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RESEARCH ARTICLE

AGRICULTURAL MIGRATION AND INTEGRATED SOILS FERTILITY MANAGEMENT IN PERIPHERAL AREAS OF THE W BIOSPHERE RESERVE IN NIGER REPUBLIC

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ABSTRACT

The recent anthropization of the peripheral zone of Niger W biosphere reserve has resulted in an advancing of the agricultural front towards its central portion. Therefore, the stabilization of crop areas requires a better understanding of the relationship between the level of integrated soil fertility management practices' utilization and the importance of agricultural migrants in the area. For this purpose, a perception survey coupled with soil parameters record was carried out along the gradient of proximity to the central core of the reserve. The results obtained show that the non-native populations composed mainly of sedentary transhumants and farmers in search of fertile land (91%) are concentrated in the buffer zone contiguous to the central area of the reserve. These agricultural settlers (88%) acquired land through clearing (purchase, donation and loan). The sedentarization of transhumants has resulted in a more intensive and integrated management of organic matter through the rotating livestock to fertilize the fields. On the other hand, typical farmers from the Northern East of the country favor shifting cropping practices to improve soil fertility. Consequently, the chemical and physicochemical characteristics of the soils show a relative abundance of the phosphorus content ranging from 37.7 ppm in the transition zone to 136 ppm in the buffer zone. In the two zones, the rate of organic matter is similar (0.62%). The Cationic Exchange Capacity values are distributed according to an increasing concentration gradient as one approaches the central core, going from 12.6 Meq / 100g of the soils in the transition zone to 15.5 Meq / 100g of soil in the buffer zone. These results underline the need to promote integrated diversified soil fertility management practices with an in order to stabilize the agricultural front in the peripheral zone of the W reserve in Niger.

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INTRODUCTION

The W Cross border Biosphere Reserve is a set of protected areas with remarkable biological diversity. It covers a total area estimated at 1,023,000 ha shared between Niger, Burkina Faso and Benin Republics and the areas adjacent to it (buffer zones and transition zones) (Ambouta, 2002).The Niger portion of this reserve covers a total area of approximately 725,000 ha (ECOPAS, 2005). The peripheral zone includes the total reserve of Tamoufauna (77,740 ha), located on the right bank of the Niger river and the partial reserve of Dosso fauna (306,000 ha) at the left bank (Ambouta, 2002). In 1976, part of the total Tamou fauna reserve was declassified to provide agricultural areas for food security (Amadou, 1994; Toutain. *et al.*, 2001; Mounkaïla, 2005). This breach has favored a spectacular influx of populations from the North, seeking for fertile lands (Benoit., 1998; Toutain*et al.*, 2001). This migratory movement associated with significant demographic growth (increment population rate = 3,9%) combined with the flexibility of land tenure has led to land saturation (Amadou, 1994; Amadou, 2004). It is therefore natural that protected areas adjacent to agricultural areas became poles of attraction for peasants in search of more fertile land. Thus, these spaces are eaten away every year by newcomers (Maman*et al.*, 2011). Under these conditions, the challenge of stabilization of the agricultural front limits dependshow soils fertility is managed by the agricultural migrants. In this perspective, the objective of this paper is to highlight the relationship between the density of agricultural new settlers and the level of integrated soil fertility management utilization. This will help to identify clear directions that can fuel reflections in favor of a sustainable integration of humans with the ecosystems of the W biosphere of Niger.

METHODOLOGY

Study zone: The study was conducted in the peripheral area of the W park central portion in Niger Republic.

