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Management patterns of *Jatropha curcas*: Impact on the microbial and the mycorrhizial biomasses in different phyto-geographic zones of Burkina Faso

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ABSTRACT

To reduce its dependency on foreign power sources, Burkina Faso has started since 2008 to grow Jatropha curcas to produce bio-fuel. But this vegetal species was adopted without sound knowledge of its plausible effects on the part of the soil colonized by the roots. This study aimed to determine the influences of different management patterns of Jatropha curcas on the fertility features of soils. To that end, on a transect going from the south-sudanian to the north-sudanian zones of Burkina Faso, three sites were chosen; two management patterns of Jatropha curcas per site (pure plantation of Jatropha and Jatropha mixed with other crops) and five plants of Jatropha per field were followed. Composite soil samplings were collected between 0 and 20 cm depth at three levels: 0 m from the stem of Jatropha curcas, 1 m from the stem and the control (far away from the Jatropha plant). Then analyses were performed to determine the total carbon, nitrogen, potassium, the pH-water, the pH-KCL, the microbial biomass, the respiration activities and the density of spores. the results indicate that Jatropha curcas improves pH and biomass quality (low values of C / N) of the soil. In addition, microbial biomass and respiration activity is greater in plants of Jatropha curcas. In addition, an important mycorrhizal flora is observed in plants, especially in the North-Sudanian zone of Burkina Faso. Jatropha curcas significantly improves soil fertility. Therefore, its promotion in rural areas could help to improve the livelihood of the people.

Key words: *Jatropha curcas*, soil, carbon, nitrogen, microbial biomass, mycorrhize

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INTRODUCTION

Introduced in Burkina Faso since colonial era, cultivation of Jatropha that occupies around 5% of arable lands [1], aims to promote bio-fuel production in Burkina Faso. Indeed in 2008, the government of Burkina Faso commits to promote *Jatropha curcas* to reduce dependency on fossil energy. However, there is increasingly opposition to *Jatropha curcas* adoption since the extension of Jatropha farms may be a threat to cereal crops that represent the staple food in Burkina Faso. Thus the way of avoiding this difficulty is to mix Jatropha with cereal crops on arable lands. This solution is feasible since it has been demonstrated that Jatropha associated with cereal crops is economically more profitable than pure cereal farms [1]. Furthermore, Jatropha can be grown on marginal soils, i.e.

soils with low fertility and low rate of nutrient elements that cannot be used for cereal growth [2, 3]**.** That is because of its developed root system that allows it to withdraw water and nutrients from deep layers of soil. The rapid growth and the huge ramification capability of the root system allow *Jatropha curcas* to be quoted among plants that contribute to preventing soil erosion [4]**.**

Soil living organisms play a key role in soil bio-geo-chemistry and in soil biologic balance [5]. Indeed, it is because of these organisms (mycorhizian fungus) that *Jatropha curcas* L. is able to develop on poor soils in terms of nutrient elements. The roots of *Jatropha curcas* L. in symbiosis with tree mycorhizian funguses prevent deficiency of nutrient elements (N, P and K) in the soil [6].

Despite the apparent advantages of growing *Jatropha curcas*, there is so far no scientific data showing the effects of this plant on the root zone of soil, particularly on the biological communities influencing crop productivity when associated with Jatropha. This study aims to determine the impacts of different management patterns of *Jatropha curcas* on soil microbial and mycorhyzian biomass to optimize the productivity of new agricultural systems that are in development in Burkina Faso.

MATERIALS AND METHODS

Site of the study

The sites cover a climatic gradient with annual precipitations between 700 and 1000 mm (figure 1). The sites of Torokoro and Boni are located in the South-sudanian zone (annual rainfall between 850 and 1000 mm) and the one of Imkouka is in the North-sudanian zone (annual rainfall between 700 and 850 mm). On these sites there were plantations of *Jatropha curcas* between 4 and 7 year-old.

