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Soil organic inputs and water conservation practices are the keys of the sustainable farming systems in the sub-sahelian zone of Burkina Faso

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ABSTRACT

The sub-sahelian region is confronted to demographic growth and climatic change that impeded the sustainability of environmental resources. Harmful changes in environmental conditions could be compensated by the adaptation of farming practices.
In Ziga, located in yatenga region, a research program was occurred between 1980 and 1987. In 2005, a survey in the same village was carried out to assess the evolution of farming practices. According to the enquirie made, two practices, called “zaï” and “djengo”, were largelly used to cereals crops. The characteristics of “zaï” and “djengo” practices have been assessed. The practices effects on grain crop yields were measured.
The “zaï” characteristics depend on the farm manure availability. In addition, another practice has been noticed in Ziga that was not described in previous works. As the “zaï”, the “djengo” practice associated, soil and water conservation techniques and organic matter localized supply. In the case of “djengo”, the micro-basin is dug after the first rain. The “djengo” was less expensive in time. These two practices revealed a strategy of farming systems intensification by localization of organic and mineral fertilization, as well as a better management of rainwater. Thus, these practices increased significantly grain crop production. Results also showed that a large tree regeneration occurred in Ziga where “zaï” or “djengo” practices were used.
This study highlight that it is necessary to control soil water and manage organic matter resources in farming systems to ensure agrosystem viability as a key of green revolution in the sub Saharan region.

KEY WORDS: soil, sustainability, farming practices, zaï, djengo, Yatenga.

1. Introduction

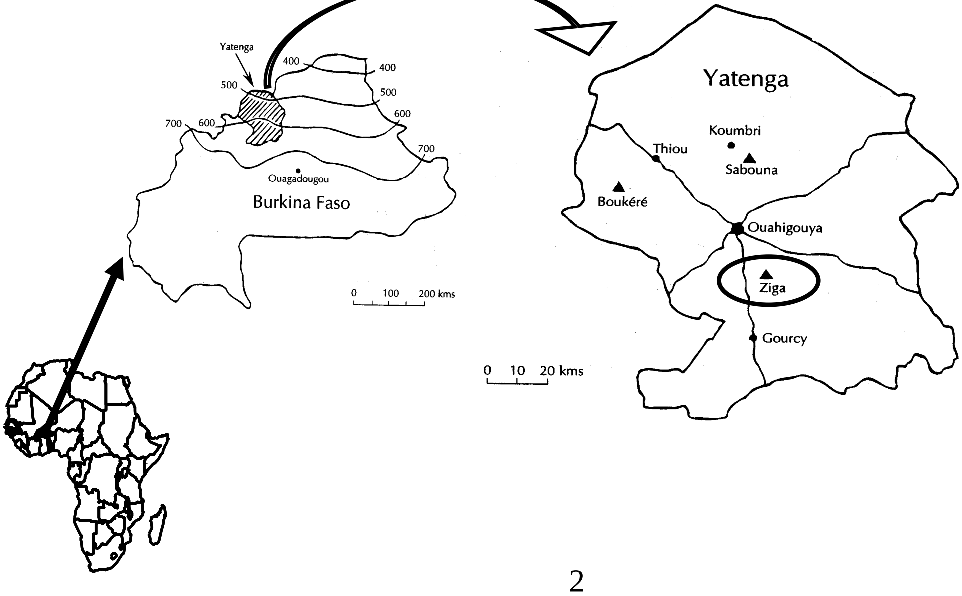
Maintaining soil fertility is vital for sustainable soil productivity, especially in resource-poor countries (Yang, 2006). Sub-Saharan African (SSA) countries have registered a continuous demographic increase these last decades (Jouve, 2005). This growth is about 3% per year, which results in a twofold increase of the population every 25 years. In this regard, what is the capacity of natural resources such as soils to support this demographic growth and how can agriculture contribute to food security?
Studies for several years have shown an increase of exploited areas for agriculture and grazing. This increase was done at the expense of natural forests and long-term fallows, considered to be the fulcrum of soil fertility management in West Africa savannahs. This has resulted in a reduction of fallow duration over the past few decades from duration of more than 20 years to less than 6 years (Bilgo *et al*., 2006). Consequently, soils degradation processes and fertility losses set in and this involved an increased vulnerability of farming systems, in particular during periods of drought.
In Northern Burkina Faso, and the Yatenga in particular, soil degradation was mentioned by Marchal (1983) with the appearance of "zipellés". Because of natural (climate) and anthropic phenomena, the increased degradation of soil in Yatenga involved the formation of stripped glacis