This zone is located in the commune of Tamou, department of Say between 2 ° 10 and 2 ° 20 of East longitude and 12 ° 40 and 12 ° 50 of North latitude (Figure 1). The climate in this area is Sahelo-Sudanese type with two seasons: hot (from June to September) and cold (from October to May). The annual average rainfall calculated over 69 years of observation is 630 mm (ECOPAS, 2005). The soils are of two types: little evolved soils, lithosolsandregosols on sandstone, quartzites and cuirass present on the edges of the plateau dominating the Goroubiand the Diamangourivers. The tropical ferruginous soils little leached and deep occupy the tops of the plateaus and also the plane surfaces (Gavaud, 1967; Pias, 1978; Ambouta, 1984; Couteron*et al.*, 1992; Benoit, 1998). The vegetation is represented by the shrub savannah, dominant on the plateaus and glacis, and the wooded savannah located on the subsidence of the breastplate and the valleys. Along the main valleys have developed gallery forests with the presence of large trees such as *Ficusplatyphylla* (Benoit, 1998). The area is populated by 89,782 inhabitants composed mainly of Peuls and Gourmantchés (INS, 2001). Agriculture is the most dominant economic activity with 102,700 ha of arable land, only 25% is cultivated.

Data: The data were collected along a transect following a gradient of proximity to the central core of the reserve. This transect begins from the village of Tchallagoungoudi, (2 ° 9'41 " East longitude and 12 ° 53'06 " North latitude) and extends over a distance of 40.2 km to the limit of crops toward Weylgorouvillage (2 ° 33'56 " East longitude and 12 ° 35'40 " North latitude). Along this transect two zones have been distinguished: the transition zone comprising the villages of Tamou, Alambaré and Boli and the buffer zone known as *Ayinoma* (literally do agriculture), contiguous to the central core and comprising the villages of MoliHaoussa, Werigorou and Fombeni. Data collection was conducted on the basis of an individual interview using a questionnaire guide. This questionnaire addresses aspects related to the respondent's status of autochthonous or non-native origin, land tenure, availability of agricultural labor, land availability, level of agricultural equipment (possession of a tractor-drawn cultivation unit) and the type of extra-agricultural activity (market gardening, breeding, crafts, trading, etc.). The survey was carried out from 05 to 27-07-2006 and in total, 72 operators were interviewed, ie a survey rate of 10.03%. The choice of interviewees was guided by the criterion of responsibility as farm manager. In each zone, a soil pit was made to characterize the level of soil fertility. The following operations were carried out at each soil profile: collecting three soil samples using an auger on the humus (Ah), eluvial (Ae) and alluvial (B) horizons, determination of the color of the horizons using the Munsell code, assessment of the level of biological activity (importance of micro-galleries on the profile) using an observation sheet.

Method for analyzing the distribution of soil fertility management practices according to origin status and sector The Excel spreadsheet was used to generate the socioeconomic profile of farmers in the area. The XLSTAT 2015 software was used to apply a Principal Component Analysis (PCA) on the matrix types of soil fertility practices with the original status of the farmers. This analysis is performed in order to figure out the relationship between types of soils fertility management and the original status of the respondent.The same type of analysis is performed on the matrix types of soil fertility practices with the distance of proximity gradient to the central core of the reserve.

