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Sustainable Intensification of Agriculture in Benin: Myth or Reality? Lessons from Organic and Cotton Made in Africa Production Systems

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Abstract – **In agriculture, the concept of sustainable development emergence and its omnipresence in political discourses suggests that farming systems move toward systems considered as more environment-friendly and human health-friendly. In Benin, cotton is one of the most sectors concerned by this transformation. Indeed, in spite of the importance of cotton in the economy of Benin, its sustainable production is nowadays threatened by conventional production approach. Various alternatives of production are developed and considered as more environment-friendly than the conventional production approach. This article analyses the sustainability of organic and cotton made in Africa (CmiA) production systems from the sustainable agricultural intensification theoretical perspective. Structured and non-structured interviews with individuals and focus groups were used to collect data from 90 organic cotton farmers of the municipality of Kandi, and 100 CmiA farmers of the municipality of Pehunco, one of the largest areas of cotton production in the North of Benin. Data were analyzed with methods of normative and relativist comparison, descriptive statistics and analysis of variance. Kolmogorov-Smirnov (K-S) test was used to verify the normality conditions and in some cases, logarithmic transformation was done to test the variance homogeneity. The comparison of means was done with the test of Least Significant Difference. It appears from the results that in the current condition of implementation, the alternatives system to conventional cotton production approach are not intensively sustainable. Soils fertility and pests' management face enormous constraints and do not allow improvement of yields, economic performances, and environment protection. So, the sustainability of the alternative systems of cotton production is not guaranteed and can hardly become a reality if additional relevant conditions are not created.**

Keywords – **Benin, Cotton, Farming Systems, Intensification, Sustainable.**

I. Introduction

In agriculture, the emergence and omnipresence of the concept of sustainable development in political discourses suggests that agricultural systems move toward systems considered as more environment-friendly and human health-friendly [1]. Benin Republic does not stay at the margin of these changes. Given its importance, cotton sector is one of the main sectors concerned by these changes. In spite of its contribution to the economic development of Benin, cotton sector is nowadays seen as hindering for the sustainable agriculture [2]. So, after more than 50 years of a productive agriculture based only on economic growth, the perverse effects of this model are now visible and persistent. The craze evoked to farmers by cotton production due to facilities offered by the State induces high agricultural colonization and over-exploitation of soils [3]-[4]. According to [5]-[6], the drop of soil fertility constitutes the main environmental impact resulting of agricultural development in cotton areas. The uncontrolled and improper use of Synthetic Chemical Pesticides (SCP) was proved prejudicial for human wealth and environment [7]. Thus, cotton production would be responsible of bodily burns, food intoxications, soil, water and air pollution, destruction of useful soil microorganisms, degradation of tree cover and biodiversity decline [8]-[9]. Although the accidents related to the use of SCP are poorly documented, 280 cases of human poisoning with 47 deaths were recorded in Benin Republic during 1999-2000 cotton's season [10]. In addition, [11] reported 105 cases of poisoning including 9 deaths between May 2007 and July 2008. Poisonings occur especially during phytosanitary treatments or after the consumption of food contaminated by SCP. The impact of these active materials on fishery resources was also highlighted by some authors who reported the presence of residues of SCP in aquatic species and sediments of rivers in areas of high cotton production [12].

Regarding the economic aspect, cotton sector is facing a disorder since a decade because of institutional failures repeatedly. This situation demotivates conventional cotton farmers and impacts negatively economical performance of the sector. Following [13], [14] found that the performance of the cotton sector of West French Africa countries as well as the membership of farmers decline strongly. Also their competitiveness shrinks against concurrent countries and advances in quality are slower. Although the fall in global cotton price and the depreciation of US dollar contribute to the failure of these sectors, [14] affirms that changes in the institutional arrangements under the privatization process / liberalization are primarily responsible, by poorly taking into account constraints and concerns of farmers.

In response to these bottlenecks, alternative systems for cotton production have emerged in Benin Republic for over a decade. This article attempts to answer this question. Its main objective is to use the theoretical model of the sustainable intensification of agriculture in order to analyze organic cotton and Cotton made in Africa farming systems. Then, after setting the theoretical framework, the article will look at the description and analysis of organic cotton and cotton made in Africa (CmiA) farming systems to highlight the factors affecting the sustainability of these systems.

II. Theoretical Framework

The concept of sustainable development is subject to several theoretical and methodological developments. Sustainable development has been defined in many ways, but the most frequently quoted definition is from the Brundtland Report which considers sustainable development as a "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [15]. Sustainable development rests on a trivet involving environmental, economic and social sustainability [16]. Regarding agriculture, [17] defines sustainability as the whole process of transformation of production systems that enhance and improve short-term income and living conditions of populations exploiting agricultural, forestry and pastoral production, with respect to social cohesion and environmental conditions required to maintain and diversify in medium or long term these productions.

In other words, the concept of sustainable development in agriculture refers to the concept of sustainability and in particular the sustainability of agricultural production systems. However, this notion of sustainability is not unanimous. Reference [18] reports that since the introduction of the concept of sustainable development, nearly hundred definitions of sustainability have been published each focusing on values, priorities and different practices.

Generally, sustainability refers to the ability for something to continue for a long time without changing. Some authors suggest defining it based on sustainable income. According to [19], sustainable income is the maximum value that a person or a company can consume during a given time and hope still to be wealthy at the end of the period than at the beginning. Reference [18] says that an agricultural system is sustainable if the amount of income allocated each year for consumption can be sustained over time. The sustainable system must be able to meet the food needs of a growing population whereas respecting the environment and natural resources [20].

