INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 7, No. 2, p. 163-172, 2015

RESEARCH PAPER OPEN ACCESS

Restoration of soil fertility by using organic and mineral amendments: the case of the urban perimeter of Franceville (Gabon)

Maurice Ognalaga*, Pherla Ichida Oyanadigui Odjogui, Alain Ondo Azi, Jacques Ndzoutsi

Agrobiology Research Unit, University of Sciences and Technology, Franceville, Gabon

Article published on August 16, 2015

Key words: *A. cruentus*, Growth parameters, *C. odorata*, Cattle manure, Pig manure.

Abstract

A study on the response of *Amaranthus cruentus* seedlings to four amendments was carried out at the urban perimeter of the "Institut Gabonais d'Appui au Dévelopment" in Franceville. The applied doses were 300 kg/ha for NPK, 60 t/ha for green manure *Chromolaena odorata* and 20; 25; 30 t/ha for both cattle and pig manure. The trial was conducted on a split-splot device with 9 treatments and three replicates for a total of 27 experimental plots. The results are significant ($P < 0.05$) at 5% level. The values obtained on the plants of *A. cruentus* grown on plots fertilized with NPK (300 kg/ha), green manure (60 t/ha) and manure from cattle and pig (30 t/ha) on the parameters (diameter and height of stems, leaf area, number of leaves and production) were higher, compared with the control and other treatments respectively at the order of 68%; 73%; 85%; 89% and 96%. The application of these amendments at low doses caused a growth and low development, similar to what was observed on the plants from control plots non- fertilized. The results of this test allowed to propose farmers for the cultivation of *A. cruentus*, the possibility to choose between the NPK (300 kg/ha), *C. odorata* (60 t/ha) and manure from cattle or pig (30 $t.ha^{-1}$).

* **Corresponding Author:** Maurice Ognalaga ✉ ognalagam@live.fr

In Central Africa and particularly in Gabon, the farmers remained the main producers of various crops including many of the vegetables that were produced seasonally. Very few farmers do not even consider the possibility of modernizing their farming systems by providing inputs (Mvondo, 1989). This fact contributed to amplify the golden food deficit in the tropics; the population needs for fresh vegetables are estimated to 30 kg / man / year (Monzenga *et al.*, 2007). The Gabonese authorities have recognized the problem around 1992 with the creation of the "Institut Gabonais d'Appui au Développement" (IGAD). The main objective was to secure the supply of the urban markets in fresh local products. This determination was supported by the creation and the installation of private pilot farms in a real situation on the periphery of urban centers. This option aimed a sedentary, intensive agriculture which allow protection of the environment. However, given the problem of land, grounds are over-exploited in urban and suburban areas, as almost everywhere in Africa (Assogba-Komlan *et al.*, 2007; Ondo, 2011) causing their physical and chemical degradation (Sawadogo *et al.*, 2008; Ondo, 2011). Indeed, poor land management and control of non-organic inputs (Edima Ndoum, 1993; Ondo, 2011) are limiting factors. The inevitable consequence is the loss of fertility that affects production and yields (Sawadogo *et al.*, 2008; Kiye More Nkoy *et al.*, 2013) of a diversity of speculations of which the amaranth. This plant is the main crop adopted by farmers because of the benefits generated by it marketing, justifying its use as a test plant.

The average yield of the amaranth, on the truck-farming perimeter of IGAD Franceville, varies from around 9 to 15 t/ha. It is lower than the norm situated between 25 and 30 t/ha (Grubben *et al.,* 2004). This is a significant shortfall for these gardeners whose main input in the cultivated plots is NPK. Given the above, the contribution of this work aims at verifying if the reduction in the productions and yields on the amaranth would not be bound to the degradation of soil fertility (Ondo, 2011; Kiye More Nkoy *et al.*, 2013). To do this, the work consists in comparing the NPK, widely used on the site, with organic amendments. A positive reaction of the amaranth (*Amaranthus cruentus*) should be beneficial for gardeners who do not know any more orientation to take in response to the deteriorating situation.