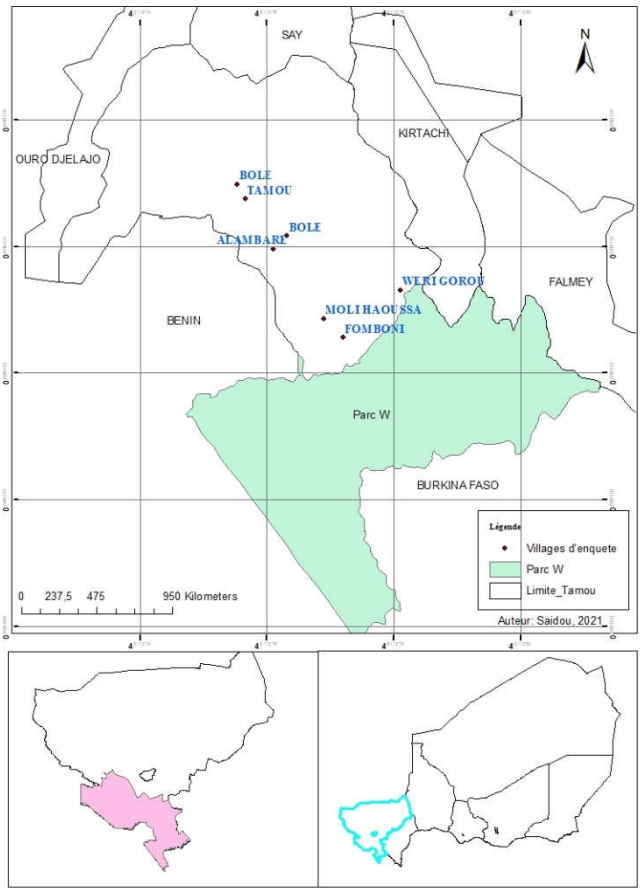

Figure 1. Location map of study area

Method for assessing the level of soil fertility: The soil samples collected on the field were analyzed at the soil science laboratory of the Faculty of Agronomy of AbdouMoumouni University in Niamey. These analyzes consisted of determining the physical, physicochemical and chemical parameters, according to the protocols specified in Table 1.

Table 1. Protocols of soils samples analysis

Parameter	Methods
Soils texture	Soils grain separation
pH	pH meter
Exchangeable anions	Ammoniumethanoate
Carbon	Anne method
Total nitrogen	Kjeldahlmethod
Total Phosphorus	Attack with nitric acid on the soil sample, destruction by boiling of other chemical elements, displacement of total phosphorus by sulfuric acid after filtration, fixation with a sulpho-molybdic solution and determination with a spectrophotometer at 890 nm.
Mobilizablephosphorus	Extraction by Bray I solution and by spectrophotometry at a wavelength of 660 nm in the presence of ammonium molybdenum and ascorbic acid.

RESULTS

Socioeconomic profile of respondents: The Socioeconomic profile of respondents is provided in Table 2. It highlights the distribution of the respondents following their original status, land tenure and other socioeconomic traits. The results from

Table 2 show that the natives farmers are in the majority in the transition zone with 87% of the citations. On the other hand, non-natives are more important in the buffer zone, where they represent 91% of the frequency of citations. A strong disparity is also recorded in terms of land tenure, availability of land and equipment for animal harnessing. The tenure by inheritance is more important in the transition zone (68% of the citations), whereas in the buffer zone, the clearing (expressed in the form of donation, loan or purchase with respectively 63%, 25% and 21% frequency of citations) represents the main means of access to land. The availability of land in the two zones is characteristic of land saturation with 2.07 and 1.31 ha / labor respectively in the transition zone and the buffer zone.

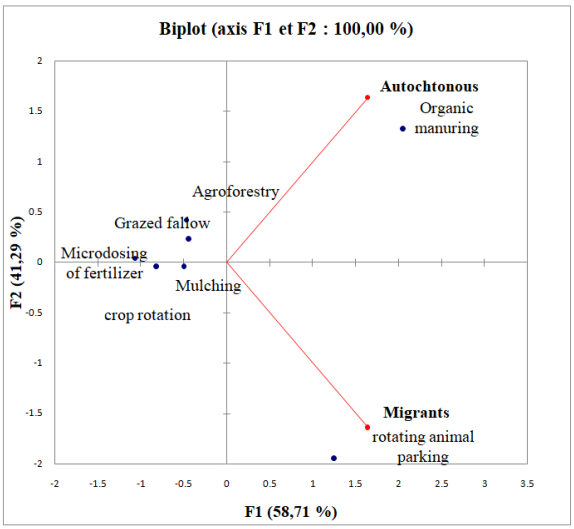

Figure 2. PCA results applied on soil fertility practices and original status of respondents

