Back to menu

1.4 SUSTAINABILITY OF CONVENTIONAL AGRICULTURE AND CONSERVATION AGRICULTURE IN SMALL-SCALE COTTON-BASED REGIONS IN WEST AND CENTRAL AFRICA: LESSONS FROM NORTHERN CAMEROON.

Oumarou Balarabé[1], Lucien Séguy[2] and Krishna Naudin[3]

[1] IRAD/SODECOTON, BP 302, Garoua, Cameroon, obalarabe@yahoo.fr
[2] CIRAD-PERSYST, Goiania, Brazil
[3] CIRAD-PERSYST, Antananarivo, Madagascar

Sustainability of agricultural practices is a suitable concept to evaluate both agronomic and economic performances of conventional agriculture and conservation agriculture. In this study, the concept of sustainability is analysed through its three main components: economic sustainability also called economic efficiency, dealing with the ability of the farming system to ensure sufficient and competitive output production to fulfil market and population needs; social sustainability or social equity, dealing with agricultural ability to ensure equitable revenue or return to different stakeholders of the agricultural production chain; ecological sustainability, dealing with intergenerational preservation of the environment referring here to the sum of natural resources used to ensure agricultural production such as soil fertility. Ecological sustainability is commonly the only aspect of sustainability taken into account by agronomists.

Sustainability of conventional agriculture is addressed in this study in small-scale cotton-based agriculture surveys in northern Cameroon. Economic efficiency of cotton in conventional agriculture is analysed through a multi-year data base of a permanent agricultural survey of SODECOTON (Cotton Development Company), while social equity is addressed based on different production cost distribution within cotton production stakeholders. Ecological sustainability is analysed through agronomic variables such as yield variation over time, and mainly soil fertility evolution.

Results of the study revealed that economic efficiency of cotton cultivation in conventional agriculture, after attaining acceptable levels in the early 1990's mainly due to high yields and prices and low inputs cost, is now declining. Fertiliser prices for example varied from 500 US $ per ton in 2005 to more than 1000 US $ per ton in 2008. Social equity even if strongly reinforced by an equalizing prices approach and inputs cost determination system, is limited with a high ecological differentiation between ecological areas varying from 600 mm rainfall in the far north to 1200 mm rainfall in the south of the cotton belt, hence affecting different respective yields. As for soil fertility, decreasing yields and increasing expenditures on fertilisers and other water harvesting and soil conservation technologies revealed progressive weak response of soil resource to cropping systems management. Conservation agriculture appears to be a suitable alternative to conventional production systems for small-scale cotton based agriculture to attain the three main objectives of a sustainable agriculture, since it can ensure economic efficiency of the farming system, a better social equity and a better soil resource management.

Key words: Sustainable agriculture, conventional agriculture, conservation agriculture, cotton, economic efficiency, social equity, ecological sustainability, cropping systems

1 Introduction

The aim of this paper is to discuss the ability of conventional production systems to fulfill sustainable development goals in small-scale cotton-based agriculture commonly represented in a wide part of Western and Central Africa. In these regions, not only agriculture, but the whole rural life and a great part of the economy have been influenced by the cotton sector. Therefore, economic results and production of other crops and available technology and productive resources depend on cotton features. Assessing the sustainability of the production systems implies focusing on cotton results. It also implies more than just addressing the economic efficiency of the commodity chain, but also taking into account the three components of sustainable development, and combining them with cotton commodity chain approach (Rastoin, 2006).

Commodity chain approach refers to a theoretical framework combining actions, interactions and technology used from the process of producing an agricultural good, to its final use by consumer, including input supplying, processing, and commercialization (Rastoin, 2008). Since the cotton sector in Sub-Saharan Africa is more or less integrated, this framework is suitable to assess its economic performance, mainly competitivity, quality and impact on institutions. However, the commodity chain approach appears to emphasize mainly the economic efficiency of the production systems and fails to address equity or ecological sustainability. Combining commodity chain approach with sustainable development concept provides a suitable theoretical framework to assess the sustainability of production systems.

According to the Bruntland report, sustainable development refers to development process which addresses actual needs without compromising future generations' ability to satisfy their own needs (Bruntland, 1987). This implies the need to consider social, economic and natural factors affecting development in the short and long term (Deybe, 1994). According to Goddart (2001), sustainable development must fulfill three objectives: environment preservation among generations, economic efficiency and social equity.

The application of sustainable development concept to agriculture implies the linkage of production systems sustainability with the satisfaction of food and services needs of people in respect to the above three objective components.

