CocoaSoils

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

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Background

ECUADOR

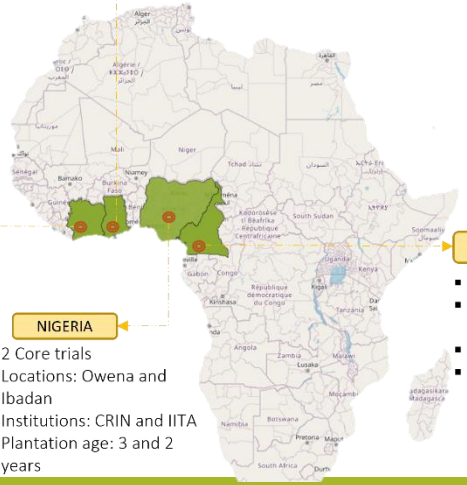
- 1 Core trial
- Located in Quito
- Institution: MARS and ESPOL
- Plantation age: 2 years

INDONESIA

- 1 Core trial
- Located in Jember
- Institution: Mondelez
- 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

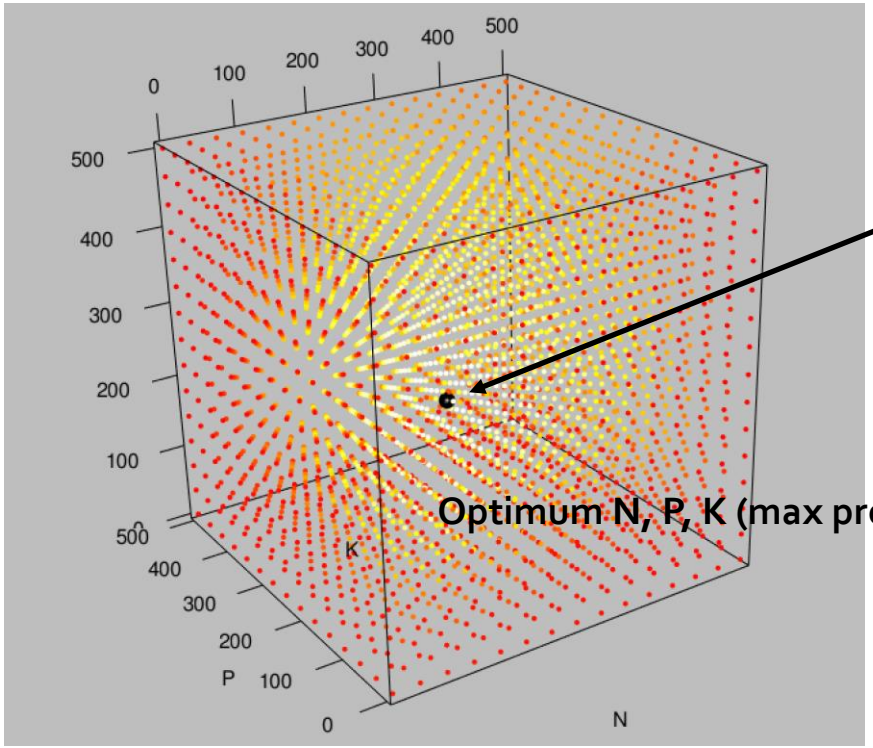
- 2 Core trials
- Locations: Nkoemvone and Mbalmayo
- Institutions: IRAD and IITA
- Plantation age: 2 years (all)

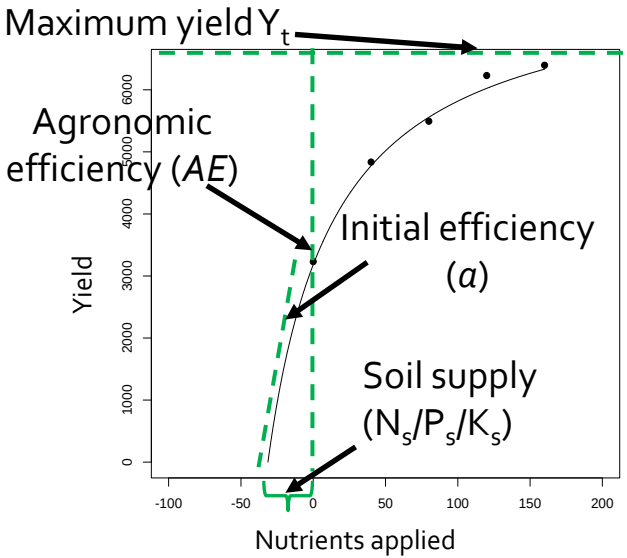
Aims

What needs to be estimated?

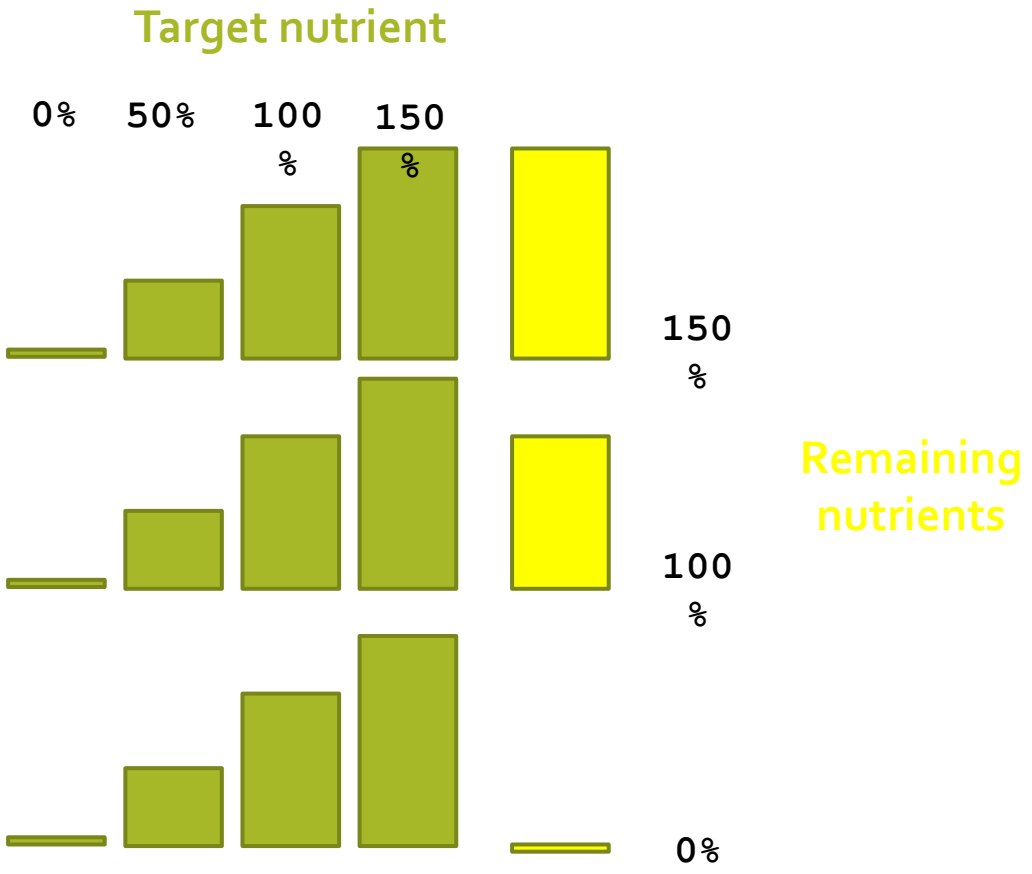
$$\frac{1}{y} = \frac{1}{Y_t} + \frac{1}{aN(N_s + N_f)} + \frac{1}{aP(P_s + P_f)} + \frac{1}{aK(K_s + K)}$$

