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Original Research Article

Soil cation exchange capacity and sugarcane yield as influenced by filter cake and mineral fertilizer in Borotou, Northwestern Côte d'Ivoire

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Filter cake is a by-product commonly used as organic fertilizer in sugarcane on plant crop for the whole plantation cycle. The study was carried out over three cropping seasons (2014-2016) on Borotou sugarcane plantations in northwestern Côte d'Ivoire, following a split-plot design involving 9 treatments and 4 replicates. Filter cake, as main factor involved 3 application rates (0 t/ha, 15 t/ha and 30 t/ha), whereas NPK mineral fertilizer stood as sub-factor with 3 application rates (0 kg/ha, 350, kg/ha and 700 kg/ha). The objective of experiment was to determine the effect of filter cake and mineral NPK fertilizer on soil cation exchange capacity and sugarcane yields. It came out that soil CEC, sum of bases (S) and base saturation ratio (V) were significantly improved with increasing rates of filter cake. Although cane and sugar yields obtained increased slightly with fertilizer rates, differences observed on each yield variable were not significant.

Keywords : Amendment, organic fertilizer, soil fertility, nutrient.

INTRODUCTION

Sugarcane productivity decreases in field (Emilie and Chabalier, 2007) in spite of the use of mineral fertilizers which have significantly increased their prices (Goulding et al., 2008). As a result, it is important to seek alternatives that would supply the soil with more economic nutrients. The organic amendment application as filter cake would be efficient as effective alternatives for traditional liming materials as reported by previous reseachears (Gana, (2007), Garcia et al. (2009), Perez et al. (2011) and Perez et al. (2013). According to Larney and Angers (2012),Ryals and Silver (2013) and Koné et al., 2013a and b), the use of organic manure could be of interest in yield stabilization regarding to its ability to improve soil physic and chemical characteristics. In addition, it contains abundant organic matter (Vidal et al., 2006). Successful experiences were reported by Bouadou et al. (2014b) for Cambisol under effect of molasses in intensive cultivation of sugarcane in Zuenoula Integrated Farm Unit. Molasse application showed its effectiveness on as amendment material and improved the soil fertility and health and support good plant growth leading to saving of fertilizers.

However, there is limited knowledge on the use of filter cake for crop production on tropical, especially in intensive cultivation of sugarcane in Côte d'Ivoire (Yao, 2014 ; Yao et al., 2015). This limited knowledge can lead to non-adequate use of SFCL for the amendment of agricultural lands. Previous research works were reported for soil improvement in Spain, Mauritius, Martinique and Gabon under of organic amendment (Soobadar, 2010; Davina, 2013; Ognalaga et al., 2015). Intensive production requires the application of filter cake for sustainable sugarcane productionon the yield stabilization. In this

Table 1. Soil characteristics in the surface horizon prior to filter cake application

Particule size (%)		Organic Material		Exchange Complex		Normal
Coarse elements	33.07	N (gkg^{-1})	0.78	K^+ ($cmolkg^{-1}$)	0.34	0,4
Clay	11.67	C (gkg^{-1})	7.4	Mg^{2+}($cmolkg^{-1}$)	0.95	2,7
Fine silt	6.67	C/N	9.47	Ca^{2+}($cmolkg^{-1}$)	2.38	5,5
Coarse silt	44.47	MO (gkg^{-1})	12.75	S ($cmolkg^{-1}$)	3.67	
Fine sand	19.93	P_2O_5ass ($mgkg^{-1}$)	32.67	CEC ($cmolkg^{-1}$)	5.33	10,8
Coarse sand	16.29	pHw	6.3	S/C.E.C (%)	68.86	80,0

P_2O_5 ass. = phosphorus assimilable ; MO : organic matter S = sum of cations, S/C.E.C = base saturation ;pHw :pH in water

context, the present work was carried out to explore the effects of filter cakeon soil CEC and sugarcane yields.

MATERIALS AND METHODS

Site of experimentation

The Borotou Integrated Farm Unit (8°20-8°40N, 7°05-7°15W, 400 m) is located in the savanna agroecological zone having a bimodal rainfall pattern with 1372 mm/yr, and an average daily temperature of 26.3°C. The soil of Borotou area is a Cambisol (Ferralic Manganiferric Paraplinthic) according to the WRB (World Soil Reference Base) (2016), with hydromorphic features (5YR 2.5/1–2.5YR 3/4) induced by irrigation water and presenting a brown colored (5YR 3/2) matrix.