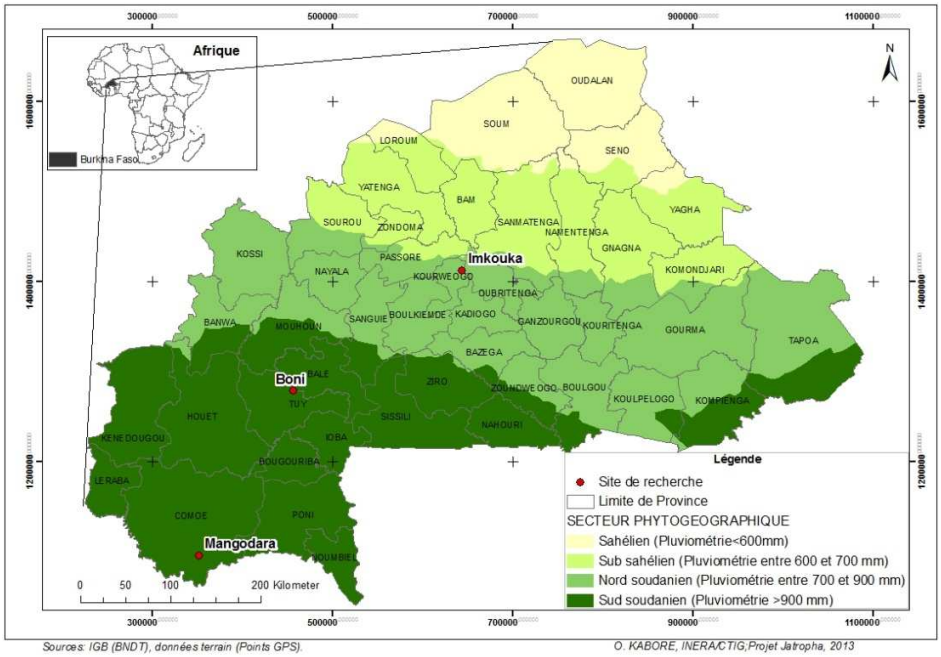


Figure 1 : Location of the considered sites

Features of farms and individuals of Jatropha on the considered sites

We considered soil samplings coming from: (1) pure Jatropha farms and (2) farms with Jatropha mixed with legumes or cereals. The characteristics of the different agricultural systems considered at each site are variable (table 1).

Table 1 : Features of the considered agricultural systems of Jatropha per site

	Sites	Agricultural system	Age	Surface	Planting mod	Spacing
1	Torokoro 1	Pur Jatropha	8 ans	01 hectare	Direct sowing	1 m x 4 m
2	Torokoro 2	Jatropha + peanut	3 ans	01 hectare	Nursery	3 m x 2 m
3	Boni 1	Pur Jatropha	5 ans	01 hectare	Nursery	6 m x 4 m
4	Boni 2	Jatropha + red sorghum	3 ans	½ hectare	Nursery	3m x 3 m
5	Imkouka 1	Pur Jatropha	4 ans	20 hectares	Nursery	3 m x 3m
6	Imkouka 2	Jatropha + Maize	4 ans	20 hectares	Nursery	3m x 6 m

1 m x 4 m = 1 meter between rows and 4 meters between plants

Five plants of *Jatropha curcas* were considered in each agricultural system. The considered plants were quite homogeneous regarding both the height of the stem and the circumference of the foliage-cover (table 2).

Table 2 : Features of the considered Jatropha plants at the different sites

	Sites	Total height (cm)	Diameter at the collar (cm)	Height at the 1st branch (cm)	Diameter of the cover (cm)
1	Torokoro 1	253.8±32.3	10.8±1.2	14.2±2.2	282.2±33.7
2	Torokoro 2	229.4±28.8	11.0±1.7	14.3±6.2	244.4±30.3
3	Boni 1	189.6±28.7	10.3±1.6	04.9±1.6	223.6±70.0
4	Boni 2	182.0±19.7	08.4±1.1	04.4±1.8	201.8±36.7
5	Imkouka 1	205.6±58.7	11.2±1.8	04.8±0.8	215.0±46.1
6	Imkouka 2	231.8±21.1	12.8±1.7	04.8±2.4	259.8±5.3

Sampling

At each site, five plants of *Jatropha curcas* have been considered in each agricultural system for the collection of composite soil samples. The sampling was carried out at 3 levels: (1) nearby the stem (0 m from the stem), (2) at 1 m away from the stem and (3) at a distance at least equal to three times the radius of the plant cover to avoid any effect of the considered plant (i.e. the witness). The soil samplings were collected with an auger following four cardinal directions at each of the 3 considered treatments. They were performed at the 0-20 cm layer of the soil.

The soil samplings were dried at shadow for a while and afterward under the sun. Then they were sifted with a sifter that has 2 mm of mesh.

Soil analysis

Chemical parameters

Total organic carbon, total nitrogen, total phosphorus total potassium pH(KCl) and pH (H_2O) were analyzed using the following methods:

- Total organic carbon was determined using the method by Walkey and Black (1934);
- Total nitrogen was determined using Kjeldahl's method;
- Total phosphorus was determined using an automatic sensor and the same extraction method as for total nitrogen;

Total potassium was determined with a flame photometer,

-pH (KCl) was measured by a solution of KCl, 1 N.

- PH (H_20) was measured by direct use of an electronic electrode in a diluted soil solution (2 volumes of soil for 5 volumes of distilled water).

Microbial biomass

There are many methods to determine soil microbial biomass [7]. The most used methods are (i) the chloroform-fumigation-extraction (CFE) method, also known as fumigation-extraction method of Vance *et al.* [8] modified by Amato and Ladd [9]; (ii) the chloroform-fumigation - incubation (CFI) or fumigation – incubation method of Jenkinson and Powlson [10]. These two methods use chloroform, a chemical which kills soil microorganisms. The CFI is suitable for fine texture soils with low organic carbon contents [11]. In our experiment, 200 grams of soil were divided into two fractions of 100 grams each and adjusted to 60 % of water holding capacity (WHC). The first fraction was fumigated for 24 h with trichloromethane ($CHCl_3$). After removing the fumigation agent by repeated evacuations (washing), samples were readjusted to 60 % WHC and incubated together with the non-fumigated soil samples using Sodium Hydroxide (NaOH, 0,5N) to trap the CO_2 released from the soil. To simulate ambient conditions in Sudano-Sahelian zones, incubation temperature was set at 28 °C and the incubation time reduced to 7

days [12]. When incubation was terminated, an excess of Barium Chloride ($BaCl_2$) was added to the NaOH solution to precipitate Carbonate (CO_3^{2-}) and the rest of NaOH is neutralized with Chlorhydric acid (HCl 0.5 N) using phenolphthalein as indicator. Soil microbial biomass (C_{mic}) was calculated by dividing the difference between CO_2 productions of fumigated and non-fumigated soils by a correction factor Kc = 0.41 [13].

