Organic Cotton Experiments in Northern Benin

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ABSTRACT

The environmental effects of cotton production in West Africa put the long-term sustainability of entire cotton-based agricultural systems at risk. Policies aimed at cost reduction and improved efficiency of the cotton sector to stabilize export income should encompass the cryptic environmental costs of production. Solutions to problems of soil fertility decline and pesticide contamination should be based on an analysis of the process of cotton cultivation, rather than on symptom solving. Research should take a 'gendered farming systems' approach and be designed to enhance participatory technology development. Organic cotton production experiments in Northern Benin focus on the use of locally available inputs as substitutes for synthetic products. Organic manure to replace fertilizers and neem seed for insect control minimizes financial risk and overcomes problems of synthetic inputs. Higher labour demand can be satisfied during less labour demanding periods in other farm activities. This paper addresses issue of organic cotton as a substitute for traditional cotton production to ensure sustainability for the future.

Introduction

Organic agriculture is new in West Africa and thus experimental by definition. Research on organic agriculture in tropical regions is too limited in both quantity and quality to justify any final judgement on its potential as a viable alternative to conventional agriculture. However, organic agriculture provides a comprehensive approach to cotton cultivation, relying on optimized use of local rather than on external resources and might provide useful lessons for increased sustainability in West African cotton-based systems. Small-scale experiments in northern Benin show that organic cotton is technically feasible, socio-economically interesting and ecologically sustainable.

Cotton Production and Sustainability

Cotton production in Benin has increased explosively since the early-1980s. The 1997/98 crop of 359,000 tons of seed cotton is more than 10 times the 1982/83, four times the 1985/86, and twice the 1991/92 crops. Production growth since 1985 is entirely due to an increased cotton cropped area that reached 378,000 ha in 1997/98, half of which is in northern Borgou and about a quarter in the central Zou area. Yields have stagnated since the mid-1980s at 1.0 - 1.2K kg of seed cotton/ha, with a recent downward trend.

Increased production is due to both the lack of markets for alternative cash crops and the scarcity of off-farm employment that drive smallholders to engage in cotton production. However, they would not have done so if a market outlet for seed cotton had not been guaranteed at favourable conditions by government schemes. A balanced package policy of both price and non-price instruments, similar to those found in other francophone West African countries, has persuaded Beninese farmers to grow the inedible cotton crop and thus to increase dependency on national and international markets and policies.

Lack of alternatives is likely to increase the dependence of Benin on cotton as a cash crop over the next decade. Cotton production in Benin represents only 0.7 % of world total and some 2 % of international cotton trade so it is unlikely to influence world markets. However, uncertainty about exchange rates (i.e. USD/FF and FF/FCFA; and the future USD/Euro and Euro/FCFA) limits the country's ability to stabilize export income from cotton. The economic sustainability of the Benin cotton sector depends on the country's ability to compete on the international market through cost reduction and improved efficiency.

Environmental effects of cotton production, however, should be an integral part of policies aiming at cost reduction and improved efficiency since environmental degradation threatens Benin's long-term agricultural potential. Recent literature provides abundant evidence of the multiple detrimental environmental effects of cotton production in West African (Ton, 1994; Raymond and Beauval, 1995; Ton and Vodouhe, 1995; Beroud, 1996; De Haan, 1997). Even though all effects cannot be attributed to cotton *per se* (van der Pol, 1992; Beroud, 1996; Bruntrup, 1997), they are closely linked to the dynamics of a cotton based agricultural system. Any improvement of the ecological sustainability of cotton production in Benin would translate into cost reduction or improved efficiency and would have a considerable impact on the sustainability of the entire cotton-based systems.

Environmental effects of cotton production

The environmental effects of current cotton production in West Africa can be grouped in two sections. The first section relates to environmental effects induced by the dynamics of the cotton-based agricultural systems. The second section consists of environmental effects of agricultural practices in cotton production.

Dynamics of cotton-based agricultural systems

1. extension of cropping area, at the expense of bush and fallow vegetation
2. cotton-related changes within the agricultural system :
   a) total clearance of land (animal traction)
   b) less crop rotation (increased importance of cotton in total area)
   c) shorter fallow periods (diminished availability of land), and
   d) raised need for pasture lands (increased animal property due to cotton revenues).

