FERTILIZER RECOMMENDATIONS FOR OIL PALM USING PORIM's FOLIAR DIAGNOSIS SYSTEM

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i 1

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The foliar diagnosis system developed by PORIM is fairly universal for making fertilizer recommendations for mature oil palm based on leaf nutrient data. The system aims to provide fertilizer adjustment recommendations based on the results of leaf analysis of frond 17. It is emphasised that initial fertilizer recommendations should be made on environmental data which requires soil, climatic, and palm data input. The purpose of PORIM's foliar diagnosis system is to correct an existing recommendation which may not be accurate due to unforeseen or unexpected factors.

DEVELOPMENT OF THE SYSTEM

The system is based on yield and leaf nutrient response equations derived from approximately fifty fertilizer trials conducted by different organisations in Peninsular Malaysia which have been analysed by PORIM.

It has been established that across environments, yield is not well related to the leaf nutrient levels.
However :

i) Provided that the levels of all other nutrients are non-limiting, and

ii) Provided that the environment (soil and climate) is not unusually limiting, and

iii) Provided that the balance with other nutrients is taken into consideration,

Yield response to N,P,K and Mg fertilizers has been found to be very closely related to the leaf levels of the corresponding nutrients.

THE DIAGNOSIS SYSTEM

The system makes use of soil and leaf response equations in such a way that the above three provisions are taken into account. In addition:

1. To ensure that the levels of other nutrients are non-limiting, a step-wise procedure is used, in which only the level of the most deficient nutrient is examined at each step.

2. Predictions using only leaf data are made only for "normal" soils and climate, identified as those where the inclusion of environmental data gives no significant improvement in prediction precision. In practice "normal" soils in Malaysia include all non-volcanic sedentary soils which have no major physical limitations.

On other soils and in extreme climates, environmental factors need to be included in the equations to take account of their influence on fertilizer nutrient recovery. Such equations have so far been derived only for coastal alluvial soils.

THE NORMAL DIAGNOSTIC PROCEDURE

In the normal dignostic procedure the steps followed are:

i) Leaf nutrient data is entered from which predictions of maximum yield response to all the major nutrients are calculated from the equations in *Table 1.*

ii) The nutrient predicted to give the highest maximum response is identified as the most deficient nutrient and a diagnosis and recommendation is made for this nutrient alone.

iii) The diagnosis is made according to *Fig. 1a* and *Fig. 2*, in which the critical level is set as the average difference between the

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maximum and most economic yield level. The default value at this critical level is 1.5. It is recommended that fertilizer rates should be increased if classified as deficient and decreased if classified as high.

iv) At each step the amount of fertilizer increase recommended is that required to bring the leaf level up to the critical level (rounded to the nearest 0.5 kg and restricted to a maximum of 3.0 kg).

v) After each step the effect of the recommended fertilizer increase on the level of all 5 major leaf nutrients is calculated from leaf nutrient response curves shown in *Table 2.*

vi) The leaf nutrient levels are adjusted by the above amounts and the new levels are then examined starting again from step i) above.

TABLE 1 : YIELD RESPONSE PREDICTIONS EQUATIONS BASED ON LEAF NUTRIENT DATA FOR "NORMAL" SOILS AND CLIMATE

Nutrient	Maximum predicted FFB yield response (t/ha/yr)								Residual error
N	216.668	- 160.0886	N	+ 28.0633	N^2	+ 0.001485	TB^2		2.43
P	225.289	- 2568.29	P	+ 7319.055	P^2	+ 12.5044	Mg		1.83
K	18.02269	- 40.2707	K	+ 16.50008	K^2	+ 0.008779	TB^2		1.83
Mg	3.8962	- 28.689	Mg	- 4.91738	N	+ 0.20907	TB		1.67

(where N = leaf %N Mg = leaf %Mg
P = leaf %P TB = leaf (Ca + Mg + K) in m.e./100g)
K = leaf %K

