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RESEARCH ARTICLE

EFFECTS OF COCOA AND COFFEE PODS HUSKS COMPOSTS COMBINED WITH NPK FERTILIZER ON THE GROWTH OF IMMATURE COCOA TREES (*THEOBROMA CACAO* LINN.) ON DEPLETED SOIL IN TROPICAL ZONE

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ABSTRACT

The fertility declining in tropical soils is a crucial problem for farmers, also agricultural practices aren't favourable for nutriments exported return back in soil, especially in cocoa production lands in Togo. A composting trial of cocoa pods husks and coffee pods husks (CKKO and CKF) with manure (4:1) then a field experiment were carried out in order to elucidate the effects of these composts combined with fertilizer NPK15-15-15 on the immature cocoa trees and the soil chemical properties. The experiment lied out in split plot design with three repetitions. The treatments consisted with three amounts of composts in principal plots (0 kg.plant^{-1}, 2 kg.plant^{-1} CKKO and 2 kg.plant^{-1} CKF) combined with three doses of NPK fertilizer in the sub-plots (0, 50 and 75 g.plant^{-1}). The field maintenance was done regularly then the parameters of compost sanitation, agronomic variables and data on soil chemical properties were collected. The results showed that the composts produced in 60 days are usable with yields of 740±3.51 and 821±8.84 kg.tons^{-1} for CKKO and CKF respectively. Both fertilizers didn't have an effect on cocoa trees lifting percentage, nor on their stem girth size. The CKKO and CKF generated respectively a cocoa trees height of 64±9.77 cm and 64.69±11.77 cm versus 52.5±13.68 cm for the control ($p<0.05$) whereas the mineral fertilizer gave 60.40±11.72 cm ($p>0.05$). The soil nutriments partial budgets revealed that soil fertility was improved with N profits (18.78±6.14 kg.ha^{-1}) in all treatments, the gains of P (14.91±19.96 kg.ha^{-1}) without composts application and the profit of K (5.25±5.49 kg.ha^{-1}) with both fertilizers addition. The balance was negative for Ca and Mg independently of composts application. The both fertilizers had a positive effect on the immature cocoa trees height and its soil fertility improvement. Organic matter strategies were important for sustainable cocoa trees production in tropical zone.

INTRODUCTION

The cacao tree (*Theobroma cacao Linn.)* is a cash crop in Togo grown by thousands of small farmers over a surface of about 1 ha on average with a low yield around 250 kg.ha^{-1} (Koudjega and Tossah 2009; DSID, 2014). It is possible to maintain or improve the yields by replanting new cacao trees orchards in the forest zone but this would constitute a source of deforestation (Wessel and Quist-Wessel, 2015). Therefore, there is a need to intensify the cocoa production on the old soils under cocoa trees as suggested by some authors, by replanting the young cocoa trees under the old one for the latter to provide shading for the young trees (Ogunlade, 2008). The cocoa production in Togo is much more supported by the use of organic fertilizers based nutrients and mainly by means of agroforestry practices. The use of organic fertilizers is described as being cheaper, friendly and healthy for the environment. The cocoa pods husks which often represent a sanitation problem in the plantations (due to the black pod disease caused by *Phytophtora spp*.) have been reported by several authors (Ogunlade *et al*., 2006; Ayeni, 2010) as being rich in nutrients. Approximately 60% of the pods are made up of husks. These husks have been suggested as possible fertilizer sources for the small farmers (Oyewole *et al*., 2012). The cocoa pods husks contain significant nutrients as N, P, K,

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Ca and Mg (Joffres, 2010) just like the coffee pods husks (Pandey *et al*, 2010). The poultry manures are also rich in major nutriments and are potentially able to feed the plants (Teurki, 2013), especially the immature cocoa trees which however do not have great needs. The works of Snoeck and Jardin (1992) showed that the nutrients uptake of young cocoa trees from 5 to 12 months with a density of 1100 plants.ha^{-1} were only 2-,5 kg.ha^{-1} of N, 1-,4 kg.ha^{-1} of P, 3 kg.ha^{-1} of K, 1,-9 kg.ha^{-1} of Ca and 3-,3 kg.ha^{-1} of Mg.

