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A note on the relative contribution of genetic and environmental factors on the yield of uniformly treated coconut trees

By

A. S. PANKAJAKSHAN
Central Coconut Research Station, Kasaragod

Shrikhande (1958) from his investigations on the relative contribution of genetic and environmental factors to the total variation in yield between trees of *Cocos nucifera*, observed that the genetic variation between trees is a more potential source of error than environmental variation. His investigation was based on the main assumption that the genetic and environmental effects on the phenotype are additive and independent and that the average yield 'y' of a tree over an even number of consecutive years can be expressed as $y = g + e$, where 'g' is the contribution due to genotype and 'e' that due to environment. Further, his estimations seem to be based on yield data for 2 - 4 years in the case of individual palms.

In the course of an extensive study on the yield pattern of a few hundred trees at this Research Station, the author could observe that most of the trees exhibit the alternate bearing tendency and that there is no well marked pattern for individual trees throughout their life period. The period of the yield cycle also varies from tree to tree during the different stages of the productive phase. It was hence felt that a more detailed and elaborate study on the lines attempted by Shrikhande should be undertaken, utilising yield data for different periods for individual trees. Similar data for periods of 2, 4, 6, 8 and 10 years were thus taken into account, in the present study.

MATERIALS AND METHODS

The yield data used in this study relate to 171 trees in Field No. 2 (Main Block) at this Research Station. Data from 1943 to 1952 have been analysed. As already stated, the method followed by Shrikhande was adopted.

RESULTS

Between cluster and within cluster mean squares are presented for different plot sizes and shapes in Table I.

Within cluster mean squares are almost always found to be less for the shape i, j (i > j) than the corresponding shape j, i for any plot size.

A steady increase in trend of between mean squares is observed with increase in plot size in all cases; but the values of these mean squares for 2 and 6 year periods were found to be high (see Figs. 1 and 2). However, within mean square values increase very slowly and in most cases fluctuate around a common value.

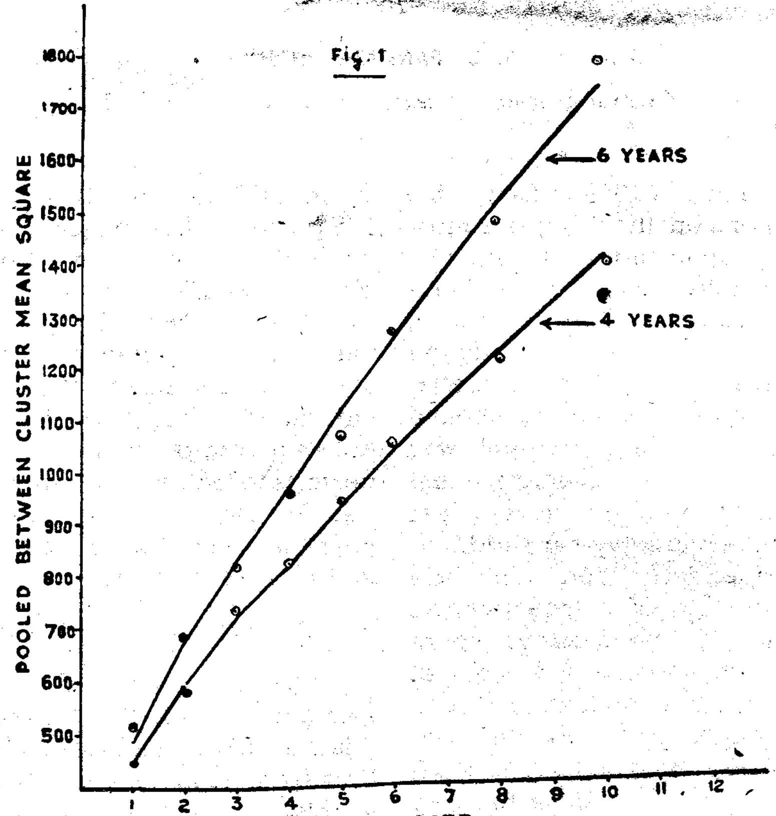

Fig 1. Comparison of curves of between cluster mean squares based on yield data for 4 and 6 years and agreement between observed and expected.

The observed values of the pooled between cluster mean squares along with the expected values based on the equation

$$W = G + EX^B \text{ where}$$

W = pooled between mean squares,
X = plot size, and
B, G, E, constants where $0 \leq B \leq I$