Picture 1. Grazed fallow in the transition zone

Links between types of soil fertility management practices and original status: Figure 2 presents the level of relationship between types of soil fertility management practices and the status of autochthonous versus non-native origin of the farmers interviewed. The F1 axis (58.71%) clearly opposes two groups of practices. The first group is made up of the following practices: crop rotation, grazed fallow (Figure 3), agroforestry and micro-dosing of fertilizers with a moderate level of use. The second group contains two practices: organic manuring and rotating animal parking. These are much more widely used practices in the area. The factorial axis F2 (41.29%) highlights the group of migrants who favor the contract of rotating animal housing over the group of natives who preferentially use organic manure and to a lesser extent agroforestry and crop rotation.

Adoption of soil fertility management practices based on proximity to the central core: Figure 4 shows the distribution of soil fertility management practices according to the proximity gradient with the central core of the reserve. The F1 axis (59.96%) discriminatesthe most used practices in both zones. These are organic manure and rotary animal parking. The use of agroforestry, fallow and micro-dosing of fertilizers is relatively moderate. The F2 axis (40.04%) highlights the practice regarding zone affinity. It point out the transition zone characterized by organic manure and mulching whereas the buffer zone is characterized by rotating animal parking.

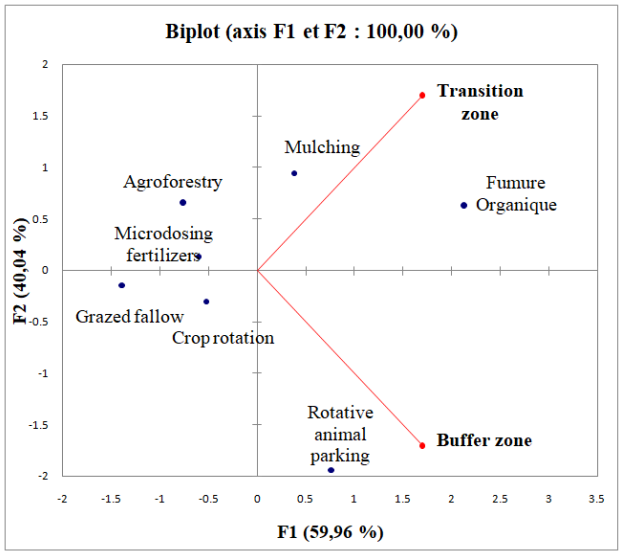

Figure 2: PCA results applied on soil fertility practices and proximity gradient toward central area of W Reserve Park

Soil fertility level according to proximity to the central portion of the W park

Physical parameters: Table 3 shows the proportions of the particle size of the soil samples. Except fine silt and fine sand, ANOVA indicates that the means are not significantly different. The fine sand fraction is dominant with 47.14 and 49.83% respectively in the transition zone and the buffer zone. For both areas, the reference to the texture triangle concludes with a sandy type texture. In addition, the soils of the transition zone are deeper (157 cm) compared to the soils of the buffer zone (79 cm).

Physicochemical and chemical characteristics: The chemical and physicochemical characteristics analysis aims to assess the level of chemical fertility of soils. The results of chemical analyzes applied to soil samples are listed in Table 4. These results show that whatever the zone, the pH values are above the critical value of 5.5 below which the presence of exchangeable aluminum causes risks of aluminum toxicity for many crops including cereals. The soils of the buffer zone and the transition zone with 5.8 and 5.6 respectively are slightly more acidic compared to the standard (6.1). In both cases, the high organic matter content in the shallow horizons drops sharply at depth. Also, it is observed that in the surface horizons (Ah and Ae) the C / N values belong to the range of 7 to 13. The nitrogen contents are also higher than the standard value which is 0.01%. As for phosphorus, which level exceedsthe standard (2.8 ppm).