Greenwood et al. 1971



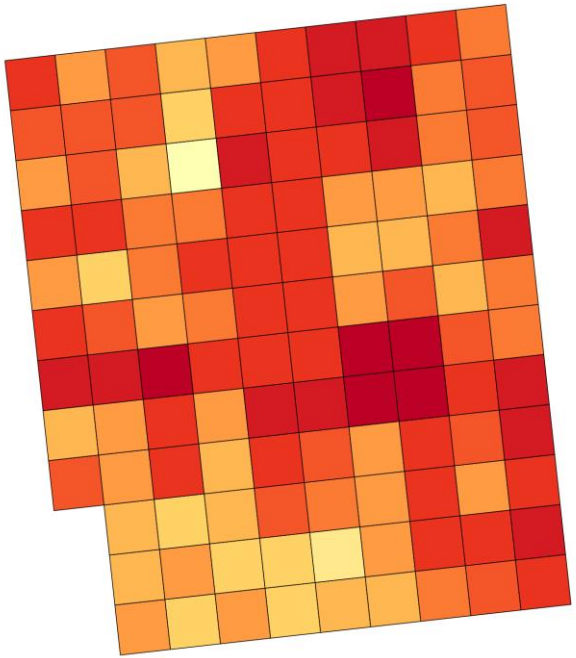


Design

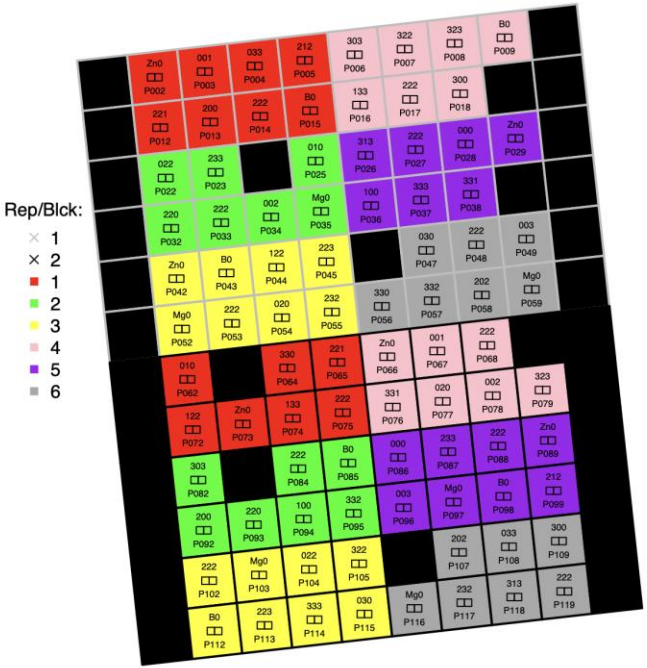


Design

Field heterogeneity
Previous maize yield
Soil chemical properties

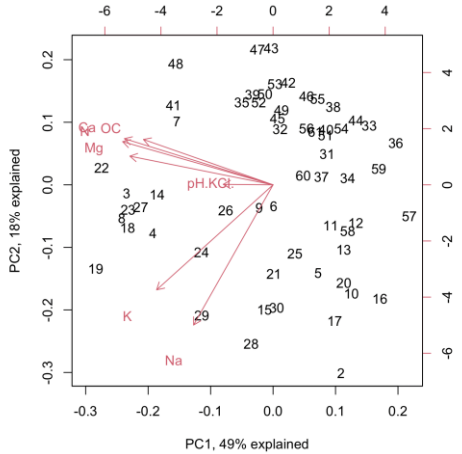


Replication/blocking

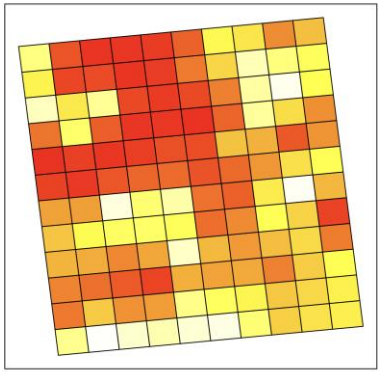


Early results

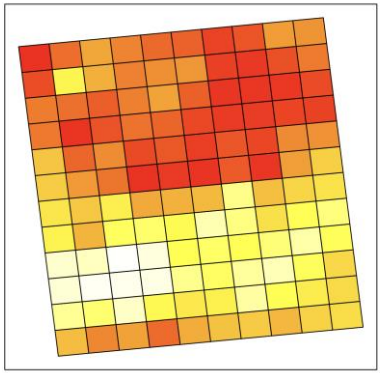
Soil heterogeneity



