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Observed effects of the animal manure application practices on the chemical parameters and status of Lixisols in the south soudanian zone (Bobo-Dioulasso, Burkina Faso)

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Abstract

The use of organic waste as fertilizers in the urban and peri-urban agriculture can contribute to maintain soil fertility and solve food security. This study was done to evaluate the effect of the manure (pig and cattle) on the chemical parameters of the soils in Bobo-Dioulasso area. With that aim in mind, eight (8) farms where the animal waste is used as well as some non-cultivated plots were identified in 2012 for the study. Some samples of soil were taken for chemical analysis in a laboratory. The results showed a fall of the pH_{H2O} balance of 0.46 and 0.51 unit respectively in the 0-10 cm and 10-20 cm depths following the use of the pig waste. The content of the manure had a positive impact on the organic status of the soils by the increase of their C and N rates. An easily absorbed phosphorus rate higher in the 0-10 cm and 10-20 cm depths was noted in the plots which were fertilized with pigs manure. Moreover, the content of the cattle manure is materialized by an increase of total K respectively 1210 ppm for the 0-10 cm depth and 1351 ppm for the 10-20 cm deph. Furthermore, the plots where cattle manure was used had a higher CEC with 7.18meq/100g so be it three (3) times of the plot where the manure was not used. Animal manure could be an alternative to overcome the high cost of the chemical fertilizers.

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Introduction

Because of its unfavorable impacts on the agricultural production, the food security and on the environment, the deterioration of the soils has become a handicap in the developing countries (FAO, 2003). The majority of sub-saharian African countries are confronted by a weak rainfall and the poverty of the soil with as consequence the weak return of the rain cultures (IFPRI, 2009).

In Burkina Faso, the traditional systems of production are known for a weak use of the mineral fertilizer because of their cost. The continuous exploitation of the soil leads to a speed degradation of the soil main biological, chemical and physical properties (Sedogo *et al.*, 1997; Lompo, 2008). These biophysical constraints explain the use of some organic fertilizers to raise back the fertility of the soils (Sedogo and *al.*, 1997; Fening and *al.*, 2011). Several methods of fertility management including the use of organic matter from various sources are practiced in Burkina Faso, as in most countries of West Africa (Sedogo *et al.*, 1997; Bationo and Buerkert, 2001; Mando and *al.*, 2005; Achieng and *al.*, 2010). Most of these studies focused on the effects of management practices on soil fertility nutrient balances.

It's however recognized that the enrichment of the soil with a fresh or decomposed animal waste can be the key to the success of sustainable agriculture in the developing countries (Diao, 2004; Moral and *al.*, 2008; Maltas *et al.*, 2012). However, just as the challenge of the maintenance of the soil fertility under a continuous culture is arisen with acuteness, all the sources of organic waste are less or not good exploited in the semi-arid regions (Autfray *et al.*, 2012).

In this context, manure has an important place taking in view of many functions that it has on certain components of the soil.

Indeed, many studies (Dambreville and *al.*, 2004; Nacro and *al.*, 2006; Pallo *et al.*, 2008) had emphasized its capacity to limit the fall of the soil organic matter, to maintain the CEC, the capacity of water retention and to limit the exchangeable aluminum rate through some complexassion processes.

Then, a reasonable supply of the farm fertilizers contributes to the increase of the cultures output and to a better conservation of the quality of the soil by the consolidation of the main mineral elements (Huaiying and *al.*, 2009; Maltas *et al.*, 2012).

Moreover, to our knowledge, there are no scientific references on our country that evaluated the effects of the single long-term application of animal manure on the evolution of chemical soil parameters.

However, the repeated use of the organic fertilizers, mainly in the short and in the long terms, can cause an overfertilization of the soil which can lead to aluminum toxicity phenomenon in the plots, the accumulation of the heavy metals and water pollution due to a transfer (Bock, 1994; Ramade, 2009). It is then necessary to have some optimal doses for each type of soils and cultures (Sedogo *et al.*, 1997; Fening and *al.*, 2011).

