

Mineral and Organic fertilization stories in Côte d'Ivoire

Re-internalization of deforestation-led externalized costs

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Building bridges between producers and consumers
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1. Historical Background: the externalization of deforestation costs and monoculture

- 1.1 Smallholders are the champions who keep the world price low
- 1.2 The main processes behind this response:
 - a) Massive migration (labour rent) and creation of new cocoa farms
 - b) The 'forest rent'
 - c) The food crop surplus during the agricultural frontier period
 - d) The social dimension and the building of a land rent

2. Background today: The re-internalization of deforestation costs and their likely re-integration into the world price of cocoa beans

3. First response/innovation: adoption of mineral fertilizers

- 3.1 Adoption of fertilizers and smallholders' rationality
- 3.2 Impact
 - a) 1990s: 15 years ago in Soubré
 - b) 2010s in Côte d'Ivoire
- 3.3 Interactions of pest-and-disease outbreaks: partial consequences of deforestation and monoculture
- 3.4 Innovation systems: back to smallholders' innovations

4. Second type of response/innovation: adoption of organic fertilizers

- 4.1 The new 'chicken manure' value chain
- 4.2 Adoption of chicken manure
- 4.3 Spectacular impact of chicken manure
- 4.4 Other types of organic manure: pod husk, rice husk, oil palm bunch residues, sheep manure, pig manure, etc.

Conclusion

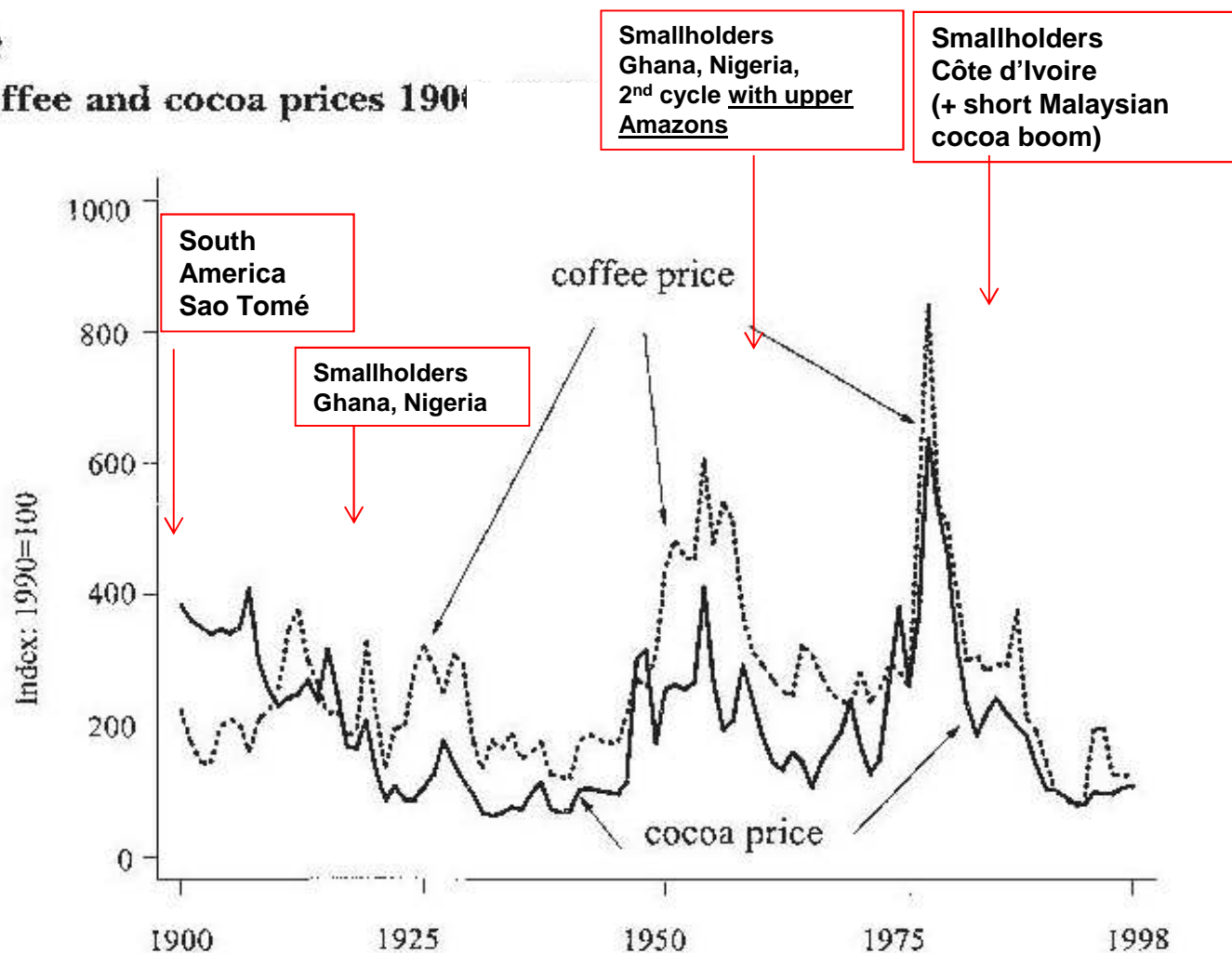
1. Historical Background: the externalization of deforestation costs and monoculture

1.1 Smallholders: champions who keep the world price low

Every peak of the world price of cocoa (and coffee) is neutralized. The main reason is the capacity of (often new) cocoa smallholders to respond to price hikes

Figure 2

Real coffee and cocoa prices 1900



Source: World Bank data.

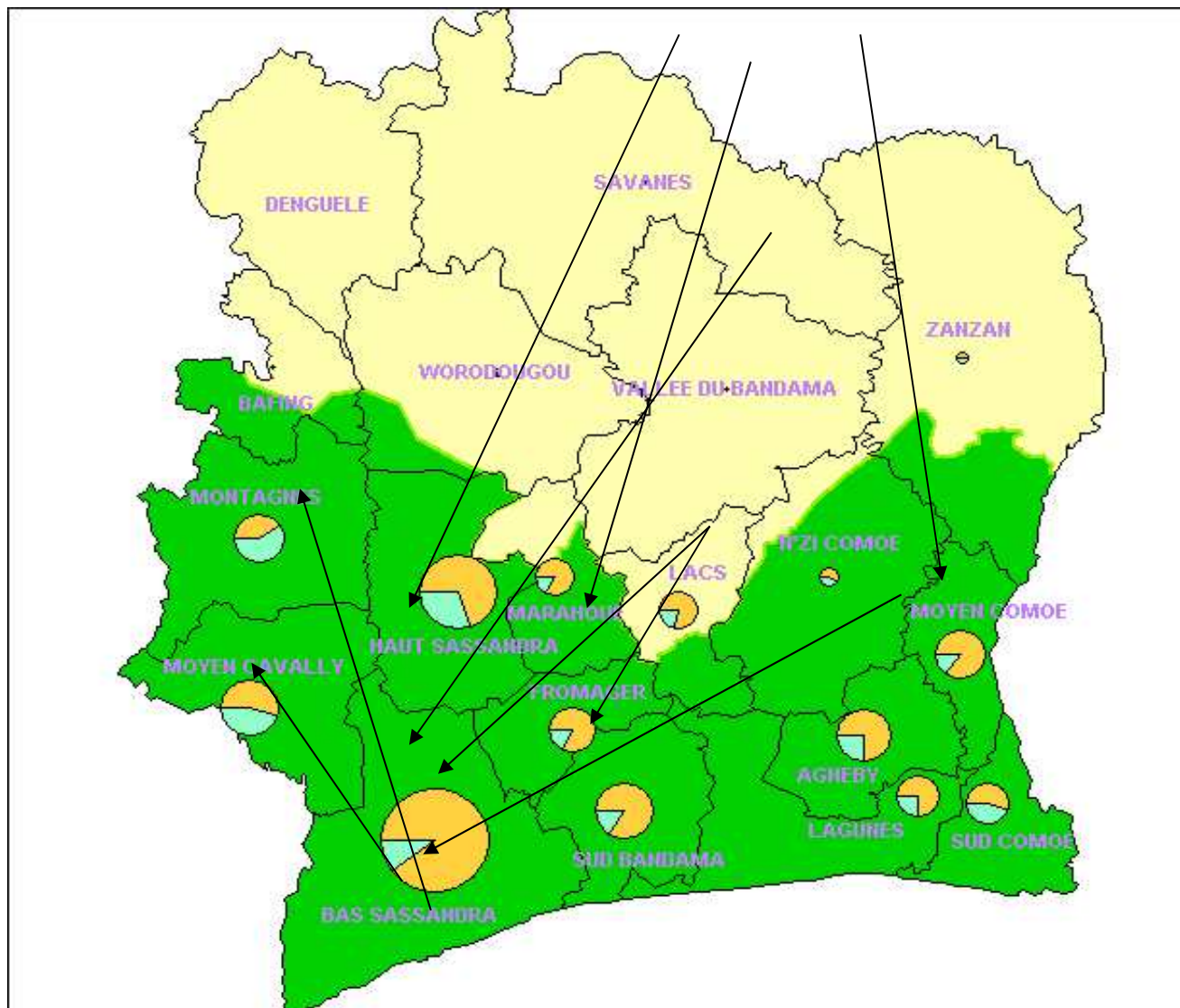
Price Chart by **Deaton 1999**.