Respiration's tests and microbial activities

The most known and simplest method to estimate soil microflora's global activity is to measure carbon and nitrogen mineralisation under controlled conditions close to biological optimum. Soil samples were incubated for some time at 28ºC under condition close to field water holding capacity in order to allow resume of microorganisms' activities [14, 15, 16]. Soil basal respiration (Cresp) was determined using 100 g of non-fumigated soil and the CO_2 released was measured daily as described above, during 21 days.

Assessment of the diversity and density of mycorrhizial fungus in soils

Diversity and abundance of fungus in the root zone of *Jatropha curcas* were assessed in the different agricultural systems.

Extraction of spores

In a spade of 1 liter, a soil sampling of 100 g coming from an agricultural system of *Jatropha curcas*. is put in suspension in 500 ml of tap water and vigorously agitated to separate the fungal particles from the soil particles. The suspension is then poured on superimposed sifters with decreasing meshes (500 to 50 µm). The same soil is again submerged, agitated and the wet sifting is so repeated several times until a limpid water is obtained after agitation. The content of each sifter is retrieved, put in suspension in tap water and placed in centrifugation tubes. In each tube, a saccharose solution of 60 g/ml is injected through a syringe. The tubes are then put under centrifugation at 3000 tr/mn during 10 mn. The spores in each sampling are retrieved at the water/saccharose solution interface with a syringe and abundantly rinsed in distilled water in a sifter of 50 µm.

The retrieved spores after rinsing are either put in a Petri's box for observation, or in Eppendorf's tubes containing a mixture (glycerol and absolute ethanol V/V) for a better conservation at 4 °C.

Observation and counting of the spores

The extracted spores are observed through magnifying glasses and a manual sorting is carried out following morphologic characteristics such as the color, the shape, the size and joining pattern of the 'hyphe' to the spore. Then all the observed types of spores are counting. Finally the same-shape spores of each lot are conserved in a mixture of glycerol/ethanol (v/v) at 4 °C.

Statistical analyses

The collected data were analysed by software such as Excel and XLSTAT 7.5.2. The means of the variables were compared through the Newman-Keuls test at the confidential level of 5%.

RESULTS

Dynamic of the soil pH, carbon and nitrogen under the influence of *Jatropha curcas*

Evolution of soil acidity

The soils of thestudy sites are characterized by a low acidity despite their high acidity potential. The pH (water and KCL) of the soils under pure Jatropha is not significantly different whatever the treatment (Table 3). In intercrop system of Jatropha, the pH of the soil nearby Jatropha plants is different from the pH of the soil far away at Torokoro and Imkouka. At Imkouka, the pH-water in treatments 0 m and in the control is statistically equivalent.

Variability of the organic carbon, total nitrogen and the report C/N

The contents in total organic carbon (Ctotal) and total nitrogen (Ntotal) are not statistically different (P<5%) regarding the different treatments (0 m, 1 m and the witness) at the site of Torokoro, whatever the agricultural system (table 4). Nevertheless, the values are more important, nearby the Jatropha plants, comparatively with those of the witness. The quotient C/N also shows indifferent values for all the treatments.

Table 3: Evolution of soil acidity at different sites

Sites	crop system	Treatments	pH-water	pH-Kcl
Torokoro	Pure	Toro1 0 m	7.00 ± 0.62 [a]	6.03 ± 0.68 [a]
		Toro1 1 m	6.91 ± 0.49 [a]	5.77 ± 0.60 [a]
		Toro1 Control	6.55 ± 0.07 [a]	5.26 ± 0.00 [a]
	intercrop	Toro2 0 m	7.33 ± 0.46 [a]	6.26 ± 0.52 [a]
		Toro2 1 m	7.30 ± 0.72 [a]	6.16 ± 0.91 [a]
		Toro2 Control	5.92 ± 0.01 [b]	4.61 ± 0.00 [b]
Boni	Pure	Boni1 0 m	7.01 ± 0.35 [a]	5.41 ± 0.47 [a]
		Boni1 1 m	7.04 ± 0.34 [a]	5.39 ± 0.53 [a]
		Boni1 Control	7.02 ± 0.02 [a]	4.95 ± 0.01 [a]
	intercrop	Boni2 0 m	6.91 ± 0.51 [a]	6.07 ± 0.69 [a]
		Boni2 1 m	6.94 ± 0.54 [a]	6.02 ± 0.72 [a]
		Boni2 Control	6.09 ± 0.01 [a]	4.98 ± 0.01 [a]
Imkouka	Pure	Imkou1 0 m	6.32 ± 0.43 [a]	5,18 ± 0.44 [a]
		Imkou1 1 m	6.40 ± 0.56 [a]	5,11 ± 0.66 [a]
		Imkou1 Control	5.86 ± 0.01 [a]	4.38 ± 0.00 [a]
	intercrop	Imkou2 0 m	6.07 ± 0.17 [b]	5.01 ± 0.37 [a]
		Imkou2 1 m	6.40 ± 0.25 [a]	5.34 ± 0.39 [a]
		Imkou2 Control	5.86 ± 0.01 [b]	4.38 ± 0.00 [b]

For each variable (column) and cropping system, values that have the same subscript are not significantly different according to the Newman-Keuls test at the 5% level.

