Original Research Article

Valorisation Of Agro-industrial Bio-waste From Seed Cotton In The Restoration Of Degraded Soils In The District Of Korhogo In Northern Côte d'Ivoire

ABSTRACT

Aims: This study was investigated to restore degraded soils with organic manure from agro-industrial bio-waste (seed cotton) in the Department of Korhogo in Northern Côte d'Ivoire.
Study design: The experimental design is a Fisher block with four treatments, namely T0 (control soil), T1 (bio-waste at 1 month of biodegradation), T2 (bio-waste at 3 months of degradation) and T3 (bio-waste at 6 months of degradation).
Place and Duration of Study: The work was carried out from 2018 to 2019 in the district of Korhogo in Northern Côte d'Ivoire.
Methodology: On each of the treatments, bio-waste was applied using spreading technique and the variety F8128 of corn was sown to evaluate the agronomic performance of bio-waste. Five agronomics parameter that are plant height, collar diameter, ear weight and grain yield were measured in corn. Likewise, the physical and physic-chemical and chemical analyses were achieved both the soil (before sowing and after corn harvesting).
Results: Corn grain yield is more significant at the treatment level (T1 = 2.26 T/ha; T2 = 1.98 T/ha and T3 = 1.48 T/ha) than that of the control soil (T0 = 1 T/ha). Laboratory analyses of the soil and bio-waste indicate a very low level of organic matter (MO varies from 0.55 to 0.77 $g.kg^{-1}$) in the soil of the experimental plot and good mineralization of the organic matter in the bio-waste regardless of the decomposition time (C/N varies from 12 to 13). After application of the bio-waste, the organic matter content (T3 = 10.28 $g.kg^{-1}$; T1 = 23.61 $g.kg^{-1}$ and T2 = 23.63 $g.kg^{-1}$) and nitrogen content (T3 = 0.69 $g.kg^{-1}$; T1 = 1.16 $g.kg^{-1}$ and T2 = 1.21 $g.kg^{-1}$) of the various treatments significantly increased compared to the control soil (MO = 0.66 $g.kg^{-1}$ and N = 0.013 $g.kg^{-1}$). In terms of pH, from strongly acidic for the control soil (4.8 to 5.1), the soils after application of organic manure became slightly acidic (5.7 to 6.4).
Conclusion: Our study showed the effectiveness of organic fertilizer on corn yield. The seed cotton bio-waste has had an improving effect on the degraded soil of in Northern Côte d'Ivoire.

Keywords: bio-waste, Côte d'Ivoire, corn, restoration and degraded soil.

1. INTRODUCTION

Land degradation is a phenomenon that leads to a permanent loss of the biological and economic productivity of ecosystems and agro-ecosystems. It concerns all types of environments exploited by human societies to ensure their livelihoods [1]. The soil, which is one of the main bases of agroforestry production in sub-Saharan Africa, faces major degradation problems. This natural resource is particularly affected by the loss of its multiple potentialities [1]. High soil degradation, particularly in sub-Saharan Africa, is linked to climatic conditions aggravated by high land pressure and inappropriate agricultural practices (mining agriculture) [2]. Indeed, as soon as litter is cleared and disappears, there is a rapid decrease in soil organic matter (MOS) and the beginning of chemical, biological and physical degradation of surface horizons. The fire brutally mineralizes the litters, temporarily straightens the pH, but releases CO_2 and ash which are blown by the wind or washed away during the first storms. Plowing in turn introduces oxygen into the soil, accelerates organic matter mineralization, and mixes the underlying humus and mineral horizons. In total, cultivated soils are becoming both less productive and less resistant to rainfall energy [3]. Those in the Korhogo district (Northern Côte d'Ivoire) do not remain on the margins of this very advanced degradation because of their overexploitation, which is linked to population growth [4].

The general objective of this work is to improve the degraded soils with organic manure (seed cotton) from the waste come from the textile industry in the district of Korhogo. Specifically, it will be (i) evaluate the effect of the organic manure on corn cultivation, a plant that is widely consumed in Northern Côte d'Ivoire (ii) examine the behaviour of this organic fertilizer on the properties of some degraded soils in the Korhogo district and (iii) establish a correlation between the decomposition time of cotton fibers and/or seeds (organic manures) and the properties of degraded soils in relation to corn yield.