Cultural practices in cotton production

1. fertilization practices :
   a) general neglect of organic matter balance (almost complete reliance on synthetic fertilizers)
   b) inefficient use of organic matter available (burning of cotton residues)
   c) risk of increased erosion (risk of organic matter deficits leading to poor soil structure)
   d) inadequate fertilization (expensive external input)
   e) unbalanced fertilization (high uniformity in composition of fertilizers : disconnection of fertilization and soil composition)
   f) risk of contamination of surface and ground waters (diffusion of residues of products)
   g) neglect of fertilizer effect on resistance of plants (disconnection of agronomic and entomological research), and
   h) neglect of fertilizer effect on microbiological activity.
2. crop protection practices :
   a) direct risk of intoxication (use of highly toxic synthetic pesticides, without taking proper precautions)
   b) indirect risk of intoxication (diffusion of residues of products by wind and water, by fodder and food, and persisting for days, weeks or months)
   c) increased direct and indirect risk of intoxication (increased use of water-soluble products resulting in more handling operations)
   d) destruction of natural enemies of cotton pests (lack of selectivity of products)
   e) development of secondary pests (destruction of other natural enemies)
   f) risk of pesticide resistance (successive use of same or similar active ingredients), and
   g) increased risk of pesticide resistance (local lack of spraying, uncontrolled mixture of products, inadequate doses).

In search of sustainable cultural practices in cotton production

Solutions to these problems have been sought. Most West African research seems to have been devoted to aspects of soil fertility (erosion control measures, increased fertilizer use, optimized crop rotation, improved fallow, use of organic fertilizers) and to pesticide use in crop protection (pesticide efficacy, pesticide resistance, secondary pests). The environmental impact of an increased cotton area and cotton-related changes in agricultural systems seem to have drawn limited attention. Many aspects of West African soil fertility and crop protection have received less attention than they deserve.

Research has generated a wealth of information and an impressive range of possible solutions to specific problems. However, many of the solutions proposed have been `more of the same kind', as they concentrated on the symptoms of environmental degradation rather than on underlying causes. The proposal to add chalk elements to counterbalance acidification processes induced by the use of synthetic fertilizers (Beroud, 1996) and the plea for increased fertilizer subsidies (Beroud, 1996) where price elasticity of fertilizer use is low (van der Pol, 1992; Bruntrup, 1997) are examples. In crop protection, there are: the regular changes from one active ingredient to another to limit resistance in insects, the introduction of synthetic pesticides to combat secondary pests, and the plea for burning cotton residues to prevent pest outbreaks (Vaissayre, 1998).

Some solutions to specific environmental effects of cotton production can also be considered technically-feasible but not adapted to local conditions. For example, there is a tendency to promote o*ptimum* use of manure through composting and improved cattle parks but most farmers do not use any manure at all. The introduction of leguminous fodder crops is unlikely to be successful in regions of relative land abundance where even crop residues are under utilized as a source of fodder. The future of the integrated pest management system (`Lutte Etagee Ciblee') now promoted is doubtful, as it enables farmers to *count* cotton pest populations and act in response by help of peg-boards rather than help them *judge by observation* the incidence of relative pest populations and their natural enemies.

Recent developments that may lead to a more comprehensive approach to environmental effects of West African cotton production can be noted. Firstly, there is increased interest by researchers on integrated pest management strategies that are not merely insecticide management (Vaissayre *et al.*, 1995; Sylvie, 1998; Vaissayre, 1998). In this respect, a critical and participative evaluation of current experiences with the introduction of the `Lutte Etagee Ciblee' will be useful. Secondly, attention to organic fertilization has increased but the extension of existing knowledge is limited and there are reasons to doubt the appropriateness of some of the technologies proposed. Thirdly, increased interest in farmers' organizations, that translates into greater involvement of male cotton producers in policies and in participative experimental projects such as cultivar trials.

Cotton-related research in West Africa should change from symptom solving and focus on the process of cotton cultivation. Environmental degradation should be prevented rather than cured. Farming system's analysis should be at the core of cotton-related research to prevent technically-feasible but unadapted technologies developed by monodisciplinary research. Cotton-related research should also take an active and gendered approach towards the involvement of all stakeholders in problem definition, priority setting, research monitoring and evaluation and the extension of new technologies. Participatory technology development is almost absent in West African cotton sectors. Research is still highly defined by fiber quality considerations of cotton marketing boards and fostering of input use by the chemical industries but cotton producers themselves have little say in planning, monitoring and evaluation.