Table 4: Evolution of C_{total}, N_{total} and C/N ratio in different agricultural systems at Torokoro

Agricultural system	Treatments	Total carbon (g/kg sol)	Total Nitrogen (g/kg sol)	C/N
Pure	Toro1 0 m	10.75 ± 2.36 [a]	0.79 ± 0.32 [a]	15.16 ± 6.45 [a]
	Toro1 1 m	08.23 ± 2.04 [a]	0.65 ± 0.22 [a]	13.01 ± 2.53 [a]
	Toro1 Control	07.75 ± 0.34 [a]	0.59 ± 0.02 [a]	13.08 ± 0.64 [a]
Associated	Toro2 0 m	08.45 ± 2.11 [a]	0.63 ± 0.19 [a]	13.67 ± 1.70 [a]
	Toro2 1 m	07.11 ± 1.86 [a]	0.55 ± 0.22 [a]	13.54 ± 2.38 [a]
	Toro2 Control	06.90 ± 0.56 [a]	0.45 ± 0.04 [a]	15.26 ± 1.29 [a]

For each variable (column) and cropping system, values that have the same subscript are not significantly different according to the Newman-Keuls test at the 5% level.

At Boni, contents in total organic carbon (Ctotal) and the total nitrogen (Ntotal) do not show significant differences (P<5%) whatever the crop system. Nevertheless, these values are more important, nearby Jatropha plants comparatively with the values of the controls (table 5).

The values of C/N are significantly different (P<5%) between the treatments and also between the crop systems. Indeed, under the foliage of *Jatropha curcas*, the value of C/N ratio is less high than those of the controls.

Table 5: Evolution of C_{total}, N_{total} and the C/N ratio in different crop systems at Boni

crop system	Treatments	Total carbon (g/kg sol)	Total nitrogen (g/kg sol)	C/N
Pure Jatropha	Boni1 0 m	10.46 ± 2.21 [a]	1.08 ± 0.31 [a]	09.91 ± 0.98 [b]
	Boni1 1 m	09.84 ± 1.86 [a]	1.00 ± 0.28 [a]	10.04 ± 0.99 [b]
	Boni1 control	08.71 ± 0.61 [a]	0.69 ± 0.01 [a]	12.61 ± 0.79 [a]
Mixed crops	Boni2 0 m	09.47 ± 2.61 [a]	0.90 ± 0.26 [a]	10.54 ± 0.68 [b]
	Boni2 1 m	09.18 ± 2.17 [a]	0.81 ± 0.23 [a]	11.47 ± 1.23 [b]
	Boni2 control	08.71 ± 0.36 [a]	0.69 ± 0.01 [a]	12.62 ± 0.66 [a]

For each variable (column) and cropping system, values that have the same subscript are not significantly different according to the Newman-Keuls test at the 5% level.

At the site of Imkouka, in north-soudanian zone, the value of Ctotal is statistically significant (P<5%) between the treatments in the pure crop of Jatropha. Indeed, the Ctotal of the witness is higher (05,40 ± 0,29 g/kg) than the Ctotal under the foliage of Jatropha (04,48 ± 0,45 g/kg et 04,22 ± 0,66 g/kg) (Tableau 6). In the intercrop system, the treatments do not show any statistic difference in the evolution of the value of Ctotal .

Whatever the crop system of Jatropha, the total nitrogen values are not statically different (P<5%) between the different treatments (under and outside the foliage of Jatropha). The quotient C/N in pure crop system of Jatropha is statistically less higher under Jatropha foliage (10,60 ± 1,08 et 11,95 ± 1,50) than outside the foliage (14,89 ± 0,80).

In the intercrop system, the value of C/N ratio is statistically different between treatments. The quotient C/N increases from the nearby of Jatropha plant to the control.

Table 6: Evolution of C_{total}, N_{total} and the C/N ratio in the different crop systems at Imkouka

crop system	Treatment	Total carbon (g/kg sol)	Total nitrogen (g/kg sol)	C/N
Pure	Imkou1 0 m	04.48 ± 0.45 [b]	0.43 ± 0.06 [a]	10.60 ± 1.08 [b]
	Imkou1 1 m	04.22 ± 0.66 [b]	0.43 ± 0.05 [a]	11.95 ± 1.50 [b]
	Imkou1 control	05.40 ± 0.29 [a]	0.36 ± 0.04 [a]	14.89 ± 0.80 [a]
Mix system	Imkou2 0 m	05.04 ± 2.03 [a]	0.50 ± 0.22 [a]	10.26 ± 0.88 [c]
	Imkou2 1 m	04.82 ± 1.48 [a]	0.39 ± 0.15 [a]	12.74 ± 1.66 [b]
	Imkou2 control	05.40 ± 0.29 [a]	0.36 ± 0.04 [a]	14.89 ± 0.80 [a]

For each variable (column) and cropping system, values that have the same subscript are not significantly different according to the Newman-Keuls test at the 5% level.

Evolution of total phosphorus and potassium

The value of the total Phosphorus doesn't reveal any significant different among the treatments no matter the site and the crop system (table 7).