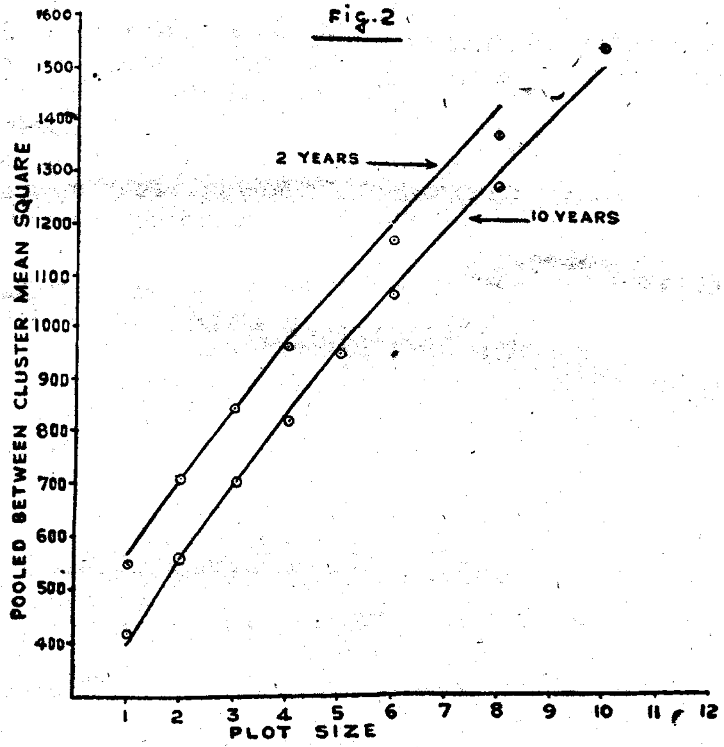

Fig. 2. Comparison of curves of between cluster mean squares based on yield data for 2 and 10 years and agreement between observed and expected

for different plot sizes are given in Table II.

The observed and expected frequencies are seen to be in good agreement (vide Figs. 1 and 2).

The estimates of σ_g^2, σ_e^2 and B with their standard errors are also given in the Table. It is seen that the genetic and environmental components of the total variation between trees are in the ratio 3:2 for averages based on two years and 1:1 for four years. For six and eight year periods the ratio changes to 2:3 and it shifts to 1:2 for the ten year period, thus indicating that the environmental component is more important for periods higher than four years.

In the light of the above findings, earlier observation of Shrikhande that the genetic variation between trees is a more potential source of error than the environmental variation, does not seem to hold good in all cases considered.

The environmental component of the within cluster variation estimated by $\hat{E} = \frac{X}{+x-1}(1-x^{B-1})$ Eo and the observed and the expected

$(Go + \hat{E})$ values of the within cluster mean squares are presented in Table III.

In the case of averages based on 2 years, the ratio of the genetic to the environmental component of the within cluster mean square is found to vary from 19:2 to 3:1 for plot sizes varying from 2 to 10. In the case of 4 years it varies from 7:1 to 2:1. Similarly for averages based on 6 and 8 years the ratio varies from 9:2 to 3:2. However, the ratio in the case of averages based on 10 years varies from 7:2 to 4:3. These results show that genetic component is the dominant one in within cluster mean square, and for smaller plot size it is more prominent.

In cases where a treatment applied to a tree is not likely to affect the neighbouring trees, giving more importance to the genetic factors in experimental designs is likely to increase the precision. But in a crop like coconut, where the roots spread to a great distance, usually 30' to 40' and in some rare cases up to 80' (Menon and Pandalai, 1957), especially in case of manurial experiment, the direct use of this result is very limited. The use of covariance techniques with a plot size of 8 to 10 trees seems to be the best alternative in such experiments. In the case of short term experiments and where the plot size is not to exceed four trees it is always advantageous to give importance to the genetic component to get the desired level of precision.

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TABLE I

Between (Bn) and within (Wn) cluster mean squares

Plot size (x)	Shape row x column	Source	d. f.	Mean squares based on yield data for the periods				
				1943-44 (2)	1943-46 (4)	1943-48 (6)	1943-50 (8)	1943-52 (10)
1	2	3	4	5	6	7	8	9
1	1 x 1	Bn	170	541.98	444.38	524.14	452.50	421.10
		Wn	—	—	—	—	—	—
2	2 x 1	Bn	82	718.25	593.92	695.76	599.03	566.72
		Wn	83	367.93	284.61	341.65	292.00	265.95
	1 x 2	Bn	76	715.39	569.84	672.58	595.60	564.81
		Wn	77	374.25	315.95	376.88	310.45	278.94
3	3 x 1	Bn	53	873.55	784.51	882.03	770.00	739.84
		Wn	108	385.69	279.38	363.15	308.44	271.54
	1 x 3	Bn	51	813.55	679.89	777.89	689.63	675.24
		Wn	104	357.18	291.21	377.15	313.60	277.52
4	4 x 1	Bn	38	983.78	832.18	986.28	861.60	823.70
		Wn	117	403.87	306.78	375.65	313.94	276.74
	2 x 2	Bn	33	1107.62	934.70	1021.83	888.92	880.96
		Wn	102	385.13	314.18	425.39	352.34	313.83
	1 x 4	Bn	38	879.13	751.58	875.38	784.93	780.04
		Wn	117	421.76	352.09	427.07	356.45	318.47
5	5 x 1	Bn	31	1080.95	1023.35	1048.25	959.52	959.57
		Wn	128	400.95	302.52	283.61	263.82	247.01
	1 x 5	Bn	31	1008.62	911.69	1096.31	959.16	940.20
		Wn	128	437.31	339.05	398.48	342.27	305.16
6	6 x 1	Bn	23	1223.15	1103.92	1293.92	1109.16	1071.82
		Wn	120	379.01	284.23	372.32	309.49	244.35
	2 x 3	Bn	24	1253.04	1100.00	1335.28	1146.96	1134.13
		Wn	125	410.34	314.49	382.42	324.80	291.30
	3 x 2	Bn	24	1298.25	1124.33	1372.04	1172.97	1152.21
		Wn	125	399.67	311.87	373.84	317.57	280.34
	2 x 6	Bn	25	1076.09	972.83	1106.62	973.56	972.72
		Wn	130	469.35	369.58	450.46	381.80	341.93
8	4 x 2	Bn	18	1482.96	1265.28	1598.24	1394.18	1349.83
		Wn	133	341.10	325.07	380.14	322.04	286.89
	2 x 4	Bn	17	1394.14	1190.57	1365.07	1201.98	1214.04
		Wn	126	429.51	337.16	429.29	363.34	326.11
10	5 x 2	Bn	14	1409.86	1339.82	1757.04	1523.56	1526.97
		Wn	135	404.70	316.76	378.78	319.20	287.28
	2 x 5	Bn	12	1695.86	1502.57	1865.50	1601.79	1629.08
		Wn	117	397.27	311.88	408.12	340.53	306.32