Further to this considerations on soil chemical quality and regarding the fast increase in animal production within the zone of Bobo-Dioulasso (south soudanian zone), there is a need to collect scientific evidence and field data on the role of manure (various types) application on soil chemical status and composition changes.

The aim of this study is there for to evaluate the effects of the repeated application of animal manure (pigs manure and cattle manure) on the evolution of the chemical parameters of the soils.

Materials and methods

Study area

This study was done in the zone Bobo-Dioulasso, located in the west of Burkina Faso. Referenced at North 11°10' latitude and at West 4°17' longitude, in that town, especially in the peri-urban part, some mixt runnings of farming-breeding are there and contribute to supply the town with food.

Selection of soil samples

In the farms, an identification of both the plots where animal waste is used as fertilizer and some fallow plots was done for the need of the study. Among the farms, three (3) cattle types (meaning some plots where only cattle manure is used)and five(5) pig types (meaning some plots where only pig manure is used) were chosen according to the following criteria: The application only of animal waste in the plot and the age of the plot (included between 10 years and more). Four (4) witness-plots (fallow) located near the farms were also the subject of follow-up.

In total, twelve (12) plots were chosen for the selection of the soil samples (Table 1). In each farm or agricultural plot, a heterogeneous sample of animal waste was made up.

The selection of the soil samples was done in the 0-10 cm and 10-20 cm depths at the end of the harvest (December). In each plot, five (5) samples were taken on the two (2) diagonals then a heterogeneous sample per depth and per plot (manure and fallow) was made up (DAT, 2001). The samples were identified as followed:

$CattleM_{10}$: 0-10 cm depth of the soils having received cattle manure;

$CattleM_{20}$: 10-20 cm depth of the soils having received cattle manure;

$CattleW_{10}$: 0-10 cm depth of witnesses (fallow) plots located near the soils having received cattle manure;

$CattleW_{20}$: 10-20 cm depth of witnesses (fallow) plots located near the soils where cattle manure was used;

$PigM_{10}$: 0-10 cm depth for the soils where pigs manure was used;

$PigM_{20}$: 10-20 cm depth for the soil where pigs manure was used;

$PigW_{10}$: 0-10 cm depth of the witnesses (fallow) plots where pigs manure was used;

$PigW_{20}$: 10-20 cm depth of the witnesses (fallow) plots located near the soils where pigs manure was used.

Laboratory analysis

The analyses of the soil were about the total Nitrogen, the easily absorbed Phosphorus (bray1), the K-exchangeable, the organic C and the pH (H_2O and KCI). The pH (H_2O and KCI) of the soils were measured from a deferment of the soil in the water using the electrometric method at the pH-meter to the glass electrode (AFNOR, 1999). The link soil/solution is 1/2.5.

The organic Carbon was dosed according to method of Walkley and Black (1934). The easily absorbed Phosphorus of the soil was extracted through an ammoniac fluorine and chlorine acid solution according to Bray I's method (Fixen and Grove, 1990). The total Phosphorus (TP), the total Nitrogen (TN) and the total Potassium (TK) of the manures were extracted through a digestion in sulfuric acid, a salysilic acid, hydrogen peroxid and selenium. The easily absorbed Phosphorus and the total Phosphorus of the soils were dosed then with colorimetry according to the molybdo-phosphate reduced to ascorbic acid. The total Nitrogen of the soils was dosed by through colorimetry with the auto-analyser. The Potassium was dosed by a spectrophotometry which emits fire (Houba and *al*., 1995). The cationic exchange capacity (CEC) was measured using METSON's method (ammonium acetate IN with pH 7). The chemical characteristics of the cattle and pigs manures are presented in table 2.

Statistical analysis

The analysis of the variance and the correlation between the observed parameters was done with the software GENSTAT Discovery edition 4. The separation of the averages was done through the test of Newman-Keuls, when the test of analysis variance is significant on the threshold of at least 5%.