Boxes and comments by author

1.2 The main process behind this structural low price of cocoa:

a) Massive migration and creation of new cocoa farms

by 'new migrants' and by 'former migrants', either smallholders or sharecroppers and farm labourers acquiring land and encroaching on forests.



**A powerful labour force consisting of young migrants
= a process which can be considered a 'labour rent'**



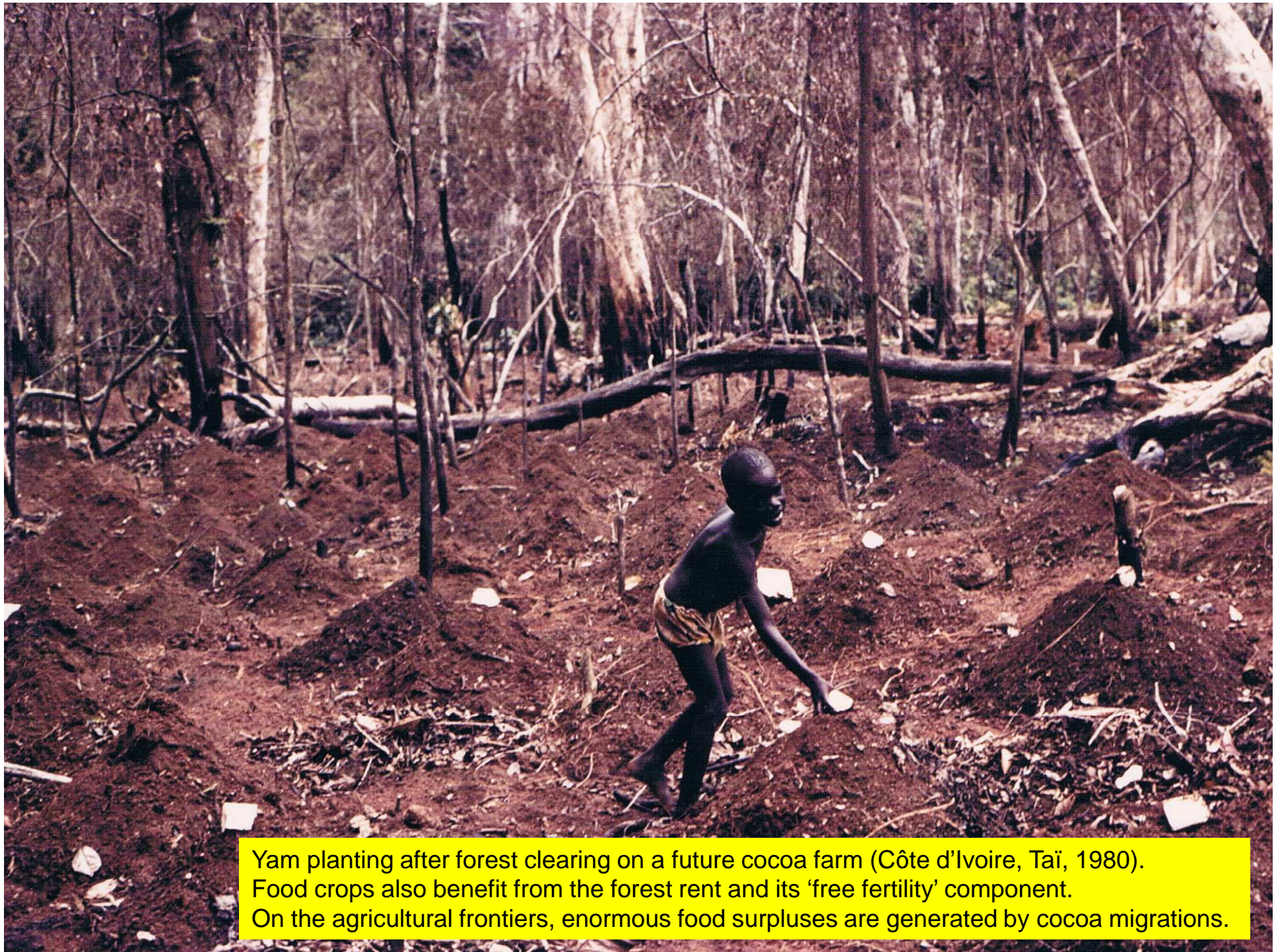


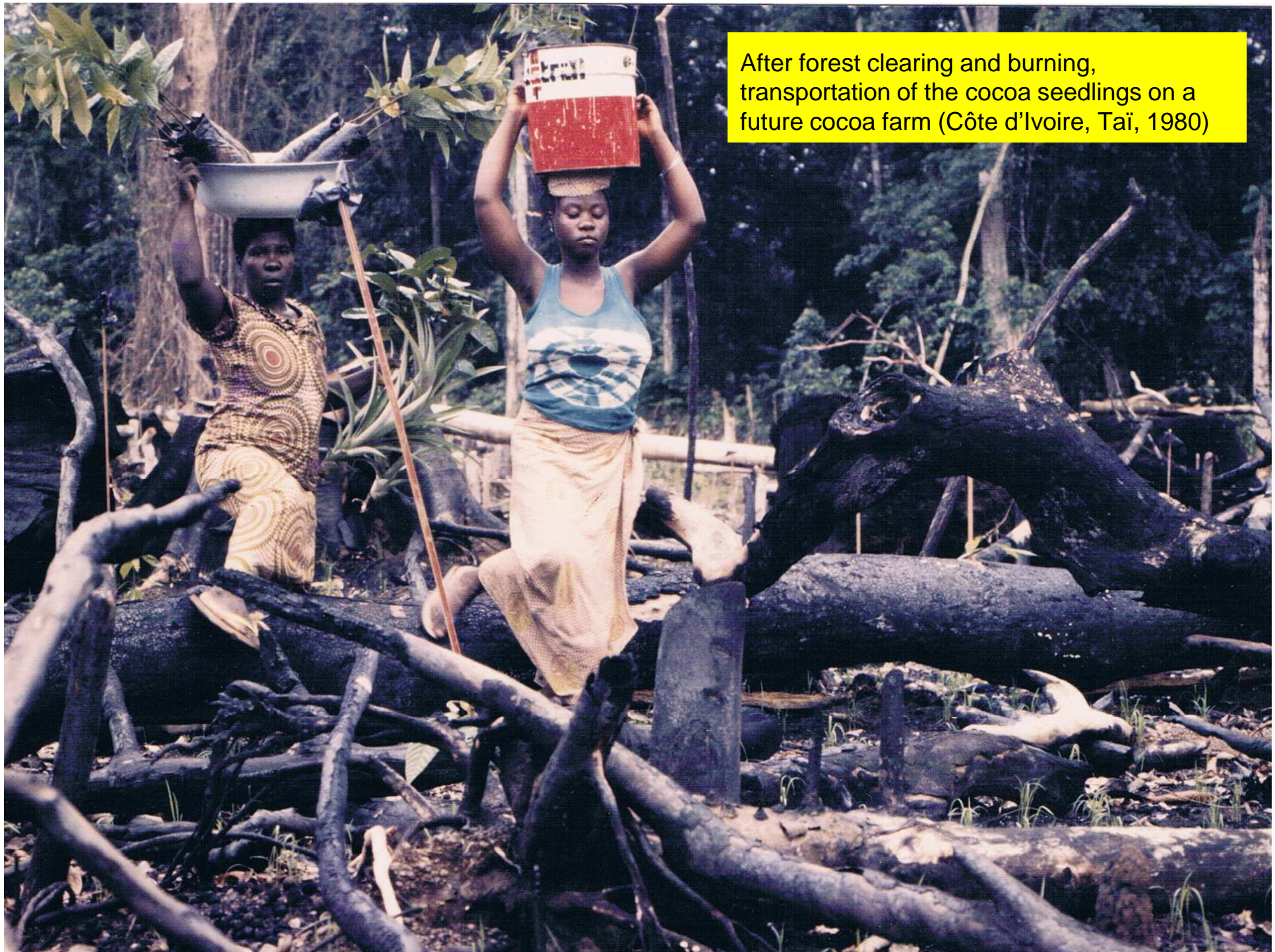
(c) and finally a ‘forest rent’/‘consumed’ by deforestation

The forest rent can be considered as an investment multiplier, enhancing the surge of a cocoa boom. The search for land and for forest rent by cocoa migrants are major deforestation agents in all cocoa producing countries