This paper's originality relies on its attempt to address not only conventional agriculture, but also interact with alternative cropping systems based on conservation agriculture. Conservation agriculture in this paper refers to FAO (Food and Agriculture Organization) definition of agricultural cropping systems based on:

- Minimum soil disturbance
- Permanent soil cover
- Appropriate crops rotations and associations.

Based on these three main component applied simultaneously, conservation agriculture not only refers to cropping systems but also to the whole production system, since in small-scale agriculture, successful combinations of this principle are determined by farm household external conditions.

To assess the sustainability of cotton-based production systems, this paper relies on a three part analysis, each focusing on a single component of sustainable development. In each part the analysis focuses first on conventional agriculture, before discussing the impact on introduction of conservation agriculture on the specific component.

2 Context description

Cameroon cotton belt is characterized by diversified and constrained agro-ecological conditions, a conflictual socio-cultural context and favorable agro-economic conditions.

The diversified agro-ecological context include mainly a single mode rainfall ranging from 600 to 1200 mm annual rainfall distributed within 3 to 4 months rainy season and different types of soils with both a high risk of erosion and erodibility.

In agriculture, cropping systems appear to be homogenous with little crop diversification and a high influence of cotton in crops selection and spatial arrangement on the field (Dounias, 1998, Roupsard, 2000). Final crops arrangement include cereals and cotton. In some part of the region and specific types of soils, legumes can appear (especially groundnuts and cowpea on sandy soils). Dry season sorghum is also cultvated on vertisoils to fulfill grain and forage needs of the household, in specific regions where vertisols are available.

Figure 1: Cotton region and rainfall in northern Cameroon

The impact of cotton on the cropping systems relies on input and credit supply by the cottonn company and mainly covered by seed cotton production. Cropping systems intensification has also been mainly supported by technical sheet improvement on cotton especially use of fertiliser, herbicides and insecticides, and wide dissemination of innovation by cotton company's extension team (Roupsard, 2000).

The socio-cultural context appears to be conflictual according to fertility and organic matter management (Balarabé, 2008). This is mainly due to :

- A high demographic pressure especially in the north of the region, leading to population migration to the southern part, since agriculture is mainly space consumer and fertility management relies on fallows and marginal fertiliser application.
- Extensive to pastoral livestock keeping with little fertility transfer and a strong crop/ livestock communities opposition on residue management. Crop residue management is organised through residue tranfer from agricultural plots to animals, when not simply burned (Dugué, 1998). Only legumes residues and small part of cereal's stems are sored for internal use of the farm household.
- Strongly embedded traditionnal institutions with poorly defined property rights on land and crop residues.

On the other hand the agro-economic conditions are favorable, leading to optimistic perspectives in term of innovation dissemination. This is mainly due to:

- Agriculture development based on cotton as main cash and intensification crop
- Integrated agricultural key functional facilities (input and credit supply, market and extension, farmers organization,

Within this described context of cotton belt of Cameroon, sustainable development will be analysed through its main components which are:

– economic sustainability also called economic efficiency, dealing with the ability of the farming system to ensure sufficient and competitive output production to fulfil market and population needs.

– social sustainability or social equity, dealing with agricultural ability to ensure equitable revenue or return to different stakeholders of the agricultural production chain ;

– Ecological sustainability, dealing with intergenerational preservation of the environment referring to the sum of natural resources used and preserve to ensure agricultural production

3 Small-scale agriculture and economic sustainability

Economic sustainability within the study area is more concerned with the small-scale size of a farm household, especially farm productive resources and will focus on cotton as principal crop due to lack of data on other crops. According to Madi (1994), the best indicators for assessing economic performances of cotton commodity chain must at the overall level concern total production area, number of cotton farmers, total cotton production; as individual indicators, average cotton yield, fertiliser cost, farmer's average gross and net revenue. Figures 2 to 4 provide the economic information from year 2000 to 2008.

In conclusion, according to these figures and other similar studies (Richard, 2007), economic efficiency of conventional agriculture in small-scale production systems after rising from 70's to the early 90's has been reducing considerably since then. Reasons frequently cited to explain are:

- Climatic factors like rainfall global diminishing trends
- Agronomic factors like poor innovation on agricultural fields (seed improvement, phytosanitary of cotton, fertiliser formulation)
- Socio-economic factors like demographic factors influencing the use rate of agricultural soils, fertiliser price and availability to the whole cropping systems, cotton purchasing price, and extension tools and framework adaptability.

