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RESEARCH ARTICLE

IMPACTS OF *P. RETICULATUM* ON CHEMICAL AND BIOLOGICAL PROPERTIES OF FALLOWS IN SUDANIAN ZONE OF BURKINA FASO

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ABSTRACT

Piliostigma reticulatum is a pioneer species of Sahelo Sudanian fallows. It contributes to degraded soils recovery. This study aimed to measure impact of *P. reticulatum* on fallows soils in north and south sudanian zones of Burkina Faso. Two fallows were used for experimentation: Saria site in north sudanian zone and Sala in south Sudanian zone. Soil samples were collected on soil layer 0- 20 cm under crown, limit of the crown with a control and followed four cardinal directions for chemical and biological analysis. Chemical and statistics analyzes showed that cardinal direction influenced status of Organic mater, total nitrogen and total phosphorus, in north sudanian zone. The east side presented best status of soil fertility parameters. In south sudanian zone, cardinal directions had no significant effect on chemical elements evolution. Considering parameter under crown and limit of crown, organic matter was improved by 28.34% and 10.54% respectively in north and south Sudanian zone under the crown. Total nitrogen was enhanced by *Piliostigma*'s crown both in north and south Sudanian zones. Microbial activities and biomass were improved by *P. reticulatum*'s crown. Microbial properties of soil are more marked in south Sudanian zone than north sudanian zone.

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INTRODUCTION

Agriculture remains an important economic sector in Burkina Faso. The agricultural system is traditional and is dominated by cereal crops (millet, sorghum, maize) that cover almost 90% of cultivated areas (Albergel *et al.*, 1985). This system continues for generations by smallholder with mostly a low-input and archaic farming tools. This causes soils degradation which is materialized by organic matter and nutrients depletion leading to a low productivity (Bâ, 2014). However existence in this type of system of ligneous plant species is an opportunity to improve soil fertility and crop yields (Boffa *et al.*, 2000; Bayala *et al.*, 2002; Bayala *et al.*, 2006). Indeed, Woody spared in farms lead to improve soil fertility by litter decomposition and nutrients recovery which are then used by crops (Joet et al., 1996). Species traditionally encountered in farms in central plateau of Burkina, are *Vitellaria paradoxa*, *Acacia albida*, *Parkia biglobosa*.

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Many studies have focused on their contributions to soils fertility and crops yield (Depommier 1996; Boffa *et al.*, 2000; Kho *et al.*, 2001; Bayala *et al.*, 2002; Traoré *et al.*, 2007; Gnamkabary *et al.*, 2008). However, in recent years, because of climate variability, there is a strong establishment of some gregarious ligneous species in parklands (Millogo/ Rasolodimby, 2001). Thus the landscape is increasingly marked by establishment of *P. reticulatum*. Studies on the contribution of this species in soil fertility improvement are little known (Kizito *et al.*, 2007; Lufala *et al.*, 2008; Lufala *et al.*, 2009; Dossa *et al.*, 2009 ; Yélémou et al., 2013). This study aims to evaluate the influences of *P. reticulatum* on fallow soils in north and south Sudanian climatic zone of Burkina Faso

MATERIALS AND METHODS

Study Sites

The study is carried both in the research station of INERA in Saria, located in north sudanian zone and in Sala in south Sudanian climatic zone in Burkina Faso (Fig 1)