The giant trees of the forests: burnt for cocoa

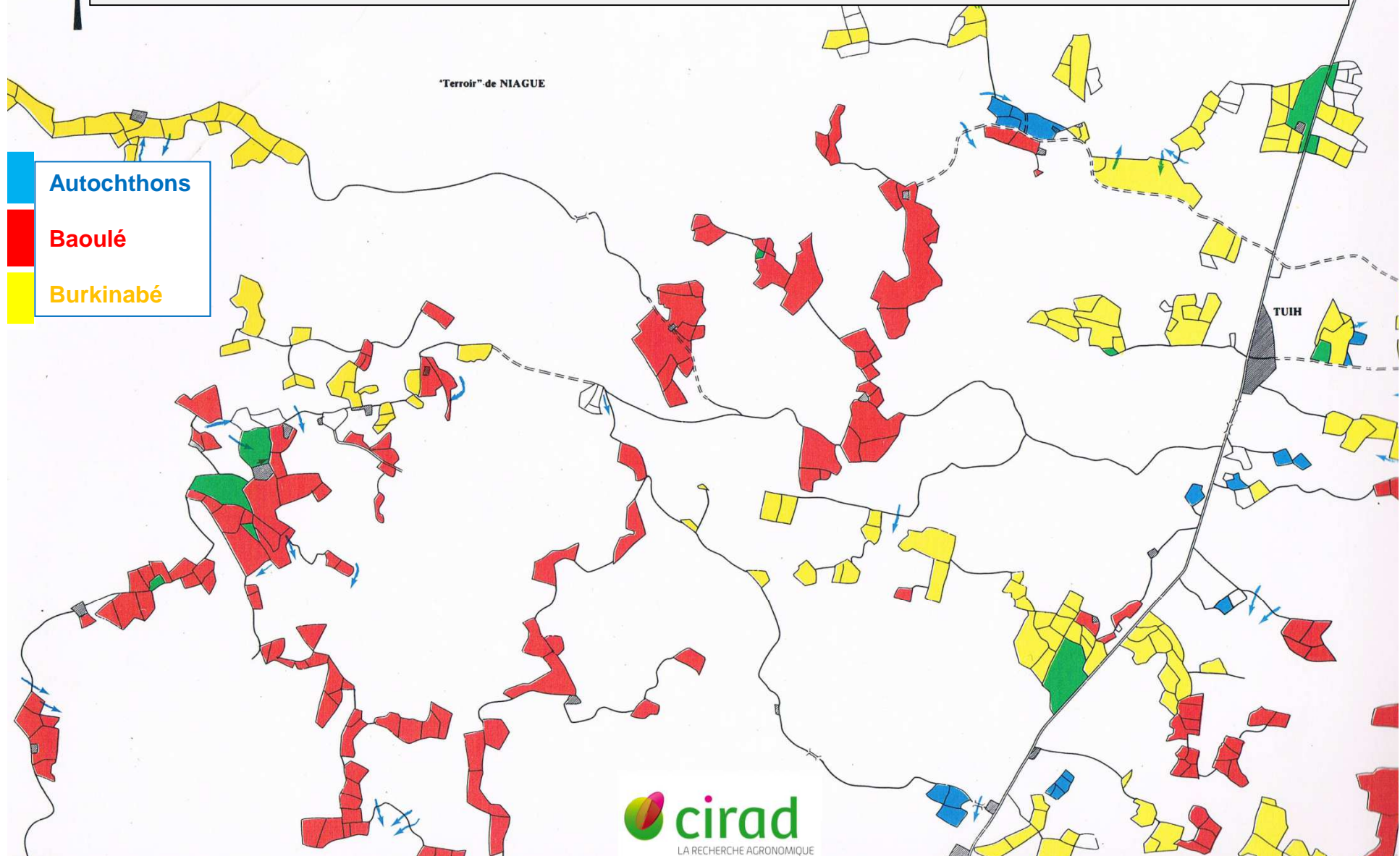




After forest clearing and burning,
transportation of the cocoa seedlings on a
future cocoa farm (Côte d'Ivoire, Taï, 1980)

The social dimension and land rent. Cocoa farms created around Touih by the early 1980s

The social dimension of this massive conversion of forests into cocoa farms is the construction of a new multi-ethnic society. However, in most cases, the social differentiation frequently reflects a rapid demographic and economic domination by migrants at the expense of autochthons.



2. Background today: a re-internalization of the deforestation costs, starting to be reflected by the increase in the world price of cocoa beans

After almost a century of cocoa cultivation and dependency upon abundant forests,

- . Land conflicts increase, prices of land start to increase
- . The 'forest rent' is gone.
- . Climate change takes its toll.
- . Yields of ageing cocoa and food crops may drop.
- . Maintenance costs increase.
- . Replanting costs remain high.
- . Revenues drop, investment in cocoa farms becomes risky.
- . Food shortage and insecurity

Actually, costs of cocoa farming which have been externalized for decades are being re-internalized. With the exception of periodic price hikes, **the world price of cocoa has always reflected this externalization: the world price of cocoa did not include the cost of rebuilding a forest environment.**



We still do not know if the current increase of the world price will continue and will reflect this re-internalization of deforestation costs, or if new forest encroachments will be triggered again, but we do know that migration and deforestation remain active in Africa, South America and Asia



At the same time, in many 'old cocoa countries and regions', **most smallholders know that they need to 'rebuild something'.**

But what?

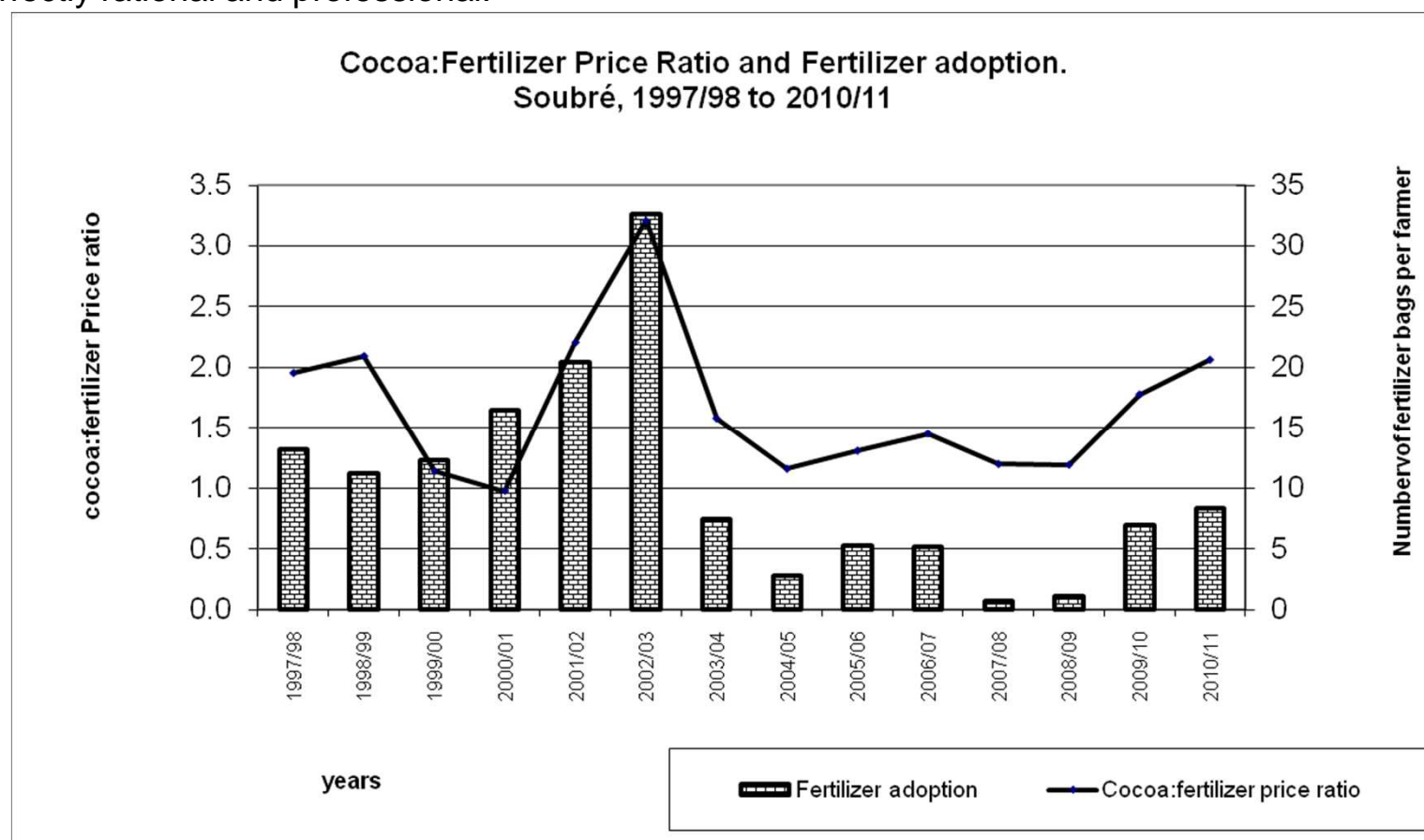
3. First response/innovation: adoption of mineral fertilizers to overcome part of the loss of the forest rent



But the shift from a free forest rent to a costly fertilizer implies an adequate increase in the cocoa price, which means a re-internalization of the deforestation/reforestation related costs in the world price, which in turn means that all countries have to stop encroaching on their forests to plant cocoa.