whose importance becomes worrying (Dugué, 1986; Kambou and Zougmoré, 1985). The drought years compelled many peasant families to leave their villages and to settle in regions of higher rainfall elsewhere in Burkina Faso (McMillan *et al*., 1990) or in coastal countries, particularly in Ivory Coast. Others were attracted to urban centers (Reij *et al*., 2005). These dynamics illustrate the relations between population and environment such as conceptualised by the neo-Malthusians thesis, contrary to those developed by Boserup. The first indicates that the increase of population involves land degradation and soil loss of soil productivity, which are solved by migration or rural exodus.
However, another choice for solving soil productivity degradation is to adapt farming practices to natural resources (soil, vegetation), to new pedoclimatic and socio-economic conditions (Boserup, 1970). These changes of practices, which relate to the fight against erosion and water conservation, the intensification of farming systems, make it possible to maintain or to restore agricultural production to support the rural population.
In Yatenga for twenty years, SWC practices as “zaï” and “djengo”, which combine water conservation and organo-mineral fertilization have been developed by farmers. These practices have modified soil productivity, and necessarily lead to a change in field monitoring, working force management, organic matter flux in farming systems and territory scales.
Many research institutes carried out studies in Ziga village in Yatenga. That village also benefited from NGO’s actions from 1980 to 1985 (Dugué, 1989). It was interesting to evaluate a few years after, the importance of husbandries changes. Results will contribute to promote debate on population growth and dynamic of environment.
The study aims are to: (1) to describe and make a comparative analysis of two practical innovations of organic manure use; (2) to appreciate the effects on farming systems (cereal yields, household food security) and their global effects on environment.

2. Materials and methods

2.1. Study area

This study was conducted in the North of Burkina Faso at Ziga (13°25’N, 2°19’W), a village in the Yatenga district (figure 1). This village, like the other parts of Yatenga is densely populated (70-100 dwellers/ha) by Mossi, Fulani and Dogon ethnic groups. Ziga is subjected to the rain hazards. Its average annual rainfall is between 400 and 800 mm. Since 1921, annual rainfall averages have decreased continuously up to 1990 and a light improvement over the past decade has been registered. Soils are mainly classified as ferric leptosols (FAO, 1998). They are generally not very deep and poor in organic matter.
Fig 1. Study area location



2.2. Study methods

Farms choice
At the initial state of the study, a pre-inquiry was conducted with a sample of 44 farmers in the village, randomly taken in the three neighbouring villages: Bossomboré-Yakin (BY), Biingwéogo (BW) and Légoum (LG). Then a distinction between farms was done, according to their inputs. Selection criteria were mainly: (i) plot surface and working force importance; (ii) livestock size and manure availability; (iii) farm equipment availability. Afterwards, 18 farms were chosen for inquiries. In this sample, we have distinguished 9 well tented (inputs) farms and 9 others unkempt. Farms in-between were excluded.
Inquiries
In implementing inquiries, many visits (2, 3, 4) were required on some farms. The main topics treated are summarized in the following three points:

- Farm assets: crops plots, equipments, livestock, etc.;
- Manure use and others SWC practices;
- Farm yields assessment in 2005 according to each manure practice.

Manure use practices description
For practices description, we used squares of 9m^2 (3m x 3m). These squares were placed on various plots, for comparing various farming systems which have different uses of manure (zaï and djengo), as well as making a comparison between zaï and direct sowing or sowing after ploughing. Their effects on crop yields have been assessed by agronomic measurements. In this respect, the following parameters were considered:

- zaï or djengo basin size (width, depth, diameters): shaped holes, the largest diameter (diameter 1) is distinguished from the smallest one (diameter 2) ;
- manure quantity (dry matter /ha) : while the farmer is putting manure into seed holes, he is sometimes asked to hand over the manure in his hand. That manure is collected in a little plastic bag; then, it is dried and weight. In each 9 m^2 square, this operation is renewed three times ;
- zaï or djengo basins density, time for digging holes in 1ha settlement, yields components.

3. Results and discussion

3.1. Farms main characteristics

Cultivated area, workers number and area/ worker
Results show that large farms have an average of 6,3 ha against 3,7 ha for the small ones. But it should be noted that farms at LG district are larger. Field dimensions vary according to the districts: it decreases gradually from LG to BW and finally to BY where cultivated areas are tiny. That undoubtedly indicates a stronger land pressure on BY, depending on its easy accessibility.
In addition, workers number per farm varies from 9 to 14 for large farms as against 3 to 6 for small ones. On average, the large farms have 2 or 3 times more workers than the small ones.
Labour productivity expressed by cultivated area per worker is higher on a small farm than on a large one and irrespective of the agricultural district. Considered from the large farms to the small ones, these values are respectively: 0,5 ha and 0,93 ha (BY), 0,63 ha and 1,15 ha (BW), 0,57 ha and 0,72 ha (LG). Large farms with their workers and equipment do not try to extend their cultivated areas. They are obviously brought to work on reduced areas. Would that be a sign of agricultural intensification in Ziga village ?