Plant analysis and sugarcane productivity

The sugarcane variety was SP71-1406. Three levels of filter cake as main factor (F) and three levels of mineral fertilizer NPK (E) as sub-factor were assessed in a split plot design with four replications. The levels of SFCL applied were: F0 = (0 tha^{-1}), F1 = half dose (15 tha^{-1}) and F2 = complete dose (30 tha^{-1}), while the levels of mineral fertilizer NPK were: E0 = (0 $kgha^{-1}$), E1 = half dose chemical fertilizer use (350 $kgha^{-1}$) and E2 = complete dose chemical fertilizer use (700 $kgha^{-1}$). Over the period of study (2014-2017), soil sampling was performed three times on yearly basis in 0-20 cm depth. Methods of soil analysis used were documented by Ballot et al. (2016). Standard laboratory soil analysis including the determination of CEC, sum of bases (Na^+, K^+, Ca^{2+} and Mg^{2+}) as well as base saturation ratio (V) was made in Zuénoula soil laboratory located in central Côte d'Ivoire.

Data analysis

Statistical data analysis was performed for the whole range of samples, which calculated using XLSTAT 2016 software. Differences between mean values of variables due to mineral fertilizer and filter cake were determined by Student-Newman-Keuls test. Cane and yields were predicted using a polynomial regression as follows (Vilain, 1993):

$R = R0 + \alpha X - \beta X^2 + e$

where, R represents the yield; R0: control treatment yield; α: fertilizer efficiency;β: limiting factor coefficient; X: rate of nutrient under consideration; e: residues.

RESULTS

Soil characteristics in the surface horizon prior to filter cake application

Laboratory soil analyzes show that the content of SFCL was: high humidity (15 %), pH in water (pHw: 6), organic matter (67.4gkg^{-1}), C/N (20), N (2.1 $mgkg^{-1}$), Mg (1.3 $mgkg^{-1}$), P (6.98 $mgkg^{-1}$) and Ca (5.94 $mgkg^{-1}$). Analysis of the main characteristics of the soil were summarized in Table 1. The textural class of the surface (0 to 20 cm) was a silty-clay. In addition, low content of the Exchange Complex was evident.

Soil exchange complex

Soil exchangeable cations

Analysis of the soil exchangeable cations content summarized in Table 2 shows that the KECEC [P< 0.0001], MgECEC [F = 16.427; P < 0.0001], CaECEC [F = 11.21; P< 0.0001] and NaECEC [F = 45.524; P = 0.015] were significantly affected by filter cake application rates. Tests Student-Newman-Keuls indicate significant difference test between groups.

Soil sum of cations, cation exchange capacity and base saturation

Analysis of the soil sum of cations, cation exchange capacity and base saturation content summarized in Table 3 shows that the sum of cations (S) [F = 26.844; P < 0.0001], cation exchange capacity (CEC) [F = 6.222; P < 0.0001] and base saturation(V) [F = 10.348; P < 0.0001] were significantly affected by filter cake rates. Tests Student-Newman-Keuls indicate significant difference test between groups.

Cane and sugar yields as influenced by filter cake rates

Not significant differences in cane as well as sugar yields

Table 2 . Effect of filter cake on soil exchangeable cations K^+, Mg^{2+}, Ca^{2+} and Na^+