2. MATERIAL AND METHODS

2.1 Study site

The work was carried out in the department of Korhogo in northern Côte d'Ivoire. The relief of the investigated area is monotonous, with altitudes varying, on average, between 300 and 400 m. However, granitic inselbergs sometimes reaching altitudes of more than 500 m exist in the landscape. The department is made up of lateritic plateaus that can sometimes reach three meters in height, evidence of old peneplain. These plateaus are affected by a very slight and regular slope. The average annual rainfall oscillates around 1200 mm of rain. The area consists of forest galleries, wooded and shrubby savannah vegetation [5]. The geological formations of the area consist of a succession of bands of shale rocks, migmatite rocks and plutonic rocks. These are mainly granites, granodiorites, undifferentiated shales and sericite shales [6], from which several types of soils are derived, namely Ferralsols, Cambisols, Fluvisols and Luvisols [7]. The chosen area is the site around the village of Natiokobadara in Korhogo district (Fig.1).

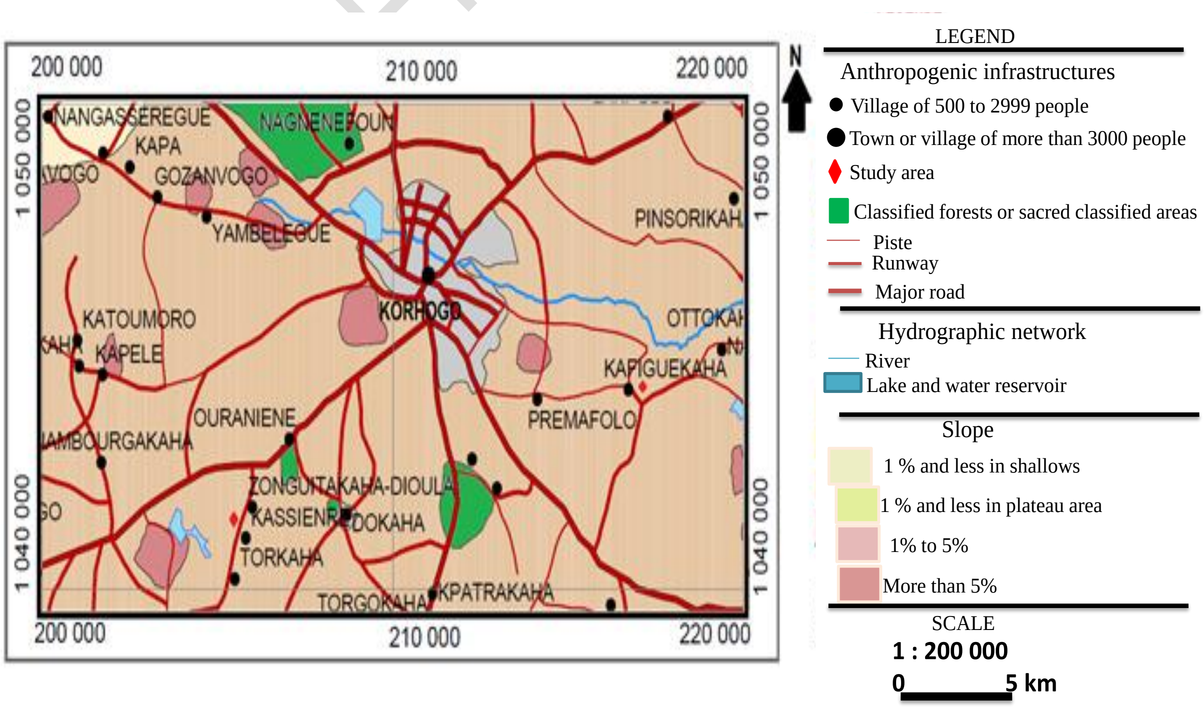

Fig. 1. Geographical location of the studied sites

2.2. Material

2.2.1. Organic manure

The organic manure (bio-waste) used is based on seed cotton from the waste from the textile industry in the city of Korhogo. Three types of manure were used depending on the duration of degradation: 1 month (T1), 3 months (T2) and 6 months (T3). In addition, soil samples from horizons with thicknesses ranging from: 0-20 cm; 20-40 cm and 40-60 cm are available (Fig. 2).