Livestock number and manure potential production

Large farms are logically those which have more livestock. By Taking account all the districts we observed that the BY district has the larger farms with more than 15 oxen, 15 sheep and goats each one (figure 2). Small farms do not have cows but only some sheep and goats (less than 5).

Moreover, this is an average and concealing the disparities between farms because some do not have any animals.

Farm potential manure production (fine powder) was obtained by taking as assumption 1 ox = 1 TBU (Tropical Bovine Unit) , a small ruminant = 0,1 TBU and by considering that 1 TBU produced 1 ton of dung (dry matter per year). This potential manure per farm is very variable, according to cattle availability. Some farms have a potential production of almost 22 t/year while others have less than 1 t/year. If we consider a homogenous spreading of this fine powder on all the cultivated area, farms which can yield 5t/ha of organic manure (national recommended dose) to satisfy their needs are scarce.

But, comparing cattle dung production (Q2) on the farm and quantities of organic manure brought this year on the field (Q3), we noticed that all the farms use more manure than they can obtain from their own cattle dejections (Q3 > Q2). So, farms have other sources for manure (household refuse, crops residues, etc.).

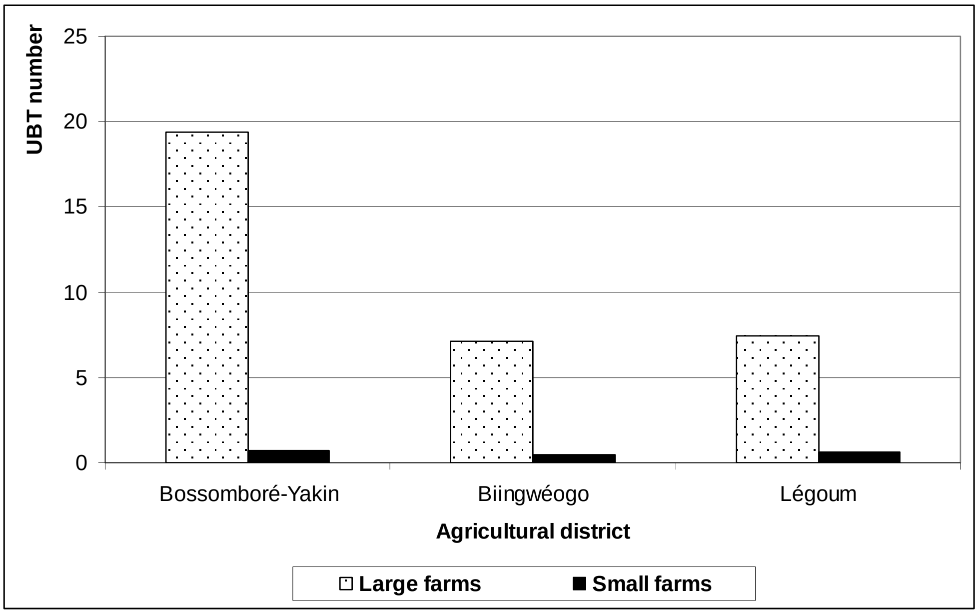


Fig. 2. Manure potential production and livestock number

3.2. Organic manure practice

Analysis of these practices may help us improve them by the use of modern technologies like complementary mineral fertilization, herbicides, selected seeds and mechanization. Conversely, observation of efficient traditional practices may help us to diagnose the physical and human environment (Roose *et al.*, 1999).

Zaï, one name for different practices

In the Moore language, “zaï” is derived from the word “zaïegré”, which means : “wake up early to prepare the seedbed”.

With regard the same zaï practice, the study highlighted many ways of doing it. Up to 53% of farmers keep in line with the current spirit of zaï: basins are dug and manure is put into these basins in the dry season. But other ways for practicing were noted. This “diversity of zaï” is reflected in three basic characteristics: basins digging period, sowing period and manure spreading or not. Results show five ways of implementing (figure 3).

This typology can be explained by the lack of manure or the lack of time for other farmers. Moreover, the beginning of the rainy season is whimsical and its lasts approximately one month (rain may start at the end of May or at late June). Zaï practiced in the rainy season will be predominant when the rainfall sets in earlier.
Diversity of zaï practices is also reflected through reopening the holes of the previous year on the same plot or digging new ones. Indeed, the analysis of the periodicity of use of the zaï reinforces the idea according to which there is not just one “standard” zaï practice but various ways around this practice.
Thus, five ways of implementing zaï were observed :