Results

Effects of the animal manure on pH, C, N, P, K and CEC of the soils

Effects on the pH of the soil

The pH reflects the ecological conditions of the area. In that way and in a first approximation, it gives information about the fertility of the soil. The variation of the pH, according to the type of animal waste used, is shown in table 3. As a whole, the pH of the soils is acid, whatever the type of the animal waste. At the 0-10 cm depth, the pH_{H2O} varies from 4.90 (soil fertilized with pigs manure) to 5.69 (soil fertilized with cattle manure) against 5.36 and 5.73 for the respective witnesses. At the 10-20 cm depth, it varies from 5.08 (soil fertilized with pigs manure) to 5.74 (soil fertilized with cattle manure) against 5.59 and 5.35 for the respective witnesses. We have not observed any significant difference between the soils fertilized (cattle and pigs manure) and the witness-soils.

Table 1. Characteristics of the plots through the the taking of soil samples.

Type of farm	Reference	Age of the application of the animal waste (year)	Area (Ha)	Quantity of the animal waste brought per year ($T.ha^{-1}$)
Cattle	1	13	1.2	2.9
	2	16	1.75	3.25
	3	14	0.9	4.5
Pigs	4	11	1.5	4.3
	5	17	1.5	4.75
	6	18	0.8	3.25
	7	13	1.75	2.5
	8	15	2.5	3.25
	9*	20	-	0
Witnesses	10*	22	-	0
(fallow)	11**	24	-	0
	12**	21	-	0

(*): Plots near catlle farms, (**): Plots near pigs farms.

Effects on the Carbon (C) and the Nitrogen (N)

The results of the effects induced from the animal waste on C and N are presented in the Picture 3. The C and N contents differ respectively from 0.42% and 0.02% (Witness-soil) to 0.96% and 0.08% (soil fertilized with cattle manure). The Witness-soils which were not fertilized with pigs and cattle manures are poor in C with some contents in all stage inferior to 1%. These contents decrease logically following the depth passing from 0.79% at 0-10 cm to only 0.73% at 10-20 cm. We noted a very significant difference between the different treatments (Table 4).

Table 2. Chemical characteristics of cattle and pigs manures used in the farms.

	pH (H_2O)	N (%)	C (%)	C/N	TP (%)	TK (%)
Cattle	8.1	2.0	35.6	18.1	1.0	2.2
Pigs	7.2	2.6	29.7	12.0	1.4	1.2

TP: total Phosphorus, TK: total Potassium.

We notice that these contents decrease in relation to the depth whatever the type of animal waste used. The examination of the results shows the C:N ratio varying between 9 and 12 at the 0-10 cm depth. The C:N ratio at the depth of the surface of the pigs manure plots is less high than the plots fertilized with cattle manure (respectively 8.8±0.47 and 11.33±1.21), showing a strong organic activity in the plots fertilized pigs manure. In the witness-fallow plots, the C:N ratio differs between 14±1.94 and 20±1.92 at the horizons of the surface.

Effects on P, K and CEC

The results about the effects of the application of the manure on P, K and CEC are reported in Table 5. We note that the plots where we used pigs manure have a higher easily absorbed P (Bray I) rate at the 0-10 cm and 10-20 cm depths. This manure increases the soil easily absorbed P content of 109 units at the 0-10 cm depth. The supply of cattle manure materializes also by the increase of the easily assimilated P rate and this rate is quite low than the one obtained in the plots where pigs manure was used. On the other hand, in the witness-plots, this rate is relatively low. The total P content follows the same tendency than P (Bray I) at all the dephs whatever the type of used substrate.

Table 3. Variation of the pH of the soil according to the type of the animal waste used.