The maintenance of organic matter in soil remains a concern, especially in the areas of larger demand for organic wastes (Ojeniyi, 2010). This is likely to continue since the adequate soil reserves no longer exist and the future cacao orchards are likely to be present on already exploited soil. A large quantities of human, agricultural, forestry and industrial wastes are produced annually but are not effectively used (Akanbi *et al*., 2014), especially the coffee pods husks and cocoa pods husks in the forest zone of Togo. However, the materials coarseness, low nutrient quality and slow mineralization are bottlenecks for the use of these pods husks (Ayeni, 2010). However, the soils under old cocoa trees are depleted in nutrients, results of continuous farming without fertilizers in compensation. Although the cocoa trees need adequate input of mineral fertilizers for optimal growth and good production, the appropriate fertilizers are not often used because of their high cost and their scarcity (Epule *et al*., 2015; Wessel and Quist-Wessel, 2015) and sometime the lack of a suitable technical recommendation. Moreover, the continued use of mineral fertilizers alone is a source of soil acidity and nutritional imbalance (Akanbi *et al.,* 2014; Crusciol *et al*., 2016; Zhang *et al*., 2016). Several studies have confirmed that the combined use of organic and inorganic fertilizers have synergistic impacts on the plants balanced nutrition and the soil fertility improvement (Epule *et al*., 2015 ; Meena *et al*., 2016 ; Wen *et al*., 2016 ; Zhang *et al*., 2016 ; Zhao *et al*., 2016). The combined use of organic and inorganic fertilizers has other benefits such as reducing the need for mineral fertilizer and aids time mineralization of nutrients from organic manures (Geng *et al*., 2015; Simpson *et al*., 2015).

The health risks related to the husks and the difficulties in the use of raw organic materials could be addressed by composting. The composting allows pathogens and weed seeds removal and the production of stabilized organic matters easier to carry and spread (Eghball and Gilley, 1999; Eghball and Lessing, 2000). During the composting, it notices a significant reduction in mass and volume (Andersen *et al*., 2011). According to Rafolisy *et al*. (2015), the mass shrinkage may be around 70%. These losses reduce the composts agronomic value (Paillat *et al*., 2005; Vandecasteele *et al*., 2016) but make them easier to handle. The composting is also characterized by the production of heat in the compost heap which leads to a rise in temperature contributing to hygienic products if the temperature exceeds 55 °C over several days (Isobaev *et al*., 2014; Rafolisy *et al*., 2015; Yang *et al*., 2016). The effects of the use of compost combined with NPK fertilizers on the young cocoa trees and the soil properties remain poorly known in the cocoa production lands in Togo.
Therefore, this study aims to test the production of hygienic composts with cocoa pods husks and coffee pods husks, then to determine the effects of these composts combined or not with the NPK fertilizer on the soil properties and the growth of immature cocoa trees grown on degraded soil.

MATERIALS AND METHODS

Site description

A field trial was conducted during the first year of growth of the young cocoa trees (for six months, the other half being carried out in the nursery) in Amlamé in Togo (North latitude 07° 30'19.2" East longitude 000° 58' 59.2', altitude 314m). This is an area with a rainfall varying between 1200 and 1600 mm per year with an average temperature of 20-35°C. The experimental area was approximately 0.15 ha grown with hybrid varieties of cocoa trees (77x42, 77x85 and 77x67) planted in holes of 0.40 x 0.40 x 0.40 m^3 with a spacing of 3 x 2.5 m² (1320 plants.ha^{-1}). The plot is a cocoa farm in full sunlight. The soil in place is described as being ferruginous with a clay dominance rich in organic matters (55g.kg^{-1}), poor in nitrogen (2mg.kg^{-1}) and phosphorus (21.9mg.kg^{-1}). The exchangeable bases content is low (0.3 K meq %, 13.4 Ca meq% and 5.9 Mg meq %) with a Cation Exchange Capacity (CEC) of 21.1 meq% and a pH of 6.7 (Koudjega and Tossah, 2009).

Compost elaboration

The compost used for the trial was locally produced. The cocoa pods husks and coffee pods husks are obtained from the surrounding plantations of the experimental centre after harvesting, and pod breaking or scarification and drying. The dung is obtained from poultry breeding farm at Patatoukou located at 18 km from the farmyard; the feces are collected daily and stored in a feces pit. The proportion of composted matters was determined on the basis of the gross mass of the dung and husks. Two piles were set up with the same proportion of dung and the two types of husks. The proportion used is 4:1. The composting technique was a compost heap with lime reversal. The piles were set up on finished basement and were wetted up to moisture content of 70-80% then covered with plastic sheeting to prevent the addition of water and retain heat in the pile. Compost elaboration takes 60 days during which two reversals were made on the 21st and 42nd day. The physical characteristics of the piles are presented in Table 1.

Experimental design and field treatments

The experiment was conducted in a split plot design with nine treatments repeated three times to control spatial variability of the site (van Es *et al*, 2004.). Each experimental main plot consisted of nine cocoa trees fenced with a line of cocoa trees. In the three main plots within the same block, were applied, before the cocoa seedlings planting, three doses of compost: the control T0 (0 kg.plant^{-1} of compost), the treatment T1 (2 kg.plant^{-1} of cocoa pods husks compost - CKKO -) and the treatment T2 (2 kg.plant^{-1} of coffee pods husks compost - CKF -). The subplot is constituted by three young cocoa trees on a line within one main plot. The subplots received, one month after planting, three doses of NPK 15-15-15: 0, 50 and 75 g.plant^{-1}. The weeding, pest and disease control have been carried out where necessary on the field.