Materials and methods

Study site

The trial was conducted from July 6th till August 7th, 2014 at the IGAD exploitation perimeter of DJAMITI Franceville in south-east of Gabon. The geographical coordinates of the site are: 300 m altitude, 13°36.611' east longitude, and 1 ° 36.394' south latitude.

Plant material

The study was realized with the amaranth (*A. cruentus*). The seeds were bought at local market in Franceville.

Experimental device

The trial was conducted on a factorial (split-splot) with 3 blocks subdivided into nine (9) micro-plots (sub-blocks); each of the 27miro-plots had an area of 1.2m². The supplied fertilizers were: *Chromoleana odorata* as green manure, pigs manure, cattle manure and the NPK. *C. odorata* and NPK were brought to the respective doses of 60 t.ha^{-1} and 300 kg. ha^{-1} while the pig and cattle manures were applied to 20; 25 and 30 t.ha^{-1} with three (3) replications.

Preparation of samples

After weighing, the fertilizers were directly brought on the experimental units. This operation consisted in to burying the fertilizers one month before sowing to favor the biodegradation and the incorporation of the organic matter in the soil. The NPK was buried in last position because of its high solubility and of its fast infiltration into the soil.

Sowing

Prior to transplanting the *A. Cruentus* seed were sow in nursery and allowed to germinated for 15 days. The transplanting on the micro-plots was realized with

spacing of 15cm x 15cm (15 cm between lines and 15 cm between seedlings) for 56 plants by micro-plots.

Maintenance of micro-plots

A weekly weeding was realized to limit the competition of weeds. The precipitations were almost hopeless during the trial period, because of the dry season; the hydric needs for the plants were covered by manual watering. The frequency of watering was once a day during the first two (2) weeks after transplanting, and twice a day towards the end of the trial, with an average of 2000 ml by micro-plot.

Measured parameters

The measured parameters on plants were: the diameter of the stem, the leaf area, the height of the stem, the production and the yield. The data collection started one week after the transplanting using the following methods:

1. The diameter of the stem was measured by means of a caliper at the level of the insertion of the first leaves.
2. The leaf area was determined by means of the software Mesurim Pro.
3. The height of the stem was measured from the collar (ground level) to the end of the last leaf.
4. The leaf number was determined by counting all the leaves on a plant.
5. The production and yield were obtained by measuring the fresh weight of the amaranth just after the harvest.

Chemical analysis

Soil and fertilizing materials were analysed in the soil science laboratory of INSAB according to the methods mentioned in the tables 1 and 2.

Statistical analysis

The data collected were analyzed using Xlstat 2007 software to analyse the variance at the threshold of 5% and a Newman-Keuls test was used for average mean comparison.

Results

Physico-chemical characteristics of the soil

The different results of the particle size, the pH, the available phosphorus, the total nitrogen and the organic material are presented in Table 1.

Table 1. Physico-chemical characteristics of the soil used.

	Particle size				Organic components				pH		
	Sand	Silt	Clay	Texture	Organic C (%)	Nt (%)	C/N	Assimilable P (ppm)	Water	KCl	ΔpH
Values	14.1	55.27	30.6	ASL*	1.16	0.138	8.41	9.52	4.5	3.7	0.5
Test Methods		Robinson Pipette			Anne modified	Kjeldhal		Olsen - Dabin	pH meter (ratio1/2.5)		

* Sandy-silty clay.

The soil has a sandy-silty clay texture; it has good organic carbon content and low total nitrogen content (Defoer *et al.*, 1998). This soil is characterized by an average potential acidity.

Analysis of the fertilizers

The table 2 gives the chemical characteristics of Cattle and Pig manures. The pH, the organic carbon, the total nitrogen are the chemical elements measured. The pH of both, cattle and pig manures is alkaline; the total nitrogen content is low and similar for both organic amendments.

Influence of the treatment on growth parameters of plants

Growth parameters from four (4) treatments (NPK, *C. odorata* or green manure, cattle and pig manures) were collected and subject to analysis of the variance and the results are presented in table 3.