Organic agriculture and sustainability

Organic agriculture is a system of ecological soil and pest management that aims at optimum use of natural ecological balances in agricultural production. It adheres to globally accepted principles (IFOAM, 1995) that are interpreted and implemented within local socio-economic, agro-ecological and cultural settings. It sets guidelines for the process of agricultural production, rather than providing solutions for environmental degradation. It is a new phenomenon in West African settings. Results obtained so far should therefore be interpreted as experimental. Research on organic agriculture in tropical regions is still too limited, both in quantity and in quality, to justify any judgement on its potential to be a viable alternative to conventional agriculture. However, as a new and comprehensive approach to agriculture, organic agriculture has certain properties that may make it fit into West African smallholder production.

First of all, organic agriculture aims for the optimum use of relatively inexpensive local resources rather than expensive external inputs. Thus it contributes to reduced production risks. Secondly, organic agriculture produces crops as well as soil fertility. Organic soil management leads by definition to so-called `arriere-effets' of fertilization (secondary effects; often noted in literature as a positive element of current synthetic fertilizer use in West African cotton), and thus will stabilize plant growth and agricultural production over time. Also, as organic agriculture takes local conditions and local resources as a starting point, participatory technology development may more easily be attained than in conventional agriculture. Finally, the appearance of specific consumer markets for organic produce in Northern countries, linked to reliable control and certification of the entire production chain between producer and consumer, enhances the comparative advantages of lower-yielding but good-quality organic produce (Ton, 1996).

Organic cotton experiments

First experiments with organic cotton production in northern Benin were launched in 1996/97 by a Dutch/Beninese integrated development project. Its organic cotton programme aims to establish a self-supporting organic cotton sector (`filiere') that permits the introduction of sustainable agricultural practices. Thus it should contribute to a reduction of environmental degradation in the region, and to diversification of farmers' incomes. The experiments carried out so far obey a rather rudimentary form of organic agriculture with substitution of synthetic external by organic local inputs. More coherent, thus complex, forms of organic agriculture are likely to result in higher yields. However, they were judged to be less adapted to local conditions at this stage because of problems wi8th extension and evaluation. So far, the experiments only concern organic fertilizers (cattle droppings, pit manure, bat guano) with neem seed extracts for crop protection.

The programme offers participants a buying guarantee at a fixed price set in advance. A premium price of 20 % above the local seed cotton price is paid to those who obey contractual obligations. These include no synthetic inputs at all, use of a plot that has not received any synthetic input over the last 2 years, isolation of plots by a 10 meter band, no use of any sprayers containing residues of synthetic inputs, use of organic fertilizers, and a plan for crop rotation. The programme provides free seeds in the same way as the conventional sector), and loans sprayers to participants without charge to prevent the use of conventional sprayers. The programme is bound to assist participants on a regular basis through a system of monitoring/research/advice. Particular attention is given to mutual exchange between project agent and participant about observations and experiences to stress the mutual learning component of the pilot-project.

The experiments have aroused interest from both female and male participants. In 1996/97, 40 people and producer groups cultivated organic cotton on plots of average 0.36 ha. First year yields were low, with an average 264 kg of seed cotton/ha compared to the regional 1,054 kg/ha for conventional cotton. Low average yield was explained by lack of fertilization and crop protection, partially due to deficiencies in the monitoring/research/advice system. However, as several participants had yields of 500 kg/ha and more, others became convinced that cotton could be cultivated without synthetic inputs.

In 1997/98, the number of participants rose to 94, 50 women and 44 men. Acreage increased to 27.5 ha, or 0.29 ha per plot. The reasons that might explain the increased interest, despite low 1996/97 yield, were absence of any risk of indebtedness, the price premium of 20 % to compensate for reduced yields and the development project as buyer instead of the state marketing board through local producer organizations. The high female participation might partially due to the lower access women have to synthetic inputs in the current system.

Methodology of research

Over the 1997/98 season, an internal monitoring and evaluation system was established by the programme, in order to prepare for control and certification of the organic produce. Data were gathered for all 94 plots by two project agents, during their regular field visits (each two weeks). Particular attention was paid to open communication between project agent and participant, in order to prevent from socially-desirable answers.

