Fertiliser use, soil responsiveness and yield gaps in cotton-based cropping systems of N Cameroon

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Background

- Productivity decline in cotton-based cropping systems of West and Central Africa: impact on regional economies
- Price fluctuations lead to discontinuous/insufficient fertiliser use in the long term: impact on soil productivity
- Cameroon National debt funds (C2D): soil fertility restoration project (SODECOTON, CIRAD)
- What determines current yield gaps, how wide are they, and how to close them?
- Data mining: reanalysis of ‘old’ and long term trials
Decline in productivity

Global fertiliser productivity at Garoua, N Cameroon

Yield = 1520 – 18 * t  \( (r^2 = 0.4) \)

Period 1986-1996

Period 1997-2005

\( r^2 = 0.7 \)

\( r^2 = 0.6 \)
Discontinuous fertiliser use

- Responsive soils
- ‘Hysteresis’
- Poorly responsive soils

Crop productivity vs. Fertiliser use
“Hysteresis” of land rehabilitation - Kenya

Tittonell et al., 2008, Agronomy Journal 100
La mémoire du sol…

Phases of depletion and restoration (Benin)

Maize grain yield (kg ha⁻¹)

Seed-cotton yield (kg ha⁻¹)

Relative yields (%)
Closing yield gaps through fertiliser use

Network of on-farm trials in 1990

- Cotton response to mineral fertilisers (N, P, K, S)
- 250 farmer fields around Garoua (n = 135)
- Soils 20-30% Clay + silt; 650 ± 80 mm
- 0, 125, 250, 375, 500 kg ha⁻¹

Average response to fertiliser by cotton in 1990

![Graph showing response to fertiliser by cotton per quintile](image)

- Seed-cotton yield (kg ha⁻¹)
- Fertiliser applied (kg ha⁻¹)

- Observed vs. Model: Y = a + b * e⁻¹⁸⁵

- n=7, n=34, n=66, n=31, n=6
Closing yield gaps through fertiliser use

Management practices affect attainable yields

![Graph showing the relationship between soil organic matter and seed-cotton yield without fertiliser. The graph includes data points for early, modal, and late sowing, with different symbols for each category. The x-axis represents soil organic matter (%) and the y-axis represents seed-cotton yield (kg ha⁻¹). The graph demonstrates how soil organic matter affects yield and how management practices can influence attainable yields.](image-url)
Soil carbon losses and productivity decline

A positive feedback

- Clearance of native savannah vegetation
- Continuous cultivation with poor C restitution

Response parameters, efficiency, yield gaps and soil organic matter
National policies with local consequences

Diversity at local scale: how to define yield potential?

Debru, J. (2009)

L’abandon de la culture du cotonnier est-il momentané ou définitif ? AgroParisTech

History of land occupation and use: current heterogeneity

Diversity of farming trajectories and styles

Number of livestock heads

Decline in livestock numbers

Evolution des cheptels de 2002 à 2009 dans le département de la Bénoué

Number of livestock heads

Peul nomades ne pratiquant pas l'agriculture

Nigeria - Peul - semi nomades, déplacements pendant la campagne agricole (culture du sorgho)

Cameroun - Nakong ou Babla - même système de production

Sedentarisation de Peul à Sabewa puis Israel et v.aladjji Maïssage culture du maïs - transhumance en fin de saison sèche et en saison des pluies, puis construction d'un village et défriche

Fixation du foyer et transhumance saisonnière des troupeaux puis défriche

Nouveaux installés

jeunes foyers installés

diversification du système de cultures

diversification du système de cultures

3A

3B

1A

3B

3A
Concluding remarks

- Discontinuous/insufficient fertiliser use widens yield gaps through cumulative effects
- Lack of reversibility in fertiliser response beyond a certain threshold of soil degradation - hysteresis or *la mémoire du sol*
- Soil organic matter as key to restoring soil productivity, but complexity of local land use systems must be embraced
- Policy innovation: e.g. could policy enforce crop rotations or fallows?
- Data mining as a method to inform yield gap analysis
Thanks for your attention
Decline in livestock numbers
National policies with local consequences
Decline in productivity

Cotton yield and fertiliser use at Garoua, N Cameroon
Discontinuous fertiliser use

Period 1986-1996

Period 1997-2005

Observed

Model

\[ Y = a + b \cdot e^{-x/185} \]

Garoua Est

Garoua Ouest

Yields N Cameroon (kg ha\(^{-1}\))

Yields study region (kg ha\(^{-1}\))

\( r^2 = 0.8 \)

\( r^2 = 0.7 \)

\( r^2 = 0.6 \)
Average response to fertiliser by cotton in 1990

Seed-cotton yield (kg ha\(^{-1}\))

Fertiliser applied (kg ha\(^{-1}\))

$0 \quad 100 \quad 200 \quad 300 \quad 400 \quad 500$

$0 \quad 500 \quad 1000 \quad 1500 \quad 2000 \quad 2500$

$Y = a + b \times e^{-x/185}$

Observed

Model
Response to fertiliser by cotton per quintile

Seed-cotton yield (kg ha⁻¹)

Fertiliser applied (kg ha⁻¹)
Soil productivity without fertiliser

\[ \text{Yield} = 5870 \ \text{SOM} - 2880 \]

\[ r^2 = 0.98 \]
Management practices affect attainable yields

![Graph showing the relationship between soil organic matter and seed-cotton yield for different sowing times. The graph includes data points for early, modal, and late sowing, with the x-axis representing soil organic matter (%) and the y-axis representing seed-cotton yield (kg ha\(^{-1}\)). The graph illustrates that soil organic matter affects seed-cotton yield, with higher yields observed at lower soil organic matter content for early sowing compared to modal and late sowing.]
Response parameters, efficiency, yield gaps and soil organic matter

Seed-cotton yield (kg ha\(^{-1}\))

- Yield without fertiliser
- Attainable yield (full fertiliser)

Soil organic matter (%)

- Fertiliser use efficiency
- Yield gap
Discontinuous fertiliser use

Global fertiliser productivity at Garoua, N Cameroon

- Seed-cotton yield (kg ha⁻¹)
- Fertiliser applied (kg ha⁻¹)

Graph showing the relationship between fertiliser applied and seed-cotton yield with two periods:
- Period 1986-1996
- Period 1997-2005

Correlation coefficients:
- $r^2 = 0.7$ for Period 1986-1996
- $r^2 = 0.6$ for Period 1997-2005