Despite their diversity, the different conceptions of sustainability recognize the need for agriculture to meet the food demand of present and future generations whereas ensuring the protection and preservation of the environment, natural resources and traditional values related to agricultural and rural people [21].

To be sustainable, a system of agricultural production must be viable, bearable, reproducible and transmissible [22]. Whereas viability refers to the level of average income of the household, the livability expresses the quality of life of the farmer and his household. Whereas the transferability is linked to the quality of social and economical relations, the reproducibility relates to the quality of ecological link measure through the diversity of the systems of production, technical itineraries and their adaptation to the local environments [22].

Considering the more and more pronounced context of rarefaction of productive resources and the degradation of the environment in which agriculture has to satisfy food needs of a rapidly expanding population, some authors speak in favor of a sustainable intensification of the systems of production. Indeed, according to [23], the productivity must be strong to compensate for the more and more pronounced decrease of agricultural area by inhabitant. For the author, in view of the fact that agriculture represents a principal activity of the rural people, it must allow to obtain a sufficient level of yield and lucrative prices in order to offer an acceptable income to rural producers whereas putting in value limited surfaces. Therefore, the challenge on a small area is not only to reduce the use of inputs but also to promote the growth of the production [24], hence the idea of intensification of agricultural production systems.

The concept of intensification remains the notion of green revolution and refers to the productive model of agricultural growth currently questioned by speeches on sustainable development. On that subject, [23] reports that "intensive agriculture" is denounced since decades as source of negative effects, in particular on environmental and human health. Nevertheless, the issue of intensification presents with it some advantages that is well associated with durability principles that can constitute a pertinent way to guarantee agricultural sustainability [23].

From this perspective, [25] states that the concept of intensification is linked to productivity and makes sense relative to a factor of production. This concept is defined as an increase in the production per unit of inputs, mainly labor, land, working time, fertilizer, seed, feed, money, etc. [26]. Focusing on its objectives, [27] reports that agricultural intensification leads to an increase in yields which makes profitable the process of production and ensure its intensification. Certain authors argue that there is intensification when a global agricultural production increases through the improvement of inputs efficiency or when the production is maintained whereas inputs decrease (weaker quantity of better applied fertilizer, better protection of plants or better targeted animals, mixed crops or crops rotation on of smaller areas, etc.).

Intensification implies also the improvement of physical relations between inputs and outputs, the increase of the yield and / or income per unit of land through an intensive investment in capital or labor. Therefore, [27] estimates that better oriented, the process of agriculture intensification can help to improve the results of production whereas minimizing the externalities inherent in agricultural intensification model advocated by the productive model; hence the concept of sustainable intensification of agriculture.

Sustainable intensification is defined as a form of production consisting in a use of physical, human and social capitals in combination with the best available technologies and inputs that minimize or eliminate damage on the environment [24]. This form of intensification of agriculture involves the management of ecological processes rather than the use of inputs of fossil fuels and seeks to have a smaller environmental footprint by minimizing the use of fertilizers and synthetic chemical pesticides (SCP), the reduction of greenhouse gas emissions greenhouse, providing and maintaining a range of public goods [28]-[29].

In this context, analyze the sustainability of agricultural production system, returns to decompose the concept of sustainable intensification in ecological, socio-economic and social intensification (Fig.1) Ecological intensification aims to implement a highly productive system enhancing ecological processes to reduce competitiveness and strengthening mutual benefits between cultures through the implementation of appropriate cultural practices such as intercropping (cultural associations, agro-forestry, agro-pastoralism, green fertilizers, etc.), integrated pest and soil fertility management [23]. As for the socio- economic intensification, it goes through the creation of an environment that ensures the linkage of small producers to markets, the development of social and human capital and sustainable livelihoods. Finally, genetic intensification involves the selection of new crop varieties and animal breeds with high performance but also highly resistant to several types of stress and shock [28]. Conventional methods such as genetic engineering, tissue culture, etc. can be combined for this purpose in order to select varieties that can adapt to low levels of use of inputs, a variety of pests and diseases and the consequences of climate change [28].

Well designed, sustainable intensification of systems production appears as a relevant approach to achieve sustainability objectives as long as certain conditions are met. It will serve as basis for analyzing conditions of sustainability of alternative systems of cotton production in Benin.