Treatments		K^+ cmolkg^{-1}		Mg^{2+} cmolkg^{-1}		Ca^{2+} cmolkg^{-1}		Na^+ cmolkg^{-1}	
F0	E0	0.274 ^{a}	(0.00)	0.944 ^{c}	(0.00)	3.095 ^{d}	(0.00)	0,037 ^{bc}	(0,00)
	E1	0.282 ^{a}	(2.72)	0.937 ^{c}	(-0.78)	3.124 ^{d}	(0.92)	0,033 ^{c}	(-10,77)
	E2	0.398 ^{a}	(45.06)	0.937 ^{c}	(-0.76)	2.713 ^{e}	(-12.34)	0,046 ^{ab}	(25,90)
F1	E0	0.303 ^{a}	(10.55)	1.008 ^{bc}	(6.81)	3.343 ^{c}	(7.99)	0,033 ^{c}	(-9,26)
	E1	0.345 ^{a}	(25.66)	1.093 ^{bc}	(15.78)	3.667 ^{b}	(18.46)	0,037 ^{bc}	(1,16)
	E2	0.427 ^{a}	(55.61)	1.114 ^{bc}	(18.00)	3.063 ^{d}	(-1.06)	0,047 ^{ab}	(28,85)
F2	E0	0.301 ^{a}	(9.54)	1.172 ^{b}	(24.13)	4.330 ^{a}	(39.87)	0,047 ^{ab}	(28,50)
	E1	0.247 ^{a}	(-9.85)	1.447 ^{a}	(53.24)	4.400 ^{a}	(42.13)	0,043 ^{abc}	(17,20)
	E2	0.277 ^{a}	(1.00)	1.193 ^{b}	(26.40)	3.685 ^{b}	(19.04)	0,052 ^{a}	(41,51)
F		16.427		11.210		45.524		2.010	
Model		< 0.0001		< 0.0001		< 0.0001		0.015	
Carbonatation lime		0.000		0.001		< 0.0001		0.260	
Chemical fertilizer		< 0.006		0.000		0.073		0,027	
Interaction		< 0.0001		0.010		0.002		0.189	

Means followed by the same letter in the same column are not significantly different at a < 0.05, according to the method of test Student-Newman-Keuls.

Table 3 . Effect of filter cake on soil sum of bases, cation exchange capacity and base saturation

Treatments		S (cmolkg^{-1})		CEC (cmolkg^{-1})		S/CEC (V%)	
F0	E0	4.351 ^{de}	0.00	6.774 ^{cd}	0.00	67.894 ^{c}	0.00
	E1	4.375 ^{de}	0.56	6.735 ^{cd}	-0.58	66.098 ^{c}	-2.65
	E2	4.095 ^{e}	-5.89	6.324 ^{d}	-6.64	66.812 ^{c}	-1.59
F1	E0	4.688 ^{d}	7.75	6.706 ^{cd}	-1.00	74.980 ^{b}	10.44
	E1	5.142 ^{c}	18.18	6.917 ^{bcd}	2.11	78.579 ^{ab}	15.74
	E2	4.651 ^{d}	6.91	6.260 ^{d}	-7.59	76.597 ^{b}	12.82
F2	E0	5.849 ^{b}	34.44	7.477 ^{ab}	10.38	84.675 ^{a}	24.72
	E1	6.137 ^{a}	41.05	7.606 ^{a}	12.28	84.759 ^{a}	24.84
	E2	5.208 ^{c}	19.69	7.138 ^{abc}	5.37	73.780 ^{b}	8.67
F		26.844		6.222		10.348	
Model		< 0.0001		< 0.0001		< 0.0001	
Carbonatation lime		0.000		< 0.0001		0.109	
Chemical fertilizer		< 0.0001		0.708		0.001	
Interaction		< 0.0001		0.858		0.002	

Means followed by the same letter in the same column are not significantly different at a < 0.05, according to the method of test Student-Newman-Keuls.

were observed within filter cake and fertilizer treatments. Analysis of the extractable sugar (SE) and cane yields (CY) summarized in Table 4 shows that cane [P = 0.993] and sugar yields [P = 0.838] obtained increased slightly with fertilizer rates.Cane were slightly affected by as much as 0, -1.54 and -0.37% due to filter cake rates involving F0 (0 t/ha), F1 (15 t/ha) and F2 (30 t/ha) application respectively.

Sugar yields as influenced by soil nutrient

Sugar yields response to soil nutrient have an increasing parabolic shape, which suggests the strongly correlation with Ca^{2+} (R^2 = 72 %) and Mg^{2+} (R^2 = 76 %) as the optimum level (Figure 1a and b). Highly response in sugar yields as 11,1 tseha^{-1} and 11,15 tseha^{-1} were observed within Ca^{2+} (3.5 cmolkg^{-1}) and Mg^{2+} (1.45 cmolkg^{-1}) application respectively. Cane were affected by combining of the filter cake ratesas 30 tha^{-1} and fertilizer rates as 350 kgha^{-1}.