The total potassium is statistically similar between the treatments in the pure crop system of Jatropha. Reversely, in the intercrops system, total potassium is different between the treatments solely at site of Torokoro. At this site, the total potassium is higher nearby Jatropha plants comparatively with the other treatments.

Table 7: Variation of the total phosphorus and the total potassium in different crop systems of Jatropha

Sites	crop system	Treatment	P-total (g/kg de sol)	K-total (g/kg de sol)
Torokoro	Pure	Toro1 0 m	195 ± 58 [a]	1709 ± 485 [a]
		Toro1 1 m	200 ± 64 [a]	2231 ± 556 [a]
		Toro1 control	169 ± 15 [a]	1825 ± 193 [a]
	intercrop	Toro2 0 m	119 ± 36 [a]	1767 ± 527 [a]
		Toro2 1 m	106 ± 25 [a]	1458 ± 377 [a]
		Toro2 control	95 ± 14 [a]	892 ± 56 [b]
Boni	Pure	Boni1 0 m	245 ± 72 [a]	1478 ± 902 [a]
		Boni1 1 m	242 ± 60 [a]	1555 ± 991 [a]
		Boni1 control	249 ± 17 [a]	521 ± 48 [a]
	intercrop	Boni2 0 m	128 ± 13 [a]	9686 ± 4682 [a]
		Boni2 1 m	115 ± 17 [a]	7137 ± 2341 [a]
		Boni2 control	130 ± 12 [a]	5752 ± 435 [a]
Imkouka	Pure	Imkou1 0 m	87 ± 9 [a]	1226 ± 209 [a]
		Imkou1 1 m	79 ± 13 [a]	1246 ± 97 [a]
		Imkou1 control	94 ± 10 [a]	988 ± 56 [a]
	intercrop	Imkou2 0 m	107 ± 42 [a]	1033 ± 173 [a]
		Imkou2 1 m	84 ± 20 [a]	1014 ± 110 [a]
		Imkou2 control	94 ± 10 [a]	988 ± 56 [a]

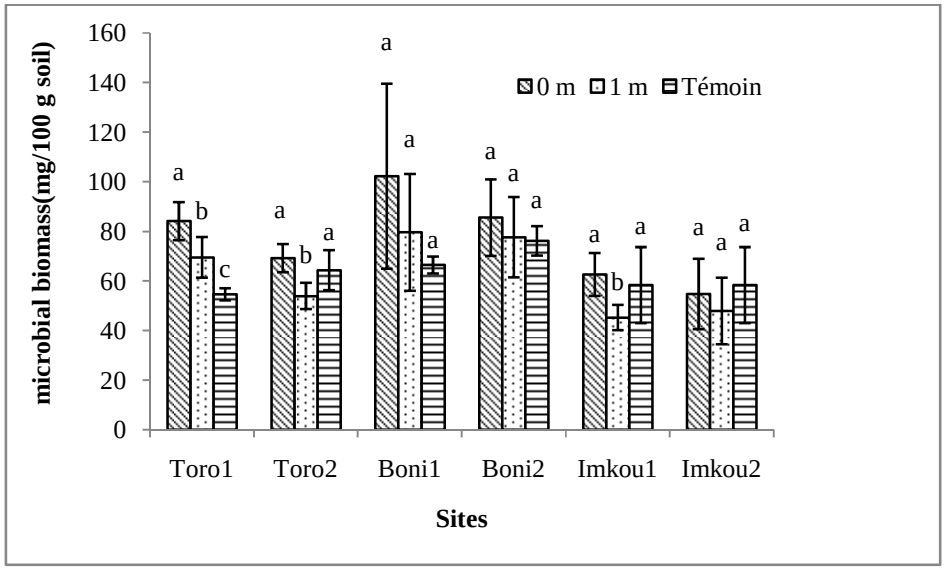
For each variable (column) and cropping system, values that have the same subscript are not significantly different according to the Newman-Keuls test at the 5% level.

Variability in microbial biomass and in respiration

Variability in the microbial biomass

The microbial biomass of soil, in the pure crop system of Jatropha, decreases respectively from 0 m under Jatropha plants to the control (figure 2) except at Imkouka where the value at 1 m from Jatropha plants is statistically less high than those of control. In intercrop system, the microbial biomass is not statistically different between the treatments except in the site of Torokoro.

At Boni, the microbial biomass is statistically indifferent between the treatments whatever the crop system.