Data gathered encompassed, locality, gender, area per crop, use of synthetic inputs per crop, plot installation (plot history, plot isolation, individual/collective plot), soil preparation, organic seed treatment, sowing dates, organic fertilizer practices (type of fertilizer, quantity applied, source, mode of transport), plant density, number of cultivations, number of sprayings, periodicity of sprayings, estimation of real crop area, yield estimation, real production of seed cotton. The data gathered permit a first experimental analysis of the technical, socio-economical and ecological sustainability organic cotton production in northern Benin.

Sustainability of organic cotton production in northern Benin

Organic production of cotton in northern Benin can obey to all certification requirements set out in the EEC regulation 2092/91 (June 1991) on organic agriculture and food processing. The main obstacle to certification in the short term will be the prohibition of dual production of organic and conventional cotton by one household. The risks of complete conversion to organic production are rather high at present so a solution might be sought in the design of village blocks of organic agriculture where plots continue to be cultivated individually.

The main technical recommendations were sowing date ≤ June 20; number of neem sprayings ≥ 7 applications per season at 7 day intervals and organic fertilization with either ≥ 2,500 kg of cattle manure/ha or ≥ 1,500 kg of pit manure/ha, or ≥ 600 kg of bat guano/ha. Of all participants, 26 % (N=23) was able to comply with all three recommendations, resulting in an average yield of 580 kg/ha. The average yield of the other participants was 352 kg/ha (N=65). Non-compliance was mainly due to late sowing due to lack of access to animal traction (women) and poor distribution of information (ploughing was perceived to be obligatory and ridging prohibited) and a lack of crop protection due to incorrect intervals between applications.

Average 1997/98 seed cotton yield was 411 kg/ha or about 50 % higher than the previous year. No differences where observed for men or women, although women usually have less access to production factors. Compliance with sowing date was found to be crucial, with sowing ≤ June 20 yielding 493 kg/ha (N=47), 50 % more than crops sown later (326 kg/ha; N=45). The number of neem applications and the level of fertilization proved to be crucial (Table 1).

Socio-economic analysis was carried out using the `Marge Apres Remboursement des Intrants', i.e. gross margin after repayment of input credits (MARI). As local organic inputs used in the programme are almost for free, the following equation was used for comparison of the MARI of conventional and organic cotton:

OC yield x (100 + 20% price premium) = CC yield x (100 - 30% input credit repayments).

The MARI of the average 1997/98 yield of 411 kg of organic cotton/ha becomes the financial equivalent of about 700-kg of conventional cotton/ha. The current organic cotton production was found to be a financially viable alternative for about a quarter of the conventional cotton producers in the area. The average yield of those complying with the recommendations (580 kg/ha) would result in a MARI equivalent to 1,000 kg of conventional cotton / ha. An average organic cotton yield of 600-650 kg/ha would make organic cotton production financially viable for the average cotton producer (average 1996/97 yield: 1,054 kg/ha).

Labour requirements are assumed to be higher in organic than in conventional cotton production. Labour costs have been excluded from the equation, however, as the regional opportunity costs for labour are a function of seasonality (Bruntrup, 1997). Higher labour demand for organic production is mainly due to gathering and transport of cattle manure for organic fertilization and, to a lesser extent, seed collection, pounding and higher number of applications of neem. These operations can be carried out during periods of relatively low labour demandwith the gathering of manure and neem seeds during the dry season, and pounding and spraying operations during August and September after the main weeding operations. The assumed higher labour demand of organic production is partially offset by a reduced labour charge during harvest time (lower yields), when opportunity costs are relatively high.

Analysis of the **ecological sustainability** of the 1997/98 organic cotton experiments was carried out through computation of data from Raymond and Beauval (1995) on cotton nutrient exports, Sement (1988) on nutrient composition of manure and official regional data on crop area and yield. Survey data from the programme indicated that average 1997/98 manure application was about 2,400 kg/ha (N=47). Thus, a theoretical nutrient balance could be drawn up to determine the ecological sustainability of regional agricultural production if synthetic fertilizer use in cotton were substituted by organic manure at 1997/98 application rates (Tables 2 and 3).

The analysis indicates that synthetic fertilizer use in cotton could be entirely substituted by organic manure applications, without disturbing the nutrient balance of regional agricultural production. This result should be explained by the fact that nutrient exports by cotton are a function of yield. As shown above, organic cotton production might generate the same revenues to farmers at much lower yields, i.e. less export of nutrients. If external markets for organic produce could guarantee the 20% price premium in the long term, organic cotton production might generate the same revenues while reducing nutrient exports by 42 %. If no price premium were guaranteed, organic cotton production would still generate the same revenues at 30 % less nutrient losses.

