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 Buako
- Institutions: CRIG and Mondelez
- Plantation age: 3 and < 1 years

COTE D'IVOIRE
- 3 Core trials
- Locations: Divo, Tiassale 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: Nkoemvone and Mbalmayo
- Institutions: IRAD and IITA
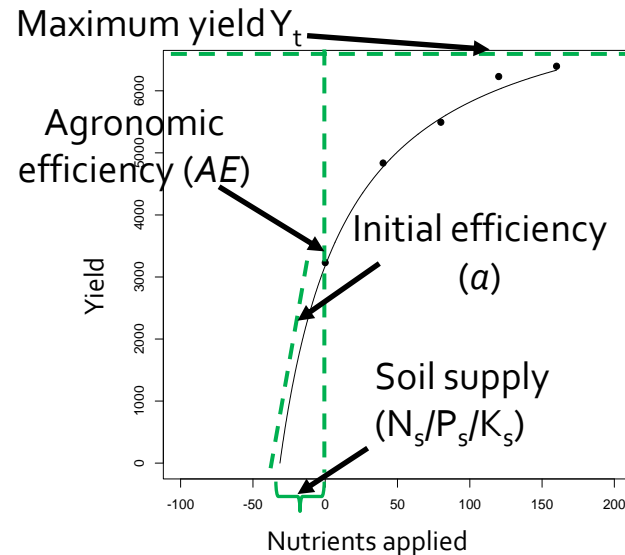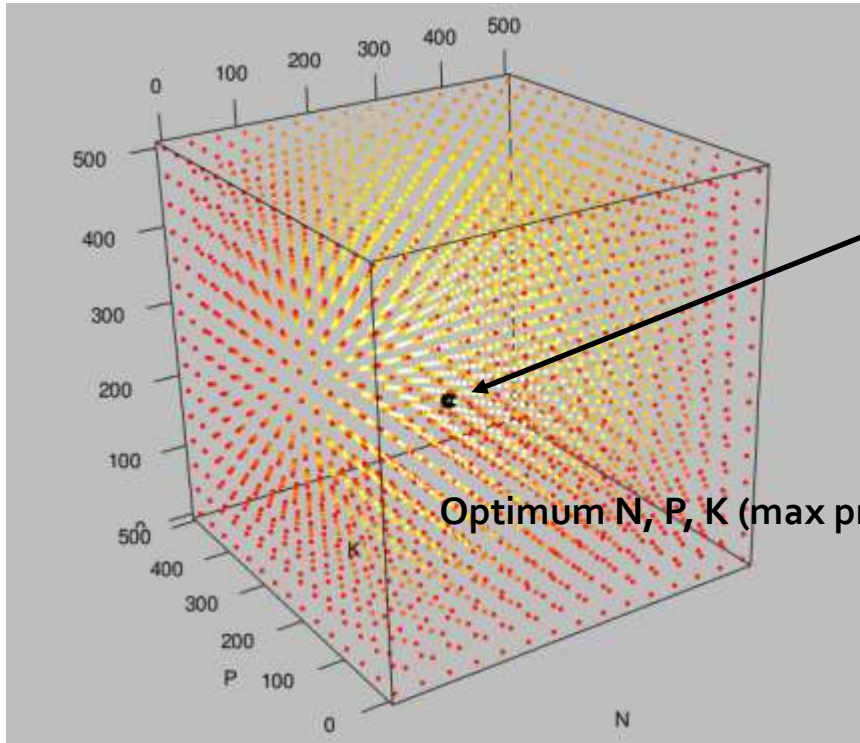- Plantation age: 2 years (all)

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

Aims

What needs to be estimated?