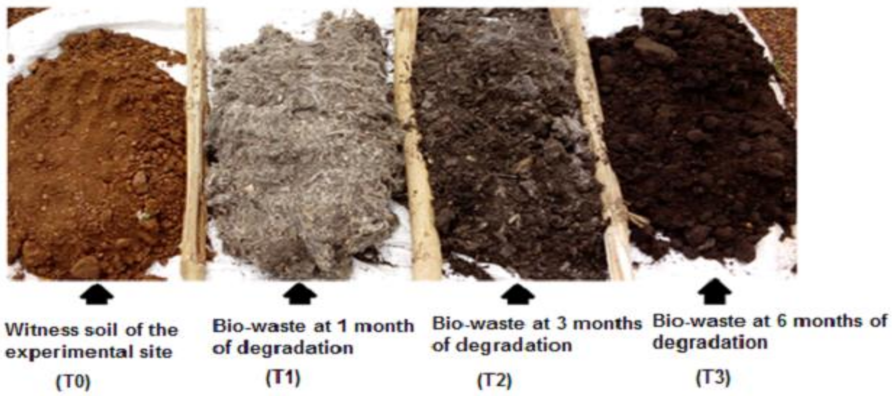

Fig. 2. Soil and organic manure used on the experimental site

2.2.2. Plant material

The plant material used for our experiments consists of corn grains of the F8128 variety improved by the Centre National de Recherche Agronomique (CNRA) an agronomic research institution of Côte d'Ivoire [8]. It is a variety with a long cycle of 100 to 120 days (Fig. 3; Table 1).

Fig. 3. Variety of corn coded F8128 used for experimentation

Table 1. Some characteristics of the corn variety F8128 used for the experimentation

Long cycle	Yield t/ha		Particular Characteristic	Seed color	Origin
	Potential	Medium			
100-120 Days	7	3 à 5	Streaks tolerance	Yellow, Horny/toothed	CNRA, 2006

2.3 Methods

2.3.1 Morpho-pedological characterization and soil sampling of the experimental site

A morpho-pedological characterization was performed at the experimental site to determine the soil type. Thus, two soil pits (100 cm x 80 cm x 120 cm) were opened and described, taking care to indicate the date, location, map sheet, vegetation, local slope, topographical position, microrelief, following the "ORSTOM" approach based on the method of [9].

2.3.2 Experimental design

The experimental design used is a Fisher blocks. Total experimental site area is 338 m^2 (26 m x 13 m) divided into three blocks separated by 2 m lanes. The various treatments were installed on elementary plots of 15 m^2 (5 m x 3 m). They are separated by 2 m aisles from each other. Four processing operations have been set up and are as follows:
T0: Soil Control = no organic fertilizer applied,
T1: Bio-waste at 1 month of decomposition,
T2: Bio-waste at 3 months of decomposition,
T3: Bio-waste at 6 months of decomposition.
For each treatment, organic manure (bio-waste) was applied to each unit using the spreading technique before the seedbed was prepared. Thus, according to the technical data sheet of the variety used, 60 kg of manure was added to each elementary plot, i.e. 60 kg of manure (bio-waste) per plots (15 m^2), which corresponds to 40 T/ha of organic manure [8]. Manual ploughing to a depth of about 15 cm was carried out to bury this manure in the first depths of the soil. Corn growth parameters measured were plant height (cm) and collar diameter (cm). At the production level, the ear weight (kg/ha) and grain yield of corn in (T/ha) were measured.

2.3.3. Analysis of soil and organic fertilizer samples

Soil samples were analyzed using standard methods [10] before sowing and after corn harvesting. This is the granulometry, by the Robinson Kölen method, of the organic carbon (C) of the soil determined by titrimetry (Walkley-Black method) after oxidation using a mixture of sulphuric acid (H_2SO_4) and potassium dichromate ($K_2Cr_2O_7$). Total nitrogen was determined by the Kjeldahl method based on wet oxidation. Total phosphorus was determined by colorimetry after reaction with phosphoric acid in the presence of ammonium molybdate and ascorbic acid. The assimilable phosphorus (Olsen-Dabin method) was extracted using sodium bicarbonate ($NaHCO_3$) at pH 8.5.
The exchangeable bases (K, Ca and Mg) were extracted using ammonium acetate. Potassium was determined using flame photometers, while Ca and Mg were determined by the flame atomic absorption spectrophotometer. The pH (water) was determined using the pH meter after adding 50 ml of ionized water to 20 g of soil followed by agitation and settling. The bulk density (da) was determined by the cylinder method, using undisturbed and fresh samples, knowing the constant dry weight of the samples at 105°C and the volume of the cylinders of the samples used [11].