Cane yields response to soil nutrient have an increasing parabolic shape, which suggests the Highly significant stressed with Mg^{2+} (R^2 = 87 %) and Na^+ content (R^2 = 59 %) as the optimum level (Figure 2 a and b). Highly response in Sugar yields as 130 and 128.5 tcha^{-1} were observed within Mg^{2+} (1.4 cmolkg^{-1}) and Na^+ (0.043 cmolkg^{-1}) application respectively. Cane yields were affected by combining of the filter cake rates as 15 tha^{-1} to 30 tha^{-1} and the fertilizer rates E1 (350 kg/ha).

DISCUSSION

Soil characteristics in the surface horizon prior to filter cake application in the experimental field is moderately acid

Table 4. Effects of filter cake on Extractable sugar and cane yields

Treatments		Sugar yields(tseha^{-1})		Cane yields (tcha^{-1})	
F0	E0	10.645 ^{a}	(0.00)	120.808 ^{a}	(0.00)
	E1	11.043 ^{a}	(3.74)	124.142 ^{a}	(2.76)
	E2	10.718 ^{a}	(0.69)	123.649 ^{a}	(2.35)
F1	E0	10.481 ^{a}	(-(1.54)	122.170 ^{a}	(1.13)
	E1	11.053 ^{a}	(3.83)	130.021 ^{a}	(7.63)
	E2	10.948 ^{a}	(2.84)	129.983 ^{a}	(7.59)
F2	E0	10.606 ^{a}	(-0.37)	122.252 ^{a}	(1.20)
	E1	11.186 ^{a}	(4.83)	129.342 ^{a}	(6.60)
	E2	10.617 ^{a}	(-0.26)	129.774 ^{a}	(7.42)
F		0.180		0.522	
Model		0.993		0.838	
Carbonatation lime		0.998		0.505	
Chemical fertilizer		0.539		0.274	

Means followed by the same letter in the same column are not significantly different at a < 0.05, according to the method of test Student-Newman-Keuls.

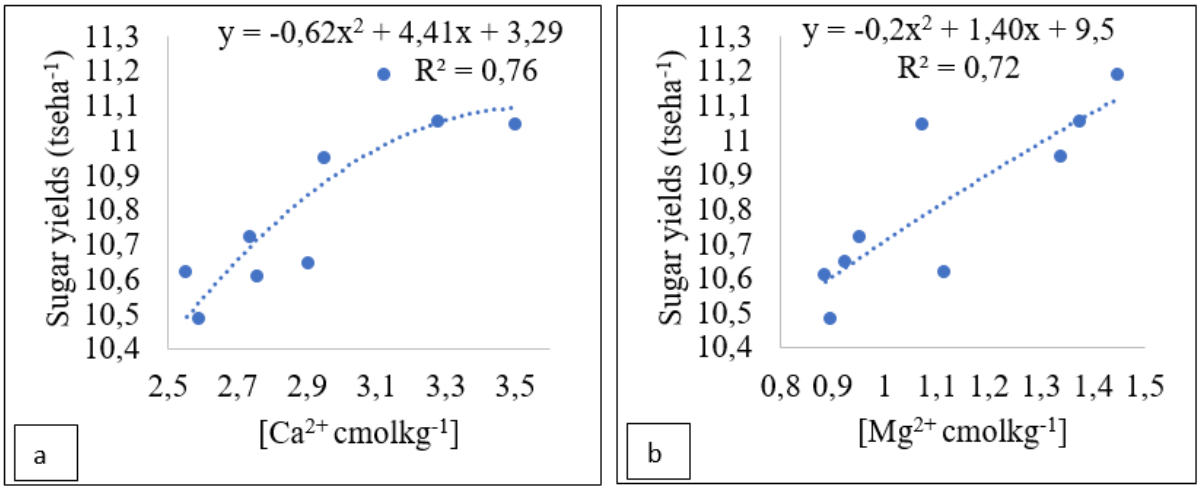

Figure 1 : Functional dependence of soil exchangeable calcium (a), magnesium (b) and extractable sugar for the sugar company SUCRIVOIRE of Borotou