soil.pc1.pred



soil.pc2.pred

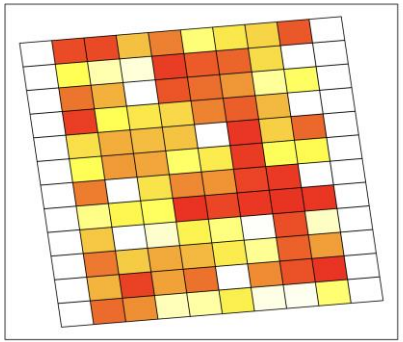


$R^2 = 0.08$

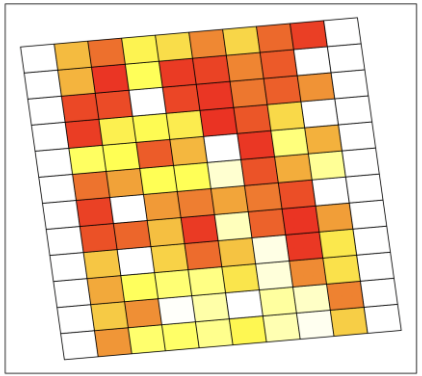
$p = 0.01$

Trait heterogeneity

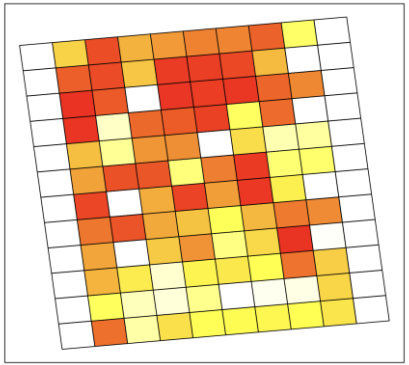
crownradius_cm

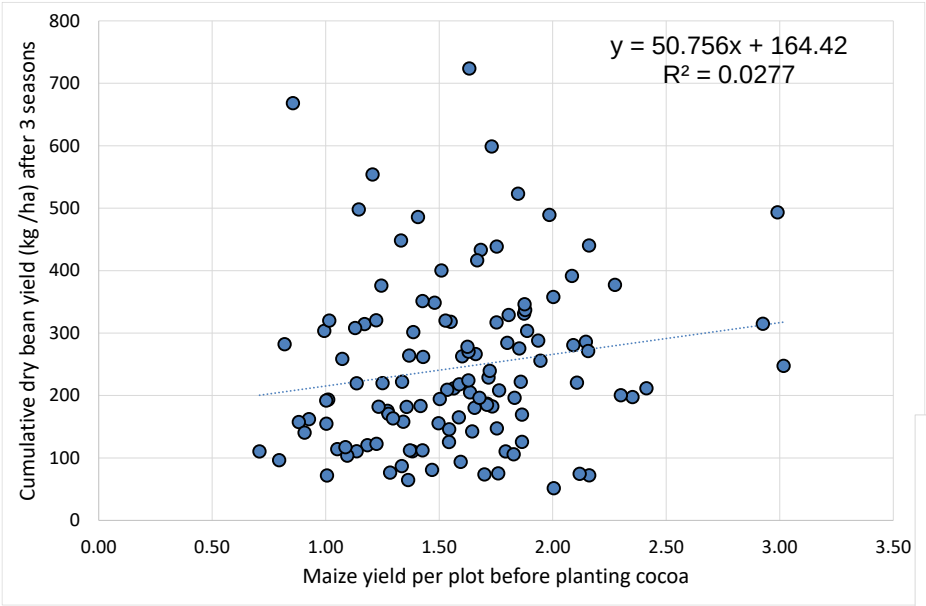


total_bean_yield_ha



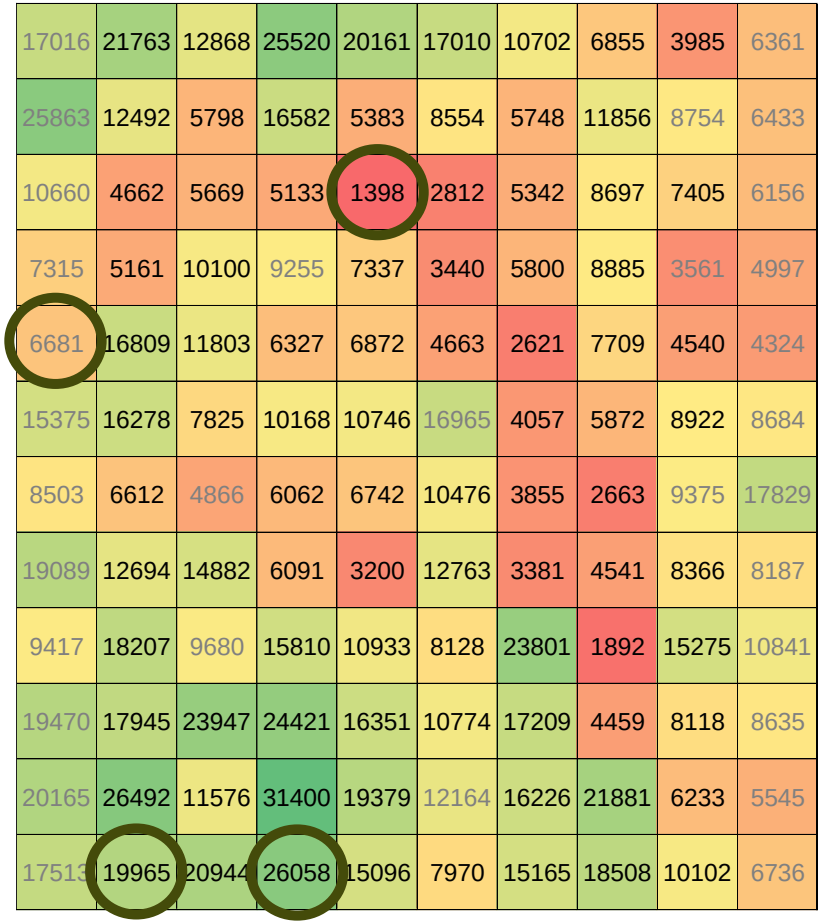
basal_area_cm



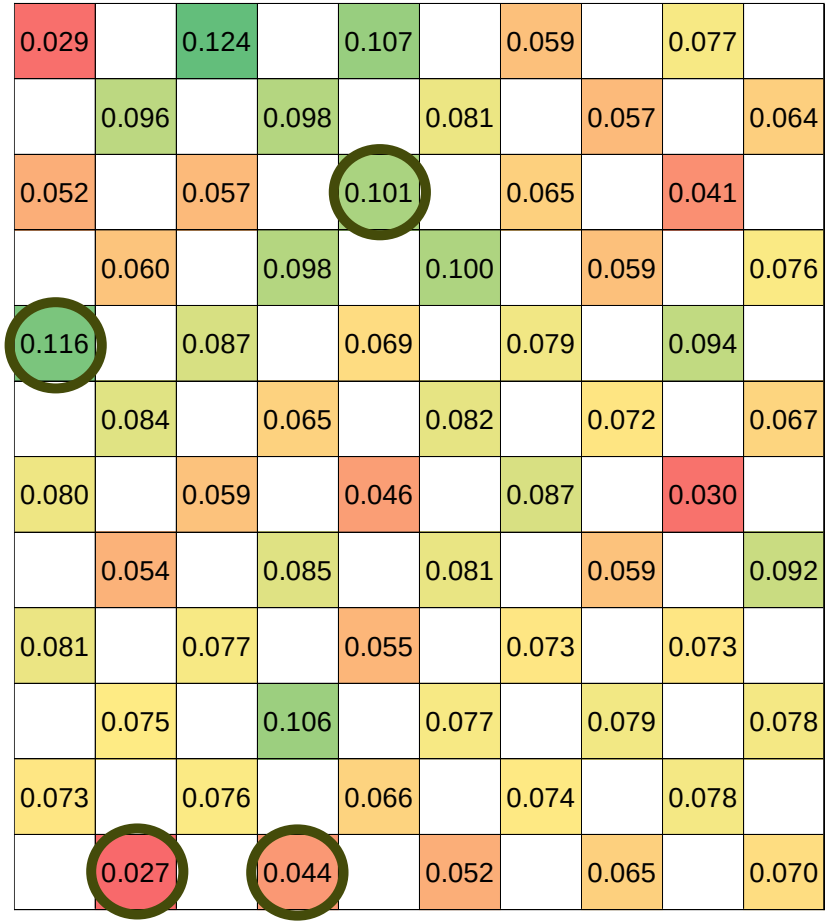