2.3.4. Statistical analysis of data

The results of the soil, bio-waste and corn agronomic parameters analyses obtained were statistically processed by an analysis of variance (ANOVA 1) with the SPSS version 20 (IBM Corp., USA) software, and in case of significant difference, TUKEY post-ANOVA test was performed to differentiate the groups. The normality of the data and the homogeneity of the variance were checked beforehand using the Kolmogorov-Smirnov and Shapiro-Wilk tests, respectively.

3. RESULTS

3.1 Corn grain yields

Statistical analysis applied to the data collected at the yield outcome level indicates a highly significant difference (F.cal = 39.66** and P.cal = 0.00023). Corn kernel yields vary from 0.99 to 2.45 T/ha depending on the different treatments and the control soil. The results indicate that the corn grain yield recorded at the control soil level is 1 T/ha compared to 2.26 T/ha for T1; 1.98 T/ha for T2 T/ha and 1.48 T/ha for T3 (Fig.4).

3.2 Physical, physico-chemical and chemical characteristics of the soil at the experimental site before sowing

The soil of the experimental site has a brown (10YR6/6) and spotted rusty ochre (7.5YR6/8) colouring, with a depth of 60 cm. The horizons of subangular polyhedral structure and sandy-clayey texture are apparently not humiferous. The drainage class is approximately 5.3. There is an indurated layer at medium depth. The charge in concretions and nodules is greater than 40%. It is a Pisoplinthic Ferralsol in the WRB classification. The soil content low organic matter (0.55 to 0.77 g.kg-1) relatively and its decomposition is very slowly (Table 2). The soil is very active (IB > 2) with a high acid pH (4.8 to 5.1) and a low nutrient reserve (CEC = 3.91 to 4.85 cmol+/kg).

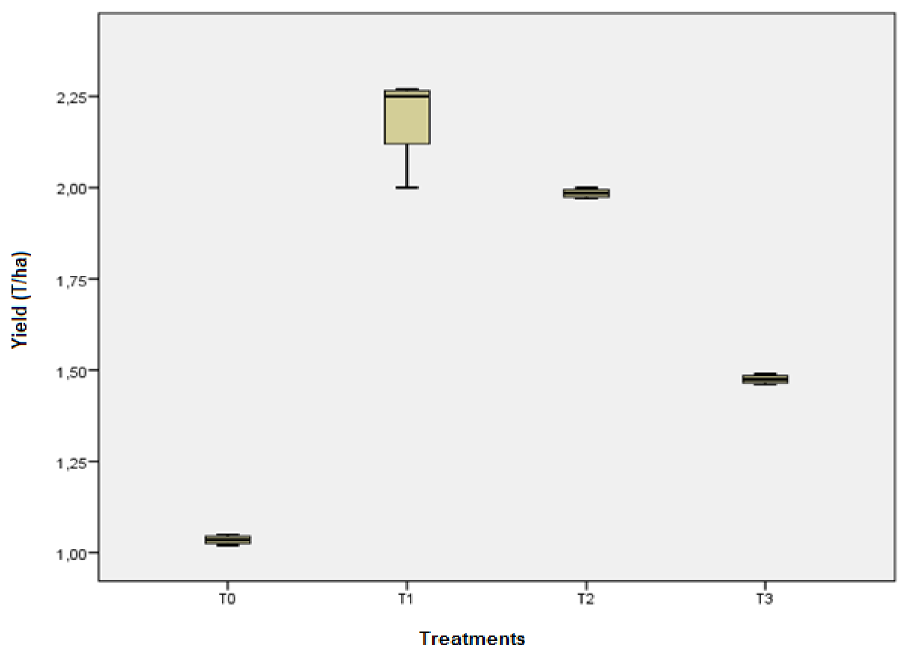

Fig. 4. Different yields (T / ha) in grain of corn depending on the treatments

Table 2. Physical, physicochemical and chemical characteristics of the soil of the experimental site