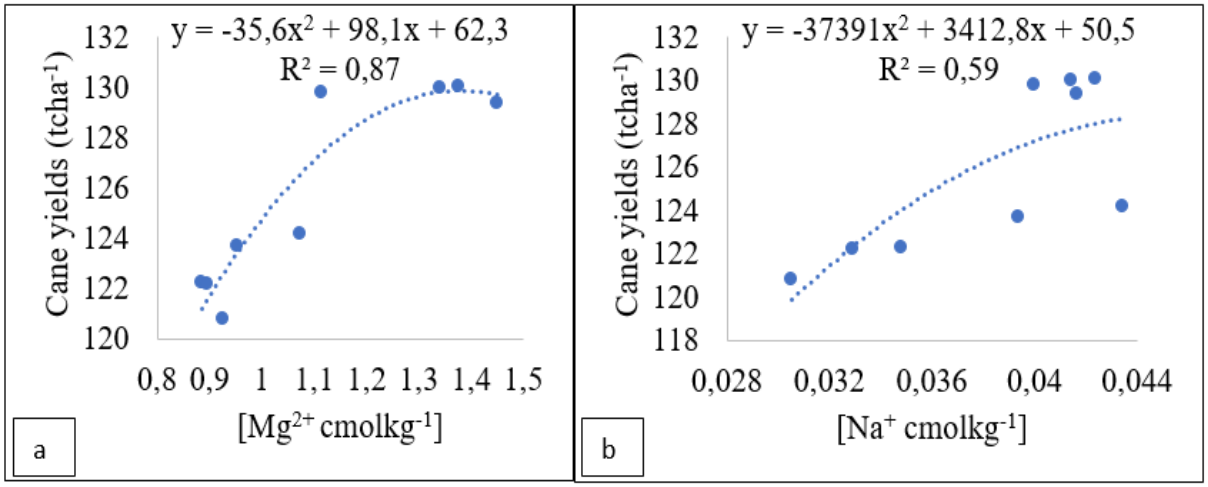

Figure 2 : Functional dependence of soil exchangeable magnesium (a), sodium (b), Sum of exchangeable cations in soil (c) and cane yields obtained in Borotou

(pH=6.3). It is also silty-clay textured, over 20 cm depth. The chemical status before setting up the experiment was marked by a lower CEC (5.33 $cmolkg^{-1}$), sum of bases (Na^+, K^+, Ca^{2+} and Mg^{2+}) as well as base saturation ratio (V=68.86%). The C/N ratio was (9.47); this finding suggests a fast organic matter mineralization process. Soil nitrogen contents were quite low with 0.78 gkg^{-1}. According to Péné et al. (2012), this fiding was due to from crop uptake, but also from leaching and volatilization processes as far as nitrogen was concerned. In contrast, available phosphorous content was high (32.67 $mgkg^{-1}$) despite crop uptake, that element being much stable in the soil profile than nitrogen (Péné et al., 2012).

After the sugar filter cake application rates, soil physical and soil nutrient as the CEC, sum of bases (Na^+, K^+, Ca^{2+} and Mg^{2+}) as well as base saturation ratio (V) were significantly improved with increasing rates of filter cake which application rates contribute to the conservation of soil nutrient. This finding was in line with results from a similar study carried out by Prado et al. (2013). This research work was reported for soil improvement by organic matter (Filter cake and vinasse) in agriculture by recycling carbon and mineral elements. Korndorfer and Anderson (1997) reported the main effects of filter cake on soil chemical properties by increasing nitrogen, phosphorus, and calcium concentrations, increasing cation exchange capacity (CEC), and reducing concentrations of exchangeable aluminum (Al^{3+}).This suggests the soil cation exchange capacity response as influenced by filter cake and mineral fertilizer in Borotou is dependent on the intensity rates of filter cake. Amending sugar mill soils with filter cake would be proposed as a means to increase soil nutrient as reported by few research works(Vidal et al. 2006;Moritsuka et al. (2006);Akanza et al. (2011);Olego et al., 2014; Bouadou et al. 2014a;Yèhouénou et al. (2016)).

Cane and sugar yields obtained increased slightly with fertilizer rates, differences observed on each yield variable were not significant.This suggests the yield response to filter cake is not dependent with increasing filter cakerates.This fiding suggests that cane as well as sugar yields response were dependent on the pedo-climatic conditions, the variety, the watering strategy adopted in most sugar mill as reported by Péné et al. (2012).