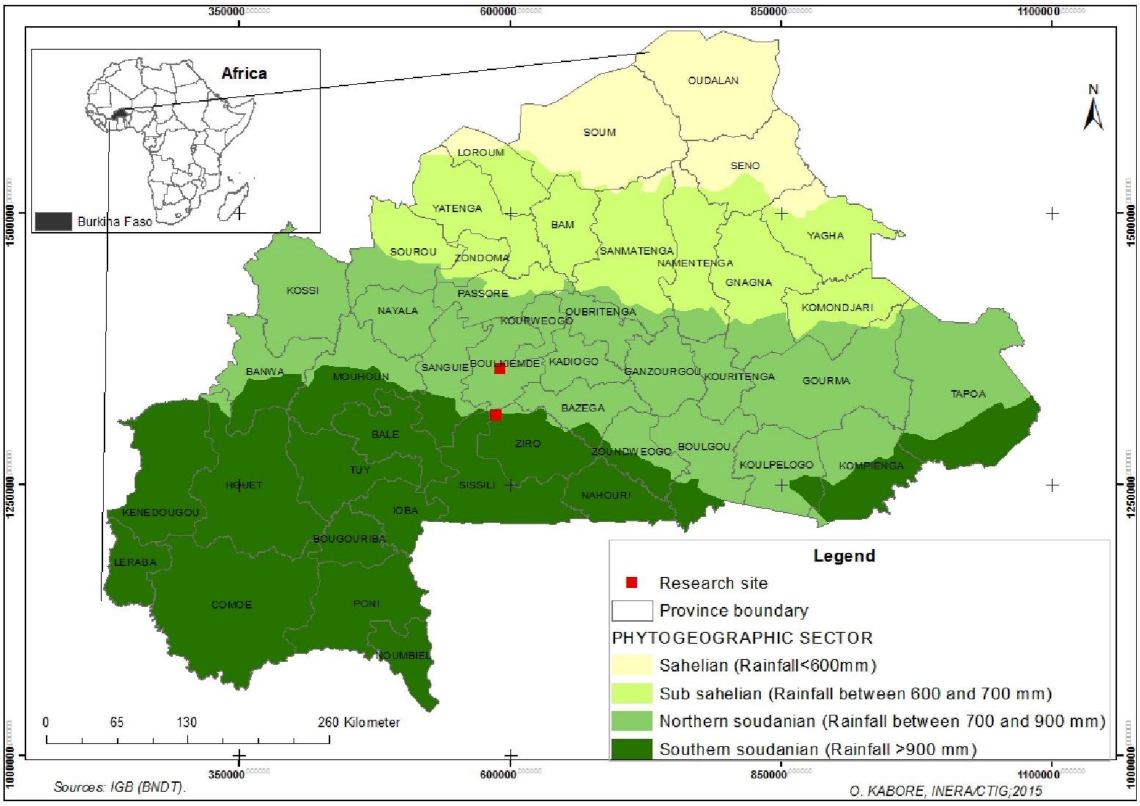

Figure 1. Site location map

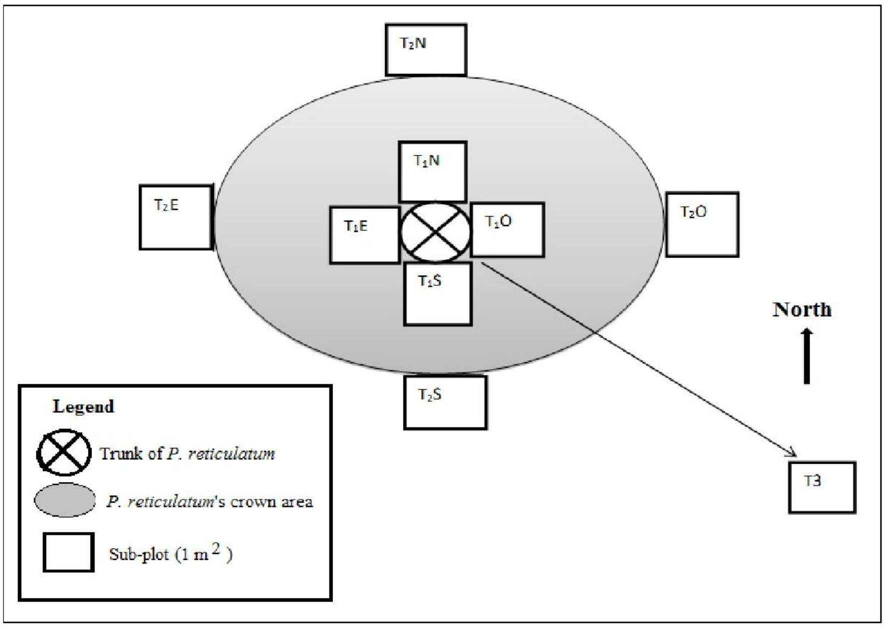

Figure 2. Experimental design

North Sudanian zone is characterized by a long dry season from October to April (7 months) and a short rainy season from May to September (5 months). Harmattan wind is cold and dry and blows during the dry season and the monsoon is the dominant wind during the rainy season. Annual rainfall in the past decade ranged between 626.4 and 980.7 mm, an average of 852.03 mm in Saria. South sudanian sector is characterized by a dry season from November to April (6 months) and a rainy season from May to October (six (6) months). The prevailing wind in rainy season is the continental trade wind. The temperature is about 35.8°C in Saria and 28°C in Sala (Yélemou et *al*., 2007).