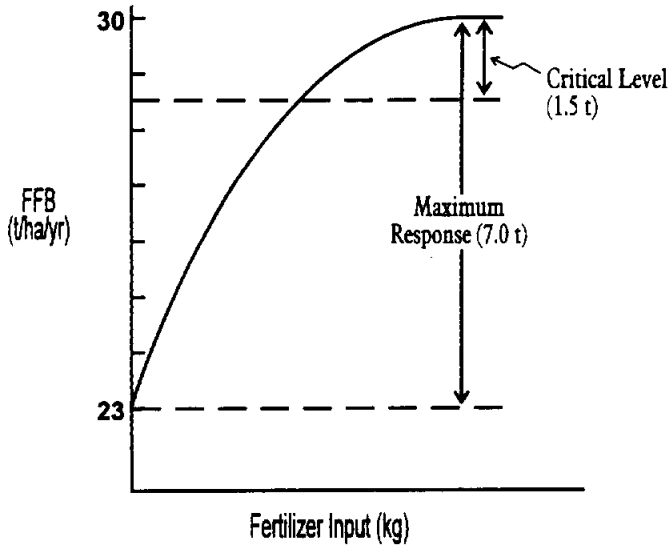

Figure 1. Normal Yield Curve

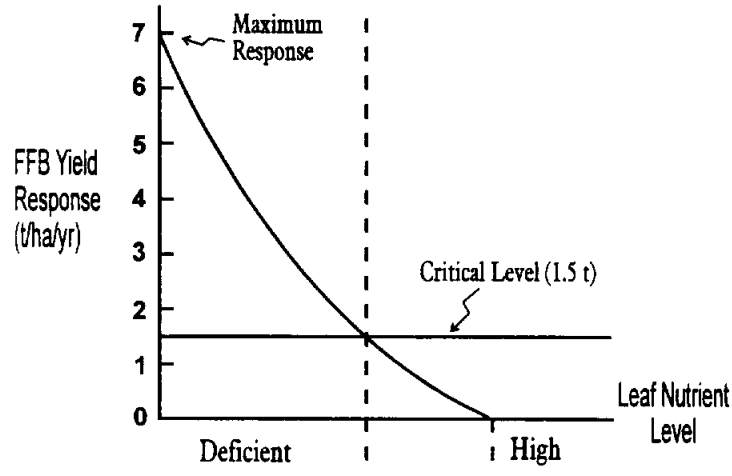

Figure 2. Normal Yield Response Curve

TABLE 2. LEAF NUTRIENT RESPONSE PREDICTION EQUATIONS

Fertilizer	Leaf nutrient	Predicted change in leaf nurtrient levels due to 1 kg fertilizer applied per palm per year
A.S.	N	0.1490 - 0.06934 N + 0.1046 C
A.S.	P	-0.0003 + 0.09295 P - 0.006322 N + 0.004301 C
A.S.	K	0.009
A.S.	Mg	0
A.S.	Ca	0
CIRP	N	0.015
CIRP	P	0.02568 - 0.1661 P + .01822 M
CIRP	K	-0.0977 - 0.0819 K + 1.459 P - 0.2814 M
CIRP	Mg	0
CIRP	Ca	0.007
KCl	N	0
KCl	P	0
KCl	K	-0.1603 - .1041 K + 1.858 P
KCl	Mg	-. 001727 - .07992 M + .01475 K
KCl	Ca	-0.009
Kies	N	0.001
Kies	P	0
Kies	K	-0.5532 - 0.2646 K + 0.1715 N + 1.922 P
Kies	Mg	0.4809 - 0.1832 M - 0.1868 N + 0.1227 K
Kies	Ca	0

(where N = leaf %N K = leaf % K
C = leaf % Ca) M = leaf %Mg
P = leaf %P

PROBLEMS

The system will fail if conditions are significantly different from any of the trials used to calculate the prediction equations. Some limiting factors that could be encountered:

1. Extreme Leaf TB Values

It is recommended that leaf TB (Total Bases) values be restricted to approximately 93 m.e. 100 g^{-1}. At higher values, anomalous curves are predicted.

2. Limiting soil or weather conditions

It is believed that the system is fairly universal and correctly indicates the most desirable leaf nutrient balance in any situation. However sometimes the environment may limit yield increase or fertilizer recovery, so that the optimum nutrient balance cannot be attained. In such cases, lower levels of fertilizer should be applied.

The best documented case is for the coastal alluvial soils in which the soil K buffering capacity limits K fertilizer recovery. In this case modified prediction equations have been derived which include those properties (silt and TEC) which determine the buffering capacity. Other limiting factors are likely to be:

i) High P buffering capacity on alluvial and volcanic soils,

ii) Dry environments which limit P and K recovery, and

iii) Stony or steep or poorly drained soils, which limit yield and fertilizer recovery.

Modified prediction equations need to be derived for these situations based on trial results.

RELIABILITY OF SYSTEM

All the prediction equations give a residual error of approximately 2 t ha^{-1} yr^{-1} FFB. Thus assuming that no unexpected limiting factor is in operation, predicted maximum yield responses should generally be within this range.

Using the default value of the critical level, the system calculates the fertilizer required to achieve a yield 1.5 tonnes below the maximum. Thus even if the true maximum yield is actually one standard error below the predicted value, response up to approximately this level will still be achieved.

CONCLUSION

The PORIM's foliar diagnosis system predicts the fertilizer rates expected to optimize profits on average. Lower fertilizer rates will give a reduced profit on average and due to the gradual slope of the response curve in this region, will not increase return substantially. Thus lower fertilizer rates are only recommended if funds are limited.

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