The effect of the NPK and the organic amendments (*C. odorata* or green manure, manure from cattle and pigs) was highly significant ($p < 0.0001$) on the stem diameter, the leaf area and the leaf number. A

significant effect ($p < 0.002$) was also observed on the stem height of *A. cruentus* (Table 3).

Effect of the treatments on the stem diameter

Regarding the stem diameter of *A. cruentus*, the average values obtained with the green manure (8.27 ± 0.34 mm) and the NPK (7.72 ± 0.40 mm) treatments are close and highly (Table 4) significant ($p < 0.05$) than those collected from all other treatments (including control).

From the 25th to the 46th day after sowing (DAS) the diameter of the stem increased by 68% for plants treated with NPK and *C. odorata*; wheareas with the other treatments that increase is of the order of 8%. At 46 DAS, the biggest diameter values of 12.39 ± 0.82 mm and 11.55 ± 0.22 mm were respectively collected on the plants fertilized with the NPK and *C. Odorata*. Those two values were 60.21% and 57.32% higher than the ones collected from the control plants. The values obtained with all other treatments were not significantly different, but by taking into account the trend, the smallest 4.33 ± 0.14 mm diameter was observed on the plants treated with pig 3 amendment.

Table 2. Chemical characteristics of Cattle and Pig manures.

	Parameter			
Manure	pH	Organic C (%)	Nt (%)	C/N
Cattle	8	0.5	0.11	4.5
Pig	7.8	1.50	0.13	11.4

Effect of the treatments on the stem height

The effect of the different treatments was significant ($p < 0.05$) on the longitudinal growth of the seedlings of *A. cruentus* (Table 5). The average value obtained with *C. odorata* (27.38 ± 0.28 cm) is higher (Table 5) and significantly ($p < 0.05$) different from that of the control (20.86 ± 0.51cm) and that stemming from all other treatments.

Table 3. P-value of the effect of the amendments on growth and yield parameters.

Parameter	DDL	Sum of Squares	Mean square	F	P value
Stem diameter	8	218.280	27.285	9.554	< 0.0001
Stem height	8	1694.916	211.864	3.390	0.002
Leaf area	8	63661.245	7957.656	14.977	< 0.0001
Number of leaves	8	46500.967	5812.621	8.773	< 0.0001
Production	8	80696502.058	10087062.757	277.653	< 0.0001
Yield	8	8063.96	1007.899	277.653	< 0.0001

The action of this green manure on the stem height was followed by the one from pig 3 (21.05 ± 0.20 cm) and NPK (20.70 ± 0.45 cm) treatment. Seedlings sowed on the plots fertilized with cattle manure, and pig 1 as well pig 2 manures showed plants heights significantly lower than those stemming from the control.

From the 25th to the 46th DAS the stems height increased by 72.76% and 65.18% respectively with *C. odorata* and pig 3 amendment; whereas with the control, the increase is only 5.40%. At 46 DAS, the biggest values 27.38 ± 0.28 cm and 21.05 ± 0.21 cm were recorded respectively on the plants from plots fertilized with *C. odorata* and pig 3. Compared to the control, the plant height of *A. cruentus* fertilized with *C. odorata* increased up to 23.81%. The smallest height (13.06 ± 0.23 cm) was observed on the plants from the plots having received cattle manure of dose 1 (20 $t.ha^{-1}$). That value is statistically lower than that of the control, it is not significantly different from those

observed with Cattle 2, Cattle 3, pig 1 and pig 2 amendments.

Effect of the treatments on the leaf area

The contribution of the different fertilizers was significant ($p < 0.05$) on the increase of leaf area of *A. cruentus* (Table 6).

A. cruentus sowed on the plots fertilized with the NPK, *C. odorata*, cattle manure (30 $t.ha^{-1}$) and pig manure (30 $t.ha^{-1}$) registered bigger but rather close average values of the leaf area (respectively 70.22 ± 1.50 cm^2; 67.54 ± 1.22 cm^2; 67.54 ± 1.30 cm^2 and 76.16 ± 1.70 cm^2) and significantly ($p < 0.05$) different from those observed with all other treatments (Table 6). Plants stemming from plots having received the low levels of cattle and pig manure did not show values significantly ($p > 0.05$) different from the control which has an average leaf area of 12.38 ± 1.65 cm^2.