The common belief in West African research is that organic manure is not available in sufficient quantities to allow for complete substitution of synthetic fertilizer (van der Pol, 1992; Raymond and Beauval, 1995; Beroud, 1996). However, regional manure availability and regional inefficiency in manure use may very well justify *regional* substitution of synthetic fertilizer use. Data from official sources indicate that organic manure is theoretically available in northern Benin in sufficient quantities to maintain the nutrient balance of the current agricultural system. The question is *how* to optimize the use of locally-available organic fertilizers as substitutes for synthetic fertilizers.

Finally, it was found that neem seeds are available in sufficient quantities to satisfy the needs of the organic cotton programme in the near future. However, if all cotton in the region were to be protected by neem seed extracts, a lack of productive neem trees in the area would be faced. However, this could lead to resistance to neem products and there are numerous other organic pest management strategies that may be put in use. Future planting of neem trees is likely without external intervention if smallholders become used to using neem and are convinced by results in cotton and other crops.

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Table 1. Yields of organic cotton 1997/98 (in kg/ha), by: sowing date, number of sprayings, and level of fertilization.

Number of sprayings	< 7		7-11		> 11		
Level of fertilization*	1	2	1	2	1	2	Total
Sowing date							
June, 1-10	-	-	-	786	-	850	824
	(N=0)	*(N=0)*	*(N=0)*	*(N=3)*	*(N=0)*	*(N=6)*	*(N=9)*
June, 11-20	247	421	463	445	-	-	402
	(N=6)	*(N=11)*	*(N=4)*	*(N=14)*	*(N=0)*	*(N=0)*	*(N=35)*
June, 21-30	224	327	340	372	600	290	357
	(N=1)	*(N=4)*	*(N=6)*	*(N=12)*	*(N=1)*	*(N=1)*	*(N=25)*
July, 1-10	246	263	362	302	-	-	287
	(N=6)	*(N=7)*	*(N=2)*	*(N=4)*	*(N=0)*	*(N=0)*	*(N=19)*
Total	245	352	410	429	600	692	404
	(N=13)	*(N=22)*	*(N=12)*	*(N=33)*	*(N=1)*	*(N=7)*	*(N=88)*

* - Level of fertilizer: 1 = less manure than recommended 2 = amount of manure recommended, or more.

Table 2. Nutrient balance of the agricultural system in the Kandi district, 1996/97 (in kg/ha), with conventional cotton cultivation.

NUTRIENT BALANCE				N	P_2O_5	K_2O
Imports						
application of synthetic fertilizers (150 kg/ha : 100 kg of NPK and 50 kg of urea) on cotton				14.8	9.2	5.6
Exports						
crop	source of exports	% of total ha	yield (kg/ha)	N	P_2O_5	K_2O
cotton	seed cotton, plant residues burnt	40	1,054	9.2	4.1	5.8
maize	25 % grains sold, 25 % plant residues burnt	24	1,714	2.7	1.2	2.2
sorghum	25 % plant residues burnt	16	800	1.0	1.4	4.8
peanuts	no exports	14	1,345	-	-	-
cow pea	no exports	5	631	-	-	-
total		100	n/a	12.9	6.7	12.8
Nutrient balance						
conventional cotton : 1,054 kg/ha				+ 1.9	+ 2.5	- 7.2

Source: from CARDER (area and yield), and SRCFI/IER (Mali) cited in Raymond and Beauval (1995).

Table 3. Theoretical nutrient balance of the agricultural system in the Kandi area (in kg/ha), with organic cotton cultivation.

NUTRIENT BALANCE				N	P_2O_5	K_2O
Imports						
application of cattle manure (2,400 kg/ha) on cotton				9.2	6.2	17.8
Exports						
crop	source of exports	% of total ha	yield (kg/ha)	N	P_2O_5	K_2O
cotton	seed cotton, plant residues burnt	40	613	5.4	2.4	3.4
maize	25 % grains sold, 25 % plant residues burnt	24	1,714	2.7	1.2	2.2
sorghum	25 % plant residues burnt	16	800	1.0	1.4	4.8
peanuts	no exports	14	1,345	-	-	-
cowpea	no exports	5	631	-	-	-
total		100	n/a	9.1	5.0	10.4
Nutrient balance						
organic cotton : 613 kg/ha				+ 0.1	+ 1.2	+ 7.4

Source : Ibid.