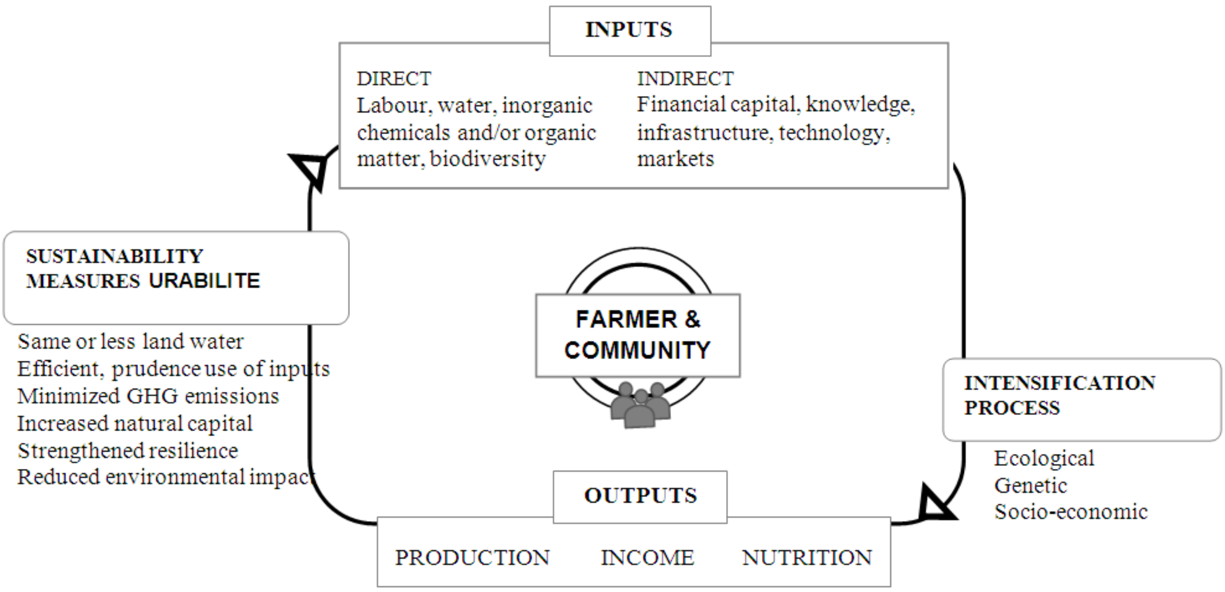

Fig.1. Theoretical model of Sustainable Intensification [28]

III. Materials and Methods

The empirical phase of the research was carried in the municipalities of Kandi and Pehunco, one of the largest areas of cotton production in the North of Benin. Data were collected from a sample of 90 organic cotton farmers and 100 CmiA farmers selected from a typology based on endogenous criteria of prosperity.

These data included mainly the characteristics of organic cotton and CmiA production systems, the main factors of production, the quantities and costs of inputs used, etc. They were collected with structured and non-structured interviews with individuals and focus groups. Data were analyzed with qualitative methods of comparison, descriptive statistics and test of comparisons of mean, using Excel and Minitab software. The comparison method is a qualitative approach permitting to establish a comparison of objects, practices or approaches in order to identify similarities and differences between the compared elements. It integrates a relativist and normative dimensions [30]. The first, focus on the relative level of development of the elements compared, appreciating the one in comparison to the other. As for to second, it analyzes each element in comparison with what it should be (norm, theory). Thus, the practices implemented on farms, for example the quantities of fertilizers brought to cotton plots were compared to quantities recommended. In addition, the test for comparison of means was performed by analysis of variance (ANOVA) with a factor. Conditions of normality were verified through Kolmogorov-Smirnov (K-S) test was used to verify the normality conditions and in some cases, logarithmic transformation was done to test the variance homogeneity. The comparison of means was done with the test of Least Significant Difference.

IV. Results

A. Brief overview on organic cotton and CmiA production systems in Benin

The promotion of certified organic cotton in Benin is performed by the Beninese organization for organic agriculture promotion “Organisation Beninoise pour le

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Promotion de l'Agriculture Biologique (OBEPAB)" and Helvetas-Benin NGO. Organic cotton production is concentrated in the center and the northern Benin. It involves over 10 out of 77 municipalities of the country. In 2010, nearly 2,695 organic cotton farmers produced 545 tons of seed-cotton certified organic (representing 0.24 percent of national cotton production) on 817 hectares (representing 0.80% of the national cotton area planted).

Organic cotton production system (SCBIO) and cotton made in Africa production system (SCMIA) differ fundamentally from each other about the way to manage farm, particularly soil fertility and pests' management (Table 1). Whereas SCBIO advocates for farm management from a holistic perspective and without use of synthetic chemicals, and for enhancing inputs locally available, SCMIA does not imagine the success of cotton production without synthetic chemical inputs. However, unlike the conventional system, SCMIA believes that because of the low level of organic matter in the soils of Benin, exclusive use of mineral fertilizers cannot promote the restoration of soil fertility in long-term. So, it advocates for a combination of organic and mineral fertilizers instead of exclusively mineral fertilizers. Moreover, SCMIA defends pests' management based on the technique of scale and target fight "Lutte étagée ciblée (LEC)".

Unlike conventional production, SCBIO and SCMIA involve more women (22% SCBIO and 15% SCMIA). The ban of Synthetic Chemicals Pesticides (SCP) and the use of inputs locally available are key factors that promote women membership to SCBIO. In both SCBIO and SCMIA production systems, farmers are mostly young, aged between 25 and 45 years (82% SCBIO and 83% SCMIA). They have a long experience in the production of cotton but are predominantly illiterate (78% SCBIO and 81% SCMIA). About 69% of SCBIO farmers and 76% of SCMIA farmers are polygamous; 56% of SCBIO farmers and 53% of SCMIA farmers have more than 3 wives. As a result, households are relatively large: 78% of SCBIO households and 65 % of SCMIA households are composed of at least 5 members. However, very few households have more than 10 agricultural workers (4% SCBIO and 9% SCMIA). Legacy remains the main way of access to land (79% SCBIO and 79% SCMIA) but the majority of farmers who adhere to the production of organic cotton or cotton made in Africa have very small lands.