Examining specifically the cotton purchasing price and fertiliser price, we can notice that from 2002, there is a continuous rise of fertiliser cost in kg/ha while average yield remains constant, thus reducing farmer's average gross and net revenue. This makes it easy to understand the overall reduction of total number of farmers, total production area and production, since marginal returns of cotton has reduced.

It appears clear that shifting to alternative cropping systems ensuring both high level of production and sustainable use of soil fertility is necessary to maintain and reinforce economic efficiency of the actual cropping systems(Pieri, 2001; Seguy et al., 2001; Rastoin, 2006; Seguy et al. 2006) . Conservation agriculture based on Direct seeding mulch based cropping systems (DMC) can ensure this (Seguy et al., 2001, Seguy et al 2006, and Erenstein, 2003). This may be done through:

- Considerable increase in production factors efficiency like land (yield) capital (costs reduction and nutrient efficiency, etc.) and labour.
- Enhancing agro-climatic conditions for diversifications, thereby providing a risk diminishing environment to agriculture and new market channels.
- Reducing agricultural and economic risk with crop diversification through:

– Crops association

– Marginal degraded field exploitation

– Climatic effects on crop yield (Figure 5)

Figure 2 : Total production, area cultivated and number of cotton farmers 2000-2008

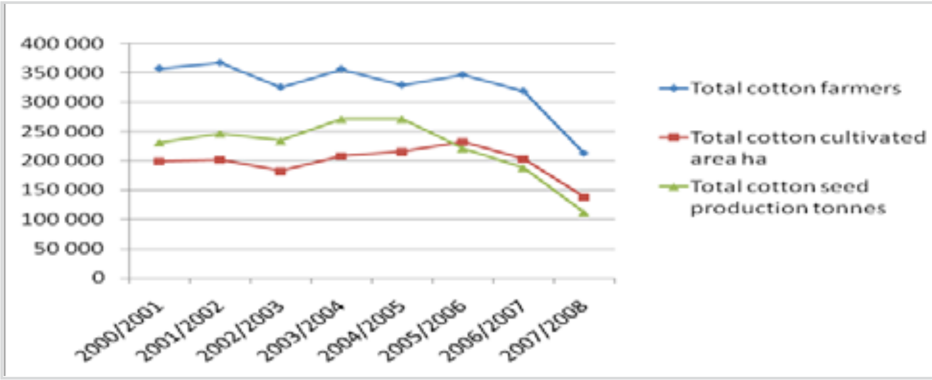


Figure 3 : Fertiliser cost, and farmer's gross and net revenue from cotton, 2000-2008