It came out that application of 3.5 $cmolkg^{-1}$ of Ca^{2+} plus 1.45 $cmolkg^{-1}$ Mg^{2+}, 30 tha^{-1} of filter cake ratesand 350 $kgha^{-1}$ of NPK-fertilizer had better residual effects on soil properties that were reflected in sugar yields (11.1 to11.2 $tseha^{-1}$) for over three years. This finding was in line with previous research work reported by Prado et al. (2013) in Brasil.The higher filter cake applications rates(30 tha^{-1}) increased soil soil nutrient and contributed to the improvement of sugar yield.As far as cane yields was concerned, the application of 1.4 $cmolkg^{-1}$ of Mg^{2+} plus 0.043 $cmolkg^{-1}$ Na^+, 15 tha^{-1} of filter cake ratesand 350 $kgha^{-1}$ of NPK-fertilizer had better residual effects on soil properties that were reflected in the yields (129 to 130 $tcha^{-1}$) for over three years.The best combination suggested by this study to optimize sugar yieldsof sugar mill located in northern Côte d'Ivoire was 30 tha^{-1} of filter cake in combination with 350 $kgha^{-1}$ of NPK-fertilizer. Also, the best combination suggested to optimize cane yields was 15 tha^{-1} of filter cake in combination with 350 $kgha^{-1}$ of NPK-fertilizer**.** This finding was in line with results from a similar study carried out in sugar mill located in Zuenoula experimental station (Centre-western Côte d'Ivoire) (Yao et al., 2017).

Conclusion

It came out that soil CEC, sum of bases (S) and base saturation ratio (V) were significantly improved with increasing rates of filter cake. Although cane and sugar yields obtained increased slightly with fertilizer rates, differences observed on each yield variable were not significant. The best combination suggested by this study to optimize sugar yields of sugar mill located in northern Côte d'Ivoire was 30 tha^{-1} of filter cake in combination with 350 $kgha^{-1}$ of NPK-fertilizer. As far as cane yields was concerned, the best combination suggested was 15 tha^{-1} of filter cake in combination with 350 $kgha^{-1}$ of NPK-fertilizer**.**The use of filter cake application rates are of great importance due to limited funds to buy chemical fertilizers in addition to its environmental benefits.

Conflict of interests

The authors declare that they have no conflicting interests.

REFERENCES

Akanza KP, Yao-Kouamé A (2011). Fertilisation organo-minérale du manioc (Manihot esculenta *Crantz*) et diagnostic des carences du sol. J. Appl. Biosci. 46 : 3163 – 3172.

Ballot CSA, Semballa S, Atakpama W, Yangakola TM, Doubro BMA, Blavet D, Zinga I, Wala K, Batawila K, Akpagana K (2016). Effet De Fumures Minérales Sur Le Rendement Et La Qualité Organoleptique Du Manioc (Manihot Esculenta Crantz) Dans La Zone De Savane Au Centre-Sud De Centrafrique. European Sci. J. 12(6) :185-211.

Bouadou F, Koné B, Yao K, Yao-Kouamé A (2014b). Effets de l'écume de canne à sucre (*Saccharum officinarum* L. (Linnaeus)) et d'engrais chimiques sur les caractéristiques d'un Cambisol tropical. Ame. J. Experim Agric. 4(7) : 732-745, 2014.

Bouadou OBF, Brahima K, Kouadio KKH, Yao K, Akassimadou E, Yao-Kouamé A (2014a).Yield and Extractable Sugar as affected by Foam and Inorganic Fertilizer in Intensive Cultivation of Sugare Cane (*Saccharum Officinarum* L. (Linnaeus) in a Forest-Savanna Ecosystem. Int. J. Sci. 3 (6) : 54-64.

Davina M (2013). Evaluation du potentiel fibreux et textile de la canne à sucre (*Saccharumofficinarum* L.). Matériaux. Université de Haute Alsace - Mulhouse. Français. 178 p.

Emilie F, Chabalier P (2007). Guide de la fertilisation

organique à la Réunion, Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD). 165 p.

Gana AK (2007). Effects of organic and inorganic fertilizers on sugarcane production. Afri. J. General Agric. 4(1) : 55 – 59.