Table 1: Practices recommended in organic cotton and CmiA production in Benin

SCBIO			SCMIA	
Techniques		Ingredients	Techniques	Ingredients
Phytosanitary protection	Biochemical method	Per hectare, a mixture of: - extract of 2 kg of neem seeds - extract of 20 leaves of pawpaw - 20 g of local soap called "koto" - 5 cloves of garlic - 1 liter of cow urine	Scale and targetfight (*Lutte étagée ciblée* : LEC)	6 basics treatments with pesticide Thian 175 O-TEQ and serphos 320 EC 6 treatments on threshold infestation with Cypercal or Cypalm 350 EC, Hostathion or Trialm and Gazelle or Kriss
	Mecanical method	Manual destruction of *Dysdercus*		
	Trap-plants and pheromone plants	Sunflower, india rosebush, gombo, maize, bean		
Fertilization	Cow dung or compost	10 to 12 tons of cow dung 5 to 6 tons of compost well decomposed	Organic fertilization	Cow dung, compost, manure, etc.
	Cattle-cake of walnut palm, ashes of woods	250kg/ha cattle-cake of walnut palm + 50kg/ha of wood ashes	Mineral fertilisation	Per hectare 150 kg of NPK + 50 kg of urea
	Residues of harvest, leguminous			

B. Characteristics of organic cotton and CmiA production systems

Main crops – Cotton, cereals, roots, tubers, leguminous, oleaginous and vegetables are the main crops produced on SCBIO and SCMIA farms (Table 2). During the 2011-2012 campaign, 2.79 (±1.82) hectares of land were cultivated by SCBIO farmers against 5.93 (± 4.79) hectares by SCMIA farmers. Cotton and maize represent the main crops cultivated (100% of SCBIO farmers and 93% of SCMIA farmers). Whereas cotton is the main cash crop, maize is destined both to self-consumption and cash. In terms of land allocation, SCBIO farmers allocate 0.91 (±0.60) hectares and 1.06 (±0.99) hectares respectively to cotton and maize. SCMIA farmers allocate to cotton and maize, respectively 2.22 (±2.07) hectares and 2.49 (±1.97) hectares (Fig. 2). In each system of production, there is a significant difference between the average areas allocated to cotton and maize (ANOVA, $p < 0.05$).

The relative importance of cotton and maize areas in SCMIA production system in comparison to SCBIO system is due to the advantage of SCMIA farmers to use minerals fertilizers. Indeed, in Kandi and Pehunco municipalities, farmers not only do not conceive the production of maize without mineral fertilizers, but also judge organic fertilization as very exhausting. In addition, because of constraints met in the management of cotton pests and in the maintenance of their field, organic cotton farmers are oblige to reduce areas allocated to cotton. Nevertheless, SCBIO farmers attach more importance to leguminous and oleaginous (14% of total area cultivated) than SCMIA farmers. The possibility given to SCMIA farmers to combine organic and mineral fertilizers can explain the weak integration of leguminous and oleaginous in their crops systems, in contrast with SCBIO farmers who, to succeed their production, are obliged to introduce more leguminous in their crop system.

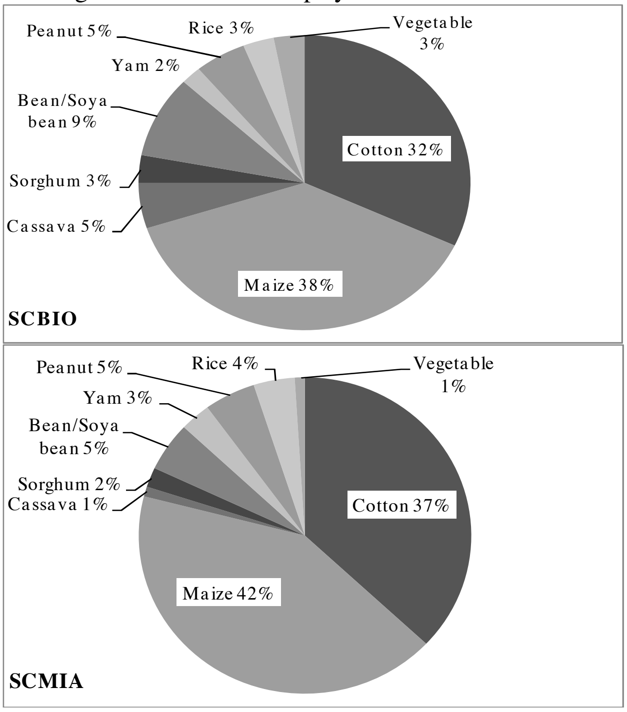


Fig.2. Land affectation to crops by SCBIO and SCMIA farmers in 2011-2012

Preparation of the cotton-seed bed – The choice of cotton seed-bed is the first activity in cotton production process. It is based on criteria which differ from production systems (Table 3).

The assessment of soil fertility by farmers is based on a multi-criteria approach involving both qualitative and quantitative factors such as: soil color, presence of weeds and earth worm, life dynamics in soil, yield obtained from last cultivation, etc. [31]. It is important to mention that, in reality, whatever the system, these requirements are not always met by farmers. Some of them install their cotton plot at the bottom of the slope, not far from conventional plots, etc.