Deph/animal waste	pH_{H2O}	pH_{KCl}
$CattleM_{10}$	5.69±0.37^{ab}	5.09±0.61^{a}
$CattleM_{20}$	5.74±1.60^{a}	4.97±0.76^{a}
$CattleW_{10}$	5.73±1.60^{ab}	5.31±1.60^{a}
$CattleW_{20}$	5.35±0.06^{ab}	4.185±0.05^{a}
$PigM_{10}$	4.90±0.53^{b}	4.35±0.49^{a}
$PigM_{20}$	5.08±0.61^{ab}	4.49±0.61^{a}
$PigW_{10}$	5.36±0.06^{ab}	4.16±0.04^{a}
$PigW_{20}$	5.59±0.30^{ab}	4.97±0.30^{a}
Probability	*0.212*	*0.401*
Meaning	*NS*	*NS*

(NS) : not significant

The values having the same letter are not significantly different on the threshold of 5% according to NEWMAN-KEULS's test.

The total K (TK) has passed from 1032.5 ppm for the witness-soils to 951ppm for the plots where TK was used in the 10-20 cm depth. The application of pigs manure in the plots materializes by a decrease of TK at the horizons 0-10 cm and 10-20 cm. Moreover, the supply of cattle manure at the same depths materializes by an increase of TK respectively 1210±249.35 ppm for the 0-10 cm depth and 1351±316.96 ppm for the 10-20 cm depth.

Table 4. Nitrogen and Carbon contents and the link C/N of the soils.

Deph	**C (%)**	**N (%)**	**C/N**
$CattleM_{10}$	0.96±0.16^{a}	0.08±0.02^{ab}	11.33±1.21^{cd}
$CattleM_{20}$	0.82±0.12^{ab}	0.07±0.01^{ab}	11.33±2.65^{cd}
$CattleW_{10}$	0.46±0.06^{c}	0.02±0.00^{c}	20±1.92^{a}
$CattleW_{20}$	0.42±0.02^{c}	0.02±0.00^{c}	15±1.42^{b}
$PigM_{10}$	0.78±0.11^{c}	0.08±0.02^{a}	8.8±0.47^{e}
$PigM_{20}$	0.65±0.17^{bc}	0.06±0.02^{b}	10.4±1.51^{de}
$PigW_{10}$	0.47±0.07^{c}	0.03±0.01^{c}	14±1.94^{bc}
$PigW_{20}$	0.44±0.04^{c}	0.03±0.00^{c}	14 ±0.92^{bc}
Probality	*<0.001*	*< 0.0001*	*< 0.0001*
Meaning	**	***	***

(*): Highly significant, (***): Very highly significant

The values having the same letter are not significantly different on the threshold of 5% according to NEWMAN-KEULS' test.

The witness's soils have a very low CEC rates. Indeed, the plots which were fertilized with cattle manure have a very higher CEC rate with 7.41meq/100g, namely three times of the non-fertilized witness-plot for the two depths.

This rate is higher at the horizons of surface for the farm soils where cattle manure was used, but remains stable at all the depths of the farms which were fertilized with pigs manure.

Table 5. Variations of the soils P, K and CEC contents according to the treatments.

Deph	Total P (ppm)	P (Bray I)	Total K (ppm)	CEC (meq/100g)
$CattleM_{10}$	161.33 ±33.96^{b}	21.43±5.14^{b}	1210±249.35^{ab}	7.41±2.62^{a}
$CattleM_{20}$	175.66±37.12^{b}	14.786±2.25^{b}	1351±316.96^{a}	6.956±2.62^{a}
$CattleW_{10}$	61 ±11.42^{c}	1.85±0.72^{b}	1088.5±103.95^{abc}	2.6±0.17^{bc}
$CattleW_{20}$	48.5±26.16^{c}	1.49±0.01^{b}	1089±103.32^{abc}	2.28±0.28^{c}
$PigM_{10}$	260.2±63.17^{a}	111.044±42.07^{a}	821.2±166.41^{c}	5.382±1.22^{ab}
$PigM_{20}$	247.6±22.28^{a}	94.87±38.23^{a}	951.4±186.58^{bc}	5.476±1.51^{ab}
$PigW_{10}$	51±12.95^{c}	1.105±0.04^{b}	1182.5±177.32^{ab}	2.185±0.30^{c}
$PigW_{20}$	55.5±12.95^{c}	1.04±0.01^{b}	1032.5±23.85^{abc}	1.81±0.30^{c}
Probability	< 0.0001	< 0.0001	<0.058	*<0.006*
Meaning	***	***	*	**

(*): Significant, (**): Highly significant, (***): Very highly significant

The values bearing the same letter are not significantly different on the threshold 5% according to NEWMAN-KEULS' test.