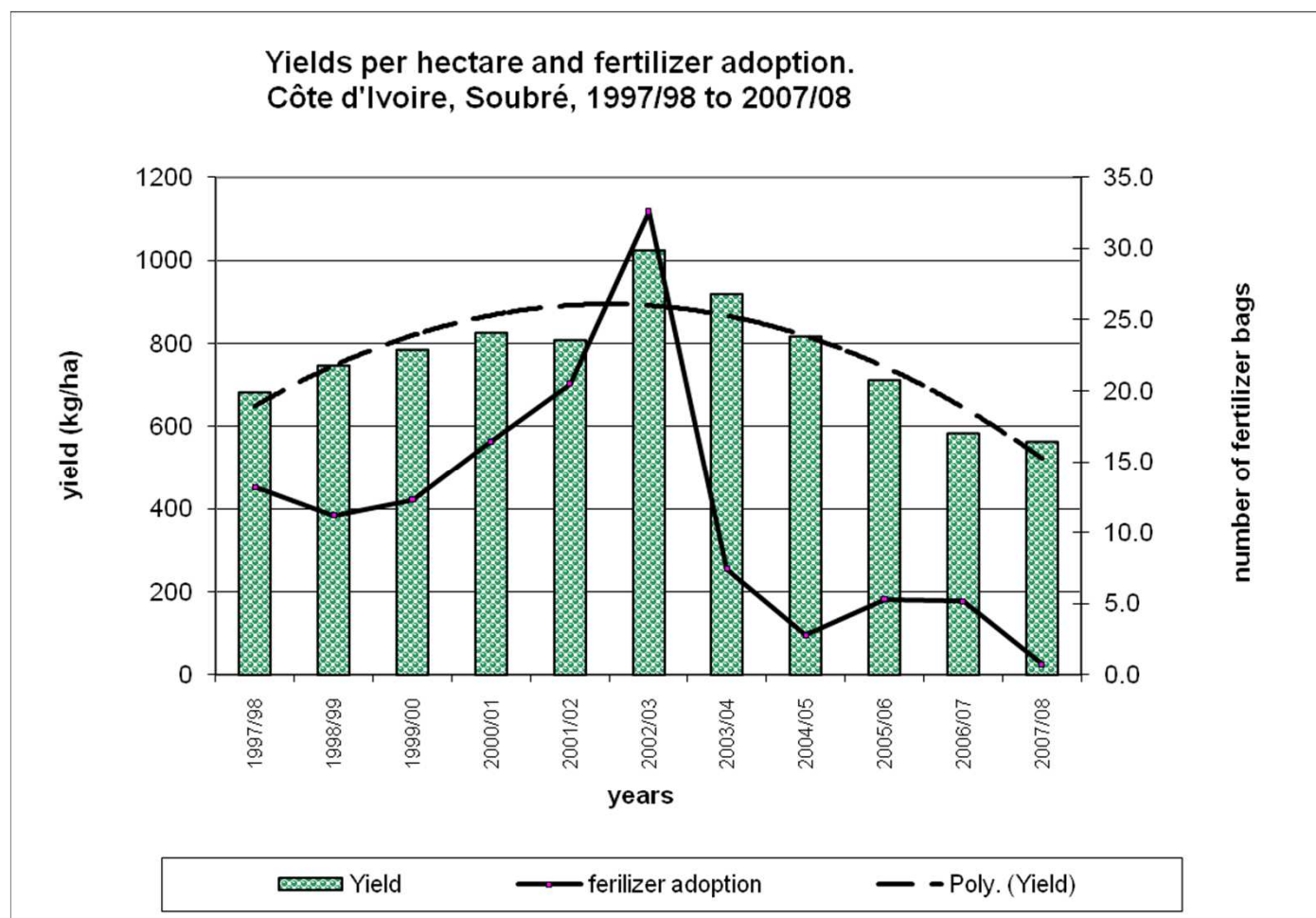
3.1 Adoption of fertilizers and farmers' rationality

In Côte d'Ivoire, the early adopters of fertilizers were in Soubré, in the Western region. Their main objective was not to maximize yields. As Soubré soils were ill-suited to cocoa cultivation, fertilizer offered a solution to reduce and delay the mortality of cocoa trees. In the late 1990s, the process of adoption was still relatively independent of the cocoa:fertilizer price ratio. Nevertheless the cocoa price hike in 2002 stimulated purchases of fertilizers. Then, the collapse of the cocoa price in 2004 followed by the doubling of the fertilizer prices in 2006 logically discouraged smallholders from using fertilizers. The collapse of fertilizer purchases after 2004 was perfectly rational and professional.



3.2 Impact a) 1990s/2000s: The case of Soubré 15 years ago

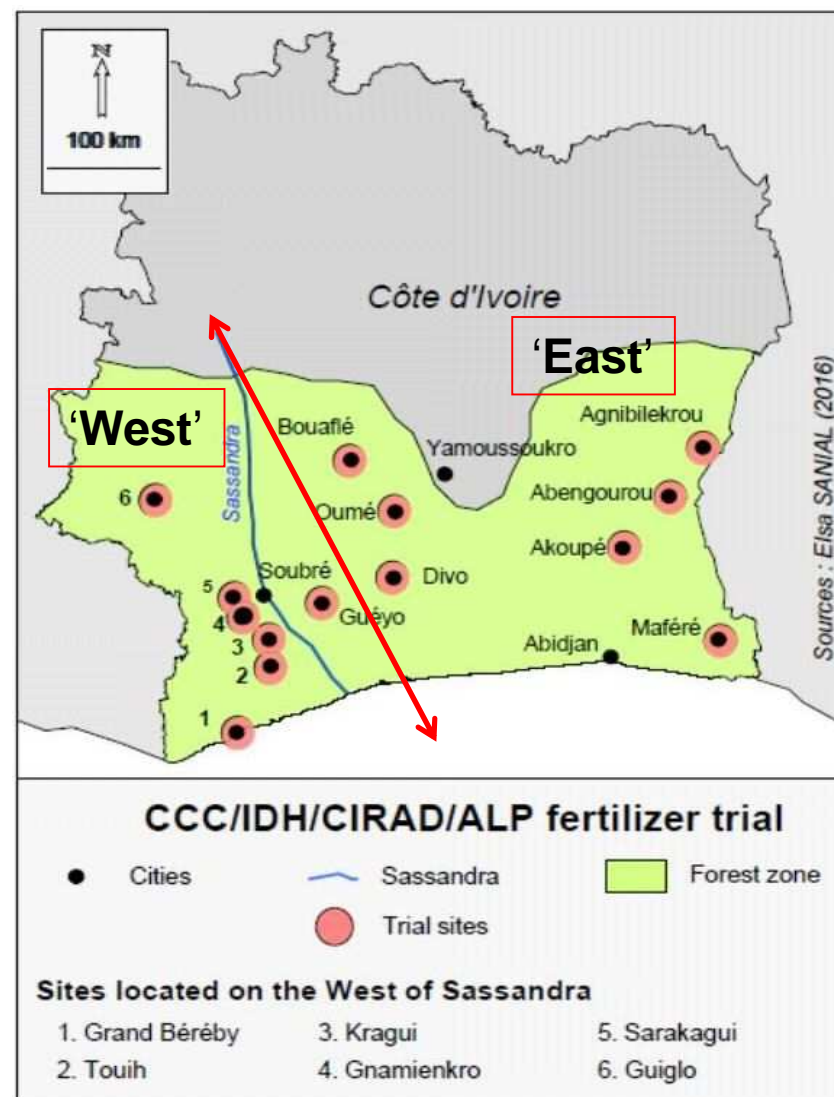
A beginning of intensification in the late 1990s/early 2000s: Soubré smallholders obtained average yields of around 800-1000 kg of dry cocoa beans per hectare. This intensification was 'broken' by the collapse of the cocoa price in 2004 followed by the doubling of the fertilizer price in 2008.



Source: [Ruf 2016](#). La fertilisation des cacaoyères en Côte d'Ivoire. 35 ans d'innovations villageoises
Agronomie, environnement et sociétés (under press)

3.2 Impact b) 2010s

A semi-participatory test
with 140 farmers



Source: Ruf F, Tanoh R, Galo Kla A. 2016. Semi-participatory tests with fertilizer without nitrogen in the cocoa farms of Côte d'Ivoire: an invite for 'N'? Abidjan, Montpellier and Utrecht, CIRAD/CCC/IDH/ALP. 20 p.

Preliminary results: Fertilizer remains too costly an input

Per quadrate of 20 trees	2012-2013 hypothesis				2015-2016 hypothesis			
Hypothesis	Hyp. 1	Hyp. 2	Hyp. 3	Hyp. 4	Hyp. 5	Hyp. 6	Hyp. 7	Hyp. 8
Gain in pods	90	130	180	240	90	135	180	240
Estimated gain in kg of dry cocoa	3.0	4.3	6.0	8.0	3.0	4.5	6.0	8.0
Price of cocoa per kg	750	750	750	750	1,000	1,000	1,000	1,000
Quantity of fertilizer per tree taken into consideration (kg)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Quantity of fertilizer per quadrate (kg)	14	14	14	14	14	14	14	14
Cost of one 50-kg bag of fertilizer	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
Additional cost per quadrate (excluding labour)	4,200	4,200	4,200	4,200	4,200	4,200	4,200	4,200
Profit/loss per quadrate over the 15-month period	-1,950	-950	300	1,800	-1,200	300	1,800	3,800
Projection per hectare (assuming 1000 trees per hectare)								
Estimated gain in kg/ha over the 15-month period	150	217	300	400	150	225	300	400
Profit/loss (CfaF / ha)	-97,500	-47,500	15,000	90,000	-60,000	15,000	90,000	190,000

Source: Ruf F, Tanoh R, Galo Kla A. 2016. Semi-participatory tests with fertilizer without nitrogen in the cocoa farms of Côte d'Ivoire: an invite for 'N'? Abidjan, Montpellier and Utrecht, CIRAD/CCC/IDH/ALP. 20 p.

