FERTILIZER RECOMMENDATIONS AND YIELD PREDICTION FOR OIL PALM USING PORIM's ENVIRONMENTAL DATA SYSTEM

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45

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INTRODUCTION

The Environmental Data System (EDS) developed by PORIM is used for making initial fertilizer recommendations and to predict oil palm yield response curve from site data from which the optimum yields can be deduced. The optimum yield is defined as the yield level above which response to fertilizer is not profitable. With the aid of a computer programme, the above calculations are easily computed and thus the system will guide the user on the expected yield profile and the predicted fertilizer requirements.

DEVELOPMENT OF THE SYSTEM

The basic objective of this system is to relate yield response data to environmental parameters. The equations in EDS have been derived mainly from field trials conducted in the region of Peninsular Malaysia, omitting anomalous soils. The system makes use of the following:

1. The environmental factors included are the site characteristics, soil properties and rainfall data.

2. Using differential equations, the relationship between yield response due to the addition of N and K fertilizers and the environmental factors is established (*Table 1*).

3. An integration of the above equations with an additional equation that includes the interaction between N and K fertilizer, fresh fruit bunch (FFB) yields can be predicted for all possible combinations of N and K fertilizers.

4. Given a specific crop value and fertilizer cost, the most economic yield and the fertilizer inputs required can be calculated for a particular site.

The system should work provided that:

i) The sites are within the region covered by the trials, *i.e.*, major alluvial and sedentary soils of Peninsular Malaysia.

ii) Other nutrients are non-limiting especially phosphate fertilizer.

iii) The annual rainfall in the area is between 1 800 mm and 2 500 mm.

PRACTICAL IMPLICATION

On typical coastal alluvial soils such as the Selangor series, the optimum yield obtained is about 26 t/ha/yr (*Table 4*). Coastal soils due to their high silt content have a high K buffering capacity thus resulting in poor response to K fertilizer. Generally high yields could be achieved even with little or no K fertilizer inputs. Therefore, it is not worthwhile applying K fertilizer when yields are above the optimum level.

On sedentary soils such as the Rengam series, it is worthwhile applying higher rates of fertilizers to achieve FFB yields above 28 tonne/ha/yr. However, the limiting factors to achieve higher FFB yield are soil slope and soil drainage conditions. For example, a poorly drained soil or soils with a steep slope, the FFB yield can be as low as 20 tonne/ha/yr.

The amount of annual rainfall and some soil physical properties, such as slope, can vary quite widely within the same soil series, causing an appreciable range of optimum yields on similar soil series. Therefore, the expected optimum yields at a particular site is best calculated from the specific characteristics of that site.

The input data for the system and the range of values accepted for a reliable calculation are given in *Tables 2* and *3* for alluvial and sedentary soils, respectively. An illustrated computer output from the system is given in *Tables 4* and *5* for alluvial and sedentary soils, respectively.

RELIABILITY OF SYSTEM

The accuracy of prediction of the response curves for N and K is reflected by the residual errors shown in *Table 1*. These

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TABLE 1. FITTED FFB YIELD RESPONSE EQUATIONS

Dependent variable	n	Fitted response equation	R2	Residual error
K Response				
On alluvial soils	37	$\frac{dY}{dK} = 1.836 - (.01591X_6 - .007733X_5)\,Y - .2356X_5 + .4095X_5 - .001566X_8$ (**, **, **, **, *)	47.5	0.33
On sedentary soils	60	$\frac{dY}{dK} = 3.455 - (.1183 + .01541X_1)\,Y - .03820X_5 + .0006146X_7$ (**, *, *, +)	54.2	0.60
N Response				
On alluvial soils	37	$\frac{dY}{dN} = 9.739 - (.4630 + .01491X_2 - .0001409X_7)\,Y + .01029X_4 - .1086\times10^{-5}X_7^2$ (**, *, *, *, **)	59.3	0.45
On sedentary soils	57	$\frac{dY}{dN} = 8.780 - (.1991 + .02405X_2 - .02252X_3)\,Y - .8927X_1 - .001137X_7$ (**, *, *, **, *)	63.0	0.71

(**,*,+ = Significant at P = .01., .05 and .10 respectively)

$\frac{dY}{dK}$ = FFB yield response (tonne/ha/yr) to 1 kg potassium chloride applied/palm/yr