Relationship between maize yield before planning cocoa and the dry bean yield after three harvest seasons.

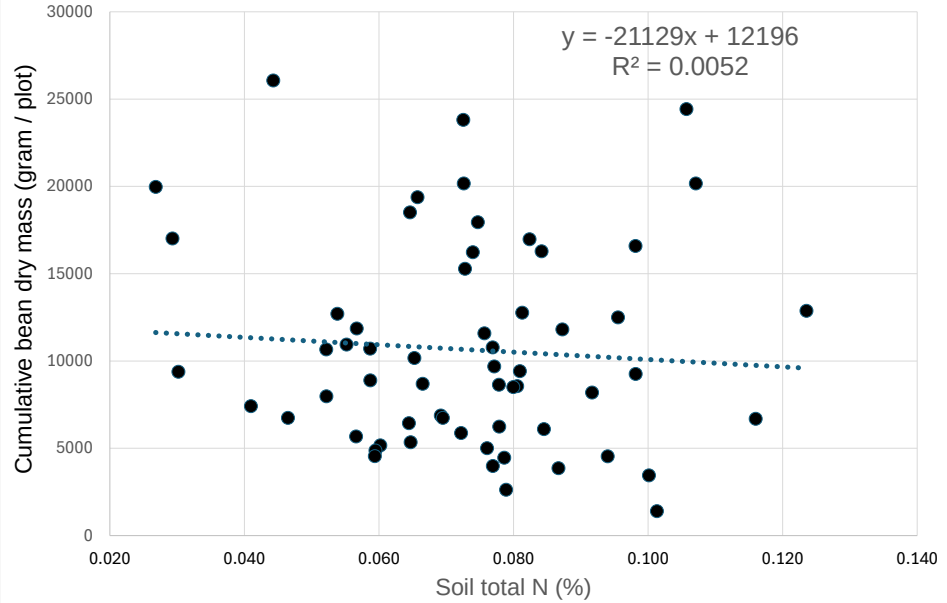
Relationship between maize yield before planning cocoa and the dry bean yield after six harvest seasons.



Cumulative bean dry mass (gram)

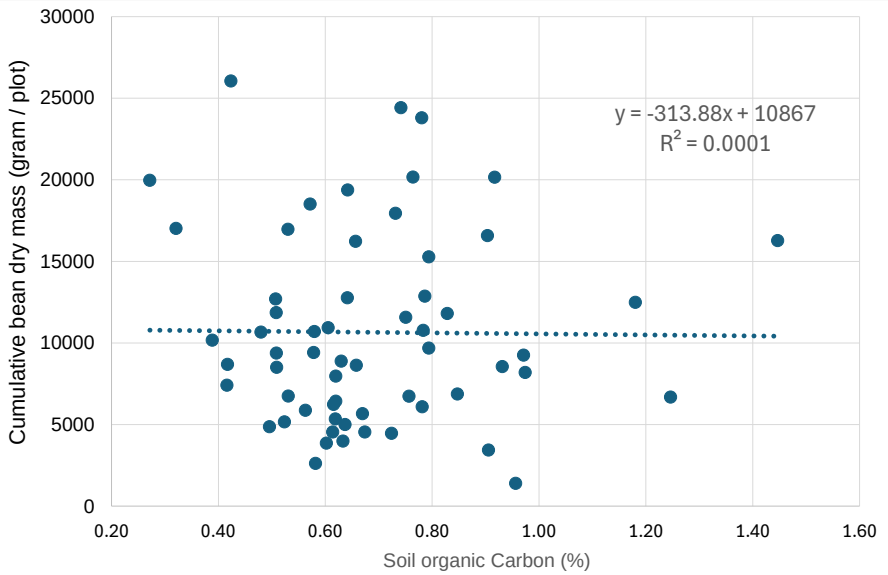


Soil N concentration 0-30 cm (%)

