FORECAST OF ANNUAL YIELD OF COCONUTS, BASED ON BIOMETRICAL CHARACTERS

by

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ABSTRACT

Based on the observations recorded for four years, at Kasaragod and Kayangulam, Kerala, India, on palms of ordinary tall variety, growing under rainfed conditions, appropriate prediction equations have been proposed to estimate the annual yield of coconuts, at selected periods of the year, based on a total count of nuts in different stages of maturity.

INTRODUCTION

Forecasting of crop yields is now a widespread practice. Advance knowledge of the yield levels is vital to planners, government agencies and estate managers; its utility is much more in multiharvested crops, where it is difficult to monitor all the harvests. Basically there are two different methods for forecasting crop yield. Of these, one is the traditional method, according to which forecasts are made on the basis of crop condition factor, which is determined visually, making it highly subjective. The other method which is both scientific and objective, involves building up appropriate regression models, based on biometrical characters and/or weather parameters. A prediction model involving the use of biometrical characters as explanatory variables automatically takes into account, though somewhat indirectly, the integrated effect of weather, at least upto the stage of recording the observations on biometrical characters.

In coconut, Abeywardena (1968) and Vijaya Kumar et al (1989) have developed crop forecasting formulae based on rainfall and other weather parameters, with a multiple correlation coefficient of 0.94 and 0.91 respectively. Nair and Unnithan (1986) and Jacob Mathew et al (1988) have also proposed regression models based on weather parameters. Use of these formulae is limited by the paucity of climatic information. Also for relatively small areas, it is not sufficiently sensitive

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to show yield differences due to management factors. Reynolds (1979) has suggested that to get a fairly accurate estimate of annual coconut production in an area, 10 percent of the palms in that area may be selected, then obtaining a mean figure for large nuts by counting with the help of binocular, and multiplying this mean figure by the number of palms and then increasing it by percentage factor of 35, to compensate for not counting the smaller nuts. Arul Raj et al (1979) have also tried to estimate the yield in a calendar year using characters like number of nuts above and below fist size and the number of bunches as explanatory variables. In this paper, an attempt has been made to propose a regression model, based on biometrical characters, to predict the annual yield of individual coconut palms. The study involved in identification of suitable biometrical characters for this purpose, and suggests the best period for recording observations. This appears to be the first organised study in this line in coconut.

MATERIALS AND METHODS

Monthly observations recorded for a four year period beginning March 1979, for a group of 133 palms of ordinary tall variety - 83 palms spread over two plots at Kasaragod (North Kerala, India) and 50 palms from Kayangulam (South Kerala, India) - on bunch-wise yield of nuts, number of female flowers, number of bunches and number of leaves, have been made use of for this study. Kasaragod and Kayangulam are over 500 km apart, on the south west coast of India, with marked differences in the total rainfall and pattern of rainfall received. The plot at Hill Block (HB), Kasaragod had 40 palms aged about 20 years at the start of the experiment. This was a pure coconut garden, without inter and mixed crops, during the experimental period. At East Block (EB), Kasaragod, 43 palms have been selected belonging to the age group 25-50 years. In this plot intercrops were being grown very often. At Kayangulam, the palms selected belonged to the steady bearing age, with many of them showing symptoms of root (wilt) disease. In all the plots, the palms were growing under rainfed conditions, receiving the recommended doses of fertilisers. Corresponding to the observations on biometrical characters, recorded at every month, the yield of nuts obtained during succeeding 12 month period was compiled. Pearson's correlation coefficients were worked out; month-wise and block-wise, for the annual yield of nuts with the following biometrical characters - total number of nuts in the first five bunches (that is, the first whorl) (x1), number of nuts above fist size (x2), total number of nuts in the crown (x3), number of bunches (x4) and number of functioning leaves (x5) (Table 1). Characters having high correlation with yield were then considered in simple and multiple regression models (Table 2), to find out whether the variations in annual yield are reasonably explained by

Table 1. Relationship between the biometrical characters recorded in the different months and the yield of coconuts in the next one year- Range for the coefficients of correlation obtained during 1979 to 1983