Soil preparation begins deforestation which implies the slaughter and the cutting of large trees. Traditionally, this activity is done manually with an ax, but because of it is a hard activity consuming a lot of time, farmers prefer using fire to burn trees. The prohibition of fire in organic cotton production explains that only SCMIA farmers use fire for deforestation. Furthermore, certain tree species such as Sterculia stigera, Adansonia digitata, Afzelia africana, Khaya senegalensis, are preserved during deforestation. Even if it is recommended to farmers to preserve 20 trees per hectare in their field, it is necessary to mention that the respect of this requirement is rather facilitated by the fact that in the cosmology of Baatonu, socio-cultural group to which the majority of farmers belongs, these tree species provide shelter for kind spirits.

Cleaning follows deforestation and consists of removing stumps, woods and fallen logs from the plots. Generally, tree trunks are used for carbonization and branches or stems of shrubs as used as fire wood in the domestic unit or market.

Plowing – This operation is done at the beginning of the first rains, sometimes between April 20th and May 30th at a depth of 15-20 cm. It is practiced by animal traction and allows burying organic fertilizer and controlling weeds. Ridging remains the main type of tillage practiced because it facilitates following cultural activities, mainly weeding. In addition, in order to remove children from some farming operations such as tillage and to facilitate their schooling, organisation promoting CmiA introduced a practice called "guidage arrière" of cows' traction. This consists of directing animals by the farmer who manipulates the ploughshare, instead of the children who, in peasant practice, remain at the front of the plow. However, only 7% of SCMIA farmers have adopted this practice because of the lack of plowing equipment, farmers and animals training. It results in the refusal of animals to move without the children and the slowness of the work.

Table 2: Main crops cultivated by organic cotton and CmiA farmers

	Rate of practice		Area (Ha)		Main uses
	Organic	CmiA	Organic	CmiA	
Cotton	100%	100%	0,91 (0,60)	2,50 (1,97)	Market
Maize	93%	95%	1,06 (0,99)	2,22 (2,07)	Consumption and market
Cassava	35%	30%	0,14 (0,22)	0,32 (0,65)	Selling, processing, consumption
Bean/Soya bean	47%	16%	0,24 (0,22)	0,09 (0,16)	
Peanut	5%	2%	0,14 (0,22)	0,14 (0,23)	Selling, processing
Yam	33%	35%	0,04 (0,14)	0,11 (0,20)	Selling, consumption
Rice	9%	7%	0,09 (0,19)	0,23 (0,48)	Consumption
Sorghum	16%	20%	0,09 (0,20)	0,32 (0,65)	Consumption, processing
Vegetables	82%	78%	0,07 (0,20)	0,03 (0,21)	Selling, consumption
Total			2,79 (1,82)	5,93 (4,79)	

Notes: Values in brackets represent standards deviation of means

Table 3: Criteria determining the choice of the future cotton plot in organic cotton and CmiA systems

Criteria	SCBIO	SCMIA
Localization	At least 10 meters from conventional cotton plots Not down-slope	Away from watercourses Not down-slope
Cultural passed	Not having received crop treated by synthetic chemical pesticide at least the 3 last cotton season	No requirement
Soil fertility	Good fertility	Good fertility
Accessibility	Easily accessible to facilitate organic matter transport and the internal/external control at every seasons	No requirement

Sowing – Both SCBIO and SCMIA use for sowing a non-GMO variety H -279 -1 seeds distributed by the structures supporting SCBIO and SCMIA farmers. Usually, seeds come from cotton ginning of last season. At the SCBIO level, untreated conventional cotton seeds can also be used. Moreover, before sowing, the seeds undergo an antifungal treatment with urine, cow dung, and soil or clay in the case of SCBIO farmers and I Calthio 350 in the case of SCMIA farmers.

Sowing is usually early and takes place between 20 May and 10 June. It is realized to a depth of 3 to 5 cm with a spacing of 0.80 m x 0.40 m. Quantities of seed used (34 kg/ha by SCBIO farmers and 33 kg/ha by SCMIA farmers) are above the 25 kg/ha recommended. This situation is due to climatic hazards that oblige farmers to replanting.

Weeding – It is for SCBIO farmers the main method to struggle against weeds. It is done with a hoe or animal traction. SCMIA farmers associate the Kalach SL 360, a non-selective synthetic chemical pesticide, to weeding.

Soil fertility management – Regarding the management of soil fertility, it is based, depending on the production system, mainly on the use of organic and/or mineral fertilizers, rotation and intercropping practices. Organic fertilizer is the main fertilizer used by SCBIO farmers. It includes animal manure, residues of harvest and agro-food processing, household waste, etc. (Fig. 3) Cow dung remains the most common organic matter used. It is mobilized through direct parking of cattle on the plot or through collection in manure parks in farmers' residence or Fulani camps. The quantities of cow dung applied to cotton plant vary according to the system of production: an average of 2,886.67 kg/ha by SCBIO farmers and 246.76 kg/ha by SCMIA farmers. The difference between these quantities is highly significant (ANOVA 1; P -value < 0.001). The high standard deviation of the mean suggests a variability of practices in the supply of cow dung (Table 4).