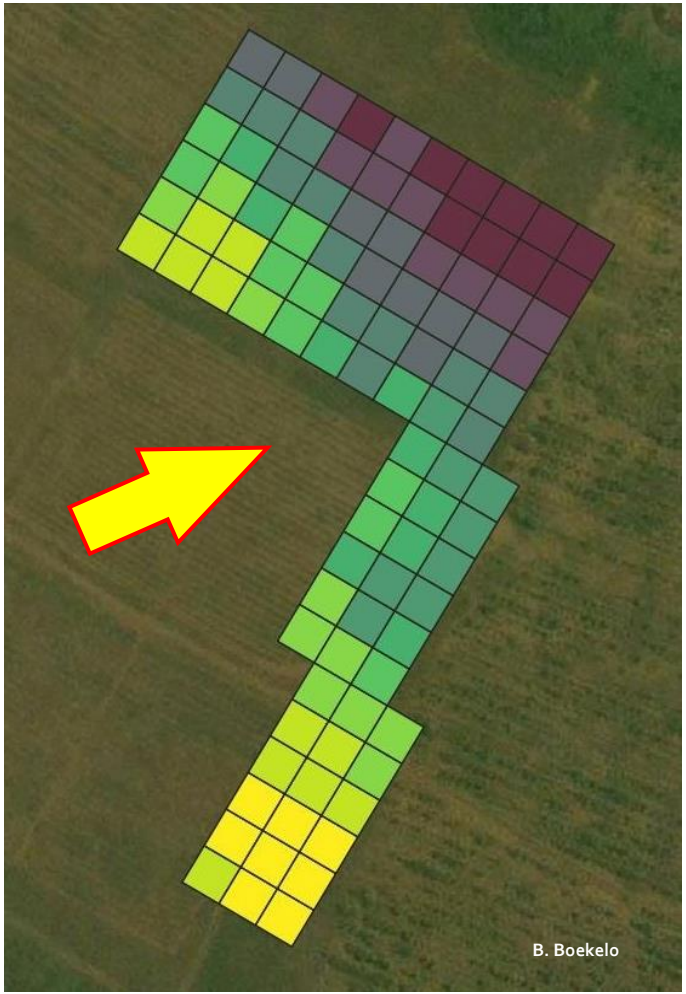


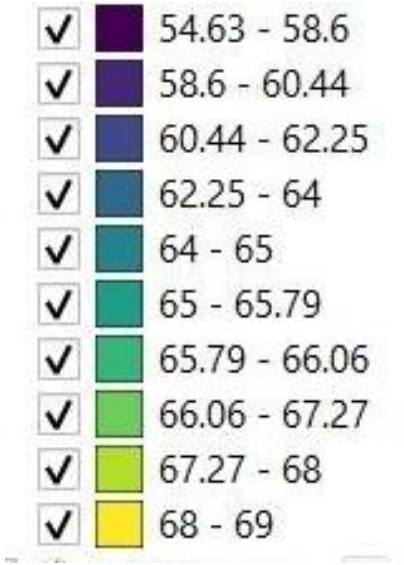
Relationship between the cumulative bean dry matter yield (gram / plot) and the initial soil total N concentration (%).

Relationship between the cumulative bean dry matter yield (gram / plot) and the initial soil organic carbon concentration (%).



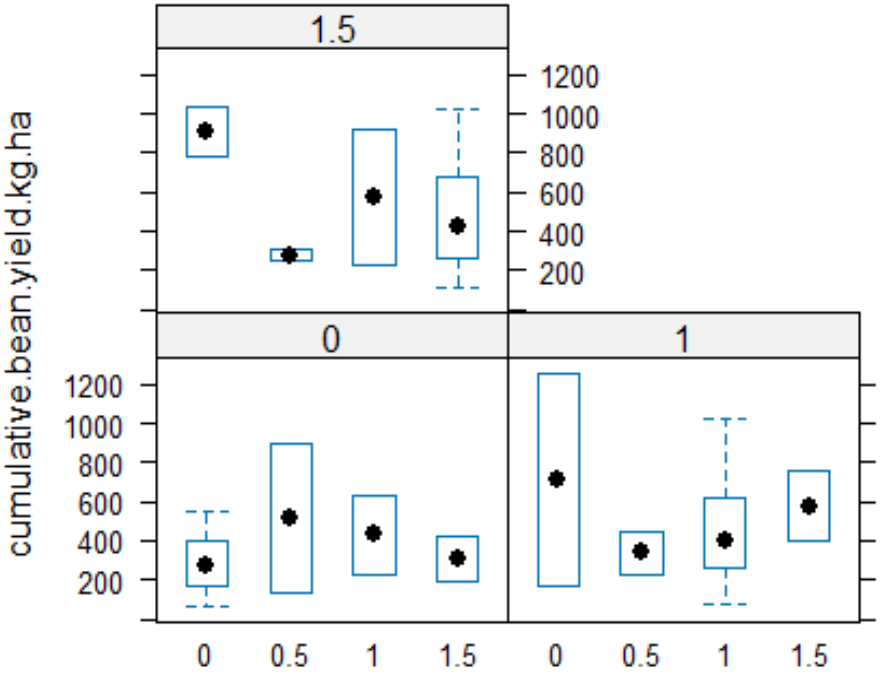
Spatial variability – Tiassalé, elevation