$$\frac{1}{y} = \frac{1}{Y_t} + \frac{1}{aN(N_s + N_f)} + \frac{1}{aP(P_s + P_f)} + \frac{1}{aK(K_s + K)}$$
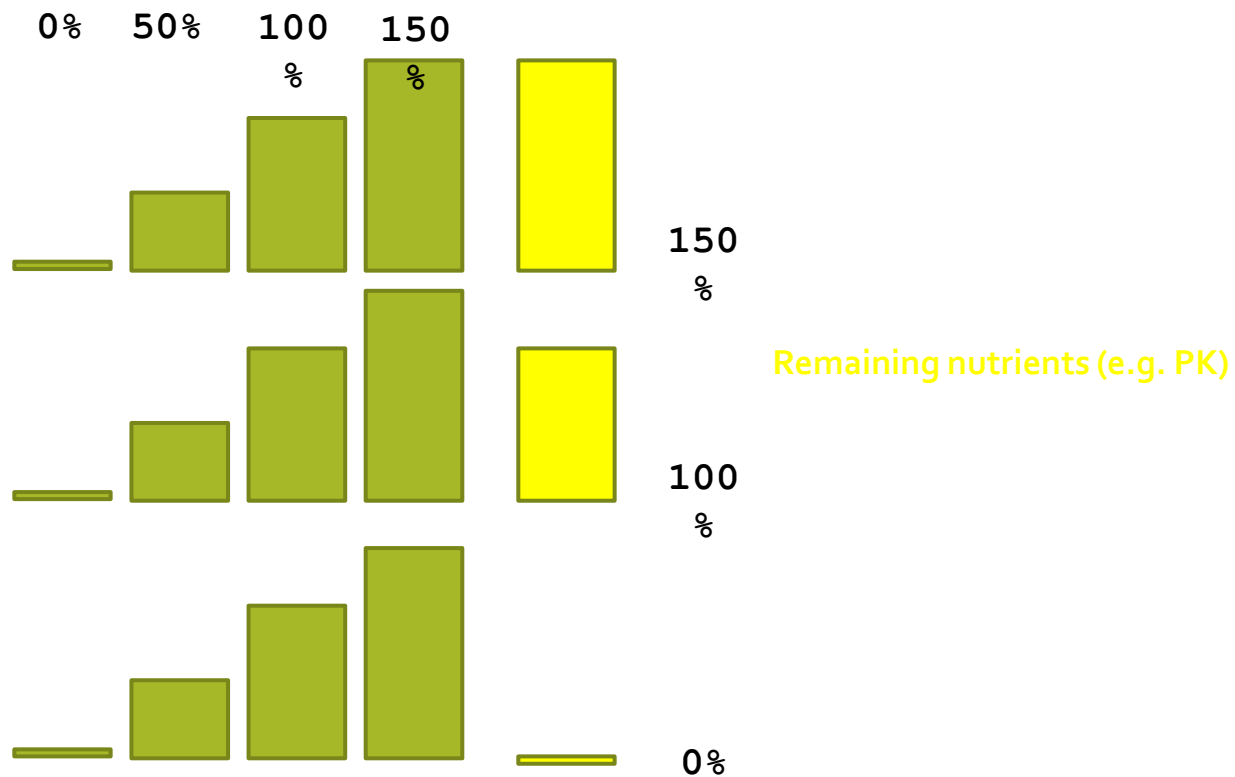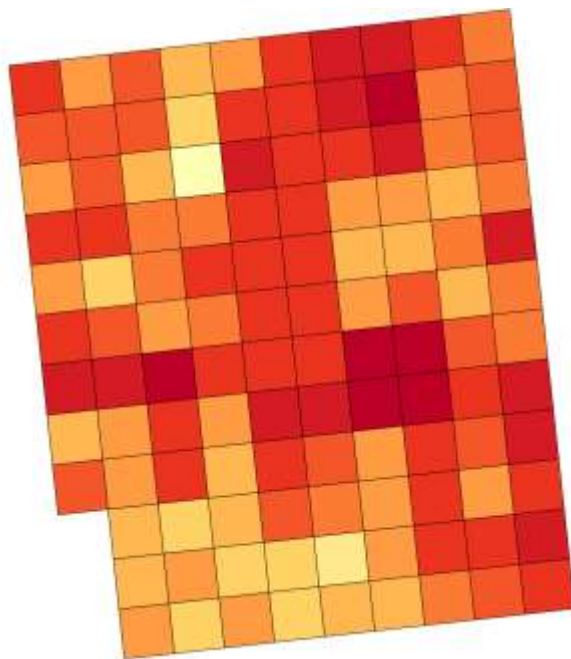
Greenwood et al. 1971