Month of observation	Location	x1		x2		x3		x4		x5	
		L	H	L	H	L	H	L	H	L	H
January	KSD EB	0.68	0.82	0.92	0.93	0.92	0.95	0.17	0.79	0.35	0.61
	HB	0.73	0.87	0.92	0.97	0.92	0.99	0.23	0.91	0.21	0.49
	KLM	0.77	0.85	0.87	0.93	0.87	0.98	0.54	0.68	0.40	0.56
February	KSD EB	0.65	0.83	0.86	0.92	0.84	0.93	0.30	0.70	0.21	0.74
	HB	0.60	0.89	0.90	0.95	0.89	0.96	0.18	0.87	0.03	0.49
	KLM	0.74	0.89	0.81	0.92	0.81	0.98	0.51	0.62	0.35	0.53
March	KSD EB	0.63	0.84	0.82	0.93	0.76	0.91	0.47	0.68	0.38	0.67
	HB	0.65	0.86	0.85	0.94	0.87	0.91	0.53	0.78	0.14	0.59
	KLM	0.73	0.79	0.82	0.96	0.83	0.99	0.55	0.66	0.44	0.55
April	KSD EB	0.65	0.77	0.67	0.85	0.62	0.94	0.36	0.67	0.37	0.62
	HB	0.47	0.83	0.75	0.90	0.75	0.89	0.55	0.73	0.33	0.68
	KLM	0.66	0.79	0.77	0.84	0.88	0.98	0.51	0.66	0.36	0.50
May	KSD EB	0.65	0.76	0.69	0.92	0.86	0.95	0.37	0.60	0.25	0.67
	HB	0.51	0.72	0.66	0.83	0.75	0.88	0.34	0.56	0.13	0.49
	KLM	0.52	0.87	0.75	0.94	0.83	0.99	0.51	0.64	0.40	0.51
June	KSD EB	0.63	0.85	0.77	0.96	0.74	0.94	0.22	0.59	0.32	0.68
	HB	0.49	0.80	0.77	0.96	0.83	0.96	0.09	0.67	0.07	0.44
	KLM	0.47	0.83	0.84	0.94	0.84	0.99	0.57	0.61	0.42	0.48
July	KSD EB	0.54	0.78	0.80	0.95	0.87	0.95	0.02	0.55	0.30	0.65
	HB	0.50	0.80	0.73	0.97	0.77	0.94	-0.03	0.75	0.17	0.65
	KLM	0.65	0.76	0.55	0.95	0.90	0.99	0.47	0.70	0.40	0.42

Month of observation	Location	x1		x2		x3		x4		x5	
		L	H	L	H	L	H	L	H	L	H
August	KSD EB	0.59	0.68	0.87	0.93	0.87	0.96	-0.003	0.67	0.39	0.64
	HB	0.50	0.79	0.90	0.95	0.90	0.94	0.06	0.73	0.22	0.46
	KLM	0.57	0.80	0.77	0.92	0.86	0.98	0.53	0.60	0.37	0.49
September	KSD EB	0.65	0.81	0.84	0.95	0.84	0.96	-0.15	0.50	0.36	0.70
	HB	0.51	0.85	0.88	0.97	0.89	0.96	0.07	0.76	0.23	0.52
	KLM	0.70	0.86	0.83	0.94	0.87	0.99	0.54	0.67	0.30	0.61
October	KSD EB	0.70	0.73	0.80	0.92	0.86	0.96	0.12	0.65	0.42	0.69
	HB	0.60	0.92	0.86	0.96	0.89	0.97	0.12	0.76	0.34	0.55
	KLM	0.75	0.82	0.84	0.94	0.87	0.98	0.63	0.69	0.37	0.46
November	KSD EB	0.68	0.84	0.84	0.93	0.90	0.98	-0.03	0.71	0.43	0.71
	HB	0.70	0.89	0.92	0.96	0.92	0.97	0.12	0.80	0.41	0.48
	KLM	0.75	0.91	0.86	0.94	0.89	0.99	0.56	0.71	0.39	0.50
December	KSD EB	0.71	0.83	0.87	0.94	0.86	0.96	-0.09	0.70	0.36	0.60
	HB	0.73	0.90	0.82	0.96	0.92	0.98	0.10	0.84	0.32	0.51
	KLM	0.68	0.92	0.80	0.96	0.81	0.99	0.59	0.66	0.32	0.57

x1 : Total number of nuts in the first five bunches
x2 : Total number of nuts above fist size
x3 : Total number of nuts in the crown
x4 : Total number of bunches
x5 : Total number of leaves
L : Lowest
H : Highest