Table 4. Effect of treatments on stem diameter (mm) of *A. cruentus* over time.

		DAS				
Treatments		25	32	39	46	Average values
	To	4.16±0.3	4.82±0.04	4.73±0.06	4.93±0.15	$4.66±0.13^{b*}$
NPK	NPK	4.30±0.10	5.31±0.50	8.89±0.17	12.39±0.82	$7.72±0.40^{a}$
C. Odorata	*C. O.*	3.96±0.17	6.30±0.21	11.27±0.76	11.55±0.22	$8.27±0.34^{a}$
Manure	Cattle 1	3.76±0.29	4.18±0.25	4.89±0.20	4.73±0.45	$4.39±0.30^{b}$
Cattle	Cattle 2	4.49±0.34	4.87±0.0	4.37±0.27	4.95±0.48	$4.67±0.36^{b}$
	Cattle 3	4.98±0.22	7.30±0.0	5.34±0.25	5.58±0.40	$5.80±0.29^{b}$
Manure	Pig 1	4.60±0.48	4.52±0.36	5.12±0.07	4.92±0.27	$4.79±0.30^{b}$
Pig	Pig 2	3.73±0.23	4.88±0.41	3.78±0.16	5.61±0.27	$4.50±0.27^{b}$
	Pig 3	3.74±0.13	4.15±0.06	5.37±0.28	4.06±0.10	$4.33±0.14^{b}$

*Means with the same letters in the column are not significantly different.

From the 25th to the 46th DAS the leaf area increased by 89.24%; 86.92%; 80.40% 79.9% and 61.64% respectively for pig 3, NPK, Cattle 3, pig 2 and *C. Odorata* treatments; whereas that of the control increased by only 18%. At 46 DAS, larger leaf area of 119.10 ± 1.32 cm^2; 113.0 ± 0.67 cm^2 and 90.20 ± 1.18 cm^2, were observed on the plants plots fertilized with pig 3, NPK and *C. odorata* respectively. Moreover, compared with the control, the leaf area of the *A. cruentus* fertilized with pig 3, NPK, *C. odorata*, and Cattle 3 amendments increased in the order of 82%.

Table 5. Effect of treatments on stem height (cm) of *A. cruentus* over time.

		DAS				
Treatments		25	32	39	46	Average values
	To	20.30±0.26	20.44±0.35	21.23±0.36	21.46±1.05	$20.86±0.51^{ab*}$
NPK	NPK	14.66±0.15	14.40±0.27	22.06±0.67	31.68±0.59	$20.70±0.45^{ab}$
C. Odorata	*C. O.*	13.71±0.28	13.44±0.25	32.05±0.26	50.33±0.33	$27.38±0.28^{a}$
Manure	Cattle 1	12.07±0.25	13.17±0.31	13.39±0.10	13.61±0.25	$13.06±0.23^{b}$
Cattle	Cattle 2	14.44±0.42	15.61±0.18	17.48±0.33	15.00±0.44	$15.63±0.34^{b}$
	Cattle 3	16.50±0.0	14.98±0.23	18.47±0.41	16.39±0.35	$16.58±0.33^{b}$
Manure	Pig 1	15.22±0.19	15.23±0.31	15.33±0.17	20.44±0,25	$16.56±0.23^{b}$
Pig	Pig 2	11.64±0.34	12.08±0.46	14.31±0.30	35.34±0.15	$18.34±0.31^{b}$
	Pig 3	14.06±0.25	14.28±0.28	15.47±0.22	40.39±0.10	$21.05±0.21^{ab}$

*Means with the same letters in the column are not significantly different.