Table 3. Results of soils particle size and soils deepness

Parameters	Transition zone	Buffer zone	p-value
Clay (%)	2,96±0,36	6,76±0,97	0,226
Fin silt (%)	5,09±1,01*	10,06±3,86*	0,129
Rough silt (%)	1,80±0,40	6,08±2,33	0,046
Fin sand (%)	47,14±10,36*	49,83±2,27*	0,042
Mean sand (%)	36,84±10,28	19,20±2,55	0,116
Rough sand (%)	6,17±1,62	8,06±1,64	0,990
Deepness (cm)	157	79	-

*Legend: * significantlydifferent at 5% level.*

Table 4. Results of the physicochemical and chemical parameters of the soils samples

Parameters	Horizons	Transition zone	Buffer zone
pH water	Ah	5,6	5,8
	Ae	5,6	5,8
	B	6	7
pHKCl	Ah	5,4	5,3
	Ae	5,4	5,4
	B	5,6	6,5
OM (%)	Ah	0,62	0,62
	Ae	0,22	0,41
	B	0,27	0,14
C (%)	Ah	0,36	0,36
	Ae	0,13	0,24
	B	0,16	0,08
N (%)	Ah	0,03	0,03
	Ae	0,01	0,02
	B	0,01	0,01
C/N	Ah	12	12
	Ae	13	12
	B	16	8
TP (ppm)	Ah	37,7	136
	Ae	38,9	134
	B	30,4	116
MP(ppm)	Ah	20,02	57,51
	Ae	17,03	54,1
	B	14,9	51,12
S (Meq/100g)	Ah	12	13
	Ae	11	13
	B	11	15
CEC (Meq/100g)	Ah	12,6	15,5
	Ae	12,5	15,5
	B	12,5	15,5
T	Ah	0,94	0,86
	Ae	0,91	0,86
	B	0,89	0,94

Legend: Ah : superficial horizon, Ae ; elluvialhorizon, B : alluvial horizon, OM : Organic Matter, Pass : Mobilizable Phosphorus, S : Total Exchangeable Anions, CEC : Cationic Exchange Capacity, T : Saturation Rate, Meq : Milli-equivalent.

The soils of the buffer zone with 136 ppm are richer in phosphorus than those of the transition zone where its content is 37.7 ppm.

Picture 2. Spreading of *Guierasenegalensis*specie in the grazed area of south-center of Niger

In addition, the Cationic Exchange Capacity (CEC) greatly exceeds the critical threshold of 2 Meq / 100g of soil (Soltner, 2000) with extremum of 15.5 Meq / 100g of soils in the buffer zone and 12 Meq / 100g in the transition zone. In both cases, the sum of the exchangeable anions is greater than the critical threshold of 1.4 Meq / 100g, recommended by the FAO (Soltner, 2000). It increases as one approaches the central core of the reserve with 13 Méq / 100g of soils in the transition zone and 11 Méq / 100g of soils in the buffer zone. In both cases, the saturation rate is close to 1.

DISCUSSION

Original status and types of soil fertility management practices: The socio-economic profile of the people surveyed shows a clear dominance of agricultural migrants, settled in the so-called *Ayinoma,* buffer zone of the central core of the reserve. This agricultural occupation was manifested by a proliferation of agro-pastoral camps. On this subjectAmadou. (2004) reported that this type of settlement is a major characteristic of the sedentarization of transhumant pastoralists. In addition this is the spontaneous migration of populations from the North who come to swell the existing villages or create their own villages. This form of migration is comparable to that reported by Avakoudjo*et al.* (2014) in the Beninese part of the WAP (W, ArlyPanjari) cross-border reserve. The importance of land tenure by purchase, donation or loan, rightly reflects the magnitude of agricultural clearing at the expense of natural formations. Moukaïla (2005) underlined that in the rural commune of Tamou, it is basically the natives who inherit the land. Access to land by newcomers is facilitated by the flexibility of the land tenure system that results from juxtaposition, or even a superposition, between customary land tenure and modern land tenure. Concretely, the settlement of non-natives mainly in the buffer zone reflects quite well the importance of agricultural clearing.