Nevertheless, the quantities supplied are very low in comparison to the 12,000 tons of cow dung or 6 tons of compost recommended per hectare [32]. At SCMIA farmers level, this weakness of cow dung quantities can be explained by the fact that farmers consider as a loss an important supply of organic fertilizers at the same time where they must bring the same quantities of mineral fertilizers as in conventional production. Mineral fertilization consists of the use of NPK (Nitrogen-Phosphorus-Potassium) and urea for cotton plant growth. In accordance with the requirements of organic cotton production, no SCBIO farmers use mineral fertilizers for cotton (Table 5). In reality, SCMIA farmers don't meet the quantities recommended in the use of mineral fertilizers. Indeed, a disaggregated analysis shows that 114.40 (±29.94) Kg of NPK and 65.66 (±29) kg of urea per hectare are used by SCMIA to fertilize their cotton field. Finally, as for crops rotations, results show diversified practices. Fallow periods ranging from 1 to 5 years are included in the crop sequences (Table 5).

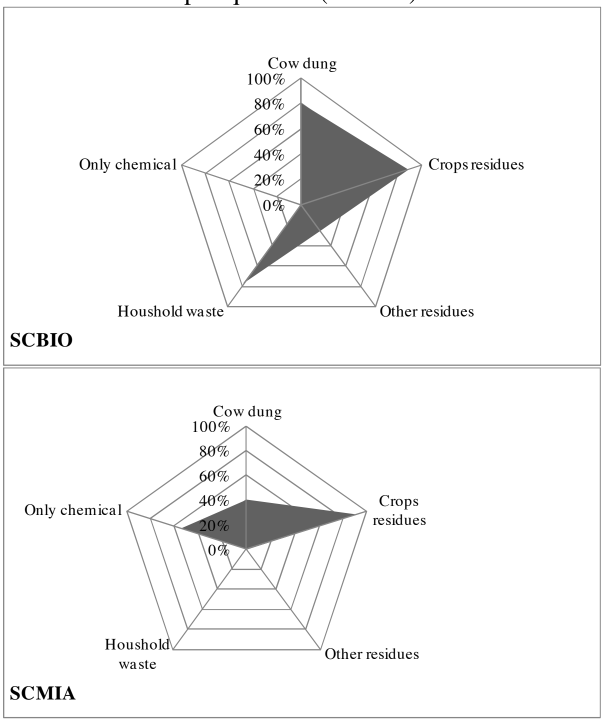
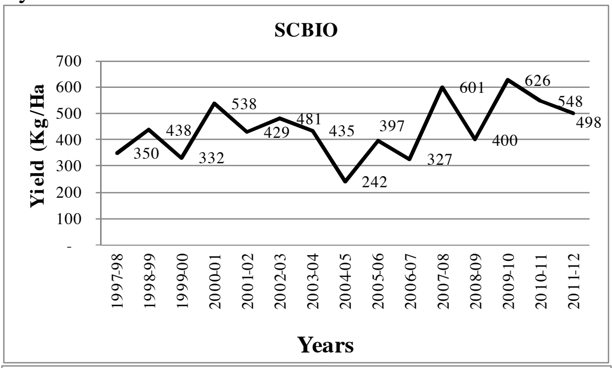


Fig.3. Main types and sources of fertilizers used by SCBIO and SCMIA farmers.

No SCBIO farmer produces cotton on the same plot during 2 cotton season successively against, at least, 51 % of SCMIA farmers. From 2008 to 2012, approximately 21% of the crop successions realized by SCMIA farmers are composed only of cotton. In addition, most SCBIO farmers include leguminous or fallow in their rotation crop system in contrast to SCMIA farmers. Globally, three types of cropping systems integrating cotton can be distinguished: single crop-farming, mixed crop farming and fallow systems (Table 6). Single crop-farming is observed within SCMIA farms and represents 21% of farming systems. Mixed crop farming includes cereals, tubers and leguminous and is represented in both SCBIO farms (58%) and SCMIA farms (68%). As for the system incorporating fallow is practiced by more SCBIO farmers (42%) than SCMIA farmers (13%). Consequently, soils under CmiA practices are used without much restitution. In contrast, the SCBIO farms seem to give greater importance to the leguminous. Thus, after two cotton seasons of use of a soil previously left in fallow, 8% of the SCBIO farmers integrate leguminous into the crop rotation system. In mixed crop farming, 56% of SCBIO farmers integrate leguminous. Only 2% of farmers of this group adopt crop succession cotton-cereals without leguminous or fallow integration. Overall, nearly 98% of SCBIO farmers integrate either fallow or leguminous to the crops rotation systems.

Pests' management – Cotton pests' management also depends on the system of production. Regarding organic cotton production system, it is based mainly on the use of biopesticides which preparation requires 4 kg of neem seed and 4 kg of maize or sorghum per hectare. Even if the quantities used by farmers are equivalent to the recommendations, the coefficient of variation, relatively high (46% and 43%), suggest a variability of practices between farmers. Even if around 80% of SCMIA farmers observe the 48 hours of biopesticides maceration as recommended, the dose of pesticides applied (25 liters per hectare) are above the dose of 15 liters per hectare recommended. Most SCBIO farmers start treatments as soon as they observe that 10 out of 30 plants are affected by Helicoverpa armigera and Diparopsis watersi. Concerning Crop protection using synthetic chemical pesticides, it is the main means used to manage pest on SCMIA farms. It is based on the LEC method whose application is facing enormous constraints such as delay in inputs set up, bad quality of insecticides. More specifically, Thian introduced to replace Endosulfan whose use was prohibited in Benin, would not be effective against cotton pests. Therefore, SCMIA farmers increase by more than 4 times the doses of pesticides or they use residual stocks of Endosulfan which systematically destroy any insects on which it is applied. Moreover, in the application of LEC method, SCMIA farmers seem to confuse the basic treatments and those on threshold that they finally summarize to the same. Indeed, all SCMIA farmers of our sample consider that the implementation of LEC consists in an application of the insecticide Thian for the first two (2) treatments of the cotton and Sherphos 320 EC for the last four (4) ones. This demonstrates that treatment on threshold is not yet applied within SCMIA farms. In the end, it is necessary to mention that the practice of intercropping is also a technique used by farmers to manage cotton pests. It consists of the inclusion of "plants traps" lines between cotton lines. The main plants used are occra (Abelmoschus esculentus), beans and maize.