Effect of the treatments on the number of leaves

The number of leaves was significantly ($p < 0.05$) affected by different treatments (Table 7). For this parameter the reaction of *A. cruentus* to the treatments is similar to that observed on the leaf area. Indeed, the average values of the number of leaves registered on the plots fertilized with the NPK, pig 3, *C. odorata,* and Cattle 3 are pretty close and respectively 62.92 ± 1.50; 57.00 ± 2.05; 53.44 ± 2.45 and 52.86 ± 2.65.They are bigger and significantly ($p < 0.05$) different from those observed with all other treatments. Plants cultivated on the plots having received the low levels of cattle and pig manures did not present a number of leaves significantly ($p > 0.05$) different from that of the control which is 11.81 ± 1.50. From the beginning to the end of the trial, the average number of leaves for all treatments passed from 8.6 to 58.52, for an increase of 85.30%.

Table 6. Effect of treatments on leaf area (cm²) of *A. cruentus* over time.

		DAS				
Treatments		25	32	39	46	Average values
	To	10.31±1.52	13.50±0.9	13.14±2.07	12.56±2.07	12.38±1.65[b*]
NPK	NPK	14.78±1.87	63.12±0,91	90.00±2.69	113.0±0.67	70.22±1.50[a]
C. Odorata	*C. O.*	34.60±0.78	67.75±1.9	77.62±1	90.20±1.18	67.54±1.22[a]
Manure	Cattle 1	13.23±1.93	14.27±3.99	21.41±2.88	16.66±0.52	16.39±2.35[b]
Cattle	Cattle 2	15.31±2.68	16.44±1.65	26.06±3.19	32.98±2.22	22.70±2.45[b]
	Cattle 3	17.20±0.85	54.96±0,95	72.90±0.48	87.62±2.84	67.54±1.30[a]
Manure	Pig 1	18.79±1.86	17.87±0.78	19.63±0.69	24.00±1.87	20.07±1.30[b]
Pig	Pig 2	11.11±1.10	31.62±2.40	44.35±1.76	55.23±1.84	35.58±1.80[b]
	Pig 3	12.81±0.64	76.21±1.55	96.52±3.18	119.10±1.32	76.16±1.70[a]

*Means with the same letters in the column are not significantly different.

Effect of fertilizers on production and yield

The contribution of the amendments significantly influenced ($p < 0.05$) the production of the biomass of *A. cruentus* (Table 8). However, Cattle 1 (20 t.ha^{-1}), Cattle 2 (25 t.ha^{-1}) and pig 1 (20 t.ha^{-1}) present values which are not significantly different from that of the control (To). When tacking the results to the m², the three above-mentioned amendments induce low productions that are respectively 97.22 ± 24.06 g; 208.50 ± 41.67 g; 167 ± 0.0 g and 208.5 ± 41.7 g (To). In spite of the absence of significant difference, Cattle 1 and pig 1 amendments present productions that are lower than To treatment (Table 8). The largest biomass (5111.11 ± 96.23 g) was obtained with pig 3 (30 t.ha^{-1}) followed by *C. odorata* (3833.33 ± 500 g) at the level of 60 t.ha^{-1}, which represents a respective difference of 96% and 95% of the To treatment.

The results (Table 8) indicate that the greatest yield (51.09 ± 0.96 t.ha^{-1}) is induced by pig 3 whereas the lowest (0.97 ± 0.24 t.ha^{-1}) observed with Cattle 1 is not significantly different from those presented by pig 1, Cattle 2 and To treatments.

Discussion

The continual exploitation of the plots on the urban perimeter of IGAD - Franceville without obvious rotation affects in a significant way the production and the yields of vegetable crops. The improvement of soil fertility of the site by providing fertilizers, having been the object of this work showed that the effect of organic amendments (*C. odorata* or green manure, manure of cattle and pigs) and of the NPK was highly significant ($p < 0.0001$) on the growth and the yield. Compare to the control, the diameter of the stem, stem height, number of leaves, leaf area and the production increased respectively of the order of 68%; 73%; 85%; 89% and 96%. This difference on

growth parameters of *A. cruentus* between the control and the fertilizers treatments, could be explained by the phosphorus deficiency, the low contents in organic matter and in total nitrogen of the soil used. Ognalaga and Itsoma (2014) observed similar results on *H. sabdariffa* after the contribution of *C. odorata* and *L. leucocephalae* on a ferrallitic savanna soil.