Garcia FJ, Amorós JA, Sanchez CJ, Bravo S, Márquez E, Jiménez R(2009). Application of sugar foam to red soils in a semiarid Mediterranean enviromnent. Environ. Earth Sci. 59(3) :603-611.Crossref

Goulding K, Jarvis S, Whitmore A (2008). Optimizing nutrient management for farm systems. Phil Trans R Soc B. 363 :667-680.Crossref

Koné B, Amadji GL, Touré A, Mariko M, Huat J (2013a). A case of Cyperus spp. and *Imperata cylindrica* Occurrences on Acrisol of the Dahomey Gap in South Benin as Affected by Soil Characteristics: A strategy for soil and weed management. Applied and environmental soil science. Cairo : Hindawi Publishing Corporation. 7p.

Koné B, Amadji GL, Touré A, Yao-Kouamé A, Angui TP, Huat J(2013b). Soil characteristic and *Cyperus* spp. Occurrence along a toposequence. Afr. J. Ecol. 51(3) :402–408.Crossref

Korndorfer GH, Anderson DL (1997). Use and impact of sugar alcohol residues vinasse and filter on sugarcane production in Brazil," Sugar y Azucar. 92(3):26–35.

Larney FJ, Angers DA (2012). The role of organic amendments in soil reclamation: a review. Canadian J. Soil Sci. 92:19–38.Crossref

Moritsuka N, Matsuoka K, Matsumoto Sh, Masunaga T, Matsui K, Wakatsuki T (2006). Effects of application of heated sewage sludge on soil nutrient. Japanese Soc. Soil Sci. plant Nutrition. 52 : 528-539.Crossref

Ognalaga M, Odjogui OPI, Lekambou JM, Poligui RN (2015). Effet des écumes de canne à sucre, de la poudre et du compost à base de Chromolaena odorata (L.) King R.M. & H.E. Rob sur la croissance de l'oseille de Guinée (*Hibiscus sabdariffa* L.). Int. J. Biol. Chem. Sci. 9(5): 2507-2519.Crossref

Olego MA, Coqu JJR, Garzón JE (2014). Application of Sugar Foam to Vineyard Acid Soils under Medi- terranean Conditions.S. Afr. J. EnoL Vitic. 35 (2) : 178-184.

Péné BC, Ouattara HM, Koulibaly GS (2012).Late season sugarcane performance as affected by soil water deficit at the yield formation stage in commercial farms of northern Ivory Coast.Int. J. Biol. Chem. Sci. 6(1): 77-87.Crossref

Perez RC, Amorós JA, GarcIa FJ, Bravo S, Jiménez R (2013). Grapevine leaf uptake of mineral elements influenced by sugar foam amendment of an acidic soil. Vitis 52(4) : 157-164.

Perez RC, Amorós JA, Garcia FJ, Bravo S, Sanchez C, Chocano D, Jiménez R (2011). Changes in water retention properties due to the application of sugar foam in red soils. Agr. Water Manage. 98 (4) : 1834-1839.Crossref

Prado RM, Caione G, Campos CNS (2013). Filter Cake and Vinasse as Fertilizers Contributing to Conservation Agriculture. Applied and Environmental Soil Science. 3 : 8. Crossref

Ryals R, Silver WL (2013).Effects of organic matter amendments on net primary productivity and greenhouse gas emissions in annual grasslands Ecological Applications. 23 (1): 46–59.Crossref

Soobadar A (2010). Impacts agronomiques et environnementaux de l'épandage devinasse et de cendre de charbon/bagasse sur les terres agricoles de l'Île Maurice. Earth Sciences. Université d'Avignon, France.

Vidal M, Garzón E, Garcia V, Villa E(2006). Differentiating the amending effects of calcareous materials applied to acid soils by use of optimal scaling procedures. Agrochimica. 50 (3-4) : 132-147.

Vilain M (1993). La production végétale. La maîtrise technique de la production. Agriculture d'aujourd'hui. Sciences, Techniques, Applications, Paris, France, 449 p.

WRB (2016). World reference base for soil resources 2016. International Soil Classification System for Naming Soils and Creating Legends for Soil Maps World Soil Resources Reports no. 106. FAO, Rome. 203 p.

Yao K (2014). Étude de la dynamique de l'écume, sous-produit d'extraction du sucre de canne, apporté au sol en régime irrigué, sur le périmètre sucrier de Zuénoula. Mémoire de Master Recherche. Université FHB (Abidjan/Côte d'Ivoire). 63 p.

YAO K, Diomandé LB, Gala BTJ, Yao-Kouamé A