Table 2. Variation in the annual yield of coconuts explained by the different set of characters, recorded in different months - Range for R^2 value obtained during 1979 to 1983

Month of observation	Location	x3		x3, x4		x3, x5		x3, x4, x5	
		L	H	L	H	L	H	L	H
January	KSD EB	0.85	0.91	0.87	0.91	0.86	0.91	0.87	0.91
	HB	0.85	0.97	0.86	0.97	0.85	0.97	0.86	0.97
	KLM	0.90	0.96	0.90	0.96	0.95	0.96	0.95	0.97
February	KSD EB	0.71	0.86	0.72	0.86	0.78	0.87	0.81	0.89
	HB	0.83	0.91	0.83	0.92	0.80	0.91	0.83	0.92
	KLM	0.92	0.97	0.93	0.97	0.96	0.97	0.96	0.97
March	KSD EB	0.57	0.83	0.57	0.84	0.65	0.84	0.65	0.86
	HB	0.75	0.83	0.77	0.85	0.79	0.86	0.80	0.86
	KLM	0.91	0.98	0.91	0.98	0.94	0.98	0.94	0.98
April	KSD EB	0.39	0.89	0.40	0.89	0.45	0.89	0.45	0.89
	HB	0.56	0.79	0.60	0.80	0.66	0.81	0.68	0.82
	KLM	0.87	0.96	0.87	0.96	0.96	0.96	0.96	0.96
May	KSD EB	0.73	0.90	0.76	0.90	0.74	0.91	0.76	0.91
	HB	0.56	0.78	0.58	0.78	0.57	0.78	0.58	0.78
	KLM	0.79	0.98	0.81	0.98	0.79	0.98	0.81	0.98
June	KSD EB	0.55	0.88	0.55	0.89	0.55	0.89	0.55	0.90
	HB	0.68	0.93	0.69	0.93	0.69	0.93	0.70	0.93
	KLM	0.77	0.98	0.77	0.98	0.78	0.98	0.78	0.98
July	KSD EB	0.75	0.90	0.75	0.90	0.75	0.90	0.75	0.90
	HB	0.59	0.88	0.59	0.88	0.66	0.88	0.66	0.88
	KLM	0.75	0.98	0.75	0.98	0.94	0.97	0.94	0.98

Month of observation	Location	x3		x3, x4		x3, x5		x3, x4, x5	
		L	H	L	H	L	H	L	H
August	KSD EB	0.76	0.92	0.77	0.92	0.79	0.92	0.80	0.92
	HB	0.82	0.89	0.83	0.89	0.83	0.89	0.83	0.89
	KLM	0.95	0.96	0.95	0.96	0.95	0.96	0.95	0.96
September	KSD EB	0.71	0.93	0.76	0.93	0.73	0.93	0.78	0.93
	HB	0.79	0.93	0.79	0.93	0.79	0.94	0.79	0.94
	KLM	0.95	0.98	0.95	0.98	0.95	0.99	0.95	0.98
October	KSD EB	0.74	0.92	0.74	0.93	0.76	0.93	0.77	0.93
	HB	0.80	0.95	0.82	0.95	0.80	0.95	0.82	0.95
	KLM	0.92	0.98	0.92	0.98	0.94	0.97	0.95	0.99
November	KSD EB	0.81	0.91	0.82	0.96	0.82	0.95	0.84	0.96
	HB	0.85	0.94	0.85	0.94	0.86	0.94	0.86	0.94
	KLM	0.94	0.99	0.94	0.99	0.97	0.99	0.97	0.99
December	KSD EB	0.74	0.91	0.79	0.91	0.75	0.91	0.82	0.91
	HB	0.85	0.95	0.85	0.96	0.85	0.96	0.85	0.96
	KLM	0.90	0.98	0.91	0.99	0.96	0.98	0.96	0.99

x3 : Total number of nuts in the crown
x4 : Number of bunches
x5 : Number of leaves
L : Lowest
H : Highest

these variables. Homogenity of the regression coefficients were then tested (Table 3), following Snedecor and Cochran (1968) and suitable prediction models have been proposed for different locations and periods (Table 4), by getting combined estimates for the coefficients.