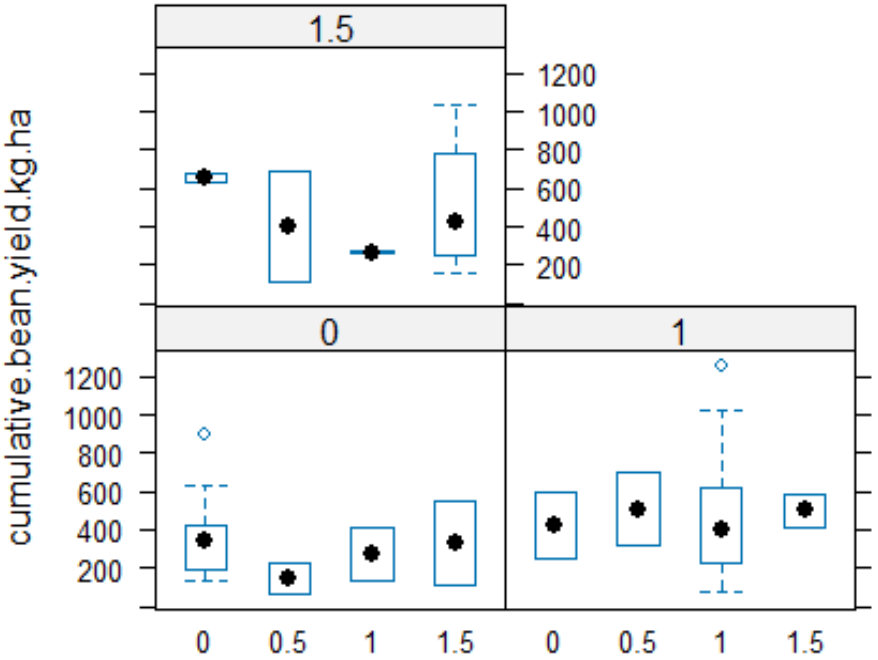
The slope of the trial sites might affect the bean yield at this early stages and under stress conditions more severely than the fertilizer.

At Tiassalé, tree performance is better at the lower end of the slope – similar to the situation at Ibadan.



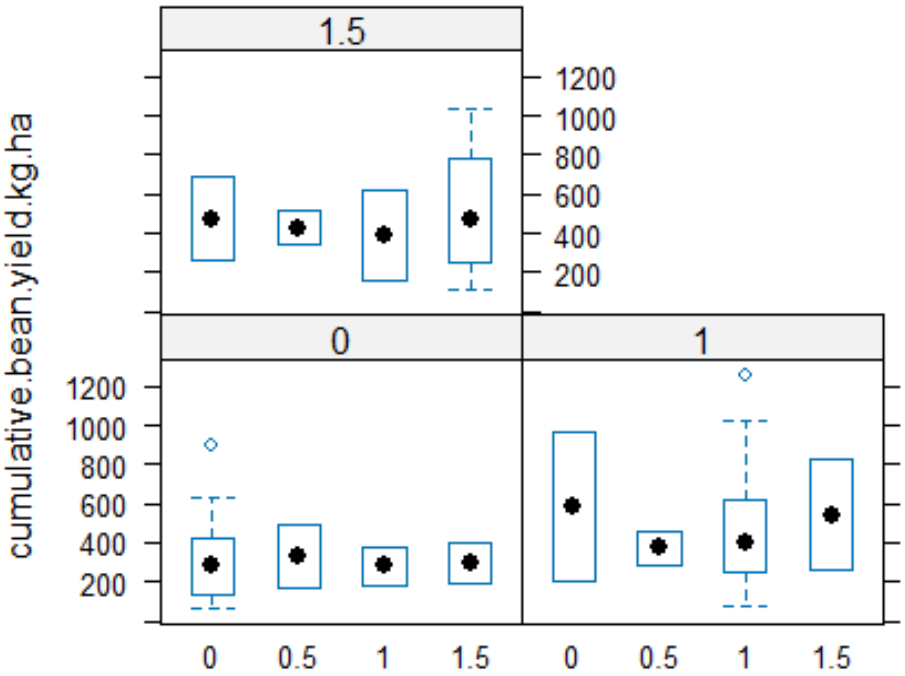
N fertilizer application level according to the off-take model at 0, 50 (0.5), 100 (1) and 150 (1.5) % of the recommended rate.

Cumulative bean yield response to N fertilizer application relative to the application of P and K.



P fertilizer application level according to the off-take model at 0, 50 (0.5), 100 (1) and 150 (1.5) % of the recommended rate.

Cumulative bean yield response to P fertilizer application relative to the application of N and K.



K fertilizer application level according to the off-take model at 0, 50 (0.5), 100 (1) and 150 (1.5) % of the recommended rate.

Cumulative bean yield response to K fertilizer application relative to the application of N and P.

Abiotic challenges

Tree death as a consequence of extreme dry season conditions 2022-23. About 400 trees shed all leaves within 2 weeks in January 2023 at Ibadan, most of them died.

Tree stems exposed to direct sun lost their bark. Possible consequence appear infections with fungi and ants settling under the detached bark.

Biotic challenges

Over the last two years an increasing frequency of stem borer attacks were noticed. There are at least 3 species drilling into stems and branches.