Preliminary results: Fertilizers remain a costly input as long as the world price does not re-integrate deforestation related costs

With the current price of 1000 CFAF per kg in 2015-2016 and an unchanged minimal price of fertilizer at 15,000 CFAF per kg, the theoretical break-even point, **without taking labour and credit into account**, is **+225 kg per hectare**.

If farmers can obtain **+300 kg per hectare**, they theoretically start obtaining positive returns, about 90,000 CFAF per hectare, but with a high risk. The expected profit would be only at 30% of the investment. A minor climatic problem would turn such a small profit into a loss.

A gain of **+400 kg per hectare within 15-18 months**, would be a better guarantee of positive returns, with an expected profit equivalent to the investment cost.

Approximately **one third** of the farms could be in this situation

Impact of the use of a 0-15-15 rock phosphate fertilizer after 18 months

A low average response, a huge variance

DEMONSTRATED IMPACT ON YIELD VARIANCE

1. 40% of the variance is explained by 3 tree & farmer characteristics

- Fertilizer as a medicine
- Hidden fertilization
- Champion trees

2. 7% of the variance is explained by 3 household characteristics

- Autochthon/migrant status
- Gender
- Status of the main worker on the farm

3. 10% of the variance is explained by spraying efficiency

4. 13% of the variance is explained by the number of trunks on a tree

IMPACT ON YIELD VARIANCE NOT (YET) STATISTICALLY PROVEN

5. Age of the trees and shade requirements

6. Soil characteristics

Impact of the use of a 0-15-15 rock phosphate fertilizer after 18 months

Something is missing in this 0-15-15 formulation, here called “Fertilizer 1”. What?

**Not enough dosage (2 applications of 200 gr per tree and per year):
Do we need more of this 0-15-15 fertilizer?
Or do we need ‘something else’: an invite for “N”?**

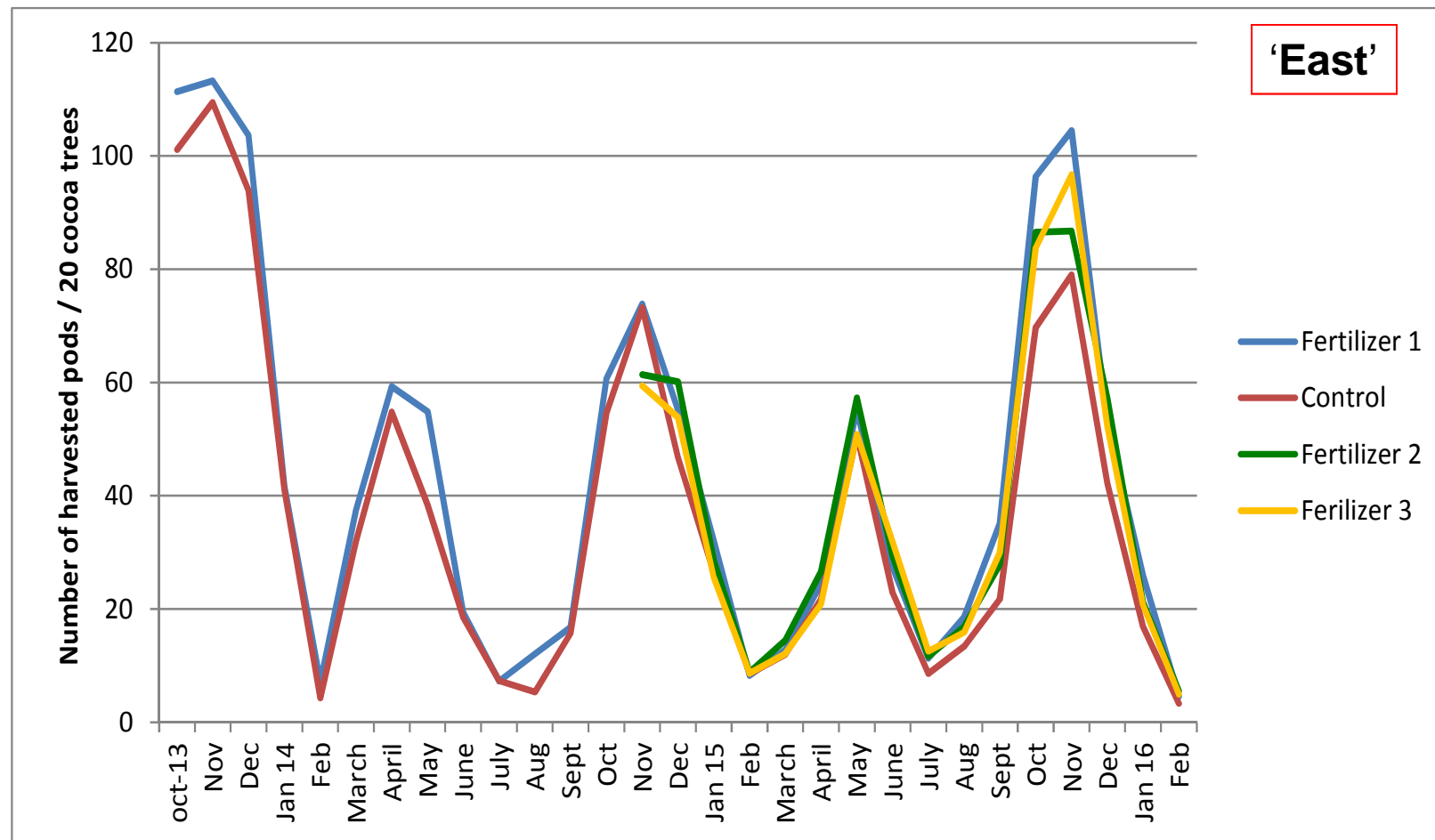
To answer these questions, two additional tests were started in late 2014

“Fertilizer 2”: experiment of a mix of 0-15-15 fertilizer with a calcium nitrate in the same bag (2 applications)

**“Fertilizer 3”: 0-15-15 fertilizer (2 applications per year
+ 1 separate application of calcium nitrate in July)**

Additional fertilizers and additional months in the 'East' (See slide 14):

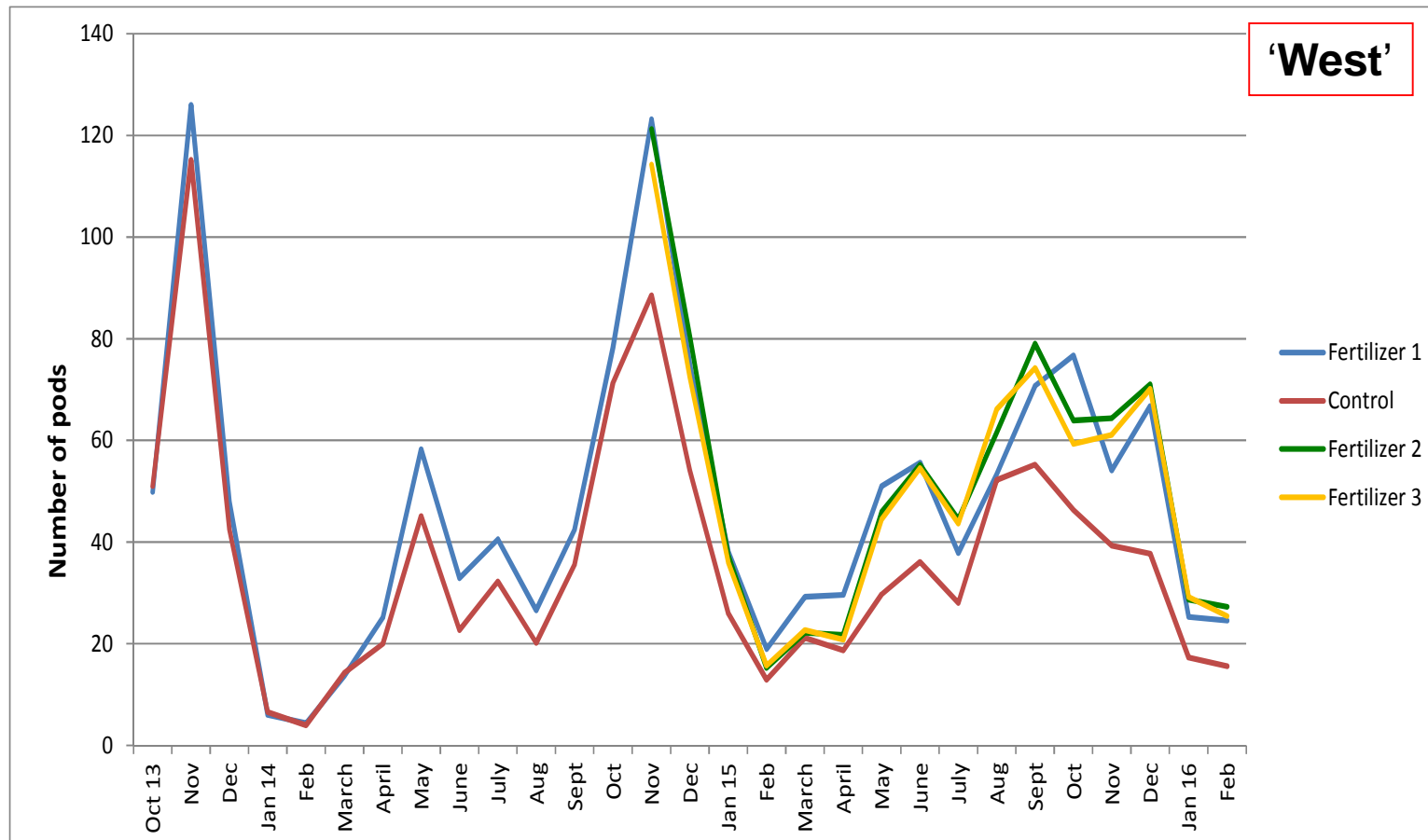
1. The 0-15-15 rock phosphate fertilizer starts having an impact on the number of harvested pods: but the tree responses in the East are slow
2. Fertilizers 2 and 3 including N do the same job within one year instead of two



Source: Ruf F, Tanoh R, Galo Kla A. 2016b. 'Fertilizer tests with nitrogen in cocoa farms of Côte d'Ivoire. A graphic approach in a context of drought. Abidjan, Montpellier and Utrecht, CIRAD/CCC/IDH/ALP. 36 p.