Seed-cotton harvest – Cotton is harvested early in order to avoid that insects do not dirty seed-cotton. Concerning organic cotton, the storage of cotton in a same place as chemical pesticides, paints, fuel, lubricant oil, etc., is prohibited. So, organic cotton is stored far from conventional cotton. Fig.4 shows that organic cotton yields present a non linear evolution. Globally, these yields are low and inferior to CmiA yields which decrease from year to year. Therefore, the increase in cotton production is more due to the increase in areas and not to improvement of yields.



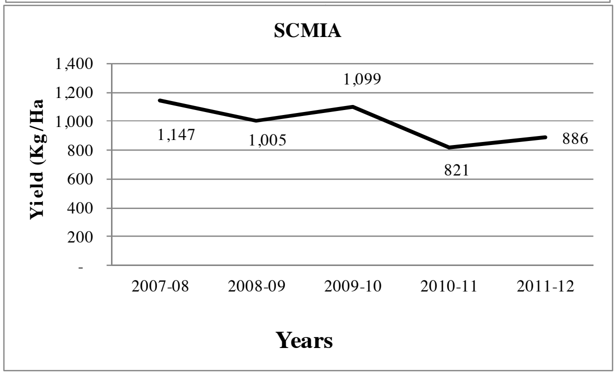


Fig. 4: Evolution of the average of cotton-seed yields according to the production system

Table 4: Types and quantities of organic matter used in organic cotton and CmiA production systems

	SCBIO		SCMIA	
	Organic matter	Mineral fertilizer	Organic matter	Mineral fertilizer
Mean	2,886.67	0.00	246.76	179.64
Standard deviation	2,265.42	0.00	47.46	26.63
Minimum	700	0.00	140	135
Maximum	8,000	0.00	280	300

Table 5: Types of crops rotations adopted by SCMIA and SCBIO farmers.

SCBIO			SCMIA		
Rotation	Frequency	Importance (%)	Rotation	Frequency	Importance (%)
B-C-M-C	15	17%	C-C-C-C	21	21%
F-F-F-C	12	13%	Y-C-M-C	6	6%
B-C-M-S	9	10%	M-C-M-C	6	6%
F-F-M-C	6	7%	F-C-C-C	5	5%
S-M-C-M	6	7%	M-C-C-C	5	5%

F-C-M-C	6	7%	F-F-C-C	5	5%
F-M-C-M	5	6%	C-M-C-C	4	4%
F-B-M-C	3	3%	C-S-M-C	4	4%
P-M-M-C	2	2%	C-So-M-C	4	4%
F-S-C-M	2	2%	M-M-C-C	3	3%
C-B-C-M	2	2%	Y-C-C-C	2	2%
F-P-C-M	2	2%	C-A-C-C	2	2%
F-F-C-M	2	2%	Y-M-C-C	2	2%
			C-B-M-C	2	2%
			C-M-B-C	2	2%
			C-C-C-M	2	2%
			C-C-So-M	2	2%

Notes: C = cotton, M = maize, F = fallow, S = soya bean, P= peanut, B = bean, Y = yam, So = sorghum. Only systems practiced by at least 2 % of farmers are presented in the table. They represent 80% of the different crops rotations practiced by SCBIO farmers and 77% of those practiced by SCMIA farmers.

Table 6: Types of systems of cultures practiced by SCBIO and SCMIA farmers

Groups of crops systems		Crops systems	Importance
SCBIO	Mixed farming (58%)	Cotton-cereals	2 (2%)
		Cotton-leguminous- cereals -tubers	50 (56%)
	Fallow system (42%)	Cotton-fallow	12 (13%)
		Cotton-fallow-cereals-tubers	19 (21%)
		Cotton-fallow-tubers-leguminous	7 (8%)
SCMIA	Single crop-farming (21%)	Only cotton in continuous culture	21 (21%)
	Mixed farming (66%)	Cotton/cereals	45 (45%)
		Cotton/tubers	2 (2%)
		Cotton/ leguminous	4 (4%)
		Cotton/ leguminous /cereals/tubers	17 (17%)
	Fallow system (13%)	Cotton/fallow	10 (10%)
		Cotton/fallow/cereals/tubers	3 (3%)

C. Financial analysis of organic cotton and CmiA production

Financial analysis of organic cotton and CmiA production is based on the determination of the added value (VA), gross operating income (GI) and net operating income (NI). Formulas used are presented bellow [33]:

$$VA = P – IC \quad (1)$$

P represents the product obtained at the end of the process of production and IC the inputs completely consumed during the processes of production (fertilizers, seeds, pesticides, etc.).

$$GI = VA – FC \quad (2)$$

FC represents the fixed costs relating to the production factors used partially in the process of production (labor, interest on loans, insurance, etc.). In our case, the fixed costs are limited to the cost of labor. It was valued at 1,000 FCFA per work day of 8 hours, the rate applied in study area.

$$NI = GI – WO \quad (3)$$

WO refers to the value of depreciation of production equipment.