Maximum yield Y_t

Agronomic efficiency (AE)

Initial efficiency (a)

Soil supply ($N_s/P_s/K_s$)

Yield

Nutrients applied

Optimum N, P, K (max profit)

Low	High

Design

Target nutrient (e.g. N)

0% 50% 100% 150%

150%

Remaining nutrients (e.g. PK)

100%

0%

Design

Field heterogeneity

Replication/blocking

C0NI002_Y2020

Rep/Blck:
× 1
× 2
■ 1
■ 2
■ 3
■ 4
■ 5
■ 6
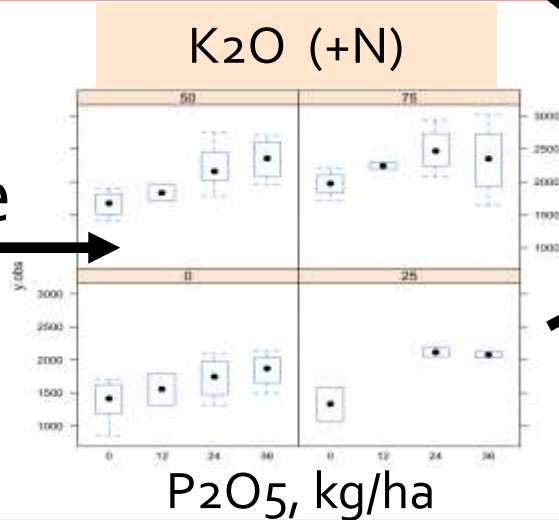
Theoretical proof of concept

CocoaSoils
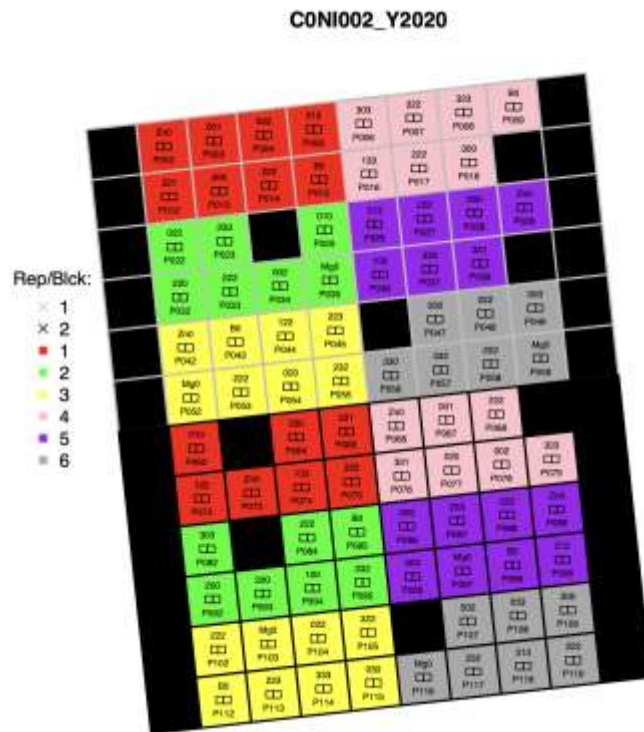
$$y_{obs} = \frac{1}{\frac{1}{Y_t} + \frac{1}{aN(N_s + N_f)} + \frac{1}{aP(P_s + P_f)} + \frac{1}{aK(K_s + K)}} + Error_{(rep)} + Error_{(block)} + Error_{(plot)}$$
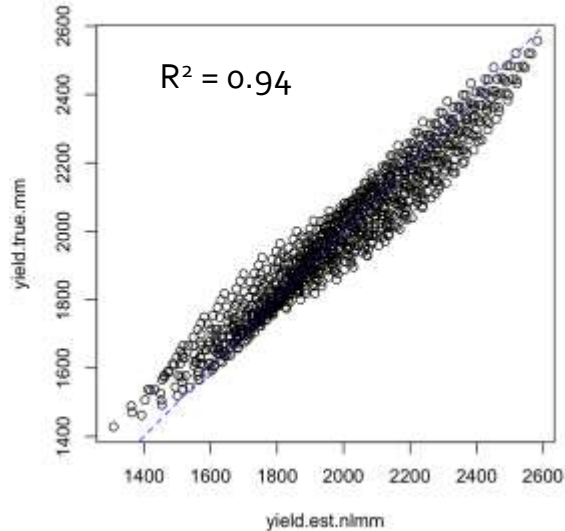
K2O (+N)