Correlation between pH, C, N, P, K and CEC of the soil

Correlation between pH, C, N, P, K and CEC of the soil at the 0-10 cm depth

The correlation matrix between the chemical different parameters observed at the 0-10 cm depth in the soils fertilized with pigs and cattle manures is presented respectively in the table 6 and 7.

The analysis of these tables reveals the existence of many significant, even highly significant correlations.

We note a positive correlation between the soil Carbon and the soil pH_H_2O in the plots where manure was used. On the other hand, in the plots where pigs manure was used, the correlation between the Carbon of the soil and the pH_H_2O of the soil at the 0-10 cm depth is negative. We notice a negative correlation between the Carbon of the soil and the total Potassium in the plots in which pigs manure was used comparatively to the plots in which manure was used, this correlation is positive even significant.

Table 6. Correlation matrix between the soil chemical parameters fertilized with cattle manure at the 0-10 cm deph.

	pH_{H2O}	pH_{KCl}	C (%)	N (%)	C/N	CEC (meq/100g)	TP (ppm)	P (Bray I) (ppm)	TK(ppm)
pH_{H2O}	1								
pH_{KCl}	0.93	1							
C (%)	0.1	0.05	1						
N (%)	0.14	0.02	0.97	1					
C/N	0.08	0.23	-0.85	-0.93	1				
CEC(meq/100g)	-0.26	-0.19	0.88	0.77	-0.68	1			
TP(ppm)	-0.23	-0.2	0.9	0.85	-0.84	0.94	1		
P (Bray I) (ppm)	0.07	0.03	0.99	0.95	-0.83	0.9	0.91	1	
TK(ppm)	0.46	0.15	0.45	0.58	-0.5	0.05	0.1	0.42	1

TP: Total Phosphorus, TK:Total Potassium.

Correlation between pH, C, N, P, K and CEC of the soil at the 10-20 cm depth

The tables 8 and 9 show the results about of the correlation between the chemical parameters at the 10-20 cm depth of the farms soils which receive respectively cattle manure and pigs manure. At the 10-20 cm depth of the soil, the correlation between the pH of the water and the C on the one hand and on the other hand between the C and the easily absorbed P is more significant in the plots which were fertilized with cattle manure than the ones which were fertilized with pigs manure. The correlation between the C and the total N is also significant and positive in the plots in which animal waste was used.

Table 7. Correlation matrix between the soil chemical parameters fertilized wth pigs manure at the 0-10 cm deph.

	pH_{H2O}	pH_{KCl}	C (%)	N (%)	C/N	CEC (méq/100g)	TP (ppm)	P (Bray I) (ppm)	TK (ppm)
$pH_{\_KCl}$	1								
pH_{Kcl}	0.73	1							
C(%)	-0.46	0.13	1						
N(%)	-0.55	0.075	0.98	1					
C/N	0.51	-0.16	-0.86	-0.92	1				
CEC	-0.24	0.31	0.91	0.9	-0.84	1			
TP(ppm)	-0.76	-0.18	0.72	0.82	-0.88	0.65	1		
P (Bray I) (ppm)	-0.62	-0.02	0.9	0.94	-0.9	0.87	0.92	1	
TK(ppm)	0.11	-0.44	-0.37	-0.45	0.66	-0.45	-0.63	-0.56	1

TP: total Phosphorus, TK: Total Potassium.

Discussion

Effect at the animal manure on the pH, C, N, P, K and CEC of the soils

Generally speaking, the results have shown the contribution of the animal waste on the pH evolution level. This observation has already been done by many authors (Pichot *et al.*, 1981; Maltas *et al.*, 2012).