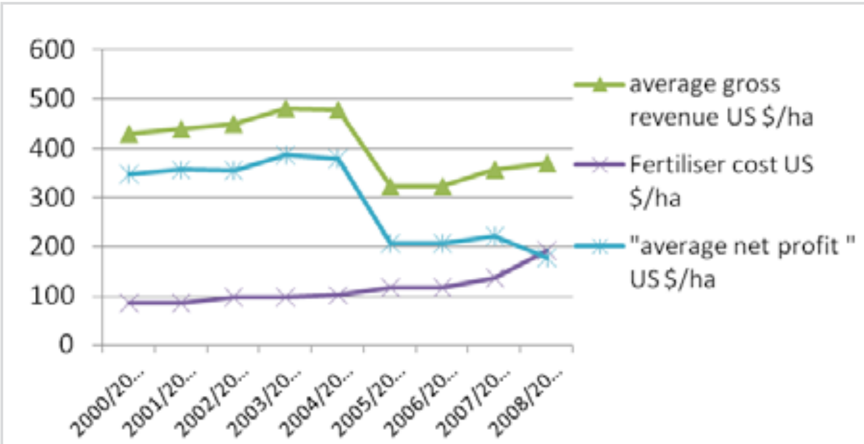


Figure 4 : Average Yield and fertiliser cost in kg/ha, 2000-2008

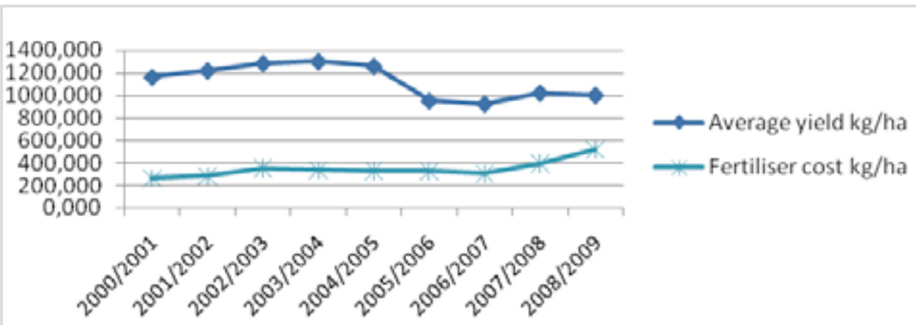
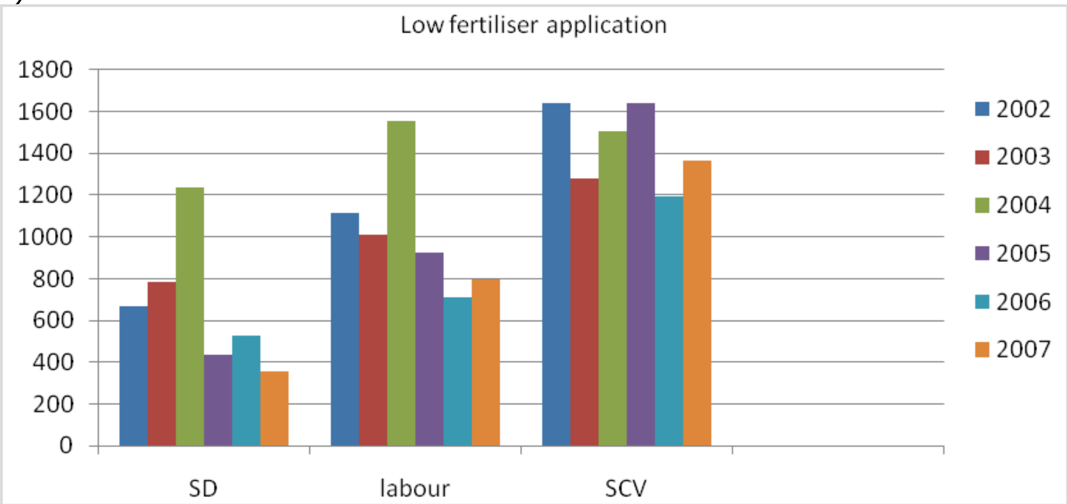


Figure 5 : Average Yield evolution in cotton station results, Zouana (750 mm rainfall average) 2002-2007

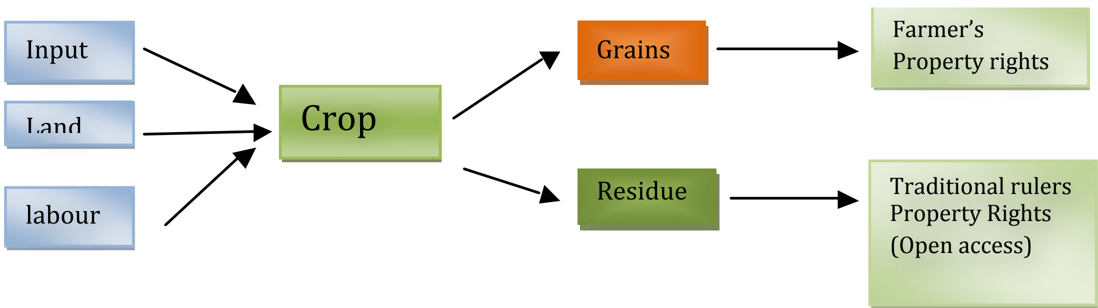


4 Cotton farming system and social sustainability

Social sustainability is addressed in this study within the cotton farming system in two different interactions level: value added sharing between cotton producing stakeholders chain, and farmers/livestock owners interactions.

In general view, social equity is ensured within farmers in term of equalizing prices in input supply and purchasing prices of cotton seeds all over the cotton belt, whatever the distance. Since there are two main stakeholders in the cotton production and commercialization, including the cotton company (input supply, transportation, seed cotton commercialization, and transformation) and individual farmers (production), value added sharing may not be completely done in equity and may need a strong involvement of farmers' organization, and government in the determination of prices.

Another field of inequity within the farming systems in northern Cameroon in general include organic matter management between farmers, livestock communities and traditional rulers. Crop residues management mainly involves traditional rulers in defining the property rights associated with them. Lack of equity here concerns the need for the farmers to invest in term of labour and input to produce both grains and residues, and the open-access provided to livestock owners on the crop residues by the traditional rulers (Balarabé, 2008). This will lead to an over exploitation of this resource as stated in the "Tragedy of the commons", and to a long term decrease ability of the farmer to ensure crop residue production.