Simulate

Estimate

P2O5, kg/ha

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

Full model (hard)
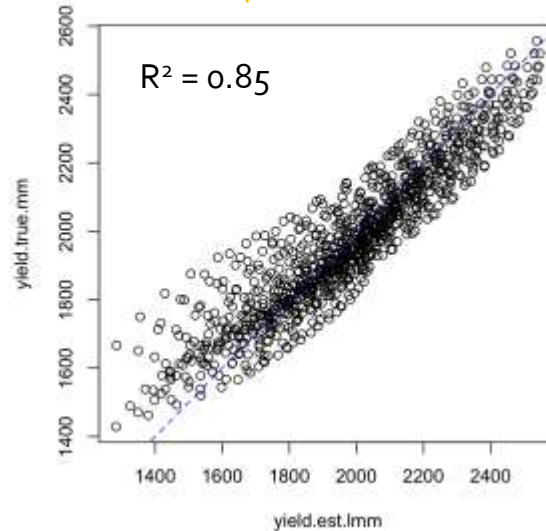
$y_{obs} \sim N + P + K + N{:}P + N{:}K + P{:}K + N^2 + P^2 + K^2 + \dots$

Simple model (easy)

Theoretical proof of concept

CocoaSoils

Full model

Simple model

R² = 0.94

R² = 0.85

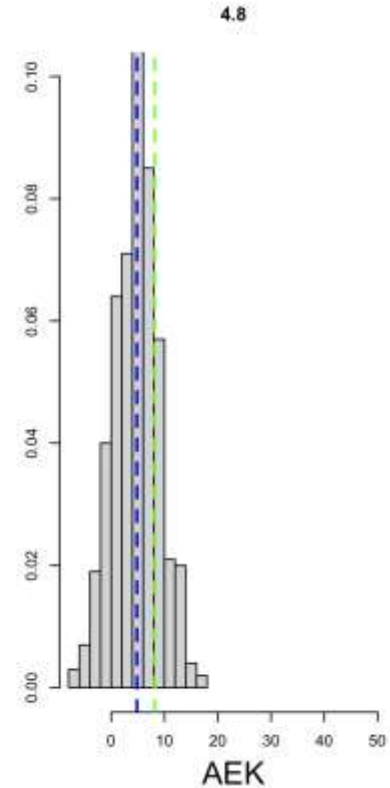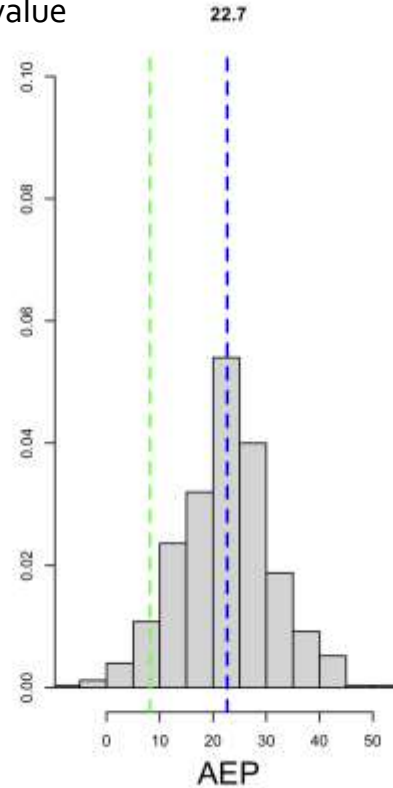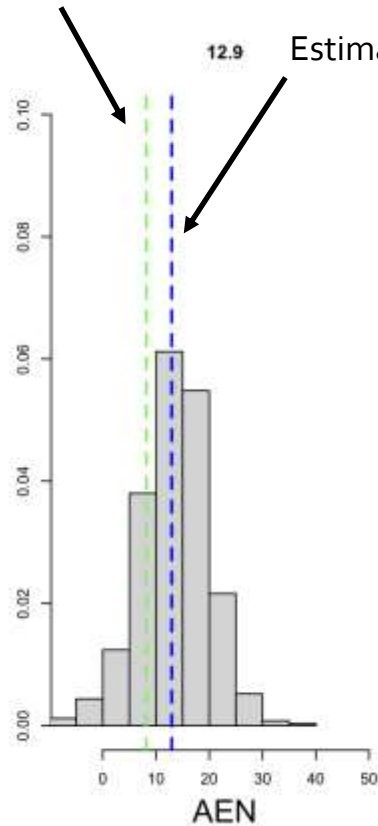