The cultivation of a soil which was fertilized with cattle manure during many years led to an increase of the pH of the soil of 0.04 at the 0-10 cm and 10-20 cm depths. In the witness-plots, the pH_{H2O} was 5.39. The averages of the pH in the layers (0-10 cm) and (10-20 cm) of the soils which were fertilized with pigs manure were lower than the ones obtained by the same layers of the witness-soils. Indeed, the average of the pH of the witness-soils differs from 5.35 to 5.73 while the one of the soils fertilized with pigs manure differs from 4.9 to 5.08. This result could be explained on the one hand by the low quantity of pig's substrate which was used and on the other hand by the cultural past of the witness-soils (fallow). Pigs manure made acid many soils than cattle manure and led to a decrease of the pH_{H2O} from 0.46 to 0.51 units respectively in the 0-10 cm and 10-20 cm depths. In the horizon 10-20 cm, cattle and pigs manures led to an increase of the pH_{KCl} from 0.79 to 0.48 unit respectively.

The C and N were the most influenced parameters by wind and water erosions and by the exports of farming products. The rates of the C obtained in the fallow-plots (0.7%) can be considered as low (Pallo *et al.*, 2008). However, the application in the medium-term of cattle manure contributes to increase the C rate of the soils at the 0-20 cm depth. This content is higher comparatively to the one of most cultivated soils in the locality. The increase of the C is the evident consequence of the use of animal waste. The increase of the organic C in compost or in manure is a current phenomenon observed in the sahelian zone of Africa (Ouédraogo and *al.*, 2001).

The results show clearly that the farms soils having got the application in the medium-term of animal waste supplied more nutritional elements to the soil if compared to the ones of the non-cultivated fallow plots. Then, the benefic effects of the application of the manure in farms are an improvement of the chemical properties of the soil namely in the main elements N, P and K but also other nutritional elements.

Certainly, the Nitrogen rate is low at the 0-10 cm and 10-20 cm depths in the plots which were fertilized with the two types of manure (N rate is superior to 0.05%). However, the N content in the same soils was higher if compared to those contained in most soils in Burkina Faso (Boulet, 1976). In the literature, it is admitted that organic matter is source of nutritional elements (N, P and K) (Rider and De Van Keuler, 1990; Stevenson, 1994; Loveland and Webb, 2003). The effect of the organic fertilizers on the total N content is similar to the one observed on the Carbon content (organic matter). Hoffman and *al.* (2001) through surveys in the rural area in the North of Nigeria, had found an improvement of the main chemical parameters, among them the Nitrogen by the use of manure and domestic waste in the fields. Maltas and *al.* (2012) had noticed some comparable results in their study about the effects of the organic fertilizers on the proprieties of the soil in the long term, in Changins, Switzerland.

Table 8. Correlation matrix between the chemical parameters of the soils in which cattle manure was used at the 10-20 cm deph.

	pH_{H2O}	pH_{KCl}	C (%)	N (%)	C/N	CEC (meq/100g)	TP (ppm)	P (Bray I) (ppm)	TK (ppm)
pH_{H2O}	1								
pH_{KCl}	0.97	1							
C (%)	0.48	0.64	1						
N (%)	0.57	0.65	0.85	1					
C/N	-0.51	-0.46	-0.5	-0.8	1				
CEC (meq/100g)	-0.01	0.18	0.86	0.65	-0.25	1			
TP(ppm)	0.19	0.38	0.91	0.83	-0.47	0.92	1		
P (Bray I) (ppm)	0.36	0.51	0.95	0.92	-0.6	0.89	1	1	
TK(ppm)	0.31	0.23	0.19	0.66	-0.95	0.06	0.3	0.4	1

TP: total Phosphorus, TK: Total Potassim.

We notice that animal waste (cattle manure) improve the Carbon content of 0.5% at the 0-10 cm depth, while pigs manure brings but 0.30% at the same depth. As far as the 0-20 cm depth is concerned, cattle manure improves on two counts the organic status of the soil if compared to pigs manure. The analysis of the samples show that the Carbon rate is low in the plots in which pigs manure was used for many years. This situation is linked to the high C rate contained in the used substrates. Indeed cattle substrates have a higher C content (6%) than pigs manure. These results corroborate those obtained by Bationo and Buerkert (2001), Mando *et al.* (2005), and Maltas *et al.* (2012) regarding the long-term repeated effect of ruminant manure that promote a significant accumulation and moderate decomposition of the organic fraction in soils contributions.