$\frac{dY}{dN}$ = FFB yield response (tonne/ha/yr) to 1 kg ammonium sulphate applied/palm/yr

Y = FFB yield level (tonne/ha/yr)
X_1 = Soil slope (Score)
X_2 = Soil drainage conditions (Score)
X_3 = Soil root growth impedence (Score)
X_4 = Soil % Clay
X_5 = Soil % Silt
X_6 = Soil Total Extractable Cations (m.e. 100/g)
X_7 = Average annual rainfall (mm)
X_8 = Average rainfall (mm) during 3 months after fertilizer application

TABLE 2 . THE RANGE OF VALUES ACCEPTED FOR ALLUVIAL SOIL

	Minimum	Maximum
Planting density (palms/ha)	125	165
Drainage condition (score)	0	2
Clay (%)	15	80
Silt (%)	8	30
Extr. K (m.e./100g)	0	0.5
T.E.C. (m.e./100g)	5	25
Annual rainfall (mm)	1 400	2 500
Rainfall after fertilizer application (mm/3 month)	200	800

TABLE 3 . THE RANGE OF VALUES ACCEPTED FOR SEDENTARY SOIL

	Minimum	Maximum
Palm age (years)	6	17
Planting density (palms/ha)	125	165
Drainage condition (score)	0	1
Consistency (score)	0	1
Slope (score)	0	1
Root growth impedence (score)	0	1
Organic matter (%)	1.2	3.8
Silt (%)	0	30
Extr. K (m.e./100 g)	0	0.5
T.E.C. (m.e./100 g)	5	25
Annual rainfall (mm)	1 400	2 500
Rainfall after fertilizer application (mm/3 month)	200	800

TABLE 4 . PREDICTED FFB YIELD ON SELANGOR SERIES

VALUES USED FOR INDEPENDENT VARIABLES	
PALM PARAMETER	
Planting density (palms/ha)	138
SOIL SURVEY OBSERVATION	
Drainage condition (score)	0.6
SOIL ANALYSIS DATA	
Clay (%)	45
Silt (%)	20
Extr. K (m.e./100 g)	0.3
T.E.C. (m.e./100 g)	14
RAINFALL DATA	
Annual rainfall (mm)	1 900
Rainfall after fertilizer application (mm/3 month)	475

errors suggest that the predictions of response on alluvial and sedentary soils, when compared with observed yield responses, are within 0.40 and 0.65 tonne/ha/year respectively.

Once the interaction of N and K is included, in which the EDS calculates the predicted yield, the results are compared with the yield calculated directly from the observed trial yields. On average, the optimum FFB yields predicted using EDS are about 1.0 tonne/ha/yr below the results obtained from an in-

PREDICTED FFB YIELD (T/HA/YR)

K Fertilizer [kg/palm]

N Fert. [kg palm]	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
8.0	22.07	24.00	25.53	26.74	27.70	28.47	29.08	29.56	29.95
7.0	22.13	23.99	25.47	26.63	27.55	28.27	28.85	29.30	29.66
6.0	22.18	23.98	25.38	26.49	27.35	28.03	28.56	28.97	29.30
5.0	22.23	23.93	25.26	26.29	27.09	27.71	28.19	28.55	28.84
4.0	22.25	23.85	25.08	26.03	26.75	27.30	27.71	28.02	28.25
3.0	22.24	23.71	24.83	25.67	26.30	26.76	27.10	27.34	27.51
2.0	22.15	23.47	24.45	25.17	25.68	26.05	26.29	26.45	26.55
1.0	21.94	23.08	23.90	24.47	24.85	25.09	25.23	25.29	25.30
0.0	21.53	22.47	23.09	23.49	23.71	23.81	23.82	23.77	23.67

Assumptions:
Price for FFB/tonne = RM 200
Cost of SA/tonne= RM 400
Cost KCl/tonne = RM 400

SUMMARY OF MOST PROFITABLE FERTILIZER COMBINATION

					[Stepwise]		
Fert. N (kg)	Fert. K (kg)	Yield (t/ha)	Fert. Cost (RM/ha)	Profit (RM/ha)	Fert. Cost (RM/ha)	Profit (RM/ha)	% Return (RM/ha)
0.0	0.0	26.65					
1.0	0.0	27.31	55.20	77.50	55.20	77.50	140.47
2.0	0.0	27.84	110.40	128.50	55.20	51.00	92.39
3.0	0.0	28.27	165.60	158.60	55.20	30.00	54.43
4.0	0.0	28.61	220.80	172.00	55.20	13.40	24.29
5.0	0.0	28.89	276.00	172.10	55.20	0.10	0.25