The non-natives living in the buffer zone favor rotating animal parking to improve the fertility of their fields. In fact, the livestock availability of sedentary transhumants favors this practice with a double organic (through excreta) and mineral (through urine) effect. This practice promotes the establishment of characteristic plant species, indicators of soil fertility (Picture 2) such as those described by Moussa *et al*. (2015). In general, this practice is common in the western part of Niger where land availability is relatively high (Guengant and Banoin, 2003). However, in the case of the W biosphere reserve in Niger, the risk of predation by wild animals on domestic animals constitutes a major constraint to this practice (Aurelie. *et al.,* 2006). The results of this study showed that the natives are concentrated in the transition zone. The low availability of land requires the use of much more varied soil fertility management practices including organic manure (based on animal droppings or millet glumes and haulms), agroforestry, crop rotation and micro-dosing of chemical fertilizers. Organic manure based on stable manure is a common practice on farmers in the Sudanian zone (Djenontin*et al*., 2003). In land saturation zones, as is the case in the south-central zone of Niger, soil fertility management practices mainly integrate assisted natural tree regeneration with organic manure (Saidou and Ambouta, 2020).

Soil fertility level and proximity to the central core of the reserve: Analysis of the structure of soil samples shows that the depth of the profile gradually decreases as one approaches

the central core of the reserve. This is probably explained by the recent cultivation of the buffer zone, declassified from 1976. The transition zone was classically an agricultural zone for a very long time. Overall, the soil characteristics of the peripheral part of the W Niger biosphere reserve are comparable to those of dune soils, tropical ferruginous little leached, well described by Ambouta*et al*. (1998). However, their high proportion of thin sands is a factor of sensitivity to encrustation and therefore to sheet erosion. The sustainable management of these soils suggests that there is a need for a better integration of crop practices and runoff and sediment collection practices. The low organic matter content (much less than 2%) and a low C / N ratio suggest low mineralization activity. On the other hand, the total phosphorus and mobilzable phosphorus contents values are clearly higher than those of most tropical ferruginous soils. It is likely that this is related to the geology of the area; because the zone is located in the middle of the LiptakoGourma zone where the granite basement is supported by West African plinth (Pias, 1978). The geological substrate would also have influenced the ratio between the exchangeable anions sum and the cationic exchange capacity (presence in abundance of swelling type clay like smectites) since the saturation rate is close to 1. Leaching is therefore low to zero although the soils are generally filtering. The conditions for cereal cultivation are favorable. Unfortunately, however, crop practices undermine the soil.

CONCLUSION

The decommissioning of W protected reserve park part in 1976 resulted in a migration of the agricultural front toward its central part. Integrated soils fertility management is a way to build sustainable integration between Man and Biosphere. The objective of this study was therefore to assess the level of soil fertility and soil fertility management regarding the original status of inhabitants. The results showed that non-natives are more concentrated in the buffer zone by agricultural clearing. This strong anthropization has essentially resulted in the sedentarization of transhumants who have converted into agro-pastoralists. They adopted rotating animal parking practice to improve soil fertility. In addition, the physical, chemical and physicochemical characteristics show that the soils are generally favorable to cereals cropping. In view of these results, the stabilization of the agricultural front in this peripheral zone of the W biosphere reserve in Niger requires intensive management of cropping practices with an intensification of agroforestry practices. This will make the integration of humans into the W biosphere of Niger sustainable.

RECOMMENDATION

In the light of the results of this study, two recommendations are addressed to the State of Niger and its Technical and Financial Partners (UNESCO among others) to support local income diversification initiatives (such as bees keeping) in order to increase the agricultural investment capacity of peasants. That will play a key role in stabilizing the advance of the agricultural front. With regard to the socioeconomic profile of non-natives, it is better to promote the use of agroforestry species to produce woody fodder in association with crops in order to control the pressure of overgrazing on the reserve.

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