In Saria, the maximum temperature (40 ° C) is riched in March-April and minimum (15 ° C) in December. In the south sudanian zone, The thermal amplitudes in south Sudanian zone is relatively lower than the one of north Sudanian due mostly to vegetation cover which form a buffer system on the climate, reducing temperature. The site in Saria is a protected fallow with monospecific vegetation of *Piliostigma reticulatum*, while in Sala site it is an open fallow, with multispecies vegetation both over 20 years. Vegetation in south Sudanian zone is characterized by *Isoberlinia doka* Craib & Stapf, which forms tree stands in woodlands of Burkina Faso.

Savanna woodlands in Sala are dominated by *Detarium microcarpum* Guill.&Perr., *Combretum glutinosum* Guill.&Perr. , *Gardenia erubecens* Stapf. & Hucth. et *Parina ricuratellifolia*. The graminaceous stratum is dominated by *Andropogon gayanus* Kunth, *Andropogon ascinodis* C.B.Clarke in old fallows, *Eragrostis tremula* Hochst. *Penissetum pedicellutum* Trin, *Dactyloctenium aegyptium*, *Andropogon pseudapricus* Stapf., *Loudetia togoensis* (Pilg.) C.E.Hubb., in recent fallow.

Methodology

In each selected site, Soil samples were taken for chemical and biological analysis. Three (03) plants of *P. reticulatum* per site have been randomly chosen. Around each tree of *P. reticulatum*, 4 monitoring plots were installed following the 4 cardinal directions, both under crown of the tree and in the edge of the crown. Also, one (1) control plot per tree was installed (Fig 2). Soils were sampled in 0-20 cm depth using an auger. Nine (09) samples were taken around each tree, 27 samples by site and whether 54 samples for both sites. For all the samples, chemical and biological analyzes were performed. The following treatments were monitored (Table 1)

Table 1. List of studied treatments

Treatments	Variances	Definition
T1	T_1E	East side under crown
(Under crown)	T_1O	West side under crown
	T1N	North side under crown
	T1S	south side under crown
T2	T2E	East side at the limit of the crown
(Limit of the crown)	T2O	west side at the limit of the crown
	T2N	North side at the limit of the crown
	T2S	South side at the limit of the crown
T3	-	Control

Chemical Analysis

Chemical analyzes were carried in INERA's Sol-Water-Plant Laboratory. Total carbon, total nitrogen, total phosphorus and water pH were tested.

- **Total organic carbon**: total organic carbon was isolated using Walkey and Black (1934) method.
- **Total nitrogen**: It was measured using Kjeldalh Houba et al. (1988) method. This method has been used in many studies related to sudanian soils (Tassambedo, 2001; Ouédraogo, 2003)
- **Total Phosphorus**: it was determined by automatic calorimetry after mineralization
- Water pH: It was determined directly through an electronic pH-meter.

Biological analysis

The following laboratory tests have also been carried out

The total microbial biomass: several methods for determining microbial biomass exist (Fardoux et *al*., 2002). The most commonly used are: chloroform- fumigation-extraction (CFE) or extraction fumigation used by Vance et al, (1987) edited by Amato and Ladd (1988) and the chloroform-fumigation-incubation (CFI) or fumigation- incubation used by Jenkinson and Powlson, (1976). Both methods use chloroform that is a Biocidal agent for soil microorganisms. However, the CFI method is recommended because it is more suited for soils with low organic matter (Kaiser et *al*., 1992).

Potential mineralization of organic carbon (respirometry): The oldest and simplest method to assess overall activity of soil microflora is to measure mineralization of carbon and nitrogen in controlled conditions that is closed to biological optimum. Samples are incubated with 28 ° C and water content neighboring to field capacity to allow the resumption of microorganism's activities (ITAB, 2002; INSAH, 2004; Zombré, 2006; Traoré et *al*., 2007). Respiration tests of soil samples were performed daily for 21 days

Statistical analysis

The contents of the soil biochemical elements were subjected to analysis of variance (ANOVA) using Fischer least squares test (LSD) to compare the means of the various parameters under and out the crown of *P. reticulatum* at the 5%. Statistical analyzes were performed using XLSTAT.