The use of organic amendments enrich the soil with nutriments promoting the growth of *A. cruentus*. Adesina and Sanni (2013) noticed that manure of poultry, pig and cow dung improve considerably the growth and the yield of *corchus olitorus*. The similar results, which reflect the beneficial effect of organic fertilizers, were reported by many authors including, Chouldary and Koumar (2013) on corn after the contribution of such fertilizers: Poultry manure, Vermicompost, farmyard manure and pig manure and Ognalaga *et al.* (2014) on *H. sabdariffa* by using *C. odorata* and *P. phaseolides*.

Table 7. Effect of treatments on the number of leaves of *A. cruentus* over time.

		DAS				
Treatments		25	32	39	46	Average values
	To	9.22±0.19	11.78±2.46	11.89±2.46	14.33±0.88	11.81±1.50^{b}*
NPK	NPK	8.33±0.88	45.78±2.78	93.33±2.67	104.22±3.56	62.92±2.50^{a}
C. Odorata	*C. O.*	9.33±0.88	35.67±3.53	63.33±2.52	105.44±2.80	53.44±2.45^{a}
Manure	Cattle 1	9.00±1	12.89±2.37	18.22±0.38	18.33±2.96	14.61±1.70^{b}
Cattle	Cattle 2	8.56±0.69	12.44±0.84	18.22±2.71	24.22±4.30	15.86±2.15^{b}
	Cattle 3	8.56±1.17	34.22±3.34	65.33±3.18	103.33±2.91	52.86±2.65^{a}
Manure	Pig 1	9.00±1.20	11.67±0.88	14.89±2.27	17.89±0.51	13.36±1.22^{b}
Pig	Pig 2	7.33±1.20	13.11±2.78	21.44±3.66	46.44±2.91	22.08±1.65^{b}
	Pig 3	8.00±1.15	43.22±1.17	84.22±3.67	92.56±2.22	5700±2.05^{a}

*Means with the same letters in the column are not significantly different.

The best growth of *A. cruentus* was observed on plants grown on fertilized plots. The nature of little manure influenced the measured parameters. However, the high doses: NPK (300 kg.ha^{-1}), *C .odorata* (60 t.ha^{-1}), cattle manure (30 t.ha^{-1}) and pig manure (30 t.ha^{-1}) had to produce more nutriments justifying the good growth of vegetables on the plots having received the strongest doses. On the others hand plants cultivated on the plots provided with very low dose of amendments and showed poor growth parameters and no difference with plants grown in control plots. Malele Mbala (2003) found a close relationship between the dose applied and the yield of the corn. Similar observations were made by Oyewole and Mera (2010) on the roselle, Ikeh *et al.* (2012) on the pepper and Ognalaga and Itsoma (2014) on *H. sabdariffa*.

Table 8. Treatment effect on production and the performance of A. *cruentus*.

Treatements	Production (g/m^{2})	Yield (t/ha)
To	208.33±41.67f*	2.08±0.42f*
NPK	1861.11±127.29d	18.60±1.27d
C.odorata	3833.33±500b	38.32±5.00b
Cattle 1	97.22±24.06f	0.97±0.24f
Cattle 2	208.33±41.67f	2.08±0.42f
Cattle 3	2708.33±208.33c	27.07±2.08c
Pig 1	166.67±0.00f	1.66±0.00f
Pig 2	1152.78±63.65e	11.52±0.64e
Pig 3	5111.11±96.23a	51.09±0.96a

*Means with the same letters in the column are not significantly different.

These results indicated that the used amendments were well appropriate and that it was necessary to bring them to strong dose to increase the chemical properties of the soil (Ayoola and Makinde, 2008; Maman and Mason, 2013). *C .odorata*, cattle manure, and pig manure must have a certain richness in phosphorus, nitrogen and other minerals which assure the good performance on the growth and the yield of plants (Atta and al., 2010; Anyinkeng and Mih, 2011; Ognalaga and Itsoma, 2014).