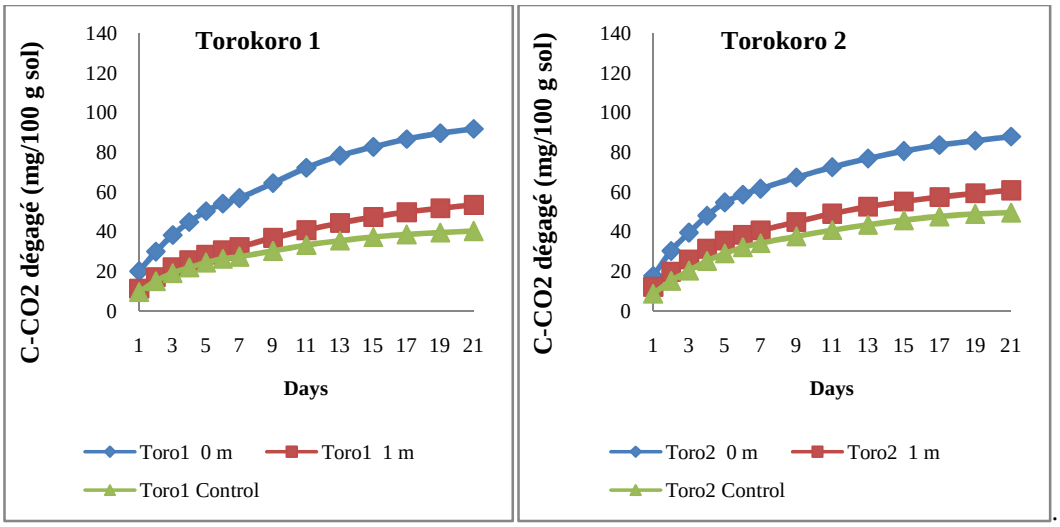
For each site, the triplet histograms topped with the same letter are not significantly different according to the Newman-Keuls test at the 5% level

Figure 2: Variability in the microbial biomass in the different crop l systems of *Jatropha curcas*

Respiratory cinetic of soils

At Torokoro, the evolution pace of the carbon mineralization is similar for the two crop systems of Jatropha. At 0 m, the speed of the carbon mineralization is higher for the treatments "1 m from Jatropha plants" and the control (figure 3).

At Boni, the speed of the respiratory evolution of the control and treatment 1 m are similar since the two graphics are confused in figure 3. However in the intercrop system, the evolution of carbon mineralization is statistically inferior to those of the treatments 0 m and 1 m. The clearing gaps of C-CO2 are more important in all the crop systems. Furthermore, at Imkouka the C-CO2 clearing speed is statistically indifferent between the treatment 1 m and the control.



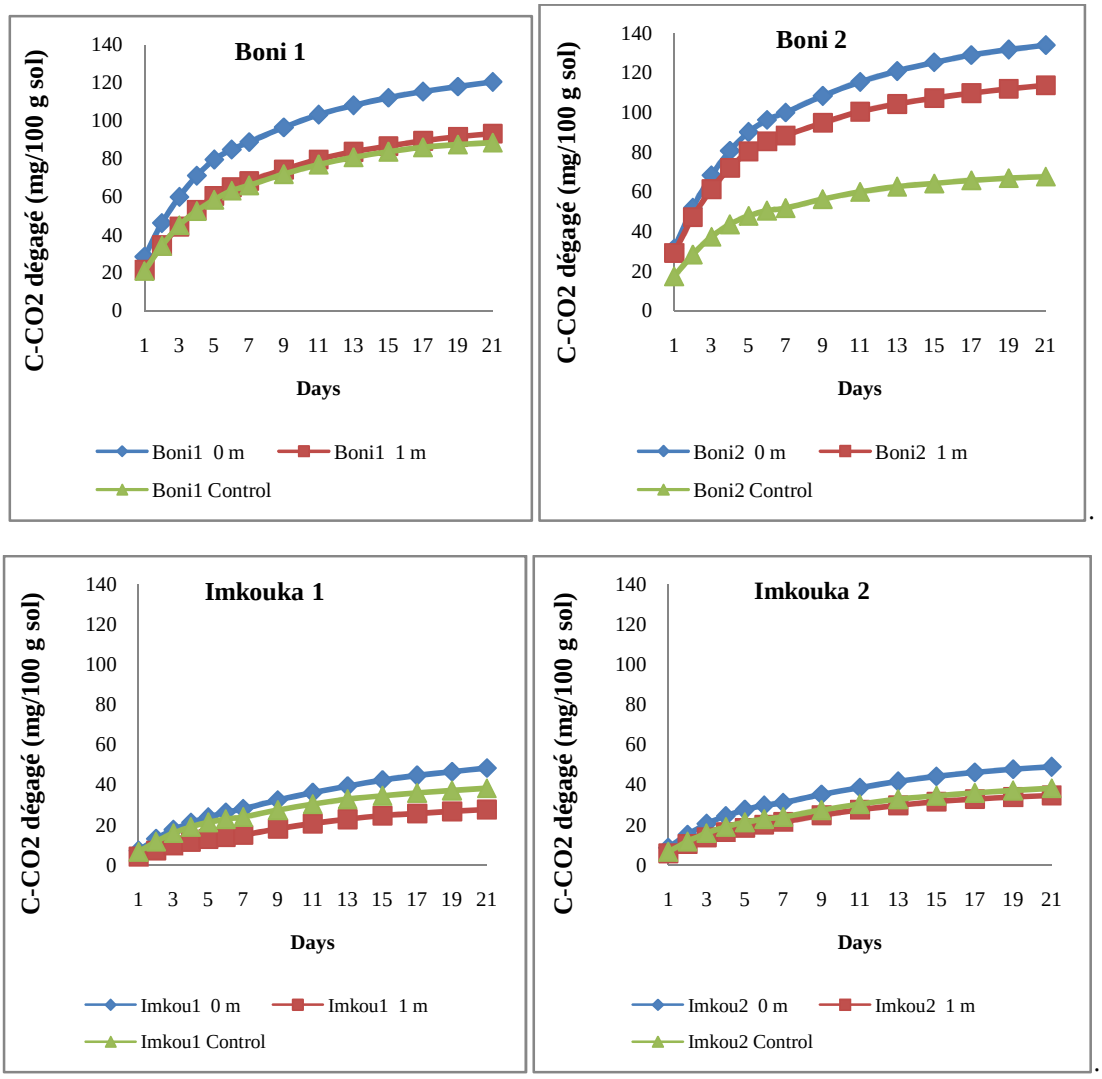


Figure 3: Evolution of the respiration in the different agricultural systems of *Jatropha curcas* during 21 days of incubation of soil collected at different distances from Jatropha plant