Analyzed soil parameters		**Depth of the horizon (cm)**		
		0-20	**20-40**	**40-60**
Granulometry ($g.kg^{-1}$) (Clay = A; Silt = L; Sand = S; thin = f et Coarse = g)	A	7.01	8.18	9.02
	Lf	17.02	16.27	16.95
	Lg	20.28	19.15	19.75
	Sf	25.11	26.23	23.35
	Sg	30.58	30.17	30.93
Apparent density ($g.cm^{-3}$)	Da	2.01	2.08	2.11
Porosity (%)	P	24.15	21.51	20.38
Carbon ($g.kg^{-1}$)	C	0.32	0.45	0.39
Organic matter ($g.kg^{-1}$)	MO	0.55	0.77	0.67
Index battance	IB	3.26	-	-
Potential hydrogen	pH eau	5.1	4.9	4.8
Total nitrogen ($g.kg^{-1}$)	N	0.012	0.014	0.015
Ratio Carbon/ nitrogen	C/N	26.67	32.14	26.00
Phosphore assimilable ($mg.kg^{-1}$)	P_2O_3ass	39.8	41.37	40.59
Cation exchange capacity ($cmol^+/kg$)	CEC	4.85	3.91	4.41
Sum of exchangeable bases ($cmol^+/kg$)	S	2.73	2.74	2.67

3.3 Physico-chemical and chemical characteristics of the bio-waste used

The characteristics of the bio-waste used in our experiments are shown in Table 3. Thus, the nitrogen and carbon contents of bio-waste for the treatments T1 (N = 0.02 $g.kg^{-1}$; C = 0.26 $g.kg^{-1}$) and T2 (N = 0.17 $g.kg^{-1}$; C = 2.04 $g.kg^{-1}$) are low compared to T3 (N = 1.38 $g.kg^{-1}$; C = 17.02 $g.kg^{-1}$). However, the degree of mineralization of organic matter is good for the T2 (C/N = 12) and T3 (C/N = 12.33) treatment compared to the T1 (C/N = 13) treatment which is slightly slow. The iron content is high for T2 (Fe = 40 $mg.kg^{-1}$) and T3 (Fe = 33.21 $mg.kg^{-1}$) treatments and low for T1 (Fe = 5.33 $mg.kg^{-1}$) treatments.

Table 3. Chemical composition of bio-waste (fibers and cotton seeds)

Manures	**Parameters**											**Level of soil mineralization (Ratio C/N)**
	N ($g.kg^{-1)}$)	**C** ($g.kg^{-1)}$)	**P** ($mg.kg^{1}$)	**K** ($mg.kg^{1}$)	**Ca** ($mg.kg^{1}$)	**Mg** ($mg.kg^{1}$)	**Fe** ($mg.kg^{1}$)	**Na** ($mg.kg^{1}$)	**Mn** ($mg.kg^{1}$)	**Pb** ($mg.kg^{1}$)	**Zn** ($mg.kg^{1}$)	
1 month (T1)	0,02	0,26	0,12	0,02	0,02	0,03	5,33	0,09	0,11	0,06	0,06	13
3 month (T2)	0,17	2,04	0,96	0,17	0,19	0,28	39,99	0,66	0,81	0,47	0,48	12
6 month (T3)	1,38	17,02	8,03	1,38	1,54	2,30	33,21	5,53	6,71	3,94	4,03	12,33

3.4 Physical, physico-chemical and chemical characteristics of the soils of the different treatments after corn harvesting