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Type III Analysis of Variance Table with Satterthwaite's method
            Sum Sq Mean Sq NumDF  DenDF F value   Pr(>F)
N           288495  144247     2 57.674  2.2244  0.11733
P           640078  320039     2 57.531  4.9352  0.01052 *
K           527255  263627     2 55.226  4.0653  0.02254 *
N:P          64556   64556     1 58.299  0.9955  0.32253
N:K          90186   90186     1 54.787  1.3907  0.24338
P:K          38992   38992     1 58.721  0.6013  0.44120
```
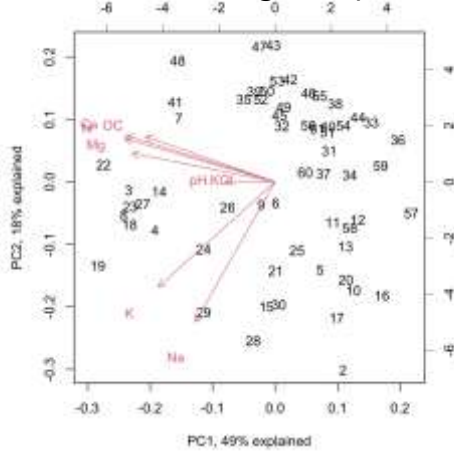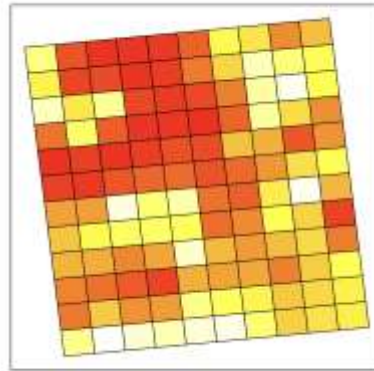
Theoretical proof of concept

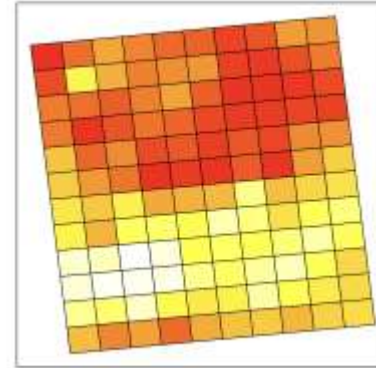# Early results (Ibadan, Nigeria)

Soil heterogeneity