RESULTS

Effect of *P. reticulatum* on soil chemical properties

The results show that *P. reticulatum* impacted differently chemical parameters following phytogeographical zones (Table 2 et 3). For all chemical soil parameters measured, the values obtained for each treatment in southern Sudanian zone are higher than those in north Sudanian one. In north Sudanian zone, there was no significant difference between the pH values of the soil following the cardinal directions (Table 2).
The organic matter was significantly different following treatments. Indeed when going from the area under *P. reticulatum* crown to areas out of the crown, organic matter content decreased significantly. The treatment T1E improved organic matter content by 28.34% compared to the control. The cardinal direction had an effect on organic matter rate both for treatment T1 (under crown) and T2 (out of the crown). The best organic matter rate was obtained in East direction.

In terms of total nitrogen, statistical analysis revealed significant differences between treatments in north Sudanian zone. The better content was found under the crown of *P. reticulatum*. Treatment T1E improved total nitrogen by 30.68% compared to the control. Again, the cardinal direction has significant effect with largest content obtained in East direction. Total phosphorus had the same trend as total nitrogen and soil organic matter. Larger quantities of Pt are obtained under the crown of *P. reticulatum*. The mean size of total phosphorus for 1kg of soil was 110.16 ± 19.43 mg with treatment T1E, either 12% more than the control and 10.72% more than treatment out of the crown. When considering the soil parameters under crown, crown boundary and control in northern Sudanian zone, all chemical elements except Pt, shows significant variations (Table 3). *P. reticulatum* crown improved soil pH. Indeed, it increased potential hydrogen index by 0.39 compared to areas outside the crown. Organic matter status was improved by 0.19%. The one of total nitrogen under the crown of *P. reticulatum* was improved by 15.08% compared to area boundary to the crown. In southern Sudanian zone, there was not significant differences between the pH values following treatments (Table 4).

Table 2. Evolution chemical parameters following cardinal directions around *P. reticulatum* in the north Sudanian zone

	Soil chimical parameters			
Treatments	pH	O.M (%)	N total (mg kg^{-1})	P total (mg kg^{-1})
T_1E	4.87 ± 0.40 ^{A}	1.63 ± 0.26 ^{C}	307.22 ± 76.02 ^{B}	110.16 ± 19.43 ^{AB}
T_1O	5.00 ± 0.30 ^{A}	1.49 ± 0.22 ^{ABC}	266.84 ± 101.90 ^{AB}	99.23 ± 4.30 ^{A}
T_1N	4.83 ± 0.55 ^{A}	1.16 ± 0.43 ^{AB}	236.41 ± 68.96 ^{AB}	98.80 ± 4.71 ^{A}
T_1S	5. 00 ± 0.46 ^{A}	1.58 ± 0.27 ^{BC}	271.72 ± 69.89 ^{AB}	120.38 ± 21.74 ^{B}
T_2E	4.67 ± 0.06 ^{A}	1.25 ± 0.08 ^{ABC}	227.73 ± 11.91 ^{AB}	98.35 ± 3.92 ^{A}
T_2O	4.53 ± 0.06 ^{A}	1.13 ± 0.25 ^{A}	206.57 ± 45.85 ^{AB}	101.25 ± 3.96 ^{A}
T_2N	4.47 ± 0.21 ^{A}	1.13 ± 0.34 ^{A}	198.18 ± 75.43 ^{A}	95.90 ± 0.73 ^{A}
T_2S	4.50 ± 0.20 ^{A}	1.12 ± 0.08 ^{A}	205.79 ± 26.22 ^{AB}	100.80 ± 8.14 ^{A}
T_3	4.53 ± 0.15 ^{A}	1.27 ± 0.16 ^{ABC}	235.08 ± 12.32 ^{AB}	98.36 ± 4.46 ^{A}
Pr >F	0.247	0.013	0.045	0.018
Significance	NS	S	S	S

In the same column, the numbers followed by the same letter are not significantly different at the 5% according to Fischer test. pH : Water pH, O.M : Organic matter, N total : Total nitrogen, P total : Total Phosphorus, T1E: East side under crown, T1O: West side under crown, T1N : North side under crown, T1S: south side under crown, T2E: East side at the limit of the crown, T2O: west side at the limit of the crown, T2N : North side at the limit of the crown, T2S: South side at the limit of the crown, T3: Control. NS: not significant, S: Significant.