- 37,5% of farmers practise zaï every year on the same plots in a basin dug the previous year. Taking into account soil type, year n^{-1} basins disappear. Thus, the basins in year n are randomly made, without taking into account preceding basins ;
- 37,5% of surveyed peasants make zaï in a permanent way by using continuously the same basins for several years. In this case, each year, year n^{-1} basins are re-opened and manure brought again ;
- 12,5% of farmers make zaï 1/2 years in the same basins on the same fields. These farmers, after practising zaï in year n, make a direct sowing in year n^{+1};
- 6,25% of peasants make zaï two years over three in the same basins of the same plot. Thus, after two years of successive zaï practice, they discontinue it and in the 3rd year thus proceed with a direct sowing for one year and revert to zaï practice for another three years.
- The last type of zaï (6,25% of surveyed) is related to farmers’ about an herbaceous biomass apparition on completely stripped soils, in particular in-between basins. Thus, they dig the basin of the year n^{-1} in order to the remains of the roots and the fine rich soil containing more organic matter to enrich spaces of inter-seed holes. Thus, basin localization remains fixed from one year to another.

Table 1 described some parameters of cultivated plots with sorghum according to zaï practice. Basins density is 23 210 ha^{-1} on large farms against 33889 ha^{-1} for small ones. It takes on average 68 days and 52 days for a worker to dig one hectare of zaï, respectively on large and small farms. In addition, zaï basins sizes are significantly different from large to small farming systems. Indeed, small diameters measure 32,9 cm and 23,5 cm respectively for large and small farms. Large diameters are 36,4 cm and 26,6 cm respectively for large and small farms. As for the depth, it is 10,6 cm for large farms and 10,3 cm for the small ones. Large farms tend accommodate big size basins, contrary to small ones. As much like holes dimensions, manure quantity in zaï basins is higher for big farmers who have an important production of manure. It is brought on average 542 g.cuvette-1 on large farms against only 230 g.cuvette-1 on small-scale farms, which corresponds to 12,6 t.ha-1 and 7,8 t.ha-1, respectively in both cases.

Fig. 3. Various types of zaï during fields priming (O.M = Organic Matter)