soil.pc1.pred
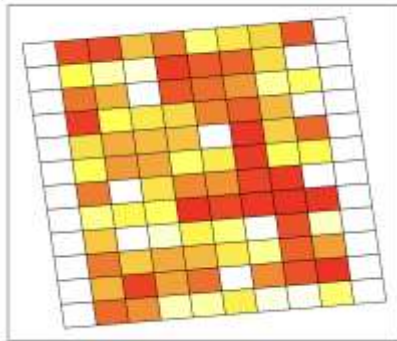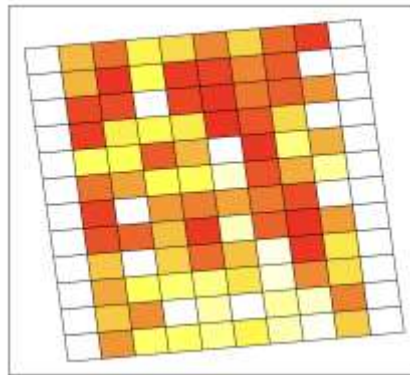
soil.pc2.pred

$R^2 = 0.08$
$p = 0.01$

Trait heterogeneity

crownradius_cm

total_bean_yield_ha
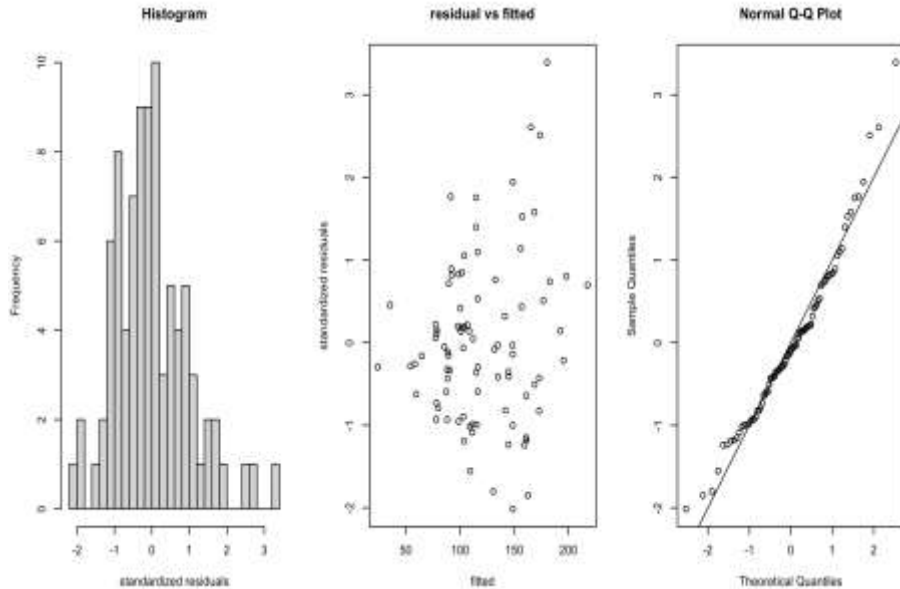
basal_area_cm

CocoaSoils

Early results (Ibadan, Nigeria)

CocoaSoils
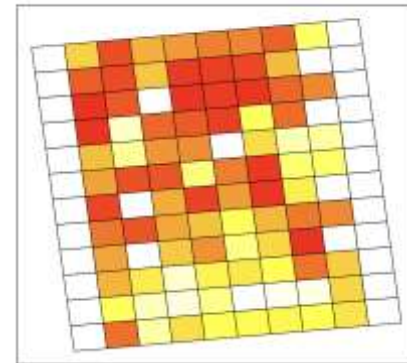
Data quality

Blocking useful


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Random effects:

Level         Variance      Std.Dev.
block:rep     1131.8        33.64
rep            673.7        25.96
Residual      4393.4        66.28
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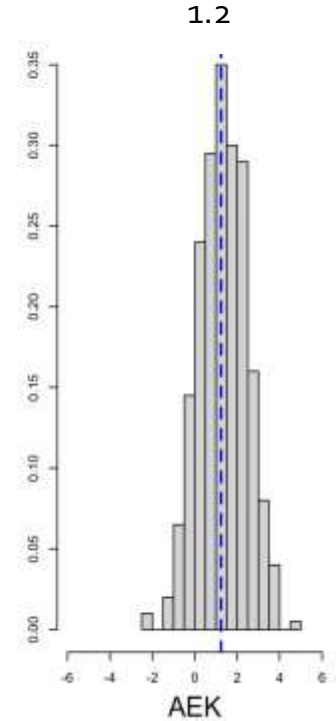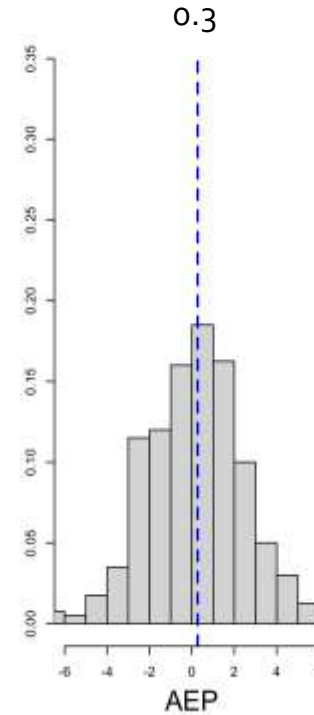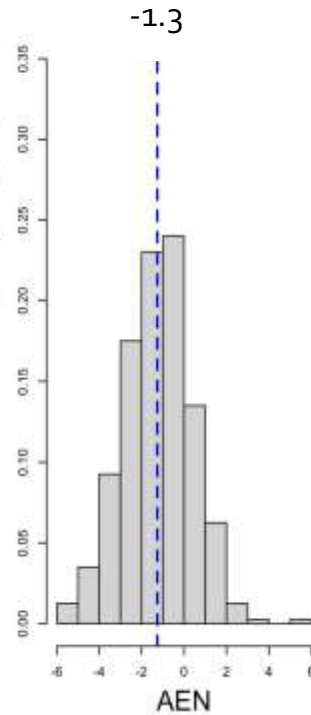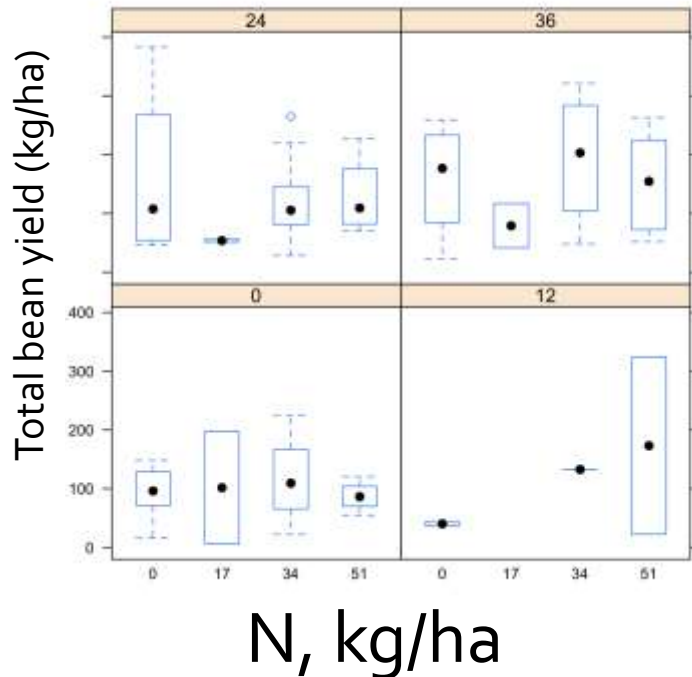
Non-systematic variation accounted for

Observed responses

Estimates of AE

P2O5, kg/ha

Total bean yield (kg/ha)

N, kg/ha

-1.3

0.3

1.2

AEN

AEP

AEK

Conclusions

CocoaSoils

- A network of 11 core trials was implemented succesfully

- 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:

Thanks:

Didier Begoude, IRAD Cameroon

Cargele Masso, IITA, Cameroon

Aka Romain, Barry Callebaut, Cote d'Ivoire

Arthur Tapi, Nestle, Cote d'Ivoire

Amos Quaye, CRIG, Ghana

Eduardo Chavez, ESPOL (Mars), Ecuador

Erwin Prastowo, ICCRI (Mondelez), Indonesia

Leonard Rusinamhodzi, IITA, Ghana

CocoaSoils

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