Tree responses in the West (see slide 14): more significant results to be analyzed:

- On the globally more acidic soils in the West, trees respond more quickly to the 0-15-15 fertilizer
- There is obviously some room for improvement in fertilizer efficiency
- A certain level/form of Nitrogen is part of this improvement process



Source: Ruf F, Tanoh R, Galo Kla A. 2016b. 'Fertilizer tests with nitrogen in cocoa farms of Côte d'Ivoire. A graphic approach in a context of drought. Abidjan, Montpellier and Utrecht, CIRAD/CCC/IDH/ALP. 36 p.

3.3 Interactions of pest-and-disease outbreaks, partial consequences of Deforestation and Monoculture

Pest-and-disease pressure and droughts keep interacting, reflecting part of the re-internalized costs of deforestation and monoculture.

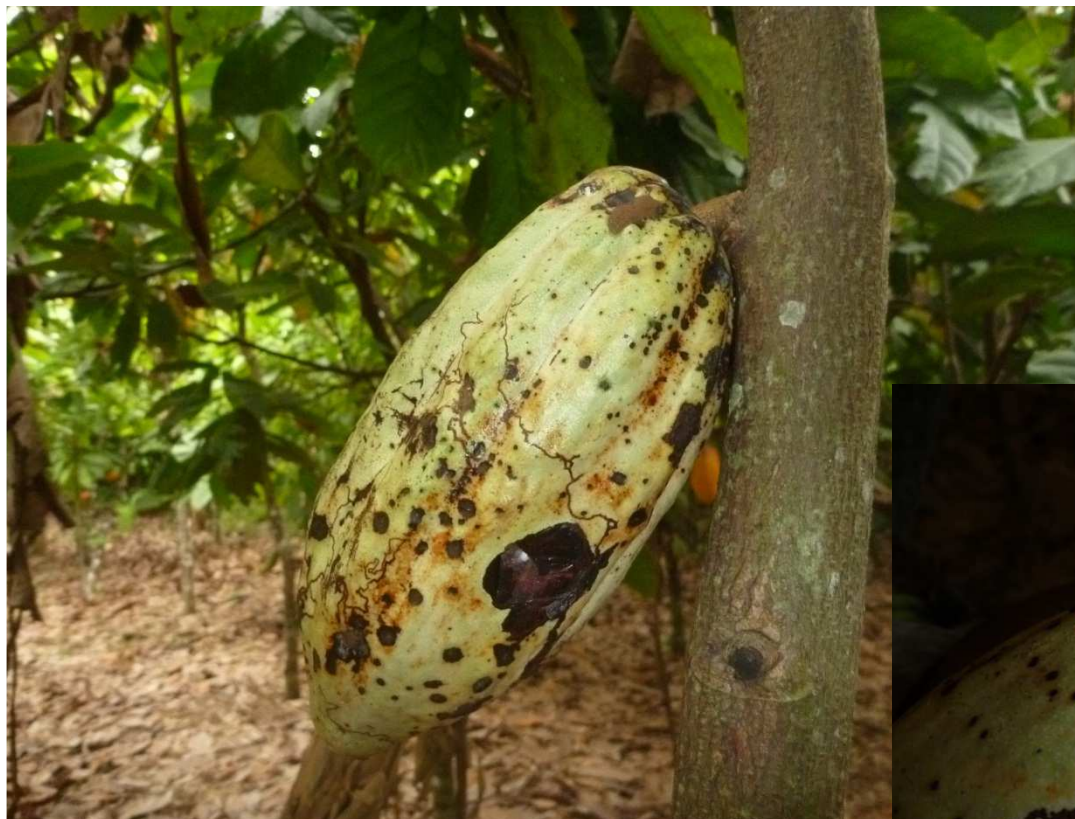
Here, the devastating effect of swollen shoot in some regions such as Bouaflé and Oumé.



Farmers keep on being confronted by a costly input and a risky investment with a trade-off between buying or not buying fertilizers which remains difficult to evaluate

Fertilizers versus pest-and-disease pressure:

Still the same issue of re-internalized costs pertaining to deforestation and monoculture



Increasing attacks of pods by bugs in several regions of Côte d'Ivoire (here in Grand Bereby)



3.4. Innovation systems: back to smallholders' innovations

Finally, soil fertility and fertilization issues are too complex to be left 'only' to mineral fertilizers and to fertilizer companies.

Smallholders develop their own innovations. In the case of organic manure, they appear as the key actors, if not the only actors, of the 'innovation systems'. This finding has two implications:

- **From an academic perspective**, this may in some way challenge the concept of the 'innovation system'⁽¹⁾ celebrating the role of multi-actor networks (traders, cooperatives, extension services, farmers, etc).

- . On the one hand this concept was a clear breakthrough compared to the '*conventional linear model of knowledge and technology transfers (from researcher to extension agent to farmer) to a more complex, process-based systems approach* (Spielman et al. 2009).

- . On the other hand, is it not a process to play down the major role of smallholders compared to other stakeholders?

- **On a practical side**, at least in this specific area, smallholders are finally far more innovative and advanced than most cocoa/chocolate companies in Côte d'Ivoire. Instead of teaching 'good agricultural practices', companies and extension services should accept to learn from farmers, at least from innovative smallholders.

⁽¹⁾ An innovation system is broadly defined as the set of agents involved in an innovation process, their actions and interactions, and the socioeconomic institutions that condition their practices and behaviors. The framework embeds technological change within a larger, more complex system of interactions among diverse actors, organizational cultures and practices, learning behaviours and cycles, and rules and norm [Spielman, D.J., Ekboir, J. and Davis, K. (2009) The art and science of innovation systems inquiry: applications to sub-Saharan African agriculture, *Technol. Soc.* no. 31, p. 399-405].

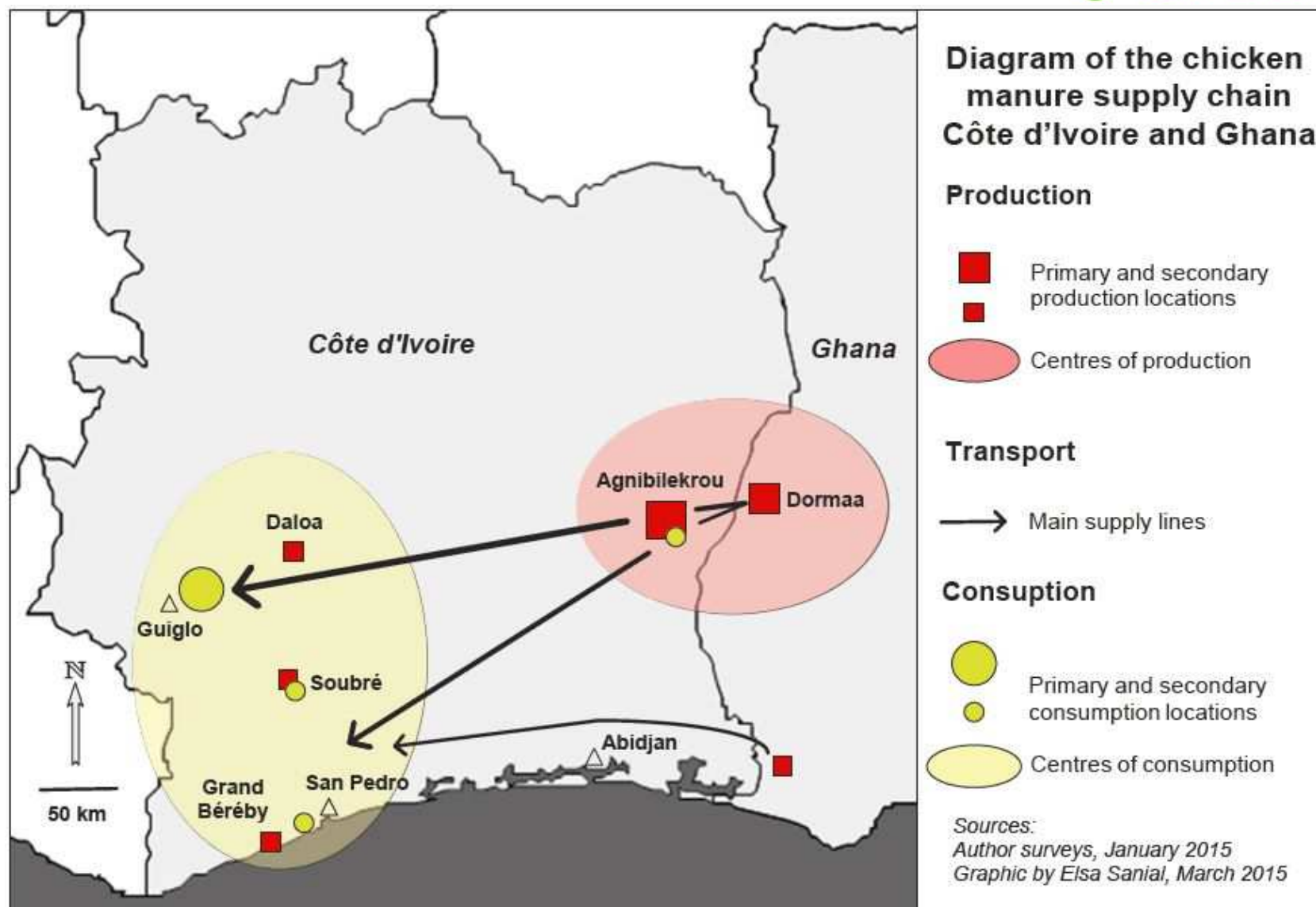
4.Smallholders' Innovations:

