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Diversity of soil fertility management practices in sudanian zone of Benin (Western Africa)

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Abstract

Various soil fertility management practices are observed in the Sudanian agrarian zone of Benin. This study highlights some traditional practices such as agroforestry, fallow, animal parking, use of crop residues as organic fertilizer, post-harvests of grasslands, farming associations and rotations, which were commonly used by 67% of farms. Five variant of agroforestry system were observed: **(i)** woody parks with *Parkia biglobosa*, *Vittellaria paradoxa*, *Adansonia digitata* and *Ceiba pentadra*; **(ii)** fields pioneers on forest territories; **(iii)** agricultural plots planted with fruit-lofts of *Anacardium occidentale* and *Mangifera indica*; **(iv)** shifting cultivation using *Eucalyptus camaldulensis*, *Acacia auriculiformis* and *Leucaena leucocephala*; **(v)** fallows planted with *Tectona grandis* and *Gmelina arborea*. This traditional system is more largely used, as well as planted fallows of fruit trees, collective grazing fallows under contracts and fixed parking of sedentary herds. Crop residues and domestic wastes are largely exploited. Revenues from grasslands post-harvests were higher than those from leguminous plants and foster the control of flows of post-harvests residues and the development of mechanisms that guarantee grasslands. The cereal-leguminous plants account for 63% of farming associations, and are observed where the organic manure is less commonly used. Successions of cotton by cereals are associated with significant depletion in mineral while those of cereals by leguminous resulted in nitrogen gain. The improved practices such as improved parks, composting, cropping of plants that enhance soil fertility (i.e. *Vigna unguculata*, *Glycine max*, *Mucuna pruriens*, *Cajanus cajan*, *Aschynomene histrix* and *Moringa oleifera*) were adopted. Adoption rate of "Biological Cotton" increased by 8% per year and yielded 600 kg of cotton per ha while the non biological cotton showed 980 to 1200 kg per ha. It reduces investment costs, risks in animal and human health and enhances agroforestry practices. Improved cropping techniques such as thinning, flat ploughing, application of optimal quantities of mineral manure and of organic manure were successfully adopted by 25%, 52%, 71% and 55% of farmers respectively.

Keywords: Benin, diversity, fertility, management, practice, soil, Sudanian agrarian zone

Introduction

The agricultural landscape in northern Benin highlights some traditional as well as "improved" soil fertility management practices which have proven as consuming less space. Their importance was already indexed in sahelian traditional societies (Boulier & Jouve 1990, Landais & Lhoste 1993). These practices define farming systems. The landscape was affected by the abandonement of fallow areas, developing overused areas and increasing the use of unproductive land. To maintain the soil fertility in the current increasing demography context requires some detailed knowledge on practices for sustainable landuse. This work presents the typology of soil fertility management practices throughout monographs of farming systems and an analysis of the Sudanian agrarian space in Benin.

Study area

The district of Kandi in northern Benin (10°45'-11°27' Lat. N; 2°38'-3°16' Long. East) covers 3480 km² with 76% used for agriculture and livestock breeding. Average temperature is 28.8°C. Relative humidity ranges from 7 to 100%. The sunny period during research accounted for 2.900 hours. Potential Evapotranspiration was 1373.75 mm and Rain ranged from 900 to 1200 mm. Soils are brown mineral on slopes, skeletal on plates, deep on plains, hydromorphic in depressions. Vegetation comprises of shrubby savannas, timber plantations, post-farming and riparian forests. Human density ranges from 52 to 65 habitants/km^2, balancing the national rate of 48 habitants/km^2. Nine Sociocultural groups live in the study area: Mokolé, Dendi, Peuls, Gando, Bariba, Djerma, Yoruba, Boko and Haoussa. Mokolé, Bariba and Gando, all of these are farmers, and in addition the Peul, who are lifestock breeders. The Dendi, Yoruba and Haoussa are also tradesmen. The land use is based on heritage, loans, gifts and first occupation. Male groupings are devoted in inputs provisioning, cotton marketing and in financing community activities. Women work in food transformations, marketing and the elimination of illiteracy and are highly open to new technologies.