Density of spores in soils

The spores, counted in the different crop systems of Jatropha, are more abundant in the north-sudanian zone (Imkouka) than for the south-sudanian zone (table 8). At Imkouka whatever the crop system, the density of spores is higher under the foliage of Jatropha than outside this foliage;while in the south-sudanian zone (Torokoro and Boni) the density of spores remains the same between the treatments.

Table 8: Evolution of the density of soil spores in different crop systems of *Jatropha curcas.*

Sites	Crop system	Treatments	Density of spores
Torokoro	**Pure system**	Toro1 0 m	545.60 ± 241.46 [a]
		Toro1 1 m	462.60 ± 146.10 [a]
		Toro1 Control	643.20 ± 206.23 [a]
	intercrop system	Toro2 0 m	582.00 ± 306.31 [a]
		Toro2 1 m	531.40 ± 401.41 [a]
		Toro2 Control	517.40 ± 148.51 [a]
Boni	**Pure system**	Boni1 0 m	792.40 ± 240.84 [a]
		Boni1 1 m	826.60 ± 287.17 [a]
		Boni1 Control	884.20 ± 155.33 [a]
	intercrop system	Boni2 0 m	870.60 ± 293.89 [a]
		Boni2 1 m	1053.60 ± 280.16 [a]
		Boni2 Control	1126.40 ± 295.10 [a]
Imkouka	**Pure system**	Imkou1 0 m	973.80 ± 330.70 [b]
		Imkou1 1 m	867.00 ± 215.45 [b]
		Imkou1 Control	1362.00 ± 157.07 [a]
	intercrocrop system	Imkou2 0 m	730.00 ± 272.00 [b]
		Imkou2 1 m	578.00 ± 398.41 [b]
		Imkou2 Control	1362.00 ± 157.07 [a]

For each variable (column) and cropping system, values that have the same subscript are not significantly different according to the Newman-Keuls test at the 5% level.

DISCUSSION

In the different cropping systems of *Jatropha curcas*, here studied, the measured pH values are slightly acidic (pH <7) (cases of Imkouka and Boni with pure crop systems) to slightly alkaline (pH > 7) (south-sudanian climate). These results differ from those obtained by Bazongo (2011) with seeds of a *Jatropha curcas* crop system, aged of two years, in south-sudanian zone of Burkina Faso [17]. For this author, the pH values ranged from 6.06 to 6.09. In addition, northern Sudan zone of Burkina Faso, under the feet of *Jatropha curcas* 2 years, values slightly acidic pH have been obtained [18]. Our results can be explained by the fact that the plants of *Jatropha curcas* here studied are older (mean age of 4 to 5 years), which gives rise to a greater production of litter. The pH of the soil under the canopy becomes more alkaline with the age of the plants. In addition, the level of sampling the soil by Sanou [18], 0-10 cm (where the litter is more abundant), compared to 0-20cm level, can explain that we have similar pH [19], despite the age difference of the plants of *Jatropha curcas*. Under young plants of Jatropha, the pH increase from the acid to the basic state with the development of the trees. Changes in soil acidity are recognized based on the system of land use. The pure cultures of *Jatropha curcas* show no pH change following treatment (0m, 1m, control). This mode of culture is characterized by a relatively high production level of leaf biomass. In contrast, in intercropping systems, with *Jatropha curcas*, except in Boni there are pH values different from the foot of the trunk to controls . The practice of intercropping induced the use of chemical fertilizers which generally acidify the soils [20]. In addition, the type of crop (sorghum, maize, groundnuts) could partly explain the changes in pH. The peanut is a legume and may cause the development of symbiotic relationships in Jatropha system, while maize is a very demanding species for minerals [18]. At Torokoro (south sudanian climate), Ntotal and Ctotal variables are comparable regardless of the distance from the trunk of the tree and the culture system. It is the same in the case of the Boni site (south sudanian climate). The same results in south Sudanian region have been obtained [17]. Ctotal and Ntotal are relatively hight in south sudanian area. Indeed, soils of south sudanian zone of Burkina Faso, are generally richer in Ct and Nt [21]. The non variation in Ct and Nt under the canopy as compared to the outside of the canopy is probably explained by the fact that the influence of the tree is hidden by the high level of natural fertility of the area and the effect of tillage practices [22]. In south sudanian region, either in pure culture of *Jatropha curcas* or in associated culture, the values of total carbon and total nitrogen, does not vary with the distance from the tree trunk. These results are contrary to those of many authors who worked on the association between trees and Culture [23, 16, 24]. For these authors, the rate of carbon under the canopy is higher than in the control. It is the same for total nitrogen. The tree cover contributes significantly to carbon sequestration [25, 26] in arid and semi-arid areas [27]. Our results are nevertheless similar to other researchers [17].

