
15	15.09	A	B	C	D	
2	15.08	A	B	C	D	
23	14.99	A	B	C	D	
3	14.88		B	C	D	E
21	14.87		B	C	D	E
13	14.74		B	C	D	E
24	14.69		B	C	D	E
7	14.69		B	C	D	E
1	14.63		B	C	D	E
9	14.59		B	C	D	E
12	14.47		B	C	D	E
22	14.26		B	C	D	E
8	14.09		B	C	D	E
17	14.06		B	C	D	E
16	13.97			C	D	E
11	13.96			C	D	E
14	13.89			C	D	E
18	13.89			C	D	E
4	13.52				D	E
5	13.35					E

Table 5 : Summary Statistics for Means and Standard Deviations

	Means			**Standard Deviations**		
	FFBW(Kg)	**BN**	**ABW(Kg)**	**FFBW(Kg)**	**BN**	**ABW(Kg)**
Mean ($\hat{\mu}$)	84.63	5.85	13.25	58.12	3.71	5.94
S.D. ($\hat{\sigma}$)	9.86	0.70	1.04	6.58	0.49	0.96
Maximum ($\bar{x}_{24}$)	107.86	7.63	15.45	76.86	4.78	7.60
Minimum ($\bar{x}_1$)	60.31	4.43	11.46	45.29	2.92	4.16
			Scores			
$\bar{x}_1 < \bar{x}_i \leq (\hat{\mu} - \hat{\sigma}/2)$	1	1	1	3	3	3
$(\hat{\mu} - \hat{\sigma}/2) < \bar{x}_i \leq (\hat{u} + \hat{\sigma}/2)$	2	2	2	2	2	2
$(\hat{\mu} + \hat{\sigma}/2) < \bar{x}_i \leq \bar{x}_{24}$	3	3	3	1	1	1

hybrid with respect to all the three characters. Further, correlation between the scores of bunch weight and the total scores based on bunch weight, number of bunches and average bunch weight was found to be very high (r = 0.91). This indicates the efficiency of scoring technique used in selecting the promising hybrids.

Correlation Matrix

	Correlation	Probability > |r|
FFBW vs BN	0.8970	<0.0001
FFBW vs ABW	0.5534	<0.0001
BN vs ABW	0.3199	<0.0001

Scoring of Hybrids

Hybrid:	18	6	10	21	3	17	16	4	20	23	24	1
Score:	17	15	15	15	14	14	13	12	12	12	12	11
Hybrid:	5	12	13	15	19	22	8	14	2	7	9	11
Score:	11	11	11	11	11	11	10	10	9	9	9	9

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