RESULTS AND DISCUSSION

All the characters under study were found to have significant correlation with yield in most of the months (Table 1). In this study, the count of nuts in the crown was considered in three different ways, viz. number of nuts in the first whorl (x1), number of nuts above fist size (x2) and total number of nuts (x3). Among them, the correlation of x1 with annual yield was comparatively low. This is not unexpected, because in any population, a certain percentage of palms will be showing alternate bearing tendency, and a count of nuts in first five bunches (first whorl) alone is not sufficient to accurately estimate the annual yield in a mixed population of regular and irregular bearers. Though, both x2 and x3 were having high correlation with yield, irrespective of the month of observation, for further analysis x3 has been preferred, because it represents all the nuts which may come up for harvest in the succeeding one year period, and to avoid subjective error in identifying nuts above fist size, that is, above three months old especially on palms giving very large and very small nuts. Characters like number of bunches and number of leaves were also found to have a correlation of around 0.6 in most of the months. Low correlation obtained for these characters in some of the months can be due to sudden drooping of leaves and shedding of bunches, due to failure of monsoon, etc.

Regression analysis showed that, depending upon the month of observation, about 75 to 95% of the variation in annual yield is explained by the variation in total number of nuts present in the crown (x3) (Table 2). Under Kasaragod condition, for both the blocks, the R^2 values were high and consistent for January, February and August to December. At Kayangulam, consistently high R^2 values were obtained in most of the months. The more consistent results obtained for Kayangulam compared to Kasaragod, are due to the even distribution of rainfall in the different seasons, in the former place. Inclusion of characters like number of bunches (x4) and number of leaves (x5) in multiple regression models, independently or in combination, along with x3 was found to only marginally influence the R^2 values, showing thereby that x3 (total number of nuts in the crown) alone is sufficient to accurately estimate the annual yield of nuts.

Table 3. Regression equation based on count of nuts (x3) - Range of values for constant term (a) and regression coefficient (b) obtained during 1979-1983

Month of observation	Location	Kasaragod a L	Kasaragod a H	Kasaragod b L	Kasaragod b H	Kayangulam a L	Kayangulam a H	Kayangulam b L	Kayangulam b H
January	EB	0.19	9.45	0.78	1.09	-4.34	-0.17	0.86	0.91
	HB	-12.10	0.74	0.88	1.00				
	Combined	-0.0379		0.9223**		-2.7437		0.8871	
February	EB	-3.08	12.90	0.73	0.90	-5.04	-0.62	0.82	0.91
	HB	-6.35	2.85	0.69	0.97				
	Combined	2.4907		0.7880		-2.6339		0.8808	
March	EB	-3.34	27.12	0.49	0.82	-4.75	-2.30	0.88	0.93
	HB	-11.10	8.66	0.64	0.78				
	Combined	4.2118		0.6717**		-3.7810		0.8956	
April	EB	-2.68	22.02	0.55	0.98	-4.29	2.89	0.85	0.91
	HB	-4.86	10.80	0.65	0.70				
	Combined	8.1979		0.6742**		-0.9542		0.8644	
May	EB	1.18	11.26	0.68	0.86	-4.68	0.47	0.80	0.88
	HB	-9.27	16.06	0.56	0.94				
	Combined	4.1653		0.7775*		-0.6710		0.8432*	
June	EB	-0.65	17.66	0.77	0.95	-3.39	4.17	0.82	0.92
	HB	-5.34	6.83	0.76	0.96				
	Combined	2.6750		0.8727		-0.4363		0.8664*	
July	EB	-5.54	1.20	0.83	0.99	-4.59	0.75	0.86	0.96
	HB	-5.66 -	16.36	0.68	0.95				
	Combined	-0.4915		0.8751		-2.6260		0.9109*	