The Nitrogen content increases essentially with the two types of animal waste at the upper depth. Those wastes allow bringing more than 0.06 unit of Nitrogen in the plots which are still used for cultivation. At the 0-10 cm depth, animal waste (cattle one) has brought more N than pigs manure. Our results show that cattle manure contributes to more than four (4) times to the N content, while pigs manure brings but 2.6 times the N. At the 0-10 cm depth, the N content of the soil increases of 3.5 times and 2 times respectively for cattle manure and pigs manure. This situation could be explained by other factors (the heterogeneity of the soil and N potential mineralization) for the N content is nearly equal in both of the animal wastes (Table 2). Indeed, the authors (Bationo and Buerkert, 2001; Ding and *al*., 2010) reached that different organic amendments can have the same quality of some nutrients and do not have the same contribution to the improvement of soil residual. Regarding the specific case of N, this can be explained by the mineralization rate of each type of animal manure. Studies have concluded that the monogastric manure mineralizes so easily assimilated by plants (Huaiying and *al*., 2009).

Table 9. Correlation matrix between the chemical parameters of the soils fertilized with pigs manure at the 10-20cm deph.

	pH_{H2O}	pH_{Kcl}	C (%)	N (%)	C/N	CEC (meq/100g)	TP (ppm)	P (Bray I) (ppm)	TK (ppm)
pH_{H2O}	1								
pH_{KCl}	0.79	1							
C(%)	0.26	0.66	1						
N(%)	0.03	0.56	0.89	1					
C/N	0.43	-0.14	-0.39	-0.74	1				
CEC(méq/100g)	-0.09	0.41	0.85	0.8	-0.56	1			
TP(ppm)	-0.5	0.09	0.6	0.73	-0.74	0.79	1		
P (Bray I) (ppm)	-0.74	-0.25	0.34	0.56	-0.69	0.52	0.90	1	
TK(ppm)	0.39	0.15	0.23	-0.16	0.54	0.26	-0.28	-0.49	1

TP: total Phosphorus, TK: total Potassium.

It is commonly admitted that the organic matter with a C:N ratio over 20 generally immobilize the N because of the lack of N in the resources when being in the state of decay (Vanlauwe and *al.*, 2002). Yet, the manures used in the farms had a C:N ratio under 20, which probably explains a higher mobilization of the N in the farms. Moreover, the C:N ratio of the sample depths of the soils which receive animal waste is lower than the one of the fallow plots (Table 4).

In the fallow plots, an increase of the C:N ratio of the organic matter of the soil reveals a great proportion of the fresh organic matter partially in the state of decay (Maltas *et al.*, 2012). It gives a probable explanation about the C:N ratio higher obtained in the witness-soils.

The application of the organic substrates improves the biologic activity of the soils with, however, a more intense biologic activity in the soils which are fertilized with pigs manure. Indeed the C:N ratio of the pigs manure is lower if compared to one of cattle manure. This activity could be linked to the components of the organic substrates that are used.
The plots where we used the two types of manures are rich in easily assimilated P, whose qualities are sufficient for the plants nutrition insofar as the critical threshold is 8 ppm (Hien *et al.*, 1993).

The improvement of the soil in easily assimilated and total P through animal waste is linked to the quality of these substrates. At the origin, the pigs manure had a total P rate higher than cattle manure.

Moreover, many authors (Mando and Miedema, 1997; Sedogo *et al.*, 1997) had shown the poverty of the soils of Burkina Faso in P. We easily understand that the application of manure or compost could contribute to enrich the soil in Phosphorus and to improve significantly yield of the cultures.