Data collection and analysis

In order to ensure the maturity and sanitation of the compost pile, the temperature measurements within the piles in three-day interval were conducted. The temperature was recorded using a digital thermometer (digital precision A) by measuring the heat in the heart of the pile. The composite samples were collected at the end of the composting. On these samples, laboratory tests were carried out and then a phytotoxicity test was performed with the sorghum (*Sorghum bicolor*). The compost phytotoxicity is its capacity to affect the growth of a plant developed on a soil enriched with this compost. To achieve this, a part of the composite sample was collected, screened to 4 mm and distributed into three bins with two compartments, each for a particular type of compost. The products collected from the sieve in the bins were saturated with water and allowed to percolate for 24 hours, and then 100 sorghum grains per compartment were sown. A fine and regular watering was carried out every day. The counting of the germinated grains was performed 10 days later. The compost yields and yields component was also measured at the end of the composting.

On field, agronomic variables such as plant lifting percentage, plant height and stem girth size were measured at the end of the experiment. The cocoa trees lifting percentage is determined one month after planting the seedlings. The plant height was measured from the stump to the top of the plant. The stem girth size was calculated by multiplying the average plants diameter measured by π (3.142). Soil composite samples were collected randomly on the site at the beginning of the trial and in each subplot at the end of the experiment at the soil depths of 0 - 0.60 m. These samples were analysed in the laboratory to study the nutritional status and partial budget of the enriched soil under the young cocoa trees. The samples collected were air dried and sieved with a strand of 2 mm and then analysed. The organic matter content was determined by wet oxidation method by chloric acid digestion. The dosage of N was made using the Kjeldahl method. The available P extracted by Bray-I solution and its dose determined by spectrophotometry. The exchangeable bases (K, Ca and Mg) were extracted by ammonium acetate 1N then K was determined by flame photometry while Ca and Mg were determined by EDTA titration method. The CEC is determined by colorimetric dosage with continue flux of the containing ammonium in the exchange solution obtained by ammonium acetate 1N. The pH is determined by pH-meter in water. The C/N ratio is determined by the ratio of the organic C content over the total N; the organic C content is calculated by dividing the organic matter content by 1.724 (CIRAD, 2004). The statistical analysis were performed on the collected data with analysis of variance (ANOVA) and the means separation using the Duncan multiple test range at 5% probability threshold using the version 5.5 of STATISTICA software.

RESULTS

Composts sanitation, yields and quality

The temperature in the compost heaps rose from 25 °C to around 80 °C before dropping and stabilizing at less than 40 °C (Figure 1). The temperature went beyond 55 °C at the 3rd day and remained beyond for almost a month. The rise in temperature reveals a high activity of microorganisms and therefore a faster transformation of the composted materials. This temperature level during that period was sufficient to ensure that the compost obtained is hygienic. The two reversals performed led to a good homogenization of the piles. The phytotoxicity test of the two types of compost produced, translated by a sorghum germination test on these substrates, revealed that the sorghum grain germination percentage is 89±3% on the CKF compost and 91±1% on the CKKO compost. The CKF and CKKO composts produced in combination with the poultry wastes in two months are ready to be used without risk for farming soils amendment. The mass shrinkage of the compost produced is 26±0.35 % and 18±0.88 % respectively for the CKF and CKKO piles. The volume shrinkage for both CKF and CKKO is 75±1.41 % and 77±0.56 % respectively. The compost yield is 740±3.51 kg.tons^{-1} of cocoa pods husks composted with a density of 233±8.41 kg.m^{-3}, and 821±8.84 kg.tons^{-1} of coffee pods husks composted for a density of 256±2.65 kg.m^{-3} (Table 1). The composts produced have a great fertility value with a C/N ratio of 16 and 25 respectively for the CKF and CKKO (Table 2) and can be used to enrich the soil under the immature cocoa trees.

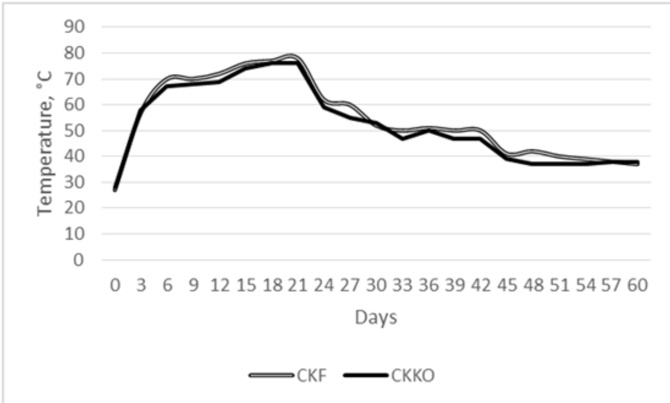

Figure 1. Temperature evolution within the composts piles CKKO: cocoa pods husks compost; CKF: coffee pods husks compost