The soil of experimental site is characterized by sandy-silty clay texture type that could have a flying behavior that can affect the growth of the plants. It appears that, in the case of treatments with organic matter, the growth is better compared to the one based on the NPK, which is more used by the gardeners. In fact the organic fertilizers contribute to improve the structure of the soil (Gbamosi, 2006; Maman and Mason, 2013; Chouldary and Koumar, 2013) by limiting the battance. The biological activity improves by causing the mineralization of the organic matter and the release of nutrients that enrich the soil solution.

The examination of the results reveals a good growth with the NPK but which remains lower than that observed with organic amendments. This fact suggests that improving soil fertility of that perimeter, gardener should consider the use of organic amendments which burst out being associated to a mineral fertilizer for best performances. The organic matter would assure a good structuring of the soil and a release of N, P and K elements that become more readily bio-available to the cultivated plants. Ayoola and Makinde (2008) and Ogundare *et al.* (2012) working on corn; Maman and Mason (2013) working on millet showed that the use of an organic substrate associated with mineral fertilizer produced good growth and good yields. However these results are similar to those of Ognalaga *et al.* (2015) who worked upper slope of IGAD Franceville perimeter with the same amendments, on a silty clay soil texture, unlike the current trial of soil sandy-loam texture. This reaction reflects a contrary effect on the soil study site.

Conclusion

Degradation of physical and physico-chemical soil around the urban perimeter IGAD-Franceville resulted in low production and yields. This situation is the result of over- exploitation of lands associated with bad cultural practices.

The envisaged approach aiming to repress the observed trend and to arouse the restoration of soil fertility consisted in bringing a mineral fertilizer and organic manure. The results obtained showed that the NPK, *C. odorata*, cattle and pig manures can be used as fertilizers. The number of leaves, the leaf area, the production and the yields obtained with the best treatments are respectively 5; 6 and 16 times higher than those observed for unfertilize control. After all, regardless of the fertilizer, the most important is that it has been brought to the ground at high doses of the order of 60 $t.ha^{-1}$ for green manure (*C. odorata*) and 30 $t.ha^{-1}$ for other organic amendments used. Apart from these formulations, other treatments did not show differences compared to unfertilized soil.

Acknowledgement

The authors thank the "Institut Gabonais d'Appui au Développement" for fundings and providing the experimental site.

References

Adesina JM, Sanni KO. 2013. Comparative effects of different organic manure on agronomic performances of *Corchorus olitorus* in rainforest agro-ecological zone of South Western Nigeria. International Journal of Agronomy and Agricultural Research **1,** 1-5.

Assogba-Komlan F, Anihouvi P, Achigan E, Sikirou R, Boko A, Adje C, Adje C, Ahle V R, Assa A. 2007. Pratiques culturales et teneur en éléments anti nutritionnels (nitrates et pesticides) du *Solanum macrocarpum* au sud du Bénin. African Journal of Food Agriculture Nutrition and developpement **4,** 2007–ISSN 1684-5374.

Atta S, Sarr B, Bakasso Y, Diallo AB, Lona I, Saadou M, Glew RH. 2010. Roselle *(Hibiscus Sabdariffa* L.) Yield and Yield components in response to Nitrogen Fertilization in Niger. Indian Journal of Agricultural Research **44,** 96–103.

Anyinkeng N, Mih AM. 2011. Soil nutrient supplementation on growth and biomass *production* of Roselle under tropical conditions. Agriculture and Biology Journal of North America. ISSN Print: 2151-7517, ISSN Online: 2151-7525, http://dx.doi.org/10.5251/abjna.2011.2.4.603.609.

Ayoola OT, Makinde EA. 2008. Performance of green maize and soil nutrient changes with fortified cow dung. African Journal of Plant Science **2,** 019-022.

Choudhary VK, Suresh Kumar P. 2013. Maize production, economics and soil productivity under different organic source of nutrients in eastern himalayan region, India. International Journal of Plant Production **7,** 167-186.