The rooting depth of the crop determines the size of the soil compartment that can be exploited by the root system. It is the lower limit of the system considered in the balance sheet method. Thus, after the various experiments, the treated soils sampled from a depth of 30 cm and analyses gave the results indicated in Table 4 below. From granulometry, statistical analyses indicate a significant difference in clay content (Fcal = 134.14; Pcal = 0.028). There is an enrichment of clay at the treatment level (T1 = 18.18 $g.kg^{-1}$; T2 = 18.46 $g.kg^{-1}$ and T3 = 18.89 $g.kg^{-1}$) than in the control soil (T0 = 8.07 $g.kg^{-1}$). After application of the bio-waste, there is a decrease in coarse sand at the treatment level (T1 = 23.61 $g.kg^{-1}$; T2 = 23.63 $g.kg^{-1}$ and T3 = $g.kg^{-1}$) compared to the control soil (T0 = 30.56 $g.kg^{-1}$). The soils under the various treatments had their porosity increased from 41.13% to 58.11% compared to the control soil (24.53%), i.e. a coefficient of variation of 35.6%. The control soils have an average pH value that is strongly acidic (pH water = 4.9). Six months after application of organic manures, the pH values obtained are moderately to slightly acidic (T1 = 6.2, T2 = 6.2 and T3 = 5.9). The CEC values obtained after application of organic manures are relatively higher (T1 = 8.57 cmol+/kg; T2 = 7.8 cmol+/kg; T3 = 7.08 cmol+/kg) than those recorded at control soil level (T1 = 4.39 cmol+/kg).

Table 4. Characteristics of telltale soil and treatments after agricultural use

Analyzed soil parameters (sampling depth = 30 cm)		Treatments				F_{cal}	P_{cal}	$P_{théor}$	CV (%)
		T0	T1	T2	T3				
Granulometry ($g.kg^{-1}$) (Clay = A; Silt = L; Sand = S; thin = f et Coarse = g)	A	8.07 b	18.18 a	18.46 a	18.89 a	134.14*	0.028	< 0.05	32.7
	Lf	16.75 b	14.07 b	15.33 b	16.34 b	159.12ns	0.065	> 0.05	7.6
	Lg	19.73 b	21.53 b	21.73 b	20.62 b	129.35ns	0.074	> 0.05	5.7
	Sf	24.90 b	22.60 b	20.85 b	26.31 b	84.53ns	0.061	> 0.05	4.2
	Sg	30.56 a	23.61 b	23.63 b	17.84 b	113.01*	0.0134	< 0.05	21.6
Apparent density ($g.cm^{-3}$)	Da	2 a	1.56 b	1.21 b	1.11 b	122.57*	0.0142	< 0.05	34.8
Porosity (%)	P	24.53 b	41.13 a	54.34 a	58.11 a	145.16*	0.0341	< 0.05	35.6
Carbon ($g.kg^{-1}$)	C	0.39 b	8.25 a	9.75 a	10.87 a	534.88**	0.0021	< 0.01	65.4
Organic matter ($g.kg^{-1}$)	MO	0.67 b	14.19 a	16.77 a	18.70 a	919.90**	0.0053	< 0.01	67.1
Index battance	IB	2.71 a	0.23 b	0.21 b	0.19 b	816.34**	0.00312	< 0.01	71.5
Potential hydrogen	pH eau	4.9 b	6.2 a	6.2 a	5.9 a	6.69**	0.0057	< 0.01	25.71
Total nitrogen ($g.kg^{-1}$)	N	0.01 b	1.24 a	1.34 a	1.41 a	913.42**	0.0045	< 0.01	62.2
Ratio Carbon/ nitrogen	C/N	28.29 a	6.65 b	7.28 b	7.71 b	853.02**	0.0027	< 0.01	61.61
Phosphore assimilable ($mg.kg^{-1}$)	P_2O_3ass	40.59 b	68.35 a	62.24 a	62.33 a	935.39**	0.0032	< 0.01	37.8
Cation exchange capacity ($cmol^+/kg$)	CEC	4.39 b	8.57 a	7.80 a	7.08 a	179.18**	0.0012	< 0.01	25.43
Sum of exchangeable bases ($cmol^+/kg$)	S	2.71 b	6.60 a	5.79 a	5.10 a	185.91**	0.0024	< 0.01	27.47

The averages followed by the same letter on the same line, are not significantly different at the Probability threshold < 0.05, according to the method of Tukey, * = significatif, ** = highly significant, ns = not significatif (F_{cal} = Calculated Fisher, P_{cal} = Calculated Probability, $P_{Théo}$ = Theoretical Probability), CV = coefficient of variation.