Table 1. Composts heaps constitution and yields

HEAPS	Compost with cocoa pod husks (CKKO)	Compost with coffee pod husks (CKF)
Before composting		
Raw matter (kg)	285	397
Poultry manure (%)	20	20
Coffee pods husks (%)	0	80
Cocoa pods husks (%)	80	0
Straws ashes (kg)	5	5
Water (m^{-3})	0.42	0.78
Humidity ratio (%)	70-80	70-80
Heaps volume (m^{-3})	1.42	1.78
Density (kg MS.m^{-3})	201	223
After composting		
Gross weight, kg	211±1.00	326±3.51
Volume (m^{-3})	0.36±0.02	0.41±0.01
Density (kg MS.m^{-3})	233±8.41	256±2.65
Yield (kg.tonne^{-1})	740±3.51	821±8.84

Effects of composts and NPK fertilizer on the growth of immature cocoa trees

The lifting percentage of the cocoa trees planted in holes enriched with the compost produced is on average 84.0±35.1

% (Table 3). This rate is 92.6±22.2 % for the control treatment T0 (without compost), 77.8±42.3 % on soil enriched with 2 kg.plant^{-1} of CKKO compost (T1) and 81.5±40.5 % on soil enriched with 2 kg.plant^{-1} of CKF compost (T2). According to mineral fertilizer, the lifting percentage is 92.6±6.4 % for the control without fertilizer, 77.8±11.1 % for the dose of 50 g.plant^{-1} and 81.5±6.4 % for the dose of 75 g.plant^{-1}. There is no significant difference ($F_{(8, 81)}$ = 0.61, p=0.7677) between the effects of the two types of composts and the different doses of mineral fertilizer brought to the young cocoa trees lifting percentage. The stem girth size of the young cocoa trees globally measures on average 4.13±0.72 cm. In relation to the organic matters input, the control treatment T0 gives 3.99±0.72 cm, the CKKO compost treatment T1 reveals 4.33±0.68 cm and the CKF compost treatment T2 gives 4.08±0.77 cm. In relation to the application of the mineral fertilizers, the control treatment gives 4.16±0.70 cm, application of 50 g.plant^{-1} reveals 4.13±0.63 cm and application of 75 g.plant^{-1} gives 4.11±0.85 cm (Table 3). There is no significant difference ($F_{(8, 81)}$ = 0.86, p = 0.5580) between the young cocoa trees stem girth size as affected by the both fertilizers. The composts and the NPK fertilizer inputs have no impact on the stem girth size of the young cocoa trees. The height of the young cocoa trees is typically 60.4±11.7 cm after first year growth in the field. In the control treatment T0, the height is 52.52±13.9 cm while the CKKO compost input generates a height of 64.69±11.7 cm and the CKF compost input gives 64.0±9.8 cm. Considering the NPK doses applied, the height of the cocoa trees is on average 60.83±11.9 cm for the control without input, 59.59±11.8 cm for the dose of 50g.plant^{-1} and 60.78±11.5 cm with the input of 75g.plant^{-1} (Table 3). There is a significant difference ($F_{(8, 81)}$ =2.18, p=0.0391) between the heights generated by the different treatments applied. The organic fertilizer input has a significant impact on the height of the cocoa trees (Figure 2), while the mineral fertilizers input, regardless of the dose, has no influence on the height of the cocoa trees (Figure 3). Both the CKKO and CKF composts have similar impact on the height of the young cocoa trees.

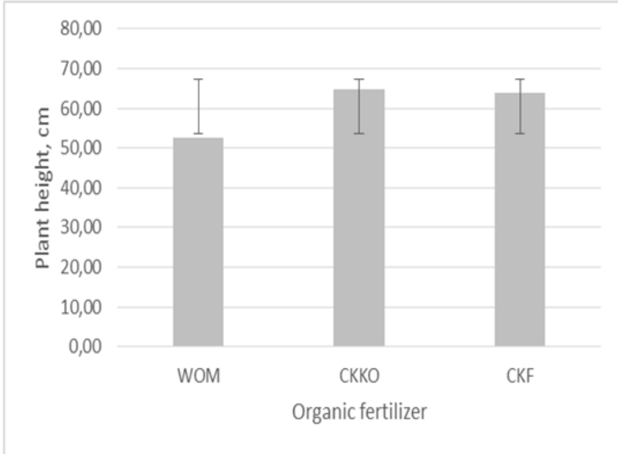

Figure 2. Effects of composts on the immature cocoa trees height WOM: without organic matter; CKKO: cocoa pods husks compost; CKF: coffee pods husks compost