To improve social sustainability in the farming systems efforts are to be done in reducing ecological differences impact on agricultural performances and improving better organic matter management among farmers and livestock communities. Farmers organization reinforcement is also needed to empower them in price negotiating and lobbying to encourage subsidies on cotton and input prices.
In this context, conservation agriculture provides a technical response in the sense that it diminishes differences in yield among different fertility level plots and fertility application level (figure) (Naudin et balarabe, 2003, 2004 and 2005; Balarabe and Naudin, 2006; Seguy et al, 2001). This is done through:

- progressive increasing yield overtime with minimum fertiliser use
- Decreasing yield differences among high and low fertiliser plots

Introduction of conservation agriculture within a farming system is not just a matter of farm household decision since it implies great changes in crop residue management. It therefore reinforces the property rights of the farmers on crop residues, by attributing a potential economic value to the residues (equal to the marginal value of yield in mulch covered plots) and enhancing farmers' investment in protecting and conserving produced revenue. Crop residues then will not only be perceived as residual resources but rather productive resources.

5 Sub-Saharan Africa and ecological sustainability

One of the most suitable definition of sustainability in agriculture according to ecological sustainability (land degradation) is provided by Perman et al. (1996): maintaining a consumption or production stream without degrading the natural capital stock. A sustainable agricultural can be defined by Lal (1991) as an agriculture system that can provide profitability on a continuous basis while preserving the natural resource base.

The issue of ecological sustainability of tropical agriculture deals mainly with the adopted technology in agriculture and its impact on soil degradation, as the main natural capital. Because of their extreme ability to erosion due to climatic constraints (accelerated mineralization, poor soil coverage, short rainfall length), tropical soil are more exposed to erosion. In addition to this some human factors accelerate soil erosion, mainly intensity of soil utilization and farming techniques.

Typically in northern Cameroon various technical choices arising from mid 70's including intensive use of mineral fertilizer, and soil disturbance, little use of organic manure, and other organic matter providing in the cropping systems (streaming of trees and burning the rest of crop residues) provide a critical mixture of practices for soil utilization that are not sustainable. Main features of ecological constraints on agriculture include:

- Soil capital depletion leading to actual marginal soil exploitation (vertisoils, degraded soils locally called "hardés")
- Biodiversity reduction on soils and agricultural ecosystems, mainly macrofauna pattern influencing soil structure (Bréveault et al., 2007)
- Watershed and Runoff control in certain areas leading to the less available total cultivated area.

The central issue concerns soil capital rehabilitation. Regardless of the rehabilitation speed, DMC techniques (synonymous with conservation agriculture) appear a good alternative to rehabilitate soil productivity (Guibert et al., 2007; Fesneau et al. 2007), and perhaps to ensure carbon sequestration by agricultural systems (Lal, 1991; Metay, 2003; Seguy et al. 2001).

With regard to ecological constraints conservation agriculture appears to be one of the best existing technology to provide simultaneous effects on both carbon mitigation, ecosystem biodiversity and soil productivity improvement with affordable labour investment (Lal, 1991, Seguy et al., 2001). Scientific and political incentives must be arranged to ensure implementation of CA and providing some more evidence on payment for environmental services.

Conclusion

Our aim in this study was to assess conventional production systems to fulfill sustainable development goals in small-scale cotton-based agriculture commonly in northern Cameroon. We assess this based on three-component definition of Sustainable definition and related them to commodity chain approach ("Approche filière" in French).

Economic efficiency is related to the ability of the farming system to ensure sufficient and competitive output production to fulfil market and population needs. The study showed out that economic efficiency of farming systems after increasing from 70's to the early 90's has now considerably reduced since due to climatic and agronomic factors as well as mainly socio-economic factors. This latter concerns the international marketing context of agricultural inputs and products. While inputs prices are rising, agricultural products prices are falling. There is little or no financial incentive against climatic and global economic factors. Instead, alternatives may be identified within agronomic innovations that are likely to temper economic constraints, and DMC (or conservation agriculture) stands among them.

Social equity in sustainable agriculture deals with agricultural ability to ensure equitable revenue or return to different stakeholders of the agricultural production chain. Conservation agriculture provides technical response enhancing social equity in the sense that it diminishes differences in income among farm households through progressive increase in yield overtime with minimum fertiliser use (economic inequity between high input household and others) and decreasing yield differences among high and low fertiliser plots (ecological inequity between high fertility and rainfall regions and others). By implying new property rights on crop residues, CA also provide an equitable context to tackle soil fertility and organic matter management within the farming system.

