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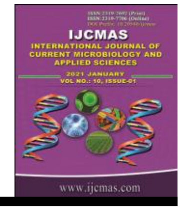

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Impact of Natural Regeneration on Texture, Electrical Conductivity, Aluminum and Organic Carbon of Soil in the Village of Magami in Niger

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ABSTRACT

In Niger, the continuous land degradation due to drought and anthropogenic actions is one of the major cause of decline in soil fertility and consequently in agricultural production. Therefore, this study was conducted in Magami village in order to assess the impacts of natural regeneration on soil texture, electrical conductivity, aluminum and organic carbon. Four agro systems were compared: (1) field without natural regeneration (CF); (2) field with 3 years natural regeneration (FY); (3) field with 10 years natural regeneration (FT) and (4) field with 15 years natural regeneration (FM). The results showed a significantly higher soil quality in the fields with natural regeneration compared to the control field. A relatively increase of soils quality parameters with age of practice of natural regeneration.

Introduction

Soil is increasingly recognized as a nonrenewable resource on a human life scale because once degraded, its regeneration is an extremely slow process (Lal, 2015). In most sahelian countries, the increase in demand for firewood as an energy source coupled with overexploitation of natural resources together with competing land uses for agricultural and pastoral production have led to a process of continuous land degradation. The consequences of this degradation are water and wind erosion, declining soil fertility and scarcity of firewood. In addition to that, traditional agricultural areas near population centers are lost due to urban development, and agriculture is pushed onto both marginal land and forested areas (Doso jnr, 2014). Also, continuously cultivated crop fields and reduced fallow periods are short-chained soil restoration processes which do not compensate for the decline in soil organic matter in most soils used for agriculture in the regions (Kintché *et al.*, 2015). To reverse this soil degradation continuous effort should be done by restoring soil productive capacity of marginal agricultural land to feed and sustains the livelihood of a continuously growing population (Tittonell, 2016). For instance, the human population of Niger has increased from 5 million in 1970 to 17 million in 2010. With a growth rate of 3. 9%, Niger has one of the highest annual population growth rates in the world (INS, 2012).

Agroforestry is a collective name of land use systems in which woody perennials (trees, shrubs, etc) are grown in association with herbaceous plants (crops, pasture) or livestock, in a spatial arrangement or a rotation or both; there are usually both ecological and economic interactions between the trees and other components of the systems (Lundgren, 1982). Woody or herbaceous species in agroforestry systems can enrich topsoil through enabling nutrient cycling from the subsoil and through biological N2 fixation by legume species (Pyame, 2015). It can also sequester significant amounts of carbon than agricultural monoculture (Luedeling *et al.*, 2011).

The dynamic of woody cover is positively correlated with its ability to regenerate naturally, studying natural regeneration of tree remains then important to understand the functioning and dynamics of systems production, allowing to establish restoration strategies and or rehabilitation of ecosystems mainly with native species (Diatta *et al.*, 2007). Therefore, this study was conducted to assess natural regeneration effects on soil properties in the village of Magami in Niger.

Materials and Methods

Location

The study was conducted in August 2015 in the village of Magami, located between 7°44’93’’ longitude EST and 13°46’98’’ latitude north. The climate of this area is sahelian characterized by short rainy season (4-5 months) with an average annual rainfall of 413. 4 mm. The temperature ranges from 10 °C to 45 °C with a mean of 29 °C.

The vegetation is mainly composed of grasses and woody species (mostly *Piliostigma reticulatum, Faidherbia albida*). Four fields have been considered. Each field is replicated two times (except for the control field). These are: fields with 15 years natural regeneration (FM), fields with 10 years natural regeneration (FT), fields with 3 years natural regeneration (FY) and fields without natural regeneration that is control field (CF).