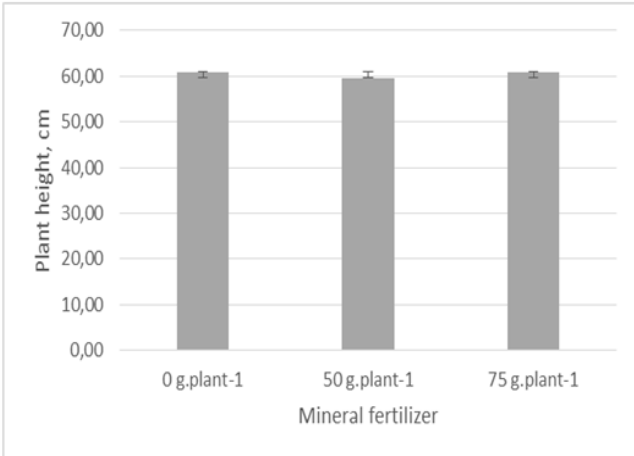

Figure 3. Effects of NPK fertilizer on the immature cocoa trees height

Table 2. Initial soil and produced composts nutrients contents

Parameters	N (mg.kg^{-1})	P_2O_5 (mg.kg^{-1})	K_2O (mg.kg^{-1})	CaO (cmol.kg^{-1})	MgO (cmol.kg^{-1})	OM (g.kg^{-1})	DM (g.kg^{-1})	C/N
Initial soil	1.4	26.7	0.36	12.2	4.6	45	-	19
CKF	1.36	0.43	3.07	0.29	0.39	38	105	16
CKKO	0.98	0.29	4.76	0.45	0.46	42	84	25

OM: Organic matter; DS: Dry matter; CKKO: cocoa pods husks compost; CKF: coffee pods husks compost

Table 3. Effects of composts and NPK fertilizer on the growth of immature cocoa trees

Compost doses	NPK doses	Lifting percentage,%		Stem girth, cm		Plant height, cm	
		Means	SD	Means	SD	Means	SD
0 kg.plant^{-1} of compost	0 g.plant^{-1}	100.0 ^{a}	0.00	4.22 ^{a}	0.39	53.61 ^{b}	8.73
	50 g.plant^{-1}	88.9 ^{a}	33.33	3.93 ^{a}	0.77	50.38 ^{ab}	15.64
	75 g.plant^{-1}	88.9 ^{a}	33.33	3.81 ^{a}	1.00	53.56 ^{ab}	16.66
2 kg.plant^{-1} of compost CKKO	0 g.plant^{-1}	88.9 ^{a}	33.33	4.12 ^{a}	0.88	64.88 ^{a}	16.72
	50 g.plant^{-1}	66.7 ^{a}	50.00	4.56 ^{a}	0.47	64.33 ^{a}	10.07
	75 g.plant^{-1}	77.8 ^{a}	44.10	4.31 ^{a}	0.70	64.86 ^{a}	8.40
2 kg.plant^{-1} of compost CKF	0 g.plant^{-1}	88.9 ^{a}	33.33	4.12 ^{a}	0.82	64.00 ^{a}	10.15
	50 g.plant^{-1}	77.8 ^{a}	44.10	3.91 ^{a}	0.64	64.07 ^{a}	9.67
	75 g.plant^{-1}	77.8 ^{a}	44.10	4.22 ^{a}	0.84	63.92 ^{a}	9.48
Means		84.0	35.1	4.13	0.72	60.40	11.72
F		0.61		0.86		2.18	
p		0.768		0.558		0.039	

CKKO: cocoa pods husks compost; CKF: coffee pods husks compost; SD: Standard deviation; the values in the colon denoted by the same letter are statistically the same.

Table 4. Effects of organic and inorganic fertilizers on the nutrients contents of soil under immature cocoa trees