Table 3. Evolution of soil chemical parameters according to distance from the trunk of *P. reticulatum* in northern Sudanian zone

Soil chimical parameters				
Treatments	pH	O.M (%)	N total (mg kg^{-1})	P total (mg kg^{-1})
SH	4.92 ± 0.38 ^{B}	1.46 ± 0.33 ^{B}	270.54 ± 73.34 ^{B}	107.14 ± 15.75 ^{A}
LH	4.54 ± 0.15 ^{A}	1.16 ± 0.19 ^{A}	209.56 ± 41.22 ^{A}	99.07 ± 4.77 ^{A}
HH	4.53 ± 0.15 ^{A}	1.27 ± 0.15 ^{AB}	235.08 ± 12.32 ^{AB}	98.36 ± 4.46 ^{A}
Pr >F	0.007	0.030	0.049	0.18
Significance	S	S	S	NS

In the same column, the numbers followed by the same letter are not significantly different at the 5% level using the Fischer test. pH : Water pH, O.M : Organic matter, N total : Total nitrogen, P total: Total Phosphorus, SH: under the crown, LH: boundary of the crown, HH: Out of the crown. NS: not significant, S: Significant.

Table 4. Evolution of soil chemical parameters following the cardinal directions and the distance from the trunk of *P. reticulatum* in southern Sudanian zone

Soil chimical parameters				
Treatments	pH	O.M (%)	N total (mg kg^{-1})	P total (mg kg^{-1})
T_1E	5.6 ± 0.20 ^{A}	2.77 ± 0.33 ^{AB}	429.91 ± 33.97 ^{A}	191.01 ± 60.61 ^{A}
T_1O	5.63 ± 0.06 ^{A}	3.27 ± 0.04 ^{BC}	482.01 ± 92.84 ^{A}	171.17 ± 45.27 ^{A}
T_1N	5.63 ± 0.06 ^{A}	2.68 ± 0.39 ^{A}	459.56 ± 89.87 ^{A}	173.65 ± 30.98 ^{A}
T_1S	5.60 ± 0.20 ^{A}	3.40 ± 0.43 ^{C}	428.05 ± 34.72 ^{A}	158.05 ± 15.19 ^{A}
T_2E	5.93 ± 0.66 ^{A}	2.92 ± 0.36 ^{ABC}	486.77 ± 133.51 ^{A}	138.33 ± 30.23 ^{A}
T_2O	5.70 ± 0.20 ^{A}	3.09 ± 0.13 ^{ABC}	506.66 ± 54.74 ^{A}	149.98 ± 19.39 ^{A}
T_2N	5.70 ± 0.10 ^{A}	3.10 ± 0.36 ^{ABC}	481.79 ± 200.54 ^{A}	178.61 ± 60.92 ^{A}
T_2S	5.70 ± 0.17 ^{A}	3.46 ± 0.38 ^{C}	428.83 ± 121.99 ^{A}	175.76 ± 44.93 ^{A}
T_3	5.73 ± 0.32 ^{A}	3.13 ± 0.23 ^{ABC}	418.59 ± 56.22 ^{A}	142.48 ± 37.07 ^{A}
Pr >F	0.908	0.010	0.960	0.789
Significance	NS	NS	NS	NS

In the same column, the numbers followed by the same letter are not significantly different at the 5% according to Fischer test. pH : Water pH, O.M : Organic matter, N total : Total nitrogen, P total : Total Phosphorus, T1E: East side under crown, T1O: West side under crown, T1N : North side under crown, T1S: south side under crown, T2E: East side at the limit of the crown, T2O: west side at the limit of the crown, T2N : North side at the limit of the crown, T2S: South side at the limit of the crown, T3: Control. NS: not significant, S: Significant.

Table 5. Evolution of soil chemical parameters depending on the distance to the trunk of *P. reticulatum* in southern Sudanian zone

Soil chimical parameters				
Traitments	pH	O.M (%)	N total (mg kg^{-1})	P total (mg kg^{-1})
SH	5.61 ± 0.12 ^{A}	3.03 ± 0,43 ^{A}	449.88 ± 63.32 ^{A}	173.47 ± 37.51 ^{A}
LH	5.75 ± 0.34 ^{A}	3.14± 0,34 ^{A}	476.01 ± 121.22 ^{A}	160.67 ± 39.83 ^{A}
HH	5.73 ± 0.32 ^{A}	3.13 ± 0,22 ^{A}	418.88 ± 56.22 ^{B}	142.48 ± 37.07 ^{A}
Pr >F	0.39	0.75	0.039	0.43
Significance	NS	NS	S	NS

In the same column, the numbers followed by the same letter are not significantly different at the 5% level using the Fischer test. pH : Water pH, O.M : Organic matter, N total : Total nitrogen, P total : Total Phosphorus, SH: under the crown, LH: boundary of the crown, HH: Out of the crown. NS: not significant, S: Significant.