Organic fertilizers



4.1 The new chicken manure value chain



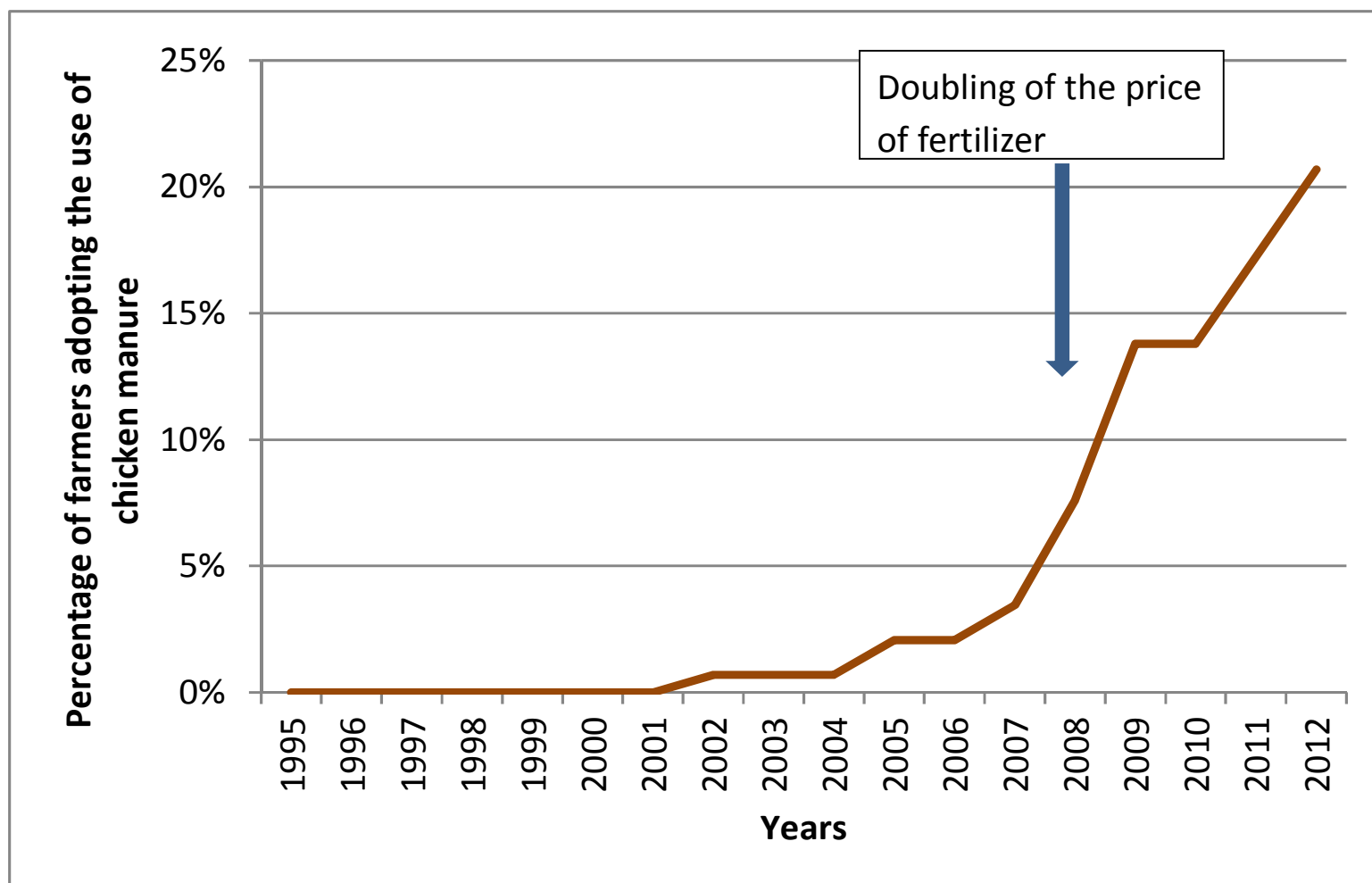


Sources : <https://www.researchgate.net/publication/285055054>

http://inter-reseaux.org/ressources-thematiques/article/innovation-paysanne-la-fiente-de?var_mode=calcul

4.2 Adoption of chicken manure

Adoption of chicken manure in 145 cocoa farms in Côte d'Ivoire. 1995-2012
(mainly in the West)

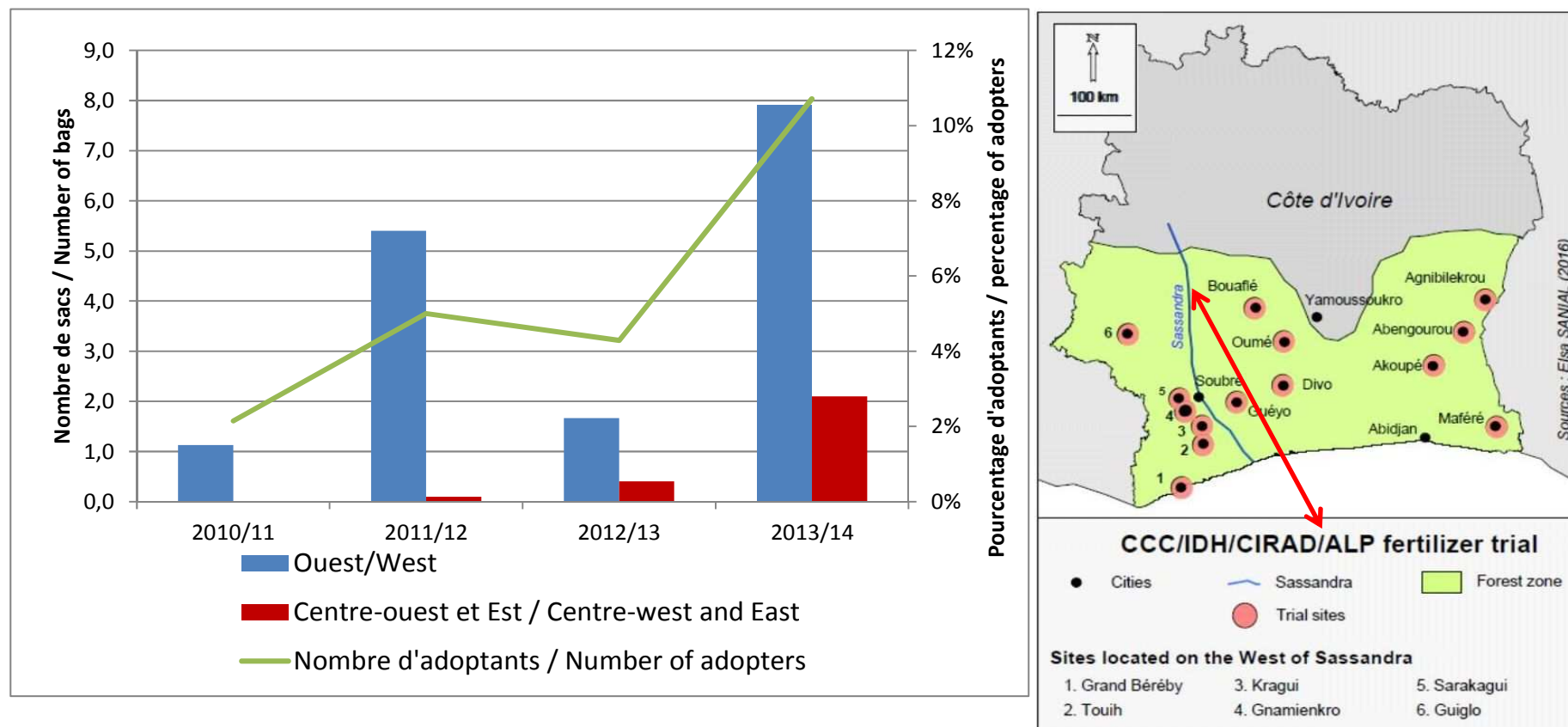


Sources : <https://www.researchgate.net/publication/285055054>

http://inter-reseaux.org/ressources-thematiques/article/innovation-paysanne-la-fiente-de?var_mode=calcul