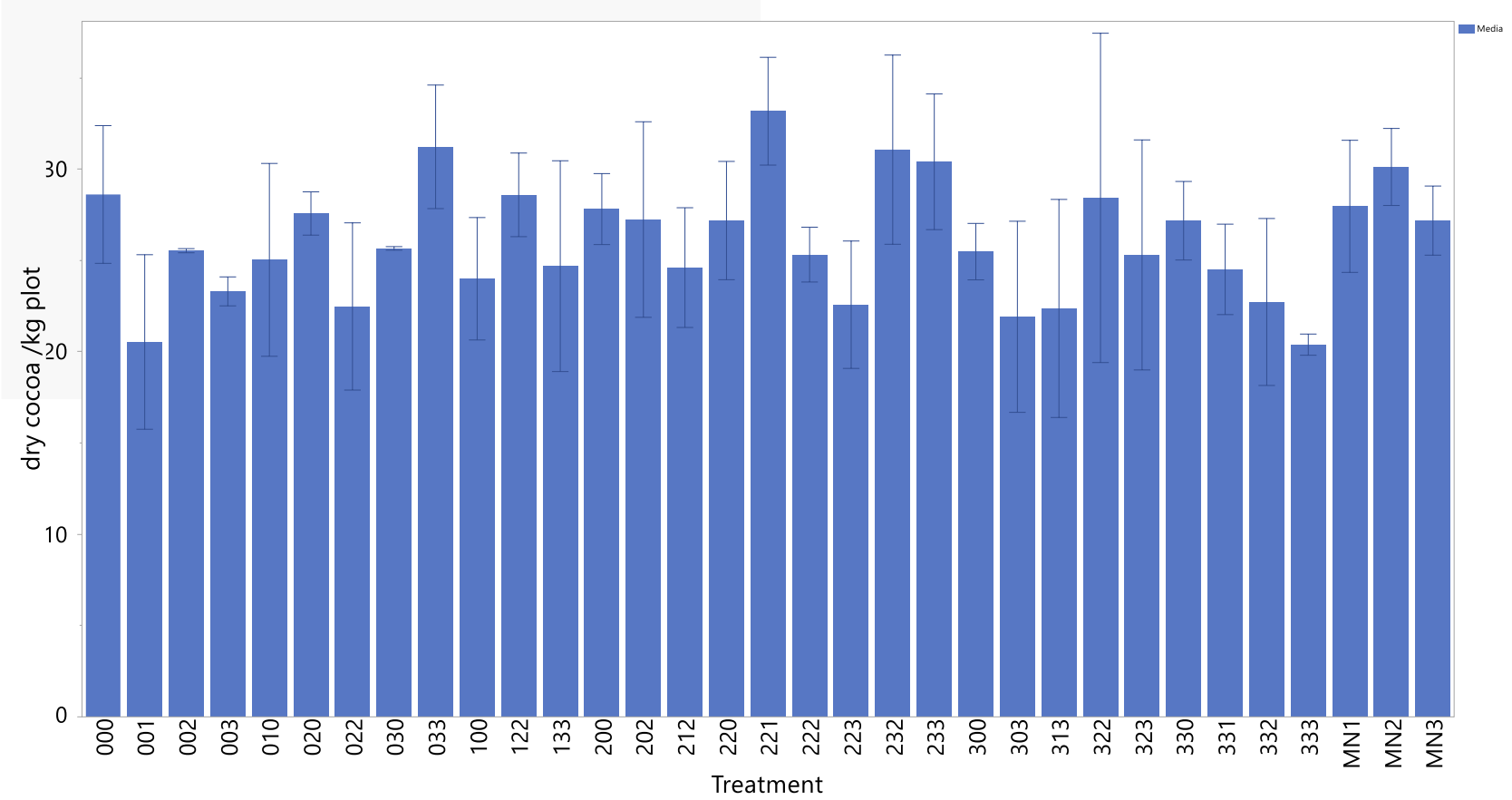
This problem is generally observed in all West African core trials. Control is labour intensive and not necessarily effective.

Field maintenance and treatment application Ecuador

Pruning (March-June-December 2023)

Treatment application (June-August-September-October 2023)

Yield data affected by treatments



As for most core trials we only have one year of bean yield data, the results are not yet relevant nor reliable.

To attain reliable results, a maximum of biotic and abiotic stress factors need to be excluded or at least minimized.

Regular data uploads of tree evaluation, and harvest data will help monitor progress and facilitate data analyses.

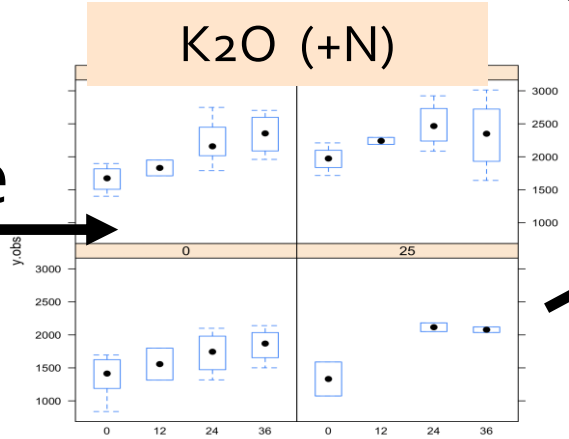
THANK YOU FOR YOUR ATTENTION

Theoretical proof of concept

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

Simulate

Estimate



P2O5, kg/ha

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

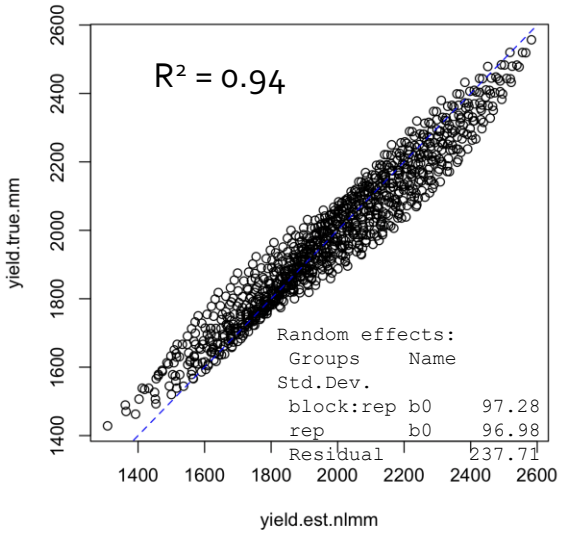
Full model (hard)

$$y_{obs} \sim N+P+K+N{:}P+N{:}K+P{:}K+N^2+P^2+K^2 + \ldots$$

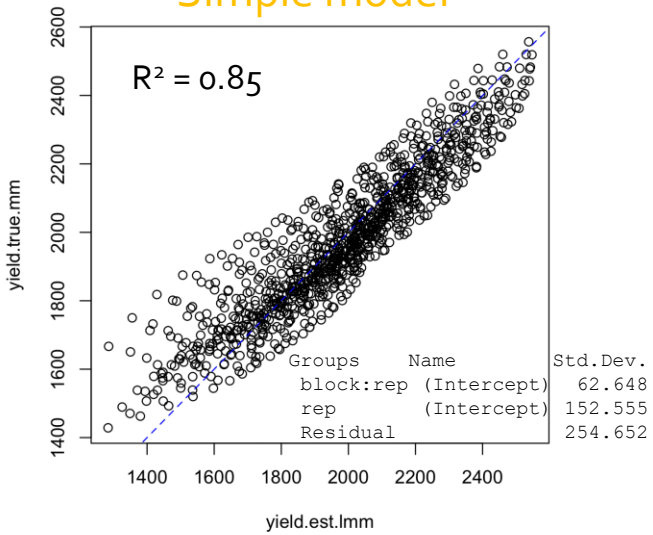
Simple model (easy)