Soil sampling

To study the variability of some soil characteristics on and off covered RNA, five individuals of the species *Piliostigma reticulatum* were selected randomly from each field. Then one composite soil sample was collected at 50 to 100 cm of the trunk of *Piliostigma reticulatum* tree and another composite soil sample was taken at 100 to 150 cm away from the canopy of *Piliostigma reticulatum* tree.

In total, 65 composite soil samples have been collected from 0 to 20 cm soil depth. Samples were then dried and passed through 2. 0 mm sieve and analyzed for textural classes, electrical conductivity, aluminum and organic carbon.

Statistical analysis

The statistical analysis of data was performed using SPSS (version, 23). The different field soils parameters were tested by ANOVA and the Tukey’s Honest test was used for a significant difference ($p<0.05$). The comparison between on covered (SH) and off covered (HH) soils parameters within field was done using the independent samples T test.

Results and Discussion

Soil Texture

The soil characteristics of the control field (CF), field with 3 years natural regeneration (FY), field with 10 years natural regeneration (FT) and 15 years natural regeneration field (MF) are presented in table 1. The soil textural fraction for all fields showed high sand fraction content and varies from 90. 5 to 94 %. The highest silt fraction (6. 7%) was obtained on field with 10 years natural regeneration while the lowest value (3. 2%) was recorded on control field. Similarly, the control field has the lowest Clay content value (2. 3%) and the highest value (3. 7%) was obtained on field with 15 years natural regeneration (Table 1).

Electric conductivity

The soil electrical conductivity (EC) of the control field, field with 3 years natural regeneration, field with 10 years natural regeneration and field with 15 years natural regeneration is presented in table 1. The lowest soil EC (0. 14 ds/m) was obtained under control field and the highest (0. 37 ds/m) was recorded on field with 10 years natural regeneration. There is a also a significant differences ($p<0.05$) between the soil electrical conductivity value of control field (CF) and the soil electrical conductivity value of fields with 3 years natural regeneration (FY), 10 years natural regeneration (FT) and 15 years natural regeneration (FM) respectively (Figure 1).

Aluminum content

Table 1 shows the aluminium content of soil of control field, field with 3 years natural regeneration, 10 years natural regeneration and 15 years natural regeneration. The soils aluminum content of all fields are extremely high but are not significantly affected by natural regeneration (Figure 2).

Organic carbon

The soil carbon content of the control field, field with 3 years natural regeneration, field with 10 years natural regeneration and field with 15 years natural regeneration is presented in Table 1. The organic carbon content varies from 0. 109 to 0. 14% obtained respectively on control field and field with 15 years natural regeneration.

There is a significant differences ($p<0.05$) between the soil carbon content value of control field (CF) and the soil carbon content value of fields with 10 years natural regeneration (FT) and 15 years natural regeneration (FM) (Figure 3).

Effect of on covered and off covered natural regeneration on soil parameters

Field with 3 years natural regeneration

The soil electrical conductivity, organic carbon, aluminum content of on covered and off covered 3 years natural regeneration are presented on Table 2. The soil electrical conductivity (0. 4ds/m) of on covered (SH) are significantly different ($p<0.001$) to the electrical conductivity (0. 3ds/m) of off covered (HH) natural regeneration (Table 2). The off covered soils have higher Al content (1004mg/kg) compared to the on covered soils (897mg/kg).

Field with 10 years natural regeneration

Regarding the 10 years natural regeneration field, the results indicates a significant difference between the on covered and the off covered soils parameters ($p<0.001$). The means value of on covered soils are higher than the means of off covered soils for all parameters except Al where the on covered (Al=850mg/kg) is lower compared to off covered (Al=931mg/kg) (Table 3).