Methodology

Target groups, surveyed stakeholders & plots, Data collection: Investigations were carried out on 3 scales: (i) 5 agro-systems (one per subdistrict) were sampled: Fouet, Alfakoara, Gogbèdè, Padé and Lowa, with a total of 316 stakeholders; (ii) 31 stakeholders were chosen using principle of representativeness and discrimination by diversity in plots, crops and followed husbandries; (iii) Plots previously spread by wastes, composts, improved technical procedure were sampled. Old farms, cropping techniques (sowing, fertilization, crops maintenance, phytopathology, harvests, and post-harvest operations) were recorded and monitored by questionnaires. A 5 months survey, with 5 days per month per agro-system lead to record the current soils fertility management practices and strategies, profiles, applied techniques and cultivation actions. The economy of compost and cotton was estimated based on the market prices during 1996-2002.

Data analysis: Practices of soil fertility management were analyzed using the traditional diagram Opportunity-Method-Effectiveness suggested by Landais (1986). We determined (i) practices; (ii) external description of practices and (iii) descriptions of their effects and consequences. An alternative method was highlighted by *in situ* investigation of effects of the practices on the systems status in time and space, taken .from concepts of "experiments without interventions" and "comparative analysis" (Landais *et al.* 1988).

Results

1. Traditional Practices of soil fertility management

A) Five **agroforestry systems** occurred in Kandi (Fig. 1): (i) Park of *Parkia biglobosa*, *Vittellaria paradoxa*, *Adansonia digitata* and *Ceiba pentadra* on agricultural lands (PAL) with agro-stockbreeders and lifestockbreeders; (ii) Fields pioneers on forest lands (FPFL) set up by the UNSO project; (iii) Planted Plots of Fruit-lofts (*Anacardium occidentale* and *Mangifera indica*) (PPFL) with farmers; (iv) Shifting cultivation alterning crops and woody hedges by *Eucalyptus camaldulensis*, *Acacia auriculiformis*, *Leucaena leucocephala* (SCWH) with farmers; (v) Planted fallows of *Tectona grandis* and *Gmelina arborea* (PFTG) with farmers and agro-stockbreeders. The Park system was widely practised, followed by planted fallows, plots planted of fruit-lofts, and shifting cultivation with

woody hedges. **B) Fallows** cover 0.4% of total area with 26% of farmers having agricultural land exceeding 15 ha. Lands used 7 years returned in 10 years fallow with farmers and agro-stockbreeders; those used 5 years' for 2 years with agro-stockbreeders. 25% of farmers used Planted fallows and collective grazing fallow, which is governed by contracts with stockbreeders. Short fallows (<7 years) on small areas (<6 ha) belonged to 62% of stakeholders, and the shortest one (3-7 years) were strongly grazed. **C)** In **turning parking** (Fig. 2)**,** post harvested fields were grazed for 15 hours per day in October-November and bovine transhumance every 15 days. Grazing and fallow respectively in dry and rainy seasons occurred on 1.5 to 6 ha. During **seasonal parking** (Fig. 2)**,** moving herds grazed under contracts for 6 dry season weeks, some post harvested fields, which were used to produce maize. In **stationed parking** (Fig. 2)**,** apart from a lack of carts, wastes were well distributed. Corn fields were grazed in dry season by moving herds (952.8 UBT) from Burkina Faso, Niger, and Nigeria.

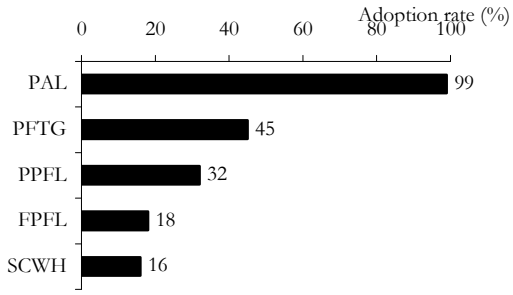

Fig. 1: Agroforestry parks in Kandi (N=31)

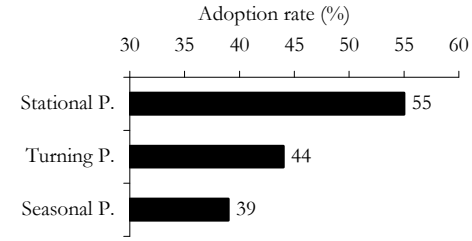

Fig. 2: Animal parkings in Kandi (N=31)

D) In **residues hiding and domestic wastes**, balking was preferred to ploughing (61% of farmers). **E) Revenues of post-harvest grazing** control residues flows. The running costs depended on the type of plot, herd size, duration and grazing frequency. To graze leguminous plots costs more than grazing corn and cotton plots (Table 1). **F) Farming associations** highlighted cereal-cereal and Cereal-leguminous in systems out of chemical manure use (Fig. 3). Corn, sorghum, groundnut and bean were associated, and more frequently with 67% of stakeholders. G) **Successions** were Cotton/Cereal and Cereal/leguminous/cereal. Leguminous were frequently associated with sorghum and corn.