Month of observation	Location	Kasaragod a L	Kasaragod a H	Kasaragod b L	Kasaragod b H	Kayangulam a L	Kayangulam a H	Kayangulam b L	Kayangulam b H
August	EB	-8.56	-1.14	0.82	0.99	-3.73	0.37	0.87	1.01
	HB	-8.26	-1.71	0.82	1.09				
	Combined	-4.0700		0.9179*		-1.7343		0.9015*	
September	EB	-5.62	1.17	0.91	1.04	-1.03	1.05	0.81	0.91
	HB	-1.92	7.29	0.72	1.01				
	Combined	-0.1863		0.8861**		-0.1233		0.8604	
October	EB	-3.71	2.57	0.88	1.00	-3.43	2.62	0.78	1.01
	HB	-6.71	-1.25	0.82	1.00				
	Combined	-2.4413		0.9403		-0.1748		0.8609**	
November	EB	-4.78	5.62	0.85	0.95	-4.72	4.80	0.76	0.94
	HB	-4.06	3.08	0.78	0.93				
	Combined	0.1168		0.8884		-1.7653		0.8657**	
December	EB	-4.53	5.79	0.84	1.02	-4.04	1.29	0.82	0.90
	HB	-0.29		0.89					
	Combined	-1.1706		0.9420		-2.0239		0.8666	

L : Lowest H : Highest

*/** Regression ceofficients not homogeneous over the years at P=0.05/0.01

Table 4. Prediction equations for estimating the annual yield of coconuts based on a count of nuts in the crown

Location	Period of observation	Prediction equation (Y = a + bx)			R^2
		a	b	SE (b)	
Kasaragod	February	2.491	0.788	0.0227	0.800
	June-July	1.092	0.874	0.0192	0.774
	Oct-December	0.479	0.922	0.0359	0.858
Kayangulam	Jan-May	-2.175	0.874	0.0178	0.933
	September	-0.123	0.860	0.0276	0.955
	December	-2.024	0.867	0.0060	0.943

Y : Estimated annual yield of the palm
x : Total number of nuts in the crown

Tests of homogenity of regression coefficients for the four different years in two blocks at Kasaragod revealed that the regression coefficients are homogeneous during February, June-July and October-December. At Kayangulam, regression coefficients were homogeneous for January-May, September and December. The differences observed in regression coefficients, between years for the same month, is due to the changes in weather years factors. For those months where the regression coefficients are homogeneous between years, suitable prediction models have been evolved (Table 4). Wherever regression coefficients are homogeneous for consecutive months, equations have been given for the pooled periods, after testing for homogenity for the whole period. In view of the marginal increase in the R^2 values and the favourable weather prevailing during the season, it is desirable to confine the observation to October-December at Kasaragod and January-May, September and December at Kayangulam. These regression models clearly show that about 87-92% of the nuts observed in the crown at any time of the year come up for harvest during the next one year period. The consistent values for regression coefficients (b) observed at Kayangulam are due to the even distribution of rainfall in the different seasons and the absence of any drastic changes in weather between years. The regression coefficients of February at Kasaragod is comparatively low due to the shedding of immature nuts in the succeeding summer months of March to May. In view of the low values for the intercepts (a) observed in both the locations, this can be taken as a general estimation procedure for any situation.

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REFERENCES

Abeywardena, V. 1968. Forecasting coconut crop using rainfall data - a preliminary survey. Ceylon Coconut Q 19 (4) : 161-176.

Arul Raj, S., Narasimhayya, G., Haveri, RR and Raja Sulochana, VR, 1979. Estimation of coconut yield based on snap observation. In Proc. PLACROSYM I, 1978, pp 525.

Jacob Mathew., Amarnath, CH., Vijaya Kumar K., Mohammed Yusuf and Balakrishnan, TK. 1988. Yield of coconuts in relation to pattern of rainfall and duration of dry spell. Cord 4 (2) : 48-55.

Nair, B.P. and Unnithan, V.K. 1986. Forecasting models to estimate annual coconut yield based on monthly weather. In Workshop on impact of drought on Plantation Crops, CPCRI, Kasaragod, 1986. pp 10-12.

Reynold, SG. 1979. A simple method for predicting coconut yields. Philippines J. Coconut Studies 4 (4) : 41-44.

Snedecor, G.W. and Cochran, W.G. 1968. Statistical methods. Sixth Edition. Oxford and IBH Publishing Co., Calcutta. pp 432-436.

Vijaya Kumar, K., Nambiar, PTN., Jacob Mathew., Amarnath, CH and Balakrishnan, TK. 1989. Forecasting of yield in coconut by using weather variables. J of Plant Crops 16 (Suppl.) : 463-468.