Adoption of chicken manure in 140 cocoa farms in Côte d'Ivoire. 2010-2014

(70 farms in the West, 70 farms in the East). Irregular supply



Sources: <https://www.researchgate.net/publication/285055054>

http://inter-reseaux.org/ressources-thematiques/article/innovation-paysanne-la-fiente-de?var_mode=calcul

4.3 Impact of chicken manure: more than 1500 kg per ha

One case study (not representative but instructive)



	2012	2013	2014	2015
Number of bags of 'boro' manure applied in April every year	20	20	20	20
p1 Simplified hypothesis of price if Mr Gabin buys manure originating from Agnibilikrou from the market	6,000	6,000	6,000	6,000
p2 Hypothesis of price if he buys bags himself at the same price as offered to his neighbour	2,000	2,000	2,000	2,000
c1 Hypothesis of cost of manure per hectare, if Mr Gabin buys manure originating from Agnibilikrou from the market	120,000	120,000	120,000	120,000
c2 Hypothesis of cost of manure per hectare, estimated at the same price of bags as offered to his neighbours	40,000	40,000	40,000	40,000
Cocoa yield (kg/ha)	833	1,075	1,656	1,757
Gross income (FCFA/ha)	833,333	1,074,667	1,655,667	1,757,333
Gross profit compared to reference year 2012 (FCFA/ha)		241,333	822,333	924,000
If manure originating from Agnibilikrou purchased from the market				
Net profit (FCFA/ha)		121,333	702,333	804,000
Return on investment in the year		101%	585%	670%
If manure purchased at the opportunity cost (his own sale price)				
Net profit (FCFA/ha)		201,333	782,333	884,000

Sources: Ruf F, Kiendré J, 2016. L'innovation « fiente de poulet » dans les cacaoyères. 2. Révolution agro-écologique ? 1500 kg/ha en Côte d'Ivoire ? *Inter-Réseaux*. Online 21 March, 2016
http://www.inter-reseaux.org/IMG/pdf/01_innovation_fiente_no_2_rdfs_1500_kg.pdf
<https://www.researchgate.net/publication/299538543>

Impact of chicken manure

Another case study close to Divo,
also far above 1500 kg per hectare



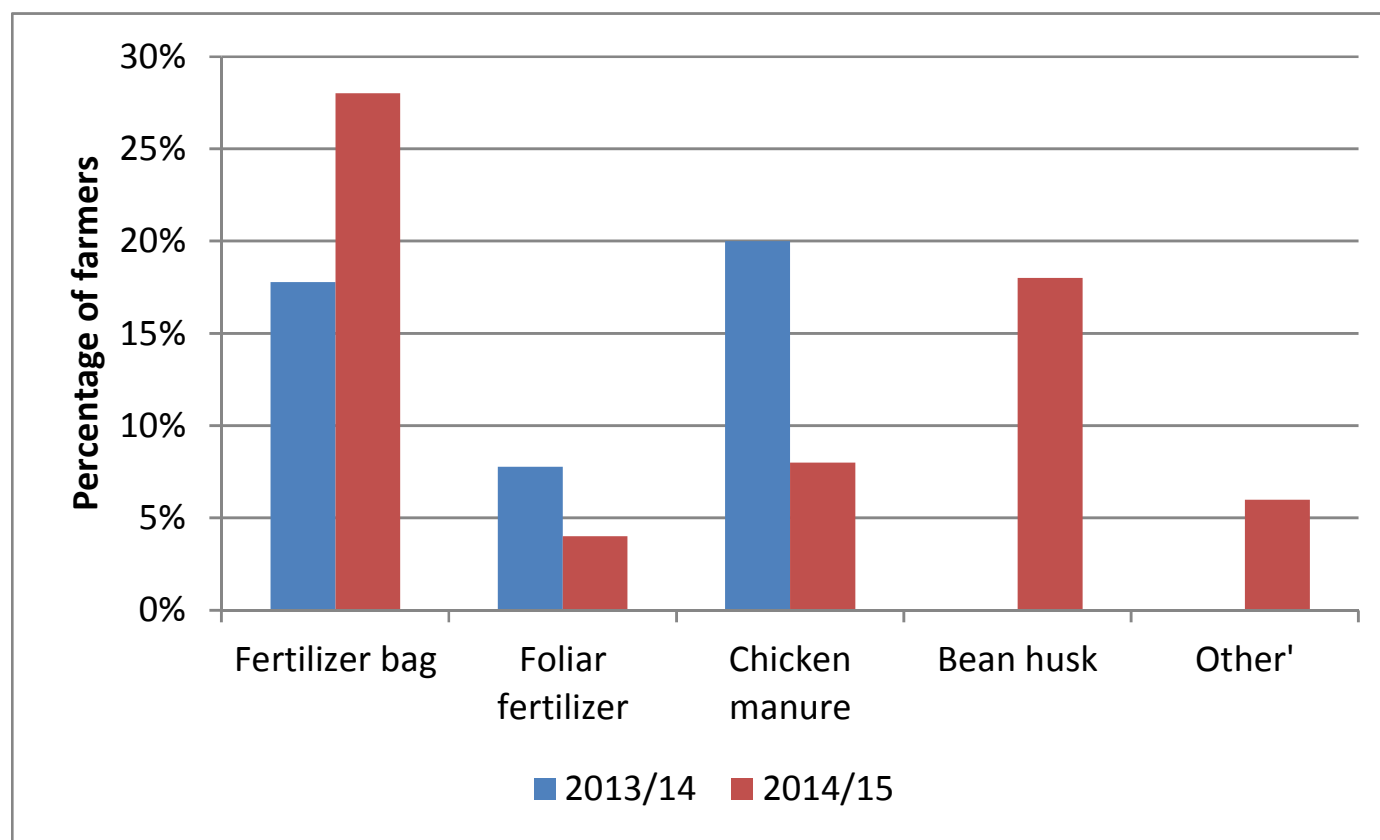
Just starting to apply chicken manure



Results after one year

4.4. Adoption of other forms of organic fertilization: crop residues such as pod husk, rice and coffee husk, residues of oil palm bunches, sheep manure; pig manure; domestic trash; etc. A radical change in recent years

**Diversification of fertilization agents in 80 cocoa farms around San Pedro.
2013/14 and 2014/15**



Source: Ruf 2016. La fertilisation des cacaoyères en Côte d'Ivoire. 35 ans d'innovations villageoises
Agronomie, environnement et sociétés (in press)

Other forms of fertilisation ... Dried pod husk



Ruf F, Tanoh R, Galo A, 2014. Cocoa and Fertilizers: an inescapable but complex duality. Report to IDH, May 2014. Montpellier and Utrecht, May 2014, CIRAD, 49 slides.

Other forms of fertilisation: here coffee husk



Ruf F, Tanoh R, Galo A, 2014. Cocoa and Fertilizers: an inescapable but complex duality. Report to IDH, May 2014. Montpellier and Utrecht, May 2014, CIRAD, 49 slides.

Conclusion

1. Obviously some limitations in the current stage of findings and presentation

- Impact: Statistical approach of mineral fertilizers versus single case studies of chicken manure. A similar statistical approach of the impact of chicken manure is needed.
- The choice of tested mineral fertilizers was too selective
- Tree crops require long-term research. Rapid conclusions are dangerous.

2. However, findings and hypotheses in terms of innovation, adoption, and impacts of these innovations, need to be taken into consideration

- Fertilizers are necessary but remain too expensive as long as the world price does not re-internalize the deforestation related costs.
- Fertilizers also seem insufficient and subject to improvement: fertilizer companies need to do their homework
- One strong hypothesis is that fertilizers are less effective today than 15 years ago. Many reasons need to be explored: Ageing farms, more exhausted soils, loss of organic matter, possibly lower quality of fertilizers?
- Organic manure, especially animal manure, remains to be studied but already seems to be essential and necessary. The factors that make them necessary need to be identified, however.
- The spontaneous birth of the 'chicken manure' value chain, and the extraordinary quest for other kinds of organic fertilisation, without a single dollar of external support, neither from the public institutions nor from the cocoa industry remind us that
 - farmers and farmers' networks are creative and innovative, and
 - farmers know what they need better than policymakers, companies, researchers.

A photograph of five young men standing in a row in a lush, green cocoa grove. They are all looking towards the camera. The man on the far left wears a light green long-sleeved shirt. The second man wears a blue and white plaid shirt with a 'SPORT' tag. The third man wears a light blue t-shirt with a graphic and a black bag slung over his shoulder. The fourth man wears a light beige short-sleeved button-down shirt. The man on the far right wears a white polo shirt with an orange collar and a logo on the chest. The background is filled with dense green foliage and trees.

Working with people: a new generation of cocoa farmers

The best (if not the only) way to move forward significantly is to consider smallholders

- Not only as human beings (as opposed to 'cocoa-producing machines')**
- But also as smart persons who do 'know a lot more', who are 'much more connected' to the world, and**
- Who 'innovate much more' than many 'experts' believe.**



**Also working with women,
their networks, their own
expertises**

(Thanks Mrs Touré)

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