Compost doses	NPK doses	N ($mg.kg^{-1}$)	P_2O_5 ($mg.kg^{-1}$)	K_2O ($mg.kg^{-1}$)	CaO ($cmol.kg^{-1}$)	MgO ($cmol.kg^{-1}$)	MO ($g.kg^{-1}$)	CEC (meq %)	pH
0 $kg.plant^{-1}$ of compost	0 $g.plant^{-1}$	1.31±0.04	21.7±3.42	0.47±0.62	7.11±0.06	1.46±0.06	43±0.58	20.2±0.25	6.5±0.17
	50 $g.plant^{-1}$	1.28±0.16	27.3±6.42	1.49±0.05	7.17±0.05	1.55±0.05	42±3.46	20.4±0.40	6.8±0.06
	75 $g.plant^{-1}$	1.36±0.17	27.9±6.45	1.58±0.13	7.22±0.16	1.56±0.05	42±3.06	20.7±0.42	6.8±0.06
2 $kg.plant^{-1}$ of compost CKKO	0 $g.plant^{-1}$	1.59±0.17	38.7±9.76	1.55±0.65	7.26±0.08	1.64±0.14	48±2.52	19.9±0.35	6.7±0.20
	50 $g.plant^{-1}$	1.69±0.25	39.4±7.52	1.79±0.16	7.51±0.17	1.54±0.03	46±2.65	20.1±0.21	6.8±0.00
2 $kg.plant^{-1}$ of compost CKF	75 $g.plant^{-1}$	1.72±0.24	40.2±6.99	1.77±0.10	7.64±0.23	1.68±0.09	47±3.21	20.4±0.17	6.7±0.10
	0 $g.plant^{-1}$	1.62±0.11	38.5±6.59	1.63±0.63	7.22±0.07	1.74±0.10	45±1.55	20.6±0.30	6.9±0.19
	50 $g.plant^{-1}$	1.73±0.20	41.1±6.97	1.71±0.10	7.41±0.11	1.59±0.04	47±3.05	20.5±0.31	6.8±0.03
	75 $g.plant^{-1}$	1.81±0.20	39.8±6.72	1.69±0.11	7.60±0.19	1.73±0.07	48±3.13	20.7±0.29	6.9±0.08
Means		1.57±0.17	35.0±6.76	1.52±0.28	7.35±0.12	1.61±0.07	45±2.58	20.4±0.30	6.8±0.10
F		0.231	0.133	1.373	2.111	0.741	0.042	1.483	0.349
p		0.800	0.878	0.323	0.202	0.516	0.959	0.300	0.719

CKKO: cocoa pods husks compost; CKF: coffee pods husks compost

Table 5. Major nutrients partial budgets in soil under immature cocoa trees at 0.6 m depth

Treatments	0 $kg.plant^{-1}$ compost			2 $kg.plant^{-1}$ compost CKKO			2 $kg.plant^{-1}$ compost CKF		
	0 $g.plant^{-1}$	50 $g.plant^{-1}$	75 $g.plant^{-1}$	0 $g.plant^{-1}$	50 $g.plant^{-1}$	75 $g.plant^{-1}$	0 $g.plant^{-1}$	50 $g.plant^{-1}$	75 $g.plant^{-1}$
Unit	---------------- $kg.ha^{-1}$ ----------------								
Nitrogen (N)									
Initial soil content (+)	11.12	11.12	11.12	11.12	11.12	11.12	11.12	11.12	11.12
Organic fertilizer (+)	0.00	0.00	0.00	2.59	2.59	2.59	3.59	3.59	3.59
Mineral fertilizer (+)	0.00	9.90	14.85	0.00	9.90	14.85	0.00	9.90	14.85
Atm deposition (+)	12.80	12.80	12.80	12.80	12.80	12.80	12.80	12.80	12.80
Final soil content (-)	10.41	10.17	10.80	12.63	13.43	13.66	12.87	13.74	14,38
Nutrient uptake (-)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Sold	10.51	20.65	24.97	10.88	19.98	24.70	11.64	20.67	24.98
Phosphorus (P_2O_5)									
Initial soil content (+)	212.10	212.10	212.10	212.10	212.10	212.10	212.10	212.10	212.10
Organic fertilizer (+)	0.00	0.00	0.00	0.77	0.77	0.77	1.14	1.14	1.14
Mineral fertilizer (+)	0.00	9.90	14.85	0.00	9.90	14.85	0.00	9.90	14.85
Atm deposition (+)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final soil content (-)	172.46	217.03	221.80	307.75	312.91	319.43	306.72	326.74	316.33
Nutrient uptake (-)	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68
Sold	37.96	3.29	3.48	-96.56	-91.82	-93.39	-95.16	-105.28	-89.92
Potassium (K_2O)									
Initial soil content (+)	2.86	2.86	2.86	2.86	2.86	2.86	2.86	2.86	2.86
Organic fertilizer (+)	0.00	0.00	0.00	12.57	12.57	12.57	8.10	8.10	8.10
Mineral fertilizer (+)	0.00	9.90	14.85	0.00	9.90	14.85	0.00	9.90	14.85
Atm deposition (+)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final soil content (-)	3.73	11.84	12.55	12.31	14.22	14.06	12.95	13.58	13.43
Nutrient uptake (-)	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60
Sold	-4.47	-2.68	1.56	-0.49	7.51	12.62	-5.58	3.68	8.79
Calcium (CaO)									
Initial soil content (+)	54.27	54.27	54.27	54.27	54.27	54.27	54.27	54.27	54.27
Organic fertilizer (+)	0.00	0.00	0.00	0.67	0.67	0.67	0.43	0.43	0.43
Mineral fertilizer (+)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Atm deposition (+)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final soil content (-)	100.89	101.76	102.40	102.95	106.53	108.44	102.40	105.10	107.80
Nutrient uptake (-)	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28
Sold	-48.90	-49.77	-50.40	-50.30	-53.87	-55.78	-49.98	-52.68	-55.38
Magnesium (MgO)									
Initial soil content (+)	14.62	14.62	14.62	14.62	14.62	14.62	14.62	14.62	14.62
Organic fertilizer (+)	0.00	0.00	0.00	0.49	0.49	0.49	0.41	0.41	0.41
Mineral fertilizer (+)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Atm deposition (+)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final soil content (-)	28.92	30.82	31.06	32.57	30.66	33.36	34.64	13.58	34.32
Nutrient uptake (-)	3.96	3.96	3.96	3.96	3.96	3.96	3.96	3.96	3.96
Sold	-18.26	-20.17	-20.40	-21.43	-19.52	-22.22	-23.57	-2.52	-23.25