Table 6. Impact of *P. reticulatum* on variation of microbial biomass

Microbial biomass (mg per 100 g of soil)		
Traitments	North sudanian zone	South sudanian zone
T_1E	48.57 ±4.57^{BC}	58.3 ±6.25^{CD}
T_1O	50.18 ±6.00^{C}	63.62 ±4.6 ^{D}
T_1N	48.83 ±7.10^{BC}	56.83 ±5.28^{BCD}
T_1S	48.18 ±5.34^{BC}	60.13 ±1.76^{D}
T_2E	41.5 ±2.29^{AB}	48.6 ±1.50^{A}
T_2O	42.3 ±5.73^{AB}	52.50 ±4.33^{ABC}
T_2N	42.78 ±6.14^{ABC}	49.77 ±4.08^{AB}
T2S	41.82 ±2.00^{ABC}	48.98 ±4.78^{A}
T_3	37.97 ±1.30^{A}	46.7 ±2.23^{A}
Pr > F	0.039	< 0.001
Significance	S	S

In the same column, the numbers followed by the same letter are not significantly different at the 5% according to Fischer test. T1E: East side under crown, T1O: West side under crown, T1N : North side under crown, T1S: south side under crown, T2E: East side at the limit of the crown, T2O: west side at the limit of the crown, T2N : North side at the limit of the crown, T2S: South side at the limit of the crown, T3: Control. NS: not significant, S: Significant.

Table 7. Compared microbial biomass following distance to the crown of *P. reticulatum*

Microbial biomass (mg per 100 g of soil)		
Treatments	North sudanian zone	South sudanian zone
SH	48.94 ± 5.03^{B}	59.72 ± 4.78^{B}
LH	42.10 ± 3.84^{A}	49.96 ± 3.67^{A}
HH	37.97 ±1.30^{A}	46.7 ±2.23^{A}
Pr > F	0.000	< 0.0001
Significance	S	S

In the same column, the numbers followed by the same letter are not significantly different at the 5% level using the Fischer test. SH: under the crown, LH: boundary of the crown, HH: Out of the crown. NS: not significant, S: Significant.

Considering the cardinal directions, *P. reticulatum* has a contrasted effect on organic matter. Indeed, around some trees it was the area under the crown that had larger quantities, while around others invidious it was the area in the boundary of the crown. However, the largest amount of organic material was found in treatment T2S and lowest in treatment T1E.

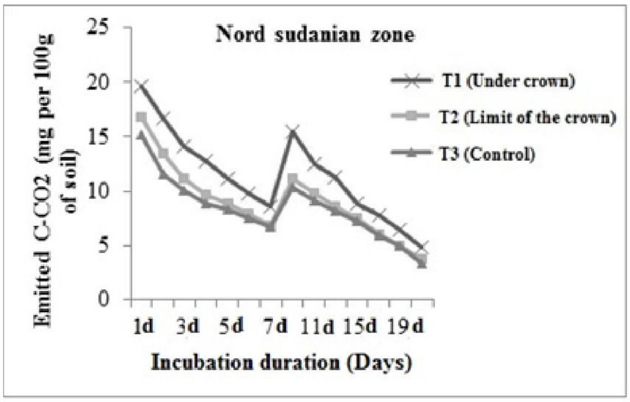

Figure 3. Evolution of emitted CO2 (mg per 100g of soil) during the 21 days of incubation in north sudanian zone

The treatment T2S improved amount of organic matter by 24.91% compared to treatment T1E and by 10.54% compared to the control. There was not significant difference of total nitrogen between treatments. It was the same trend for Pt. When considering only evolution of chemical elements relative to the crown of *P. reticulatum*, only Nt shows significant differences (P <0.05) between the control and both treatments "under crown" and "boundary of the crown" (Table 5).

Effect of *P. reticulatum* on soil biological properties

Variability of the microbial biomass

Microbial biomass in the south Sudanian zone was higher than the one in the north sudanian zone (Table 6). Results indicated that microbial biomass decreased when moving from the area under crown of *P. reticulatum* to the area out of the crown (Table 7).