TABLE II

Comparison of observed and expected values of between cluster mean squares

	Pooled between cluster mean square based on yiled data for									
	2 years		4 years		6 years		8 years		10 years	
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
1	541.98	556.77	444.38	452.37	524.14	484.20	452.50	427.84	421.10	393.73
2	715.04	716.87	582.34	597.32	684.61	672.79	597.36	590.94	565.80	562.40
3	844.50	844.13	733.20	723.90	830.96	837.46	730.59	733.35	708.16	709.67
4	962.68	984.79	835.12	839.43	958.38	987.78	843.14	863.35	825.82	844.12
5	1073.55	1044.79	967.52	947.82	1072.28	1128.81	959.34	985.31	949.89	970.23
6	1178.89	1211.10	1074.04	1050.80	1275.02	1262.79	1099.25	1101.18	1081.69	1090.07
8	1376.51	1439.81	1228.99	1244.00	1484.99	1514.16	1300.83	1318.57	1283.87	1314.88
10	1561.51	1495.71	1414.93	1424.88	1807.10	1749.49	1559.60	1522.09	1574.10	1525.34
G_o	345.47		236.09		202.92		184.50		142.09	
E_o	221.30		216.42		281.78		243.57		251.93	
B_o	0.74		0.74		0.74		0.74		0.74	
S. E. (G_o)	40.280		4.867		5.847		2.147		4.028	
S. E. (E_o)	11.780		1.423		5.406		0.628		1.178	
Ratio $G_o : E_o$	61:39		52:48		42:58		43:57		36:64	
Estimating equation	$W = 345.47 + 221.30\, x^{\cdot 74}$		$W = 236.09 + 216.42\, x^{\cdot 74}$		$W = 202.92 + 281.78\, x^{\cdot 74}$		$W = 184.50 + 243.57\, x^{\cdot 74}$		$W = 142.09 + 251.93\, x^{\cdot 74}$	

TABLE III

Within cluster mean squares observed and expected and estimates of environmental component

X	Within cluster mean square observed and expected based on yield data for														
	2 years			4 years			6 years			8 years			10 years		
	$\hat{E}$	$G_o+\hat{E}$	Observed	$\hat{E}$	$G_o+\hat{E}$	Observed	$\hat{E}$	$G_o+\hat{E}$	Observed	$\hat{E}$	$G_o+\hat{E}$	Observed	$\hat{E}$	$G_o+\hat{E}$	Observed
2	36.43	381.90	370.97	35.62	271.71	299.69	46.38	249.30	358.71	40.09	224.59	300.88	41.47	183.56	272.20
3	82.56	428.03	371.70	80.74	316.83	285.18	105.12	308.04	370.02	90.86	275.36	310.97	93.98	236.07	274.47
4	89.29	434.76	404.41	87.32	323.41	324.80	113.69	316.61	408.65	98.27	282.77	340.40	101.64	243.73	302.53
5	94.52	439.99	419.13	92.44	328.53	320.78	120.36	323.28	341.04	104.04	288.54	303.04	107.61	249.70	276.08
6	98.95	444.42	415.50	96.77	332.86	320.90	125.99	328.91	395.54	108.91	293.41	334.14	112.64	254.73	297.57
8	105.62	451.09	384.11	103.29	339.38	330.95	134.49	337.41	404.05	116.25	300.75	342.13	120.24	262.33	305.97
10	110.80	456.27	401.25	108.35	344.44	314.49	141.08	344.00	392.40	121.95	306.45	329.10	126.13	268.22	296.12