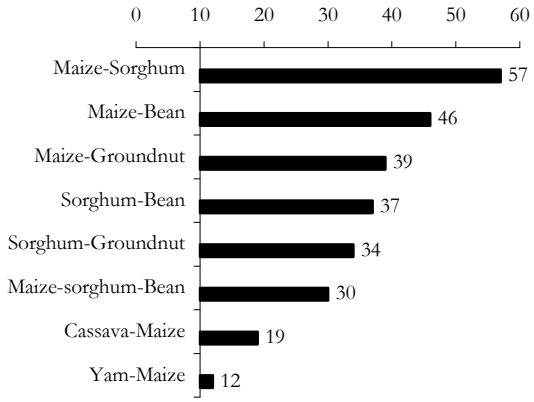

Fig. 3: Adoption rate of crops associations

Table 1: Post harvested grazing revenues in soil fertility management in Kandi

Post harvested plots	Grazing period	Bovine herd size	Grazing duration	Grazing frequency	Grazing revenue (€/UBT /ha)
Cotton	December - February	<50	2-4 h	1-3 grazings	0.39-0.46
Maize	October - November	≤50	1-4 h	1-2 grazings	0.54-0.69
Sorghum	November - January	<50	2 h	1 grazing	0.62-0.92
Bean & Groundnuts	November-December	≤25	2 h	1 grazing	1.15 -1.54

2. Improved Practices of soil fertility management

A) Improved parks ruled where compost was not used (Fig. 4). Monthly, 4 bovines were stationed on 5 m diameter carpet of farming residues and fodder straws (*Andropogon spp, Panicum spp, Hyparrhenia, Pennisetum spp*). Litter was accumulated per week in rainy season and every fifteen day in the dry season to each 20 cm thickness. Food complementation enriched in coarse elements was provided to animals. Manure was stored and conserved under hangar in season of rain and in pits

dunghills in dry season for application in April-May. **B) Composting** was used in agricultural soils and interested 50% of women (Fig. 4). Two pits of 2 m x 1,5 m x 1,5 m on branches lattice, were equipped with cereal straws and chopped grasses (*Panicum spp., Pennisetum spp., Hyparrhenia spp.*), in rowed layers and strewn with old manures. A layer of rough manure of 5 cm succeeds 20 cm thickness layers. The grinding stone was sprinkled with 4 water buckets and covered with sheets of *Borassus aethiopum, Hyphenae thebaïca* or with soil. Each grinding stone was stirred up after 3 weeks. The compost rate of 3t/ha was used to produce biological cotton, and 2t/ha for the corn before sowing. Averages of biological cotton areas were 0.5 to 2.5 ha. Yields ranged from 1.5 to 2 t/ha in corn grain and 0.5 t/ha for biological cotton. Invasive plants pressure was reduced on treated plots. Compost production costs 92.31 to 117.31 €/ha and for its utilization about 26.92 €/ha.