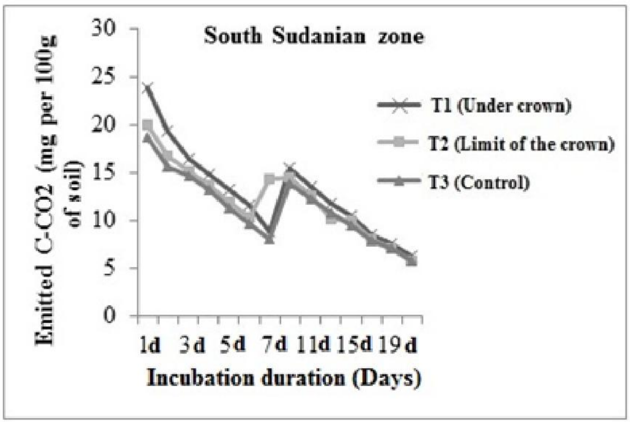

Figure 4. Evolution of emitted CO2 (mg per 100g of soil) during the 21 days of incubation in south sudanian zone

In the north Sudanian zone, there was significant differences between microbial biomass obtained in different treatments and cardinal direction. Microbial biomass under the crown of *P. reticulatum* was higher than those obtained in the boundary of the crown and in the control (non-covered).

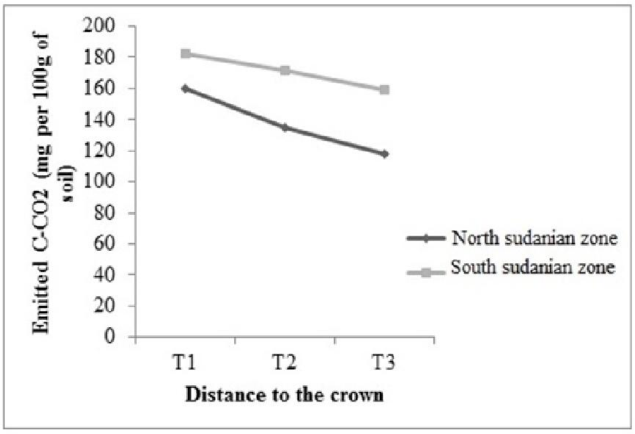

Figure 5. Mean of cumulative C-C0$_2$ based on treatments

In the south sudanian zone, cardinal direction has a significant effect on microbial biomass. More biomass was found in west direction. Treatment T1O improved microbial biomass by almost 25% compared to the control (T3). When we considered only the distance from the crown of the tree, there was significant differences between microbial biomass under trees crown and those outside of the crown (Table 7). This microbial biomass difference exists both in south and North Sudanian zones. The crown of *P. reticulatum* improves microbial biomass by 28.89% in north sudanian zone and 27.88% in south Sudanian one.

Soil respiration variation

The presence of *P. reticulatum* affected microbial activity (Fig 3 et 4). C-C02 emission was correlated to incubation time. The first week of incubation, emission was quite high and decreased day by day. At the beginning of the second week of incubation it appeared slightly increasing (eighth and ninth day), then there was decay and tend to 0 by twenty-first day. Whether north or south Sudan region, C-CO2 obtained under the crown of *P. reticulatum* was higher than those obtained at the limit of the crown that was also higher than those obtained outside of the crown

Variation of cumulative C-CO2

Distance to the trunk of *P. reticulatum* had an effect on the accumulation of C-CO2 emission (Fig 5). Indeed declining trend of the curve shown clearly that combination of C-CO2 decreased when moving away from the trunk of *P. reticulatum.* Mean value of cumulative C-CO2 for 100g of soil was 160 mg under the crown of *P. reticulatum*. It decreased to 134.6 mg on the edge of the crown and 117.69 mg in the control plot (not covered by *P. reticulatum*) in north sudanian zone. In the south sudanian zone this value changes from 182.29 to 171.5 and 158.81 mg respectively under crown, on the edge of the crown and the control. When comparing the two phytogeographic zones, it appeared that the release of C-CO2 is higher in the southern Sudanian zone compared to north sudanian one.

DISCUSSION

Our study sites are characterized by pH going to acids to relatively neutral. Sedego (1986) emphasized this property on tropical ferruginous soils of the same climatic zone. However, our results show that in north Sudanese area, the crown of *P. reticulatum* contribute to increase significantly soil pH.