Other authors (Fernandès and *al.*, 1997; Ouédraogo and *al.*, 2001) had mentioned that the quality of the soil in a semi-arid area is particularly linked to the concentration of the organic matter, among them the C of the soil.

The application of the pigs manure in the plots results in the decrease of the total K at the 0-10 cm and 10-20 cm depths. This situation is due to the low content of the animal waste in total K during the application.
Moreover, the results have shown clearly an increase in CEC following the application of animal waste.

The level of CEC obtained remains low (the highest observed CEC being 7.41meq/100g) for the CEC of the average class is between 10 and 15meq/100g according to BUNASOLS' norms.

At the different depths, the N contents and the assimilated P contents had varied whatever the type of animal waste used. There was a decrease of N and P (Bray I) at the 0-20 cm depth. These values do not vary very much. On the other hand, they seem to be stable in the witness-plots at all the depths. Indeed, there is an accumulation of the total P at the depth with cattle manure if compared to pigs manure. Besides, there is an increase of total K with the two types of manures at the 0-10 cm and 0-20 cm depths.
As far as the CEC is concerned, it increases as it goes along in the depth of the depth in the plots where pigs manure was applied and it decreases at the same depths in the plots in which cattle manure was used.

Correlation between pH, C, N, P, K and CEC of the soils
A high relation between C of the soil and the CEC was detected in our results. It means that the supply of manure in the short or in the long terms can contribute to improve C content of the soil and consequently the organic matter and to improve significantly the CEC at the 0-10 cm and 10-20 cm depths of the soil. Some authors (Robert, 2001; Marek and *al.*, 2005) had the same conclusion.

It is noticed also that the correlation between C and N is higher in the plots where pigs or cattle manure was used at whatever the 0-10 cm and 0-20 cm depths.

This gives a proof of a certain relation between the C and N content (Moral and *al.*, 2005; Jandreville, 2007). In this way, a plot in which pigs and cattle manures are used and having a high C content could produce a better N content.

We note a positive correlation between C of the soil and the pH_{H2O} of the soil. On the other hand, in the plots fertilized with pigs manure the correlation between C of the soil and the pH_{H2O} of the soil at the 0-10 cm depth is negative.

However, at the 10-20 cm depth of the soil, the correlation between the pH_{H2O} and C is positively more significant in the plots fertilized with cattle manure than in the plots fertilized with pigs manure. It means that the continuous supply of cattle manure increases more the pH if compared to the application with pigs manure. These results confirm the work of Dridi and Toumi (1999) and Mucheru-Muna and *al.* (2007) and highlighted the positive contribution of organic fertilizer to correct soil acidity.

We noticed that the correlation between C and the assimilated P is more significant in the plots fertilized with cattle manure than with pigs manure. On the other hand, the total P which was significantly correlated to the C in the plots fertilized with pig's manures were brought. This situation is linked to the quality of the pigs substrate used for pigs manure which was used to fertilized those plots was rich in N. Contrary to the farms fertilized with pigs manure, the CEC in the soils of the plots fertilized with cattle manure is correlated to the assimilated P. In general, many authors (Dridi and Toumi, 1999; Ding and *al.*, 2010; Maltas *et al.*, 2012) concluded that the animal manure contribution (low mineralization potential as cattle manure) has a beneficial effect on the availability of nutrients. The availability of these elements contribute significantly to improving the CEC where its correlation with the available P.

Conclusion

This study has emphasized the effects of the application of animal (cattle and pigs) manure on the basis parameters of the soils fertility.

The study has shown that the application in the medium term of cattle and pigs manures contributes to increase the Ca and the N of the soils at the 0-20 cm depth.

The repeated use of pigs and cattle manures had brought some positive impacts on the improvement of the chemical properties of the soils and could be an alternative to challenge the high cost of the chemical fertilizers which the producers are facing.

It is through the capacities building of the latters to adopt the good agricultural practices.

However, some protocols of researches must be elaborated and applied in order to define better the dynamic of the soil nutriments, to characterize better these animal wastes and to insure their innocuousness for their much more sustainable use in the agriculture.

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