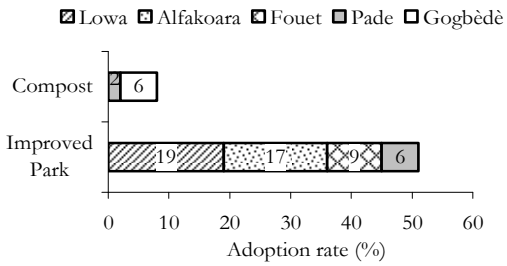

Fig. 4: Manure production practices in Kandi

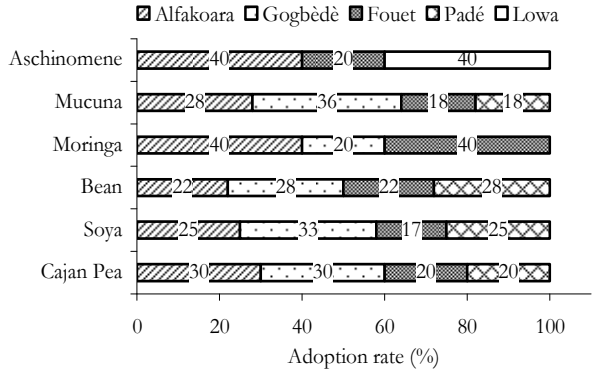

Fig. 5: Improving plants used in Kandi

C) Various **Improving plants** were adopted in rate depending on plants and farms (Fig. 5): *Vigna spp* (52%), *Mucuna utilis* and *M. pruriens* (35%), *Glycine max* (39%), *Cajanus cajan* (32%), *Aschynomene histrix* (16%) and *Moringa oleifera* (16%). These plots were used to produce exclusively corn and biological cotton biannually. **D) Biological Cotton** production occurred where no chemical fertilisers were used for 3 years. Activities were: Ploughing with 10 t/ha of compost, sowing on 40 cm x 40 cm, applying weeding twice before a weeding-ridging, and a pulverization every 7 days of 1 kg/40L/ha of *Azadirachta indica* seeds pulp. Cotton was harvested after 180 days, and subsequently stored, packed and labelled. Biological cotton was produced in 29% of villages. Adoption rate depended on years and ranged from 45% in 1996 to 53% in 2000 with increased area (157%). Yields averaged 285 kg/ha in 1996-1997, 425 kg/ha in 1997-1998 and 610 kg/ha in 1998-1999. Yield Modelled with Logarithmic curve resulted in 250 kg/ha in 1996 and 1 t/ha in 27 years. Comparative profitability was 13.5% lower than 33.5% for the non biological cotton. **E)** The **improved cropping techniques** depend on the prevailing agro-system. About 25% used thinning out, 52% ploughed flat, 71% used chemical manure while 55% used organic manure. Preference was high for balking with the flat ploughing by 65% of farmers while thinning is missing with stockbreeders.

Discussion

1. Traditional Practices of soil fertility management

(a) The agro-forestry park provides wood, fodder and medicinal products, reducing the failure level of populations. In semi-arid Kenya, corn fields are strewn with trees using 2 times more rainwater than in full overdraft (Wolf *et al.* 1990). In sudanian Senegal, the best mixture productivities resulted from maintenance of 25 trees/ha (Akpo 1993). (b) The interest for animal parking might be related to the inexpensive transfers ensured by animals with an even waste plots distribution (Landais & Lhoste 1993). Since 600 kg of dry matter by UBT are deposited annually, the improvement of soil fertility management requires increasing herds' size. (c) The hiding of crop waste products was limited by skeletal soils flat ploughing, and the Park W herds i.e. bovine and elephants overgrazing. (d) The revenue of post-harvest grazing reduces grazing pressure on agricultural wastes, guarantying mineral contributions and reinforcing the soil structural stability (Pieri 1989). Mixing chemical and organic

manures produces 1.5 to 2 t/ha for corn against 1 t/ha from chemical manure in the rate of 200 kg/ha (Gandy 1993).

2. Improved Practices of soil fertility management

(a) Change in the rate of improved parks adoption from stockbreeders to farmers might be related to: (i) a weak cart distribution and low manpower availability; (ii) a weak sensitizing and educational level of owners and managers (17%). Success in southern Mali depended on the herds grouping management and carts availability (Landais & Lhoste 1993). (b) Both composting and biological cotton techniques were practiced together where land pressures occurred. Outputs were economic for corn which was produced without urea (1.5 t/ha) and the same applies to groundnuts (1 to 2 t/ha) (Gandy 1990). (c) Biological cotton production was constrained by lack of equipment, land tenure with doubled bloom, low availability in *Azadiratcha indica* seeds and natural insecticides including *Capsicum frutescens* which cost 0.25 to 0.45 €/litre. Debt and health risks were minimized and pit inputs and compost dunghills were easily accessed. Plot insulation, cropping turning and doubled bloom needed to be amplified. The biological cotton production requires the use of both chemical and organic manures. (d) Improved cropping techniques were slightly adopted. Weak thinning out application might be related to the low manpower/area ratio (57%) and the weak rate of illiteracy elimination (Jouve 1993). Balking was preferred to flat ploughing while the respect in the use of required amounts of chemical fertilisers was financially constrained.

Conclusion

Farming systems in Kandi integrated various practices for soil fertility management such as: (i) "traditional" (agroforestery, fallow, parks, crop waste products, pooling and followings farming); (ii) "improved" (improved park, composting, improving plants, improved cropping techniques and biological cotton). The practice of biological cotton saved investments, limited health risks and developed agroforestry. In the transition to biological agriculture, fertilizing using locally available resources could be well developed and the constraints to manure transportation could be lifted. Complete equipment for a harnessed production and certification are also needed.

Acknowledges

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