Indeed in north Sudan region, under *P. reticulatum*, soil acidity is attenuated by the buffering effect of the organic matter which is highly concentrated under the crown of *Piliostigma*. This phenomenon is not observed in southern Sudan region, this could be explained by the nature and / or magnitude of soil microorganisms (Yélémou, 2010). *P. reticulatum* contribute to improve soil organic matter status, total nitrogen and total phosphorus. The ameliorative role of *P. reticulatum* on soil chemical properties was positive both in north Sudanian zone and south Sudanian one. For some authors, increased soil fertility in the shade is mainly due to the decomposition of litter (Georgiadis, 1989 ; Belsky, 1989; Traoré et al., 2007; Yélémou et al., 2013), That is true for some woody species more than others because of the quality of their litter to promote soil fertility (Traoré et al., 2007 ; Yélémou et al., 2013). For others authors, that would mainly due to decomposition of herbaceous vegetation (Bernhard-Reversat, 1980). To these possible explanations for soil fertility increasing under shade, we could add other mechanisms: providing element by rain-leaching (Tréca, 1996), nutrient supply by domestic or wild animals resting in the shade of trees or feeding on fruits or leaves and birds perching on it (Grouzis, 1998; Yélémou et al. 2007). *P reticulatum* is a shrub with abundant and thick leaves (Yélémou et al., 2008), and is characterized in sudanian zone by a large deposit of dry biomass.

Similar results of the positive role of trees on soil chemical properties were reported by other authors. Yélemou (2010) found that organic carbon increased by 31% (north Sudanian zone) and 105% (south Sudanian zone) under the crown of *P. reticulatum* compare to uncovered area. This same author reported an improvement of total nitrogen up to 66% under the crown of *P. reticulatum* compared to surrounding uncovered areas. Bazongo (2015) found that *Jatropha curcas* L. crown improved organic carbon and nitrogen in the south Sudanian zone. Our results differ from those of Yélémou (2010), by importance of amelioration effect on soil fertility. This could be explain by age of *P. reticulatum* stand. Indeed, in Yélémou 2010, trees were aged over 30 years, whereas in our present study, they were twenty years. Abundance of litter, soil microorganisms dynamics following sites (Yélémou, 2010), effect of fire on litter and chemical elements (Mills and Fey 2004; Sawadogo, 2009), could explain variations. Furthermore, because of density of vegetation that is relatively weak in north Sudanian zone compare to south Sudanian zone, the winds in the dry season (Harmattan) or rainy season (monsoon) could create a greater rousing effect. Thus biomass of some trees was driven away from the crown. Wind action in northern Sudan zone would induce fertility profile. The East direction is the treatment where soil organic matter (SOM), total nitrogen (Nt) and total phosphorus (Pt) rates were largest in north sudanian zone. Strong winds in north Sudanian that blow toward east direction explain this phenomenon. Vegetation density is higher in south sudanian zone. This acts as a windbreak and biomass is more likely to be trapped under trees crown. Soil microorganisms favoured soil nutriments accumulation. Transition from south sudanian zone to savannah zone, reduced soil biological activity (Nacro, 1997). Respiratory activity and microbial biomass under *Piliostigma reticulatum* were especially greater in area close to tree's trunk. Our results show that microbial biomass under *P. reticulatum* was higher than that obtained outside crown. According ITAB, (2002) and Lee and Jose (2003), microbial biomass and activity depend on organic matter and in particularly on its free fraction.

In south sudanian zone fallows microorganism's activities are relatively low. Land management affects microbial development. Indeed yearly bush fires in farmers open fallow destroy soil microorganisms, especially in top layer (0- 20 cm). CO_2 released by microorganisms depend on soil organic matter, nitrogen and phosphorus (Yélémou, 2010). This explains the fact that area under crown released higher CO_2 than the area in the limit of the crown that released also higher CO_2 than the control. Vast microbial activity the first days of incubation testified existence of easy mineralizable carbonaceous materials. Gradual reduction of microbial activity was due to declining of soil nutrients stock. Our results indicated that there was difference in nutrients stock and thus soil microbial activities between area under crown and surrounding areas of the crown.

Conclusion

P. reticulatum has a role in improving soil fertility. Beneficial effect is justified by abundant litter due to large leaf biomass of this specie. This contribute to improve organic matter and total nitrogen. In south sudanian zone, environmental conditions are more favorable to microbial activities compared to the north Sudanian zone. However, except the potential of hydrogen (pH) that does not show significant differences between under crown of *P. reticulatum* and the uncovered areas, the others measured soil parameters have improved their status under the crown both in the two study sites. North Sudanian zone is marked by scattering of soil nutrients due to erosion factors. Good management of *Piliostigma* stand characterized by a high potential for vegetative propagation and good soil cover, could contribute to more improve organic carbon and total nitrogen status in depleted soils and fallows. Nevertheless, better understanding of the impact of the species on soil physical properties could help to know more about the role of this species in tropical soils regeneration.

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