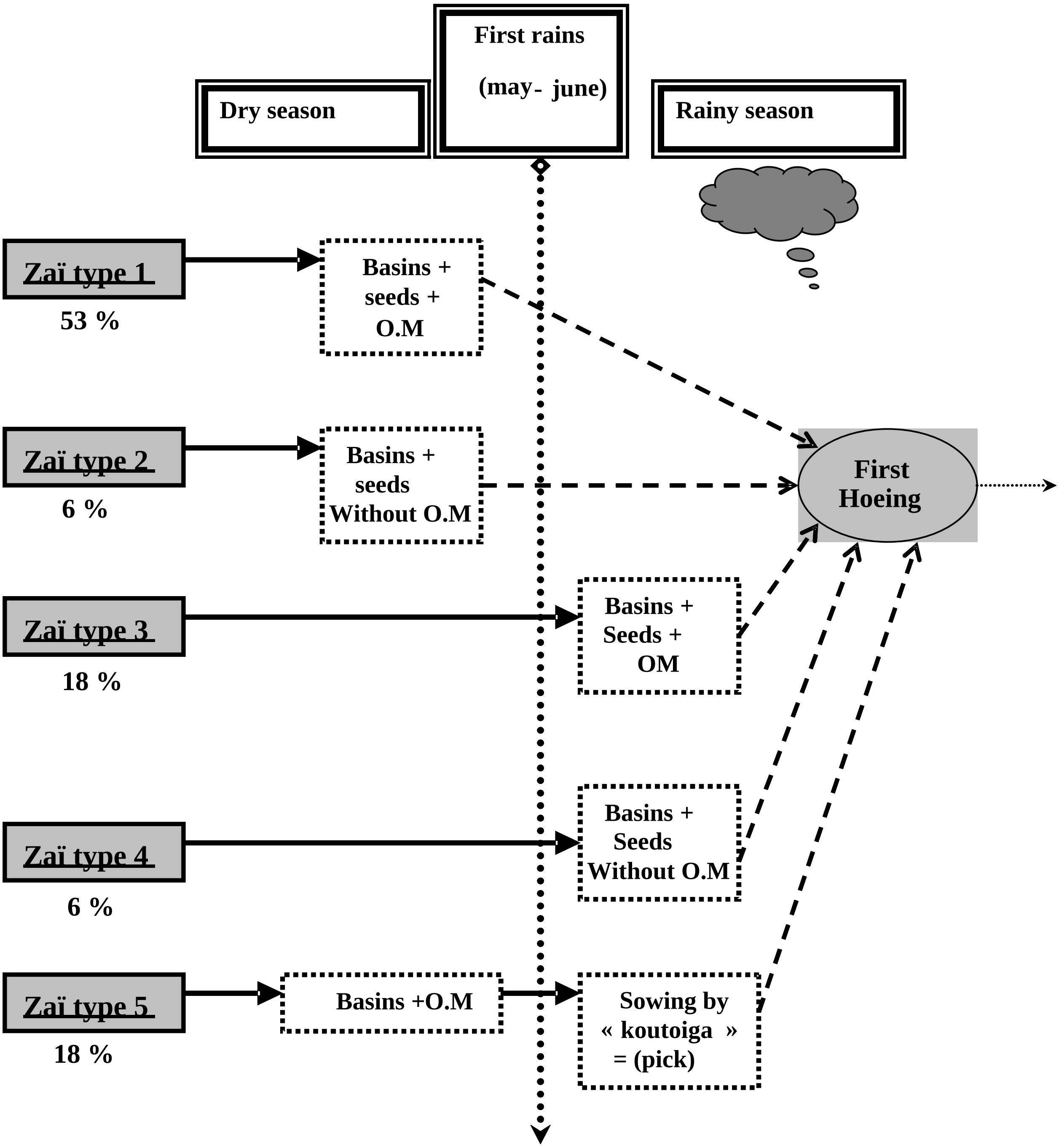


Table 1 : Characteristics of zaï and djengo practices

Practice	Farms	Basins density (number/ha)	Time for laying out 1ha (days/ha)	Diameter 1 (cm)	Diameter 2 (cm)	Basin depth (cm)	Manure quantity/ basin (g)	Manure quantity (t/ha)
	LF	23 210	68	32,9[a]	36,4[a]	10,6**a**	542**a**	12,57
Zaï	VC (%)			7,0	6,1	9,8		
	SF	33 889	52	23,5[b]	26,6[b]	10,3**b**	230**b**	7,77
	VC (%)			5,9	6,3	9,5		
	LF	41 481	15	26,9[a]	26,7[a]	7,0[a]	211,1[a]	8,76
Djengo	VC (%)			11,1	9,0	15,5	12,8	
	SF	38 889	24	22,5[a]	27,1[a]	8,3[b]	173,4[a]	6,74
	VC (%)			8,9	5,5	9,0	6,6	

LF: large farms; SF: Small farms; VC: Variance coefficient
Numbers followed by the same letter in a column are not statistically different ($P < 0,05$) for the same practice

Djengo, another practice in the use of manure

The other SWC practice similar to zaï was seen in Ziga and it is called “djengo”. The name djengo indicates the tool, a hoe with long handle, used to carry out this practice. It is practiced on sandy soils in large majority and exclusively after the beginning of rainy season. There are also several alternatives in djengo practice, which are:

- Djengo 1 (27%): “basins digging after weeding + sowing + manure”: in this case, basins are made in a already weedy plot, and then manure is brought and sowing is done ;
- Djengo 2 (33%): “basins digging after weeding + sowing without manure”: this alternative is close to the preceding one, except that it excludes the use of manure;
- Djengo 3 (33%): “basins are dug after ploughing + sowing + manure”: after ploughing, peasants make rather broad basins in this furrow. Then they put manure into the basins ;
- Djengo 4 (7%): “basins are dug after ploughing + sowing without manure”: here sowing is done without fertilizers.

From one year to the next, djengo practice remains the same for all the surveyed farmers. Indeed, whatever djengo type, basins localization is variable from one year to another.

As djengo characteristics, a relative homogeneity of the number of basins has been observed (an average of 38889 to 41481 basins.ha-1, respectively for large and small farms) and time for laying out cultivated plots (15 to 24 days.ha^{-1}, respectively for large and small farms) (table 3). In the same way, basins size in djengo are not significantly different between the two types of farms : (i) small diameters: 26,7 cm and 22,5 cm ; (ii) large diameters: 26,9 cm and 27,1 cm and finally (iii) depths: 7,7 cm and 8,3 cm. The quantities of brought manure in djengo reach 8,76 t.ha-1 on large farm vs. 6,74 t.ha-1 in small ones.

Differences between zaï and djengo are synthesized in table 2. Zaï and djengo differ above all by the used tools. The tool used for digging zaï basins is called “boamboara” and has a short curved handle, with a blade. Djengo tool has a long handle. This difference in handle size induces a difference in the worker position: to dig zaï holes, the worker bends down, while djengo is done in an upright position. Moreover, zaï holes are larger than those of djengo, whatever the nature of the soil. The offshoot of this entails more manure per basins (or per ha) in zaï than djengo (table 1). Also, zaï is generally carried out in dry season on very massive and encrusted soil while djengo is made exclusively on sandy soils after the beginning of the rainy season.