3.5 Relationship between the characteristics, physical, chemical and grain yields of corn

The various correlation tests carried out between the soil properties of the different treatments and the grain yield of corn have yielded several levels of significance. Thus, at the control treatment level (T0) significant correlations are observed between A and CEC (r = 0.90); P and IB (r = - 0.81) and P and P_2O_3ass (r = - 0.76). The total porosity is therefore negatively correlated with the beat index and available phosphorus (Table 5). At the T1 processing level, the highest correlations are observed between P and MO (r = 0.94); P and pH water (r = 0.85); P and C/N (r = 0.95). The grain yield of corn is highly correlated to the variables P, MO, C/N and CEC with correlation coefficients in the order of: 0.9; 0.90; 0.86 and 0.90 respectively (Table 5). The correlation matrix obtained after linking the data at the T2 processing level gave significant correlations between the variables: P and IB; P and pH water; P and C/N with correlation coefficients of 0.97; 0.81 and 0.86 respectively. In the same treatment, negative and significant correlations exist between: Rend and P; Rend and N; Rend and P_2O_3ass with r respectively of: -0.88; -0.98 and -0.91 (Table 5). The linking of different data obtained through the T3 processing gave significant correlations between: IB and P; IB and N with correlation coefficients of: 0.96; 0.97 and respectively between Rend and P; Rend and IB; Rend and N; Rend and P_2O_3ass for respectively r coefficients which are: 0.97; 0.99; 0.97 and 0.92.

Table 5. Correlation between soil properties of different treatments and corn grain yields

Treatments	Variable torque (X;Y)	r	r^2	t	Pr (>|t|)	Significativity
T0	A - CEC	0.9	0.81	5,02	0,0024	**
	P - IB	-0.81	0.66	-3.40	0.0145	*
	P - P_{ass}	-0.76	0.58	-2,86	0,0285	*
T1	P - MO	0.94	0.88	5.43	0.0056	**
	P - pHeau	0.85	0.73	3.28	0.0302	*
	pHeau - MO	0.82	0.67	2.82	0.0474	*
	C/N - P	0.95	0.91	6.29	0.0033	**
	Yields - P	0.91	0.82	4.29	0.0127	*
	Yields - MO	0.9	0.81	4.18	0.0139	*
	Yields - C/N	0.86	0.73	3.3	0.0297	*
	Yields - CEC	0.9	0.81	4.12	0.0145	*
T2	P - IB	0.97	0.94	7.59	0.0016	**
	P - pHeau	0.81	0.66	2.78	0.0516	*
	P - C/N	0.86	0.74	3.39	0.0275	*
	Yields - P	-0.88	0.78	-3.8	0.0192	*
	Yields - N	-0.98	0.95	-8.84	0.0009	**
	Yields - P_2O_3ass	-0.91	0.83	-4.42	0.0115	*
T3	IB - P	0.96	0.92	6.62	0.0027	**
	IB -N	0.97	0.95	8.37	0.0011	**
	Yields - P	0.97	0.94	8.02	0.0013	**
	Yields -IB	0.99	0.98	20.09	0.0001	**
	Yields - N	0.97	0.95	8.37	0.0011	**
	Yields - P_2O_3ass	0.92	0.85	4.69	0.0093	**

* = significant. ** = highly significant;

4. DISCUSSION

The different corn grain yields recorded show a significant difference. This yield is 1 T/ha at the level of the control plot (T0), 1.48 T/ha for plot T3, 2.26 for T1 and 1.98 T/ha for plot T2. These results can be explained by the fact that the control soil of our experimental site is rich in aluminum oxide, unlike oxides. However, an aluminium-rich soil creates plant toxicity and the consequence is the slowing down of plant growth, due to the precipitation of aluminium phosphates in the roots and the blocking of the cellular divisions of the terminal meristems of the roots and possibly of the aerial buds. Exchangeable aluminum strongly inhibits the activity of soil microflora and particularly blocks the development of rhizobiums [12]. The improved yields of the other treatments are explained by the fact that within the organic matter, the aluminium ion is complexed in particular by humic and fulvic acids. Organic matter reduces toxicities by complexing ions and therefore aluminium, on the browned soils of Toumodi located in Centre of Côte d'Ivoire [13]. Impacts of this improved soil fertility on maize yields have been established. A significant increase in soil fertility and maize yields due to manure is observed.