TABLE 5 . PREDICTED FFB YIELD ON RENGAM SERIES

VALUES USED FOR INDEPENDENT VARIABLES	
PALM PARAMETER	
Palm age (years)	12
Planting density (palms/ha)	148
SOIL SURVEY OBSERVATION	
Drainage condition (score)	0
Consistency (score)	0
Slope (score)	0.5
Root growth impedence (score)	0
SOIL ANALYSIS DATA	
Organic matter (%)	2.5
Silt (%)	6
Extr. K (m.e./100 g)	0.06
T.E.B. (m.e./100 g)	1.2
RAINFALL DATA	
Annual rainfall (mm)	1 900

PREDICTED FFB YIELD (T/HA/YR)

K Fertilizer [kg/palm]

N Fert. [kg/palm]	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
8.0	29.44	29.49	29.53	29.57	29.61	29.65	29.68	29.71	29.74
7.0	29.29	29.34	29.39	29.43	29.47	29.51	29.55	29.58	29.61
6.0	29.11	29.16	29.21	29.26	29.30	29.34	29.38	29.41	29.44
5.0	28.89	28.94	28.99	29.04	29.09	29.13	29.17	29.20	29.24
4.0	28.61	28.67	28.72	28.77	28.82	28.86	28.90	28.94	28.98
3.0	28.27	28.33	28.38	28.44	28.49	28.53	28.58	28.62	28.66
2.0	27.84	27.90	27.96	28.02	28.07	28.12	28.17	28.21	28.25
1.0	27.31	27.38	27.44	27.50	27.55	27.60	27.65	27.69	27.74
0.0	26.65	26.71	26.78	26.84	26.89	26.95	26.99	27.04	27.08

Assumptions:
Price for FFB/tonne = RM 200
Cost of SA/tonne = RM 400
Cost KCl/tonne = RM 400

SUMMARY OF MOST PROFITABLE FERTILIZER COMBINATION

					[Stepwise]		
Fert N (kg)	Fert. K (kg)	Yield (t/ha)	Fert. Cost (RM/ha)	Profit (RM/ha)	Fert. Cost (RM/ha)	Profit (RM/ha)	% Return (RM/ha)
0.0	0.0	21.53					
0.0	1.0	22.47	59.20	128.30	59.20	128.30	216.67
0.0	2.0	23.09	118.40	194.50	59.20	66.20	111.84
1.0	2.0	23.90	177.60	297.20	59.20	102.70	173.46
1.0	3.0	24.47	236.80	351.80	59.20	54.60	92.30
2.0	3.0	25.17	296.00	432.20	59.20	80.40	135.74
2.0	4.0	25.68	355.20	476.00	59.20	43.80	73.98
3.0	4.0	26.30	414.40	539.10	59.20	63.10	106.59
3.0	5.0	26.76	473.60	572.50	59.20	33.00	56.46
4.0	5.0	27.30	532.80	621.10	59.20	48.60	82.13
4.0	6.0	27.71	592.00	644.70	59.20	23.50	39.76
5.0	6.0	28.19	651.20	680.50	59.20	35.80	60.50
6.0	6.0	28.56	710.40	695.20	59.20	14.70	24.90
6.0	7.0	28.97	769.60	718.90	59.20	23.70	40.05
7.0	7.0	29.30	828.80	725.50	59.20	6.60	11.16
7.0	8.0	29.66	888.00	738.20	59.20	12.60	21.35

dividual trial. The standard deviation of the difference between the results is about 2.0 tonne/ha/yr FFB yields suggesting a reasonable prediction. The prediction of FFB yields from the system is generally fairly reliable, but there may be some discrepancy if some unusual factors are affecting yield at a particular site.

CONCLUSION

EDS can be used as a tool to predict the optimum oil palm yield for a new area and the fertilizer inputs required. The system gives a fairly good fertilizer recommendation based on site characteristics. It is emphasized that the initial fertilizer recommendation for a new area should be made using EDS and PORIM's foliar diagnosis system (FDS) is later used to correct an existing fertilizer recommendation that may not be accurate due to unforeseen factors (see *PORIM Information Series No. 21*).

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