Defoer T, Budeman A, Carter C, Ticheler. 1998. Soil fertility management in Africa. Resource guide for participatory learning and action research part 1. AKIT publication, forthcoming, Mauritskade 63, Amsterdan, Netherlands 181P.

Edima Ndoum DJ. 1993. Les causes de la rétention du phosphore dans les quatre types de sols de la région de Bafou (Ouest du Cameroun), Mémoire Uds, Cameroun, 13-39.

Gbadamosi AE. 2006. Fertilizer Response in Seedlings of Medicinal Plant *Enantia chlorantha* Oliv. Tropical and Subtropical Agroecosystems **6,** 111 – 115.

Grubben GJH, Denton OA. 2004. Ressources végétales de l'Afrique tropicale 2, Légumes. Fondation PROTA ; CTA ; Leiden : Backhuys, 2004, 736P.

Ikeh O, Ndaeyo NU, Uduak IG, Iwo3 GA, Ugbe LA, Udoh EI, Effiong GS. 2012. Growth and Yield Responses of Pepper (*Capsicum frutescens L.*) to varied Poultry Manure Rates in Uyo, Southeastern Nigeria. ARPN Journal of Agricultural and Biological Science **7**, 735-742.

Kiye Nkoy More N, Ayingwe L, Luyindula Ndiku L, Babelangi A. 2013. Amendement des sols: Influence des fertilisants pour l'amélioration de la culture de Vigna unguiculata (L) Walp. International Journal of Biological and Chemical Sciences **7,** 2029-2039.

Malélé Mbala S. 2003. Contribution à la remise en valeur des terres forestières dégradées de la zone périurbaine de Kinshasa (République Démocratique du Congo). XII^{ième} Congrès forestier mondial, Québec city, Canada, du 21 au 28 septembre 2003.

Maman N, Mason S. 2013. Poultry manure and inorganic fertilizer to improve pearl millet yield in Niger. Afr. J. Plant Sci. **7**, 162-169.

Monzenga L, FOMA M, Panzu. 2007. Etude de l'influence de la densité de plantation sur le rendement de l'amarante (Amaranthus hybribus L.) dans les conditions de Kisangani. Annales de l'Institut Facultaire des Sciences Agronomiques de Yangambi **1,** 18-23.

Ognalaga M, Boussiengui-Boussiengui G, Oyanadigui Odjogui PH. 2015. Contribution à la restauration de la fertilité des sols du périmètre maraîcher de l'IGAD Djamiti (Franceville) par l'apport raisonné des amendements organiques et minéral. Journal of Animal and Plant Sciences **24**, 3843-3853.

Ognalaga M, Massounga YC, NZANDI H, Mbélé CD. 2014. Effet de *Chromolaena odorata L.* et de *Pueraria phaseolides B.* sur la croissance et la production de *Hibiscus sabdariffa* L. International Biological and Chemical Science **8,** 1140-1150.

Ognalaga M, Itsoma E. 2014. Effet de

Chromolaena odorata et de *Leucaena leucocephalae* sur la croissance et la production de l'oseille de Guinée (*Hibiscus sabdariffa L.*). Agronomie Africaine **26,** 1-88.

Ogundare K, Agele S, Aiyelari P. 2012. Organic amendment of an ultisol: effects on soil properties, growth, and yield of maize in Southern Guinea savanna zone of Nigeria. International Journal Of Recycling of Organic Waste in Agriculture **1,** 11.

Ondo JA. 2011. Vulnérabilité des sols maraîchers du Gabon (région de Libreville): acidification et mobilité des éléments métalliques. Thèse Université de Provence, France, 113-128.

Oyewole CI, Mera M. 2010. Response of Roselle (*Hibiscus sabdariffa* L.) to rates of inorganic and farmyard fertilizers in the Sudan savanna ecological zone of Nigeria. African Journal of Agricultural Research **5,** 2305-2309.

Sawadogo H, Bock L, Lacroix D, Zombré NP. 2008. Restauration des potentialités de sols dégradés à l'aide du zaï et du compost dans le Yatenga (Burkina Faso). Biotechnologie, Agronomie, Société et Environnement **12,** 279-290.