Atm: atmospheric; (+): nutrients input in the system; (-): nutrients output from the system; CKKO: cocoa pods husks compost; CKF: coffee pods husks compost

Effects of composts and NPK fertilizer on the soil properties

The initial soil had a fairly low nutritional status at the beginning (Table 2) although the organic content (45 $g.kg^{-1}$), in Ca (12.2 $cmol.kg^{-1}$) and in Mg (4.6 $cmol.kg^{-1}$) are acceptable with a CEC of 19.4 meq% and level 6.8 as a pH. A deficiency in N (1.4 $mg.kg^{-1}$), P (26.7 $mg.kg^{-1}$) and K (0.36 $mg.kg^{-1}$) justifies the supplementary input of nutrients. The application of the composts and NPK fertilizers has not changed drastically the nutritional status of the final soil under the cocoa trees (Table 4) with a pH of 6.8±0.10 and a CEC which not exceeded 20.4±0.30 meq%. At the end of the test, the N content is 1.57±0.17 $mg.kg^{-1}$, the P content is 35.0±6.76

mg.kg^{-1} and the K content is 1.52±0.28 mg.kg^{-1}. The level of the organic matters (45±2.58 g.kg^{-1}), Ca (7 7.35±0.12 cmol.kg^{-1}) and Mg (1.61±0.07 cmol.kg^{-1}) remains high. There has been no significant impact of the composts and NPK fertilizers on the soil nutrient content at the end of the experiment ($F_{(2, 12)}$ = 0.939, p=0.625). For the nutrients partial budget in soil - plant - atmosphere system over a depth of 0.6 m, the situation is quite variable depending on the type of nutrient. The computing is based on the nutrients uptake of the young cocoa trees of 5-12 months provided by Snoeck and Jardin (1992). For N balance, the result is positive everywhere with a gain of 18.78±6.14 kg.ha^{-1}. The gain appears to be more sensitive with the input of NPK fertilizers; it rises from simple to double with the mineral fertilizers input (Table 5). The N atmospheric deposits (12.8 kg.ha^{-1}) are not negligible in the N input to the system. This improvement is certainly due to the presence in quality of the organic matter with a reduction a losses through runoff, leaching and infiltration.

The P result is positive without compost addition and negative with compost application (Table 5). The system gains 14.91±19.96 kg.ha^{-1} without compost input and loses 95.35±5.40 kg.ha^{-1} with the compost input. The system gains ten times less P with mineral fertilizers input only (3.39±0.13 kg.ha^{-1} against 37.96 kg.ha^{-1} for the control), while the organic fertilizer input stabilizes the losses of P (95.35±5.40 kg.ha^{-1}, less standard deviation). Without any kind of fertilizer application, the soil strives to provide P sufficiently to the cocoa trees while generating a positive result (37.96 kg.ha^{-1}), but both the organic and inorganic fertilizers addition reduces the mineralization activity of the soil intrinsic organic matter. This is translated into P losses. Concerning the K balance (Table 5), the result is positive or negative depending on the dose of the mineral and organic fertilizers applied. The result of K is negative without mineral fertilizer even in the presence of compost with losses in the range of 3.51±2.68 kg.ha^{-1}. The input of NPK results into a positive sold even in the absence of the compost with gains of 5.25±5.49 kg.ha^{-1}. The two types of fertilizers play an important role in the availability of K in the system by achieving a balance. The nutrients Ca and Mg results are all negative regardless of the organic fertilizers application (Table 4). The system loses 51.89±2.59 kg.ha^{-1} of Ca and 19.04±6.43 kg.ha^{-1} of Mg. The observation of the results of the two balances shows that the losses in Ca and Mg are not due to the composts addition because the losses are in the same magnitude value with the compost contribution or not (49.69±0.76 kg.ha^{-1} of Ca and 19.61±1.18 kg ha^{-1} of Mg without compost input against 53.00±2.48 kgha^{-1} of Ca and 18.75±8.08 kgha^{-1} of Mg with compost input). At certain points, the compost tends to reduce Mg losses.