Table. 2 : Summary of key differences between zaï and djengo practices

Elements of difference	Zaï practice	Djengo practice
Tools	Boamboara	Djengo
Basins density	27 481[a]	39 753[b]
Time for laying out 1ha	62[a]	21[b]
Basin diameter 1 (cm)	31,3[a]	25,8[b]
Basin diameter 2 (cm)	35,1[a]	26,8[b]
Basins depth	10,9[a]	7,4[b]
Manure quantity (g/basin)	417,3	185,7
Manure quantity (t/ha)	10,7	7,4
Soil type	loamy soils as a majority	Exclusively on sandy soils

Period	Dry and rainy seasons	Exclusively in rainy season

Numbers followed by the same letter on a line are not statistically different (P < 0,05)

Table 3.a : Pearson correlation test (parametric test) between yield and its components

Yield component	Sorghum (n=52)		Millet (n=15)	
	Correlation Coefficient	p-value bilateral	Correlation Coefficient	p-value bilateral
Bunch number.ha^{-1}	-0.164	0.246	**-0.801**	**0.0001**
Stems number.bunch^{-1}	0.293	0.036	0.497	0.056
Ears number.stem^{-1}	**0.630**	**< 0.0001**	0.103	0.715
Grains number.ear^{-1}	**0.610**	**< 0.0001**	**0.753**	**0.001**
Grain mass (g)	0.277	0.048	0.38	0.162

Table 3.b : Sorghum Yield (grain and straw) and its components (mean ± se) for different agricultural practices at Ziga, Burkina Faso. ANOVA and Newmans-Keuls means comparison test (means with the same letter belong to the same group)

Variables	Direct Sowing (n=20)		Djengo (n=9)		Zai (n=23)		F Fischer	P value
Bunch number.ha^{-1}	31107 ± 341	a	29336 ± 200	b	28884 ± 328	b	13.4	<0.001
Stems number.bunch^{-1}	3.09 ± 0.15		3.51 ± 0.22		3.69 ± 0.23		2.52	0.091
Ears number.stem^{-1}	0.57 ± 0.05		0.47 ± 0.03		0.49 ± 0.04		1.522	0.228
Grains number.ear^{-1}	716 ± 69	b	920 ± 127	ab	997 ± 77	a	3.54	0.037
Grain mass (g)	0.023 ± 0		0.021 ± 0.001		0.021 ± 0		2.68	0.079
Grain yield (Mg.ha^{-1})	0.93 ± 0.13		0.92 ± 0.16		1.1 ± 0.13		0.52	0.599
Straw yield (Mg.ha^{-1})	1.82 ± 0.19	b	2.32 ± 0.49	ab	2.96 ± 0.35	a	3.69	0.032

Table 3.b : Millet Yield (grain and straw) and its components (mean ± se) for different agricultural practices at Ziga, Burkina Faso. ANOVA and Newmans-Keuls means comparison test (means with the same letter belong to the same group)

Variables	Djengo (n=6)	Direct sowing (n=9)	F Fischer	P value
Bunch number.ha^{-1}	31423 ± 802	32943 ± 102	5.39	0.037
Stems number.bunch^{-1}	3.33 ± 0.13	2.78 ± 0.14	7.33	0.018
Ears number.stem^{-1}	0.53 ± 0.05	0.62 ± 0.05	1.39	0.26
Grains number.ear^{-1}	1350 ± 293	939 ± 79	2.62	0.13
Grain mass (g)	0.011 ± 0.001	0.012 ± 0.001	0.32	0.579
Grain yield (Mg.ha^{-1})	0.8 ± 0.17	0.59 ± 0.06	2.04	0.177

Straw yield (Mg.ha^{-1})	1.68 ± 0.5	1 ± 0.11	2.61	0.13

3.3. Effects of manure using practices on sorghum and millet yields

Cereals production data show that yields are correlated with grains number per panicle or per ear in the case of sorghum and millet (table 3.a). Comparison of sorghum yields according to various practices shows that there are no differences between grain yields of zaï, djengo and simple sowing (table 3.b). Nevertheless, zaï plots produced 1,1 t.ha-1 grains of sorghum against 0,92 t.ha-1 and 0,93 t.ha-1, respectively for djengo and direct sowing plots.
Millet results made it possible to compare the effects of the practices: direct sowing and the djengo, the zaï being a practice for sorghum (Kaboré, 2005). These results (table 3.c) show that there is significant difference between the two practices, neither on the grain and straw yields, nor between the components output. However, djengo allows a light profit of grain and straw per hectare, comparatively to direct sowing.
So zaï, carried out on encrusted soil makes it possible to have yields as good as those obtained on normal soil.