Table 7 shows that during 2011-2012 cotton's season, the production of organic cotton recorded a gross profit of 50,732 FCFA per hectare against a loss of 1,807 FCFA with Cotton made in Africa. This advantage for SCBIO is mainly due to the more profitable purchase price of organic cotton and a low cost of production factors. In contrast, the production of Cotton made in Africa experienced a significant drop in yields from 1,719 to 785 kg/ha between 2008 and 2012 because of the ineffectiveness of synthetic chemical pesticides, including Thian. This pesticide that substituted Endosulfan has been ineffective and for almost three successive cotton campaigns, farmers have experienced high incidence of pests.

Table 7: Financial analysis of organic cotton production and cotton made in Africa production

Components	SCBIO	SCMIA
(A) Gross (FCFA)	201.600	196.138
Average yield of seed-cotton (Kg/Ha)	672	785
Price of seed-cotton (FCFA/Kg)	300	250
(B) Costs of inputs	25.268	70.085
Seeds	680	660
Organic matters	21.477	3.744
Biopesticides	3.111	-

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Chemical fertilizers	-	39.521
Chemical pesticides + weedkiller	-	26.160
Added value (A) – (B)	176.332	126.053
(C) Fix charges (labour)	125.600	127.860
(D) Production costs without labour = (B)	25.268	70.085
(E) Production costs with labour: (B + (C)	150.868	197.945
Part of labour in production costs : 100 x (C)/(E)	83%	65%
Part of inputs in production costs : 100 x (B/(E)	17%	35%
Gross margin	50.732	-1.807
(F) Writing off	5.650	5.650
(G) Net income without labour: (A) – (D) – (F)	170.682	120.403
(H) Net income with labour: (A) – (E) –(F)	45.082	-7.457
Net revenue per kg of seed-cotton without labour: (F)/yield	254	153
Net revenue per kg of seed-cotton with labour: (G)/yield	67	-10

V. Discussion

In Benin, the increase in organic and CmiA production is due to an increase in cultivated cotton area instead of yields improvement. Analyses show that both organic cotton system of production (SCBIO) and Cotton made in Africa systems of production (SCMIA) are so extensive and thus are not extensively sustainable. Indeed, according to the approach of sustainable intensification of agriculture, the sustainability of farming systems must imply a growth of the production through the increase in crop yield and or a maintenance of the quantities produced with a decrease in the inputs used on a more restricted areas [24]-[26]-[27]-[28]. Unfortunately, as shown, the increase of cotton production is mainly associated with the increase in inputs used and a decline of yields in both organic and CmiA systems. Low yields and increase in inputs used reveal farmers' difficulties to implement alternative practices recommended. Indeed, the management of soil fertility by both SCBIO and SCMIA farmers, is limited by the low availability of organic inputs and transport equipment mainly cows and carts. Consequently, the quantities of organic fertilizers brought by organic cotton farmers are very insufficient to satisfy the requirements. Concerning SCMIA farmers, the combination of organic and chemical fertilizers recommended does not become real. Not only the quantities of organic fertilizers are very small but also chemical fertilizers are reduced. Furthermore, weeds' management suffers from the non-availability of chemical pesticides, farmers' difficulties to prepare biological pesticides, and the ineffectiveness of these pesticides. In this case, farmers find themselves obliged to increase the doses of pesticides recommended. As demonstrated by [34], in current farming systems, chemical fertilizers are not generally used intensively. To promote the durability of these systems, [26] suggests that the first condition is to improve and to maintain the fertility of soil through techniques such as harvest residues valorization, agro-forestry, crops rotation with leguminous, intercropping and chemicals fertilizers supply, etc. Nevertheless, the improvement of soil fertility could not be done without a sustainable improvement of farmers' livelihoods. On that subject, [26] think that the implementation of these means of durability is greatly linked to economical conditions of farmers.

In addition, practices adopted by farmers for soil preparation do not promote its protection. Indeed, plowing and weeding practiced in both systems of cotton production strip soil and expose it to the effects of weathering. However, as underlined by [28], soils' cultivation in tropical region brings about a decrease of the organic rate that, if it is not limited, confines in a vicious circle of soil degradation. To face this constraint, the author suggests turning to techniques such as sowing under plant cover "Semis sous couvert végétal" that provide a cover to the soil. It is based on the principle of minimum tillage with permanent soil cover, associated with adequate rotations and intercropping [35]. These practices would ensure greater protection to the soils, reduce the rate of mineralization of organic matters and promote the maintenance of soil fertility in the long-term [36]-[37]-[38]. Conditions for successful application of these technologies may be studied with an active participation of farmers.

Regarding the economic aspect, the system of organic cotton production seems to be economically more sustainable. Unlike cotton made in Africa, the gross margin of organic cotton production is positive during 2011/12 season. This economic advantage of organic cotton is due to its higher purchase price, the reduced costs of inputs, and the lower yields of CmiA because of the ineffectiveness of pesticides introduced three years ago.

VI. Conclusion

With regard to the actual context and conditions of their implement, alternative systems of cotton production in Benin, especially organic cotton and cotton made in Africa production systems, are not intensively sustainable. The improvement of sustainable livelihoods of farmers and their accessibility to the main factors of production is required to lead the evolution of these systems of production towards more sustainable systems.

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