DISCUSSION

The temperature is generally selected as a key indicator but not exclusive to measure the composts sanitation (Lopez *et al*., 2016; Yang *et al*., 2016). The raised temperature in the compost pile does not guarantee the absence of pathogenic anywhere in the pile, but it surely demonstrates the sanitation process of the compost (Ligocka *et al*., 2009; Yang *et al*., 2016). Indeed, studies have shown that seeds germination was reduced to 0-0.2 % after they were exposed for two weeks to a maximum temperature of 58 °C of the compost. The inhibition of seeds and pathogens is obtained after one month when the temperature is above 55 °C (Isobaev *et al*., 2014; Rafolisy *et al*., 2015; Yang *et al*., 2016). The high temperatures in the compost pile contribute to some extent, not only the sanitation process of the pile but also guarantee a more rapid transformation of the composted materials in order to have a mature and healthy compost in a given time. A C/N ratio between 15 and 20 with a bulk density between 80-400 kg.m^{-3} would be indicators of mature compost (CALR, 2011); this is the case of the produced composts.

Ofosu-Budu *et al*. (2010) developed a panel of tests to be applied to composts to ensure their maturity and it appears that the germination index appeared most significant in all the tests to be made. The phytotoxicity test is thus very significant for the determination of a compost maturity. The works of Zhang and Sun (2016) and Vandecasteele *et al*. (2016) proved that, it is possible to produce good quality compost (high nutriments content and nonphytotoxic) in 22 days with bio-agents adding to the composted materials. Compost can therefore be produced in 60 days by ensuring a high temperature in the pile but taking steps to check whether the compost is hygienic and nonphytotoxic. The soils under the cocoa trees require chemical properties in terms of organic matter content (≥30 g.kg^{-1}), pH (6-7.5) and content in nitrogen (≥1 g.kg^{-1}), in phosphorus (30-100 ppm), in potassium (≥100 ppm or ≥1.2 cmol.kg^{-1}), in calcium (≥5-8 cmol.kg^{-1}) and in magnesium (≥0.8 cmol.kg^{-1}) with a CEC of 20 cmol.kg^{-1} at least (Aikpokpodion, 2010; Koko, 2014; Akanbi *et al*, 2014). These requirements are not all met in the studied soil at the trial start requesting therefore additional nutrients. But the organic and/or mineral fertilizers application has neither revealed a significant impact on the growth of the cocoa trees except for their height nor the drastic change in the soil macronutrients content. Compost has high water holding and CEC (Burnett *et al*., 2016). This properties allow compost to enhance soil fertility for plant nutrition. Compost addition to soil can improved also soil organic carbon by 55% and decreased soil pH (Abujabhah *et al*., 2016). However, the CKF and CKKO composts and NPK fertilizer inputs are needed for the replacement of nutrients exported from the system and therefore break the vicious circle of endogenous practices where the continued use of the orchards does not guarantee to the soil a compensation of nutrients exported by the harvest and the losses due to erosion and other soil depletion factors. The results of the studied system provides availability even a gain in N, P and K in the soil layer of 0-0.6 m, vital depth for the root system of the young cocoa trees. This confirms the potential of organic and inorganic fertilizers combined to effectively improve the soil fertility and sustain agricultural production described by several authors (Geng *et al*., 2016 ; Epule *et al*., 2015 ; Zhang *et al*., 2016 ; Meena *et al*., 2016 ; Wen *et al*., 2016 ; Zhao *et al*., 2016).

Tropical soils deficiencies in N and P remain one of the most crucial concerns as regards soils fertility (Vandecasteele *et al*, 2016). The profits in N and P obtained in this study represent in fact the reduction of the losses of N and P in the soil arable layer. This testifies the organic matter capacity to reduce contamination risks of the subjacent tablecloth by fertilizers and thus to avoid the underground water pollution. The use of the composts in this study is more convivial with environment and especially ensures a sustainable agroressources production with the improvement of the soil organic carbon content by

10.6±0.6% in six months compared to the soil of control treatment. Moderate amounts of inorganic fertilizers associated with composts would be an absolute asset for the tropical soils and especially on cacao production lands in Togo. The strategy of optimal control of the young cocoa trees on degraded soils must be based on an increased use of organic matter, especially such elaborate as the composts.

Conclusion

This study contributed to test the composts production with cocoa pods husks and coffee pods husks and to determine the effects of these composts combined or not with NPK 15-15-15 fertilizer on the soil properties and the growth of immature cocoa trees grown on degraded soil. The composts produced in 60 days proved healthy organic matter and ready to fertilize the soil. A combination or not of these composts with NPK fertilizer was used under some young cocoa trees and contributed to significant effects. The fertilizers had significant impacts on the growth of cocoa trees height after six months in the field. The soil properties have been slightly improved as demonstrated by the various partial budgets of the key nutrients studied. Therefore, there is hope that the use of these organic and inorganic fertilizers at appropriate doses would be an input to the cocoa trees production especially during the youth time.

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