MULTI-LOCATIONAL NUTRIENT RESPONSE TRIALS FOR THE DEVELOPMENT OF COCOA FERTILIZER RECOMMENDATIONS

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Background

ECUADOR
- 1 Core trial
- Located in Quito
- Institution: MARS and ESPOL
- Plantation age: 2 years

GHANA
- 2 Core trials
- Locations: Maabang and Buaiko
- Institutions: CRIG and Mondelez
- Plantation age: 3 and < 1 years

COTE D’IVOIRE
- 3 Core trials
- Locations: Divo, Trassale and Aboisso
- Institutions: CNRA, Barry Callebaut and Nestle
- Plantation age: 2 years (all)

NIGERIA
- 2 Core trials
- Locations: Owena and Ibadan
- Institutions: CRIN and IITA
- Plantation age: 3 and 2 years

CAMEROON
- 2 Core trials
- Locations: Nkowemwone and Mbalmayo
- Institutions: IRAD and IITA
- Plantation age: 2 years (all)

INDONESIA
- 1 Core trial
- Located in Jember
- Institution: Mondelez
- Plantation age: 2 years

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What needs to be estimated?

\[
\frac{1}{y} = \frac{1}{Y_t} + \frac{1}{aN(N_s + N_f)} + \frac{1}{aP(P_s + P_f)} + \frac{1}{aK(K_s + K)}
\]

Greenwood et al. 1971

Optimum N, P, K (max profit)

- **Aims**
  - Optimum N, P, K (max profit)
  - High
  - Low

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Design

Target nutrient (e.g. N)

Remaining nutrients (e.g. PK)

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Design

Field heterogeneity

Replication/blocking
Theoretical proof of concept

\[ y_{\text{obs}} = \frac{1}{Y_t} + \frac{1}{aN(N_s + N_f)} + \frac{1}{aP(P_s + P_f)} + \frac{1}{aK(K_s + K)} \]

+ Error\(_{\text{rep}}\) + Error\(_{\text{block}}\) + Error\(_{\text{plot}}\)

K\(_2\)O (+N)

Simulate

Estimate

P\(_2\)O\(_5\), kg/ha

\[ y_{\text{obs}} = \frac{1}{Y_t} + \frac{1}{aN(N_s + N_f)} + \frac{1}{aP(P_s + P_f)} + \frac{1}{aK(K_s + K)} \]

\[ y_{\text{obs}} \sim N+P+K+N:P+N:K+P:K+N^2+P^2+K^2 + \ldots \]
Theoretical proof of concept

Type III Analysis of Variance Table with Satterthwaite’s method

<table>
<thead>
<tr>
<th></th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>NumDF</th>
<th>DenDF</th>
<th>F value</th>
<th>Pr(&gt;F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>288495</td>
<td>144247</td>
<td>2</td>
<td>57.674</td>
<td>2.2244</td>
<td>0.11733</td>
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<tr>
<td>P</td>
<td>640078</td>
<td>320039</td>
<td>2</td>
<td>57.531</td>
<td>4.9352</td>
<td>0.01052*</td>
</tr>
<tr>
<td>K</td>
<td>527255</td>
<td>263627</td>
<td>2</td>
<td>55.226</td>
<td>4.0653</td>
<td>0.02254*</td>
</tr>
<tr>
<td>N:P</td>
<td>64556</td>
<td>64556</td>
<td>1</td>
<td>58.299</td>
<td>0.9955</td>
<td>0.32253</td>
</tr>
<tr>
<td>N:K</td>
<td>90186</td>
<td>90186</td>
<td>1</td>
<td>54.787</td>
<td>1.3907</td>
<td>0.24338</td>
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<tr>
<td>P:K</td>
<td>38992</td>
<td>38992</td>
<td>1</td>
<td>58.721</td>
<td>0.6013</td>
<td>0.44120</td>
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</tbody>
</table>

$R^2 = 0.94$

$R^2 = 0.85$

Full model

Simple model

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Theoretical proof of concept

True value

Estimated value
Early results (Ibadan, Nigeria)

Soil heterogeneity

Trait heterogeneity

$R^2 = 0.08$

$p = 0.01$
Random effects:

<table>
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<tr>
<th>Level</th>
<th>Variance</th>
<th>Std.Dev.</th>
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<tr>
<td>block:rep</td>
<td>1131.8</td>
<td>33.64</td>
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<tr>
<td>rep</td>
<td>673.7</td>
<td>25.96</td>
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<tr>
<td>Residual</td>
<td>4393.4</td>
<td>66.28</td>
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</tbody>
</table>

Non-systematic variation accounted for

Data quality

Blocking useful
Early results (Ibadan, Nigeria)

Estimated AE:
-1.3
0.3
1.2

Observed responses:
N, kg/ha
P₂O₅, kg/ha
Total bean yield (kg/ha)

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Conclusions

- A network of 11 core trials was implemented successfully.
- The experimental design offers potential for estimating all key parameters.
- First data looks promising. Good quality, non-systematic variation absorbed by design.
- Responses to nutrients are not yet visible (early days + effects of basal fertilizer).
- Developed procedures and forthcoming data will benefit the cocoa growing industry at large and will hopefully aid farmers in determining the best nutrient rates.
Partnerships:

<table>
<thead>
<tr>
<th>Project Lead/Donor</th>
<th>National Research Institutes</th>
<th>Inti Research Centres</th>
<th>Private partners</th>
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<tbody>
<tr>
<td>IITA</td>
<td>idh</td>
<td>UN@WCMC</td>
<td>Cargill</td>
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<tr>
<td></td>
<td>Wageningen</td>
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<td>Olam</td>
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<td></td>
<td>Norad</td>
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<td>Mars</td>
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Thanks:

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