Theoretical proof of concept

Full model



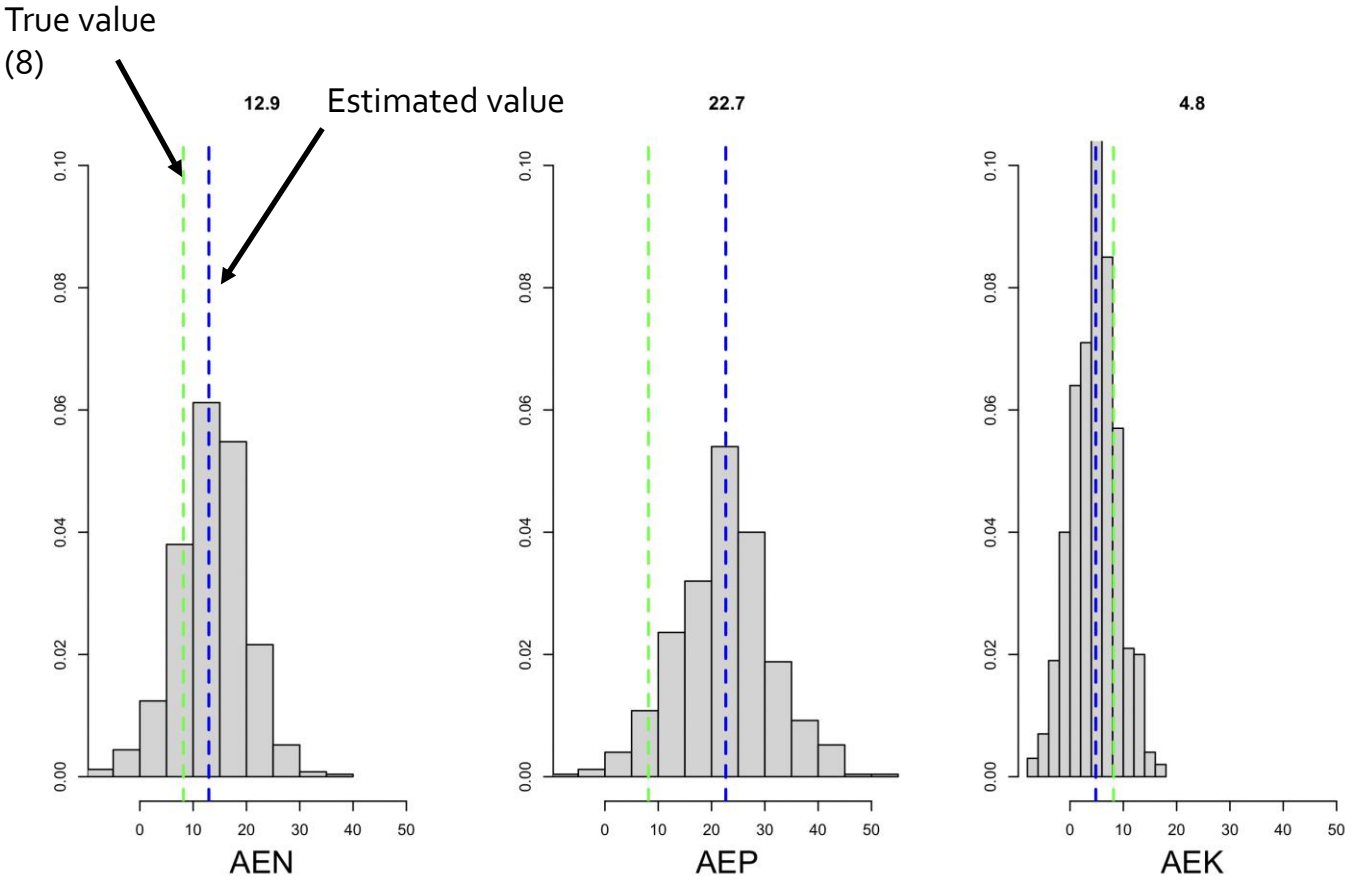
Simple model



Type III Analysis of Variance Table with Satterthwaite's method

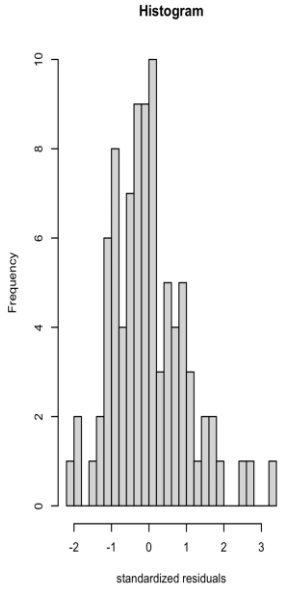
	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)	
N	288495	144247	2	57.674	2.2244	0.11733	
P	640078	320039	2	57.531	4.9352	**0.01052**	*
K	527255	263627	2	55.226	4.0653	**0.02254**	*
N:P	64556	64556	1	58.299	0.9955	0.32253	
N:K	90186	90186	1	54.787	1.3907	0.24338	
P:K	38992	38992	1	58.721	0.6013	0.44120	

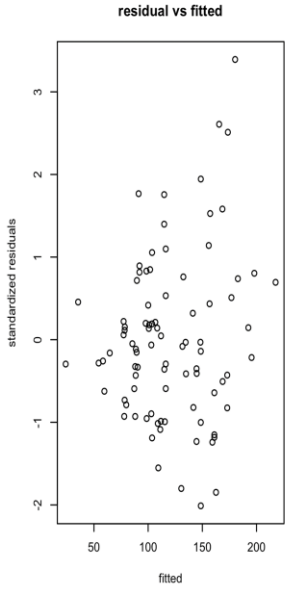
Theoretical proof of concept

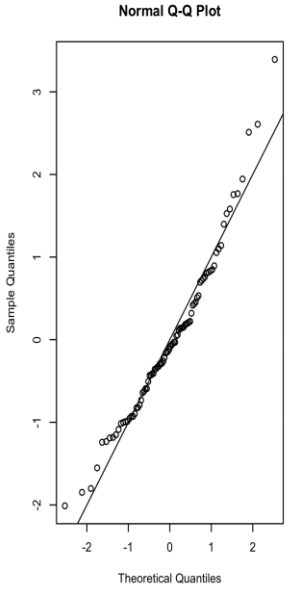


Early results

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
```

Non-systematic variation accounted for

Early results (Ibadan, Nigeria)

Observed responses

Estimates of AE

P_2O_5, kg/ha