3.4. Effects of the use of manure on the regeneration of vegetation cover

The results of this study show also trees regeneration with the use of manure and stone bounds. However, this cover remains typical clear raised and shrubby savannas of soudanian zone. Indeed figure 4 presents various species regeneration (*Azadirachta indica*, *Eucalyptus camaldulensis*, *Adansonia digitata*, *Lannea microcarpa*, etc.). At the opposite, species like *Vitellaria paradoxa*, *Ziziphus mauritiana*, *Bombax costatum*, etc. are in regression. This regeneration has two origins: natural regeneration and plantation by farmers (especially for *Azadirachta indica*, *Eucalyptus camaldulensis and Bauhinia rufescens*).
For farmers, stone bounds stop woody species seeds and provide wet and rich milieu in nutritive elements, just upstream of the bounds. Seed lifting and the young plant growth are thus supported. Moreover, benefiting from projects and NGO assistance (exotic species supply), farmers reforested several of their cultivated plots. It is the case of *Bauhinia rufescens* and *Eucalyptus camaldulensis* species, which were introduced into the village by the R&D project and which, has since proliferated.
However, species as Vitellaria paradoxa disappears more than it does regenerate, which makes it a threatened species. Thus, in 20 years on 57 ha, nearly 100 *Vitellaria* trees disappeared. All the surveyed farmers allot this tree disappearance to climatic pejoration.
In summary: i) practices described previously (zaï and djengo) associated with stone bounds supported woody vegetation regeneration; ii) regenerated species are rather of the sahelian type, useful for firewood and animal feed; iii) Sudanese species, more exigent are disappearing and that can deprive populations of food resources rich in proteins and lipids.

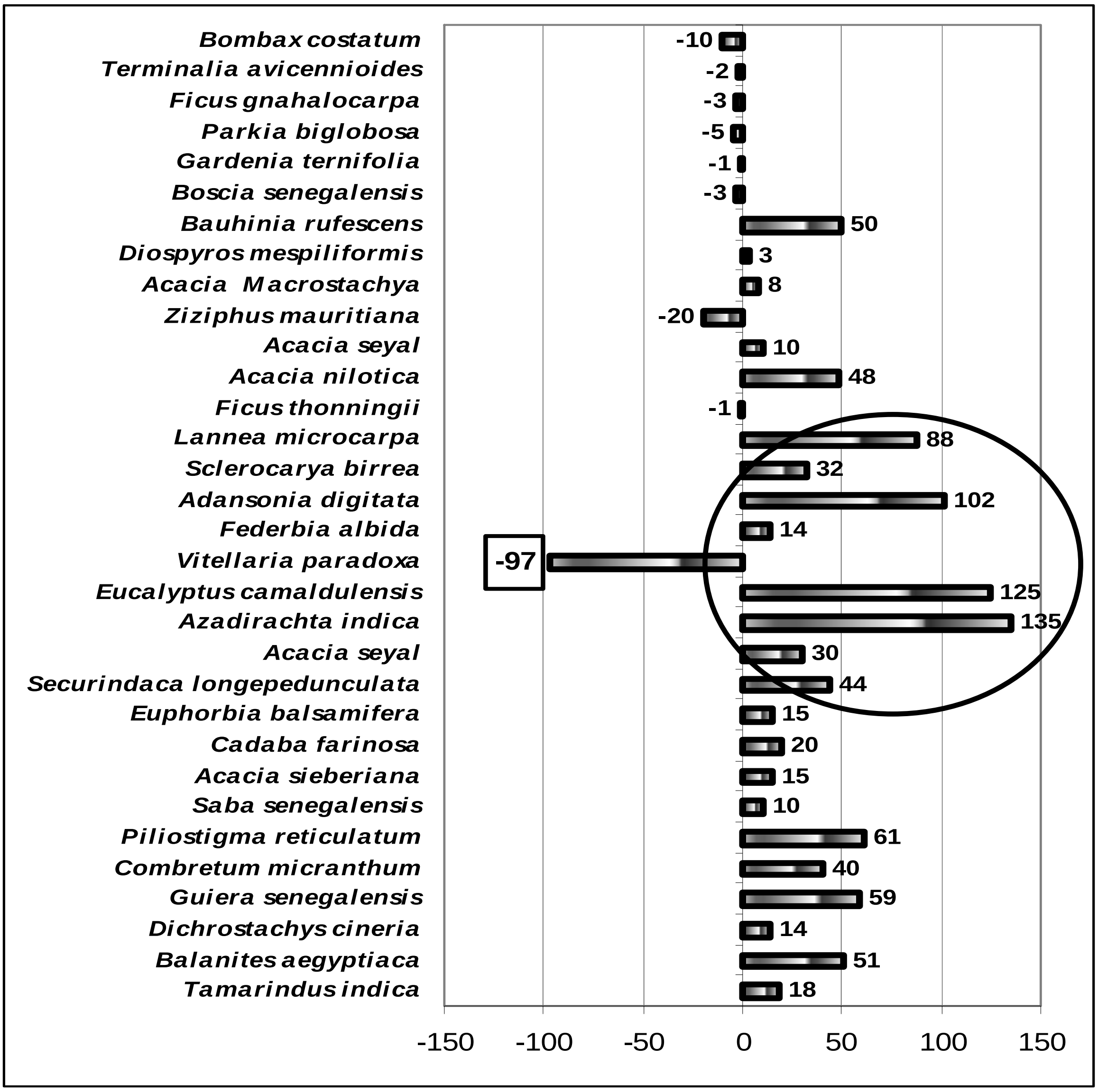


Fig. 4. Trees species regeneration in Ziga since ever the introduction of SWC practices using

4. Discussion

Manure localization, a way for Africa agricultural intensification ?