Weak ecological sustainability of farming systems in northern Cameroon arises from various technical choices including intensive use of mineral fertilizer, and soil disturbance, little use of organic manure, and other organic matter providing in the cropping systems. DMC appears to be one of the most promising agronomic alternatives to provide simultaneous effects on both carbon mitigation, ecosystem biodiversity and soil productivity improvement with affordable labour investment.

Shifting from conventional production systems to conservation agriculture is necessary and must be accompanied by support from both scientific and institutional community, especially within the small-scale agriculturak sector in developing countries with no other alternatives and severe institutional constraints.

References:

Balarabé, O., & Naudin, K. (2006). Rapport d'activités du volet Recherche-développement. Projet ESA-Sodecoton.

Balarabé, O. 2008: Evaluation économique d'une innovation agro-écologique: l'exemple du semis sous couvert végétal auu Nord-Cameroun.

Brevault, T., Bikay, S., Maldes, J. M., & Naudin, K. (2007). Impact of a no-till with mulch soil management strategy on soil macrofauna communities in a cotton cropping system. Soil and Tillage Research.

Deybe, D. (1994). Vers une agriculture durable, Un modèle bioéconomique. Paris: CIRAD.

Dounias, I. (1998). Modèles d'action et organisation du travail pour la culture cotonnière: cas des exploitations agricoles du bassin du bassin de la Bénoué au Nord-Cameroun. Paris: INA-PG.

Dugué, P. (1998). Flux de biomasse et gestion de la fertilité à l'échelle des terroirs. Etude de cas au Nord-Cameroun et essai de généralisation aux zones de savane d'Afrique subsaharienne. Acte de l'atelier Fertilité et relations agriculture-élevage en zone de savane (pp. 27-59). Montpellier: CIRAD.

Guibert, H., Crétenet, M., Fadoegnon, B., Fayalo, G., Foné, M., Dureau, D., et al. (2007). Amendement organique, productivité des cultures et dynamique du carbone du sol en Afrique Sub-saharienne. Agroécologie et techiques inovantes dans les systèmes de production cotonnier. Maroua: à paraître.

Fesneau, C., Guibert, H., & Mbiandoun, M. (2007). Evolution de la fertilité des sols dans les systèmes de production à base de coton au Nord-Cameroun. Agroécologie et techniques inovantes dans les systèmes de production cotonniers. Maroua: à paraître.

Erenstein, O. C. A, 1999. The economics of soil conservation in Developping countries : The case of crop residue mulching.

Goddart, O. 1992. La science économique face à l'environnement. In : Les passeurs de frontière, Jolivet M, Paris CNRS.

Lal, R. 1991. Tillage and agricultural sustainability. In Soill and tillage research.

Madi, A. 1994. Politique agricole et élasticité de l'offre dansles exploitations cotonnières au cameroun. Thèse de Doctorat ENSAM Montpellier.

Naudin, K., & Balarabé, O. (2003-2004-2005). Rapport d'activités du Volet Recherche développement. Projet ESA-Sodecoton.

Pieri, C. (1989). Fertilité des terres de savanes, Bilan de trente ans de recherches et de développement agricoles au Sud du Sahara. Paris: Ministère de la Coopération et CIRAD-IRAT.

Perman, R., Yue, M., McGilvrey, J., & Common, M. (2003). Natural resource and environmental economics, 3rd edition. Pearson education limited.

Rastoin J.L., 2006. Le système alimentaire mondial est il soluble dans le développement durable ? Working paper N°5 MOISA.

Roupsard, M. (2000). La production cotonnière. In C. Seignobos, & O. Iyébi-Mandjeck, Atlas de l'Extrême-Nord Cameroun. éditions IRD.

Séguy, L., Bouzinac, S., & Maronezzi, A. C. (2001). Un dossier du semis direct: Systèmes de culture et dynamique de la matière organique. . Montpellier: CIRAD.

Séguy, L., Bouzinac, S., & Husson, O. (2006). Direct-seeded tropical soil systems with permanent soil cover : Learning from Brazilian experience. Dans N. Uphoff, A. S. Ball, C. M. Erik, H. R. Hans, O. Husson, L. V. Mark, et al., Biological approaches to sustainable soil systems. (pp. 323-342). CRC Press.