The morphopedological description of the soil (control, T0) of the experimental site revealed an indurated layer at medium depth. The drainage class is approximately 5.3. Physical, chemical and chemical analyses of soil samples indicate that the relatively low organic matter (0.55 to 0.77 $g.kg^{-1}$) decomposes very slowly (C/N = 26.67 to 32.14). The soil is very active (IB > 2) with a high acid pH (4.8 to 5.1) and a low nutrient reserve (CEC = 3.91 to 4.85 cmol+/kg). The total porosity negatively correlated to the beat index is low (about 22%). From results of previous works carried out on degraded soils in Northern region of Côte d'Ivoire the characteristics of soils (Pisoplinthic and Ferralsol) described above in present study would be degraded [4]. This degradation is certainly due to overgrazing and continuous cultivation, which have strongly contributed to reducing vegetation cover and organic matter levels, thus promoting compaction.

After the application of organic manure, the clay content in the various treatments T1 (18.18 g.kg-1), T2 (18.46 $g.kg^{-1}$) and T3 (18.89 $g.kg^{-1}$), varied on average by 32.7% compared to the control soil T0 (8.07 $g.kg^{-1}$). Indeed, sufficiently high concentrations of organic matter make it possible to limit very significantly or even stop the soil leaching process [14].

The organic matter (OM) and nitrogen (N) content of the various treatments increased by 67% and 62.2% respectively compared to the control soil. At the water pH level the improvement is about 25.71%, because at the control treatment level (T0) the values obtained indicate that the soil is strongly acidic (pH=4.8 to 5.1) while after application of organic manure, the soils have become slightly acidic (5.9 to 6.2). Initially, the C/N ratio that characterizes the state of organic matter mineralization is 28.29 (very slow mineralization). After the application of organic manure, the C/N ratios at the treatment level ranged from 6.65 to 7.71.

There is a clear improvement in the mineralization of organic matter, especially in the T3 treatment. The results of the application of bio-waste mark the beginning of the restoration of this degraded soil. The consequence of a good evolution of organic matter is that humus, flocculating with clay, forms the clay-humic complex, a real reserve and nourishing base of the earth. The formation and accumulation of humus allows the storage of most of the elements (C, O, H, H, N, P, K, S, trace elements) essential to plant life [15].

The soils under the various treatments had their porosity increased from 41.13% to 58.11% compared to the control soil (P = 24.53%), i.e. a coefficient of variation of 35.6%. The correlations established between porosity (P) and beat index (IB) are: negative at the control soil level (r = -0.81) but positive and significant at the treatment levels (r ranges from 0.96 to 0.97). Indeed, humic compounds, by binding to clay, contribute to improving soil porosity and water retention capacity. As a result, the soil is more aerated, less prone to compaction, leaching and erosion by rain and watering, and it stores water better: all factors that make it more fertile. In addition, the structural role of humus induces a good penetration of the soil by the air and therefore oxygenation in depth to stimulate a good biological activity of the macro and micro fauna and flora of the soil. Roots penetrate more easily at depth, which contributes to improving their exploration of the soil and subsoil and thus their supply of water and minerals [16].

5. CONCLUSION

The results of this study show that in the locality of Natiokobadara in Korhogo, the soils investigated have, for the most part, a very low humiferous impregnation and a predominantly sandy-clayey-silt texture, very compact, with a rare or total absence of vegetation, especially on the upper slopes. They are highly acidic (pH=4.8 to 5.1) with very slow mineralization (C/N=26 to 32.14) of organic matter. The nutrient supply is very low. Six months after application of bio-waste at a rate of 60 kg per experimental unit or 33.33 tons per hectare, the soils became slightly acidic (pH=5.7 to 6.4) compared to the baseline (strongly acidic). The mineralization of soil organic matter has evolved towards normality because the C/N ratio obtained at the treatment level varies from 6.65 to 7.71. Corn grain yield is more significant at the treatment level (T1 = 2.26 T/ha; T2 = 1.98 T/ha and T3 = 1.48 T/ha) than that of the control soil (T0 = 1 T/ha). The seed cotton bio-waste has had an improving effect on the degraded soil in Northern Côte d'Ivoire.

COMPETING INTERESTS

"Authors have declared that no competing interests exist.".

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

Here is the Definitions section. This is an optional section.

ANOVA: Analysis of variance

CNRA: National Center for Agronomic Research

MO: Organic Matter

Term: Definition for the term