This author obtained, for *Jatropha curcas* system aged of 4, 3 and 2 years, identical content of carbon for the soil under the canopy and for those outside of the canopy. In a system of *Jatropha curcas* plants, aged of 2 years, lower levels of carbon under the canopy as compared to the amount obtained outside of the canopy have been obtained by

a researcher in east Burkina [18]. This phenomenon is explained by an increase in the mineralization of organic matter and initial absorption of minerals by the tree [28]. The total nitrogen shows no difference according to the treatment (0 m, 1 m and control). These results are consistent with those of Bazongo [17] with *Jatropha curcas* plants aged of 4 and 3 aged. By contrast, with Jatropha aged of 2 years, he got a higher content of Nt under canopy as compared to those outside the canopy. A higher content of Nt under canopy and outside the canopy of *Jatropha curcas* aged of 2 years, has been obtained in north sudanian zone. [18] There exists a variable period of latency, depending on the species and the area, between planting and improving the rate of Ct and Nt under the canopy. The C/N ratio reflects the efficiency of carbon. Except for Torokoro where C/N ratio shows no variation between the treatments (0 m, 1 m and control), our results show that the C/N ratio is relatively lower in Jatropha system (0 m and 1 m) and in the the control. The low value of C/N ratio (<12) shows good mineralization of organic matter in Jatropha [29]. In pure culture of *Jatropha curcas*, litter is more abundant and the phenomenon is more pronounced because the C/N ratio is lower as compared to the case of intercrop system. Organic compounds in *Jatropha curcas* system, are of good quality because according to several authors [30, 16, 24], the decomposition of litter is related to their nitrogen content. From south Sudanian to north sudanian zones, our results provide relatively poor sites for Pt. Furthermore the Pt content in the canopy of *Jatropha curcas* (0 m and 1 m) is identical to that outside of the canopy. It is the same case for the content of Kt, excepted for the intercropping Jatropha system in Torokoro. The low content of soil for these minerals is to relate with the fact that people generally use poor soils for pure plantations of *Jatropha curcas*.

The microbial biomass is an early indicator of changes in soil quality [14]. In pure culture system of Jatropha, microbial biomass decreases from the trunk of the tree to the control. in Jatropha culture, whatever the mode of culture, the microbial biomass is important. For many authors [22, 23, 31], the microbial biomass is always higher under canopy than outside of the canopy. For these authors, the amount of microbial biomass is related to the amounts of total carbon and total nitrogen. However, the amount of microbial biomass and its activity are also depending on the C/N ratio and the pedoclimatic conditions of the soil [32]. In Jatropha system, the pH is slightly acidic, which favors a significant microbial biomass. At Boni, in pure or associated culture, the biomass remains similar in all treatments, although the C/N ratio is better under the canopy. This evolution of the microbial biomass could be explained by soil management methods conducted in this area (plowing, spreading of mineral fertilizers).

At Imkouka (north sudanian zone) in intercropped system, the same trend is observed. The nature of the associated culture could explain the evolution of the microbial biomass. Indeed Maize demands water and mineral elements and its culture in north sudanian area requires chemicals inputs.

Under the canopy of *Jatropha curcas*, microbial respiration is more important at the foot of the trunk than at one meter or in the control. This phenomenon is more pronounced in south sudanian region. Mineralization in the canopy area of Jatropha system is generally higher than outside the canopy because of the quality of C/N ratio[33]. The microbial biomass and the favorable conditions of temperature and humidity favor microbial activity involved in the rate of the mineralization [29, 22, 7]. In north Sudanian zone, the microclimatic conditions under the canopy are least good than those of the south sudanian zone. This situation explains the low rate of mineralization observed in Imkouka.

The density of spores in the different treatments and t modes of cultivation (culture associated or pure culture) of *Jatropha curcas* is significant as compared to other plants [34]. *Jatropha curcas* is a plant with a high mycorrhizal power [6]. In the south sudanian region, the density of spores counted is relatively low as compared to the those of north sudanian zone. The relative weakness of the mycorrhizal power of *Jatropha curcas* in the south sudanian region could be related to the natural wealth of the soils of this region [17].

The symbiosis aims to improve water and mineral nutrition. However, plant will not find the need to form this symbiosis if nutrients are available [34]. In northern Sudan zone, the plant needs are met in part by the establishment of mycorrhizal symbiosis. That explains the proliferation of spores in the canopy in th Mycorrhizal symbiosis is established in the fine roots of the plant. In *Jatropha curcas* systems, the majority of fine roots grows outward of the canopy [35]. In addition, some authors noted in *Jatropha curcas*, root lengths of 4 meters [36]. Roots traversing the surface of the soil [35], the formation of spores will be more important beyond 1 m from the trunk is area. Also, in this area, spore density is higher in the canopy than outside of the canopy.

CONCLUSION

Jatropha curcas improves the soil pH. With *Jatropha curcas*, the C/N ratio is relatively low, this indicates the quality of the organic matter produced. The Jatropha systems maintains a high microbial biomass and a good microbial activity . The spore density in the different jatropha systems is high. In north sudanian region where soils are naturally poor, the mycorrhizal potential of *Jatropha curcas* is more important. Determining the kinds of spores associated with *Jatropoha curcas*, as well as its potential for availing phosphorus, would participate in a better understanding of the impact of the species on soil fertility for better valorization of the species in the farming system.

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