Table.1 Characteristics of soils of different fields

Parameters	Fields			
	CF	FY	FT	MF
Sand (%)	94. 4	92. 4	90. 7	90. 5
Silt (%)	3. 2	4. 9	6. 7	6. 5
Clay (%)	2. 3	2. 5	2. 4	3. 7
EC (ds/m)	0. 14	0. 36	0. 37	0. 35
Al (ppm)	880	951	890	972
C (%)	0. 109	0. 11	0. 14	0. 14

CF: control field; FY: field with 3 years natural regeneration; FT: field with 10 years natural regeneration; FM: field with 15 years natural regeneration

Table.2 Comparison between on covered and off covered soils parameters for the fifteen years natural regeneration field ($p<0.001$)

Summary of the independent samples T test					
Parameters	**Samples**	**N**	**Mean**	**Mean difference**	**Standard error of mean**
EC(ds/m)	SH	10	0. 400	0. 08	0. 0258
	HH	10	0. 320	0. 08	0. 0291
C (%)	SH	10	0. 118	-0. 001	0. 0043
	HH	10	0. 119	-0. 001	0. 0036
Al (ppm)	SH	10	897,740	106. 63	90,8491
	HH	10	1004,370	106. 63	48,4742

SH: on covered RNA; HH: off covered RNA

Table.3 Comparison between on covered and off covered soils parameters for the ten years natural regeneration field ($p<0.001$)

Summary of the independent samples T test					
Parameters	**Samples**	**N**	**Mean**	**Mean difference**	**Standard error of mean**
EC(ds/m)	SH	10	0. 38	0. 01	0. 0291
	HH	10	0. 37	0. 01	0. 0260
C(%)	SH	10	0. 146	0. 012	0. 0073
	HH	10	0. 134	0. 012	0. 0082
Al(ppm)	SH	10	850,08	-81. 07	67,9788
	HH	10	931,15	-81. 07	68,9226

SH: on covered RNA; HH: off covered RNA

Table.4 Comparison between on covered and off covered soils parameters for the three years natural regeneration field ($p<0.001$)

Summary of the independent samples T test					
Parameters	**Samples**	**N**	**Mean**	**Mean difference**	**Standard error of mean**
EC(ds/m)	SH	10	0. 380	0. 06	0. 0359
	HH	10	0. 320	0. 06	0. 0249
C(%)	SH	10	0. 145	0. 009	0. 0092
	HH	10	0. 136	0. 009	0. 0073
Al(ppm)	SH	10	959,620	-24. 97	91,8657
	HH	10	984,590	-24. 97	107,6781

SH: on covered RNA; HH: off covered RNA

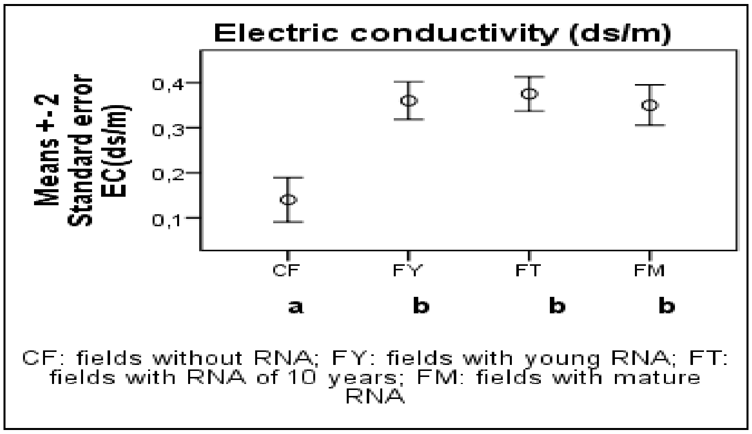

Fig. 1 Electrical conductivity mean value distribution by fields with a Tukey significant difference. Boxes with different letters at each box are significantly different at $p<0.05$