Results showed that zaï is generally practised on poor soils (encrusted soils). Even marginal, the soils implemented with zaï gives good outputs, better than those obtained with direct sowing, djengo, etc., which are often carried out on best soils.

Thus, at the village scale, we can speak about farming systems extensification, insofar as this zaï practice made it possible to cultivate soils, hitherto not exploitable by the old farming techniques and to increase lands potential offer. That is particularly fundamental in societies where demographic pressure led to an insufficiency or a reduction of farming area.

However, at the cultivated plot scale, results highlighted a true intensification of farming systems with zaï and djengo practices, since starts from a soil which does not produce anything to an identical production as the “more easily cultivable soils”. Basins digging and stone bounds making, organic manure and mineral fertilizers localization and hydrous food, constitute work, capital and others inputs intensification. However, to be powerful, zaï as well as djengo need some quantities of manure, as our results indicate it. But this manure production supposes animal husbandry and security. So donors should not only support farmers for vegetable productions improvement and rainwater management. Measurements for breeding are essential: supply concentrated cheap food, medical assistance, etc. It raises the problems of the number of cattle load in a space which are more and more used for agriculture. Indeed, maintenance of herds in the village territory demands to preserve grazing spaces in the rainy season. The Ziga farmers have not fallen short of this expectation up till now.

Agricultural practices change and agrosystem viability

First works on soil and water conservation began in Ziga in 1960 with GERES program (1960-1964). This program had a very limited success in comparison to the authorized investment and the negative effects of bounds made with soil. Consequent upon the drought (1984-1985), R&D program actions was reoriented towards regional planning in stone bounds and weedy bands. Thus, on an area of 700 ha, 18% of all the village territory were arranged in stone bounds between 1987 and 1990 (Dugué and al., 1993) with a logistic and technical support of R&D program. According to CORAF/CRDI (2002) project, 35% of cultivated fields were arranged in stony cords. Our results in 2005 show that 65% of Ziga cultivated plots are managed with stony cords. All these figures testify to a progressive and fast change of practices to fight against streaming. In his work, Marchal (1983) does not mention zaï practice at all but rather that of manual ridging intended to hide bad grass and to increase soil roughness. In 1989, Dugué did not observe a considerable width of zaï in Ziga as well as the djengo. Obviously, these practices were not well known or were not very widespread in this village in the 1980s. More recently, various works show the importance of zaï in Ziga: nearly 35% (report/ratio of R3S project, 2002) and 30% (Kaboré, 2005) of cultivated fields. It shows the SWC practice fast diffusion in the village, to face the pedoclimatic and demographic constraints.

In Ziga, we highlighted a regeneration of trees, due to the farmers' practices changes and the SWC various interventions. Reij and Thiombiano (2003) have lead to similar results in other Yatenga villages and shown an improvement of the agricultural outputs, a better management of soil fertility and a vegetable regeneration thanks to SWC.

It appears that we are witnessing the evolution of significant husbandries in Ziga, which allowed maintenance of agricultural production and even an improvement of this production. SWC associated with an organic and mineral fertilization seems determining in these evolutions. In the years 1970 and 80, rural populations of Yatenga and notably those of Ziga underwent serious food crises, which lead to a massive rural migration towards West and south Burkina Faso and to Ivory Coast. Today, the situation seems very different. As the results of this work point it out Ziga is obviously in a Boserupian type dynamic, in a context of a light increase in the rainfall averages for ten years. According to Boserup (1970), rural population increase in under developed countries is a favourable factor to agricultural intensification and for innovation processes. Diversity of techniques around zaï and djengo practices tends to confirm the dynamics farmers' innovation with the support of institutional development or associative actors.

As Mazzucato and Niemeyer (2000) works showed in Eastern Burkina Faso, social transformations and their adaptation wither to demographic and environmental changes are to a great extent in the improvement of the conditions of agricultural production after a phase of degradation. These social aspects of the evolution of natural stock management by populations will have to be thorough in Ziga.

5. Conclusions

These results showed that innovations of country husbandries, backed up by projects, research institutes and NGO can lead to an increase of agricultural yields, vegetable cover regeneration and poverty reduction. Green revolution in Africa is thus still possible by taking into account these local husbandry practices for various development projects.

6. Acknowledgements

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