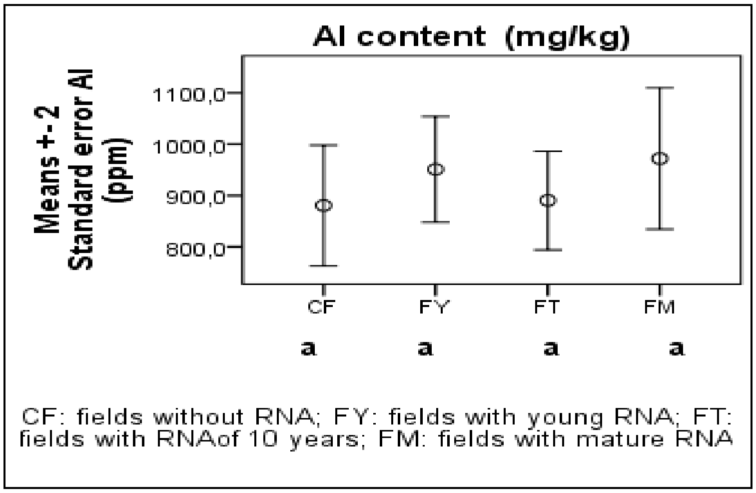

Fig.2 Aluminium mean value distribution by fields with a Tukey significant difference. Boxes with different letters at each box are significantly different at $p<0.05$

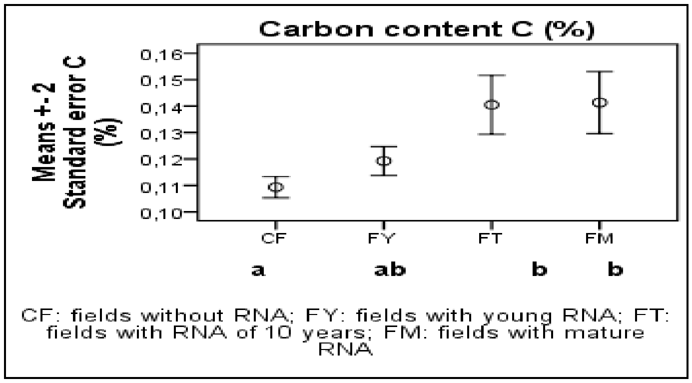

Fig.3 C mean value distribution by fields with a Tukey significant difference. Boxes with different letters at each box are significantly different at p<0. 05

Field with 15 years natural regeneration

The soil electrical conductivity, organic carbon, aluminum content of on covered and off covered 15 years natural regeneration are presented on table 4. There is a significant difference (p<0. 001) between the soil electrical conductivity, organic carbon, and aluminium content of on covered and off covered 15 years natural regeneration (Table 4).

The fields under natural regeneration practice had significantly higher soils quality compared to the control field in all analyzed soils parameters. Similar results were reported by (Susan et al and Niels et al, 2015). The relatively low EC in all samples indicates that the soils are free from salinization. The Aluminum content was extremely high in all analyzed samples. The cultivation of tiger nut and the use of mineral fertilizers may be the reason of this extremely high Aluminum content.

The organic carbon (C) content was very low for all analyzed soils. This was due the sandy soils texture and also the higher temperature of the site that favor the rapid decomposition of organic matter. The C content was significantly high in soils of the fields under natural regeneration than the soils of control field. Hence, the natural regeneration has a positive effect on the soils carbon content. In another study, Susan *et al.,* 2015 found that, the C content was greater in coffee agroforestry than in coffee monoculture. In our study, the C increase with increasing years of the land management. This results show that the interaction between land use type and years of land management has also a positive effect on the soils carbon content. Similar results reported by Haile *et al.,* 2014 but with high carbon content as compared to our findings. This was probably due to the difference in soils type and also the climatic condition. There was no significant variation between field with 10 years and 15 years natural regeneration. This may be attributed to the higher number of species present in the Field with 10 years natural regeneration. The developed vegetation community increases the organic carbon stock. This can be attributed to the continuous input of leaves, foliage and dead root by the shade tree (Thomazini *et al.,* 2015).

There was a wide variability between the on covered and off covered natural regeneration soils parameters in the ten and fifteen years natural regeneration fields. The on covered natural regeneration had higher soils quality in term of Electrical conductivity and carbon content C.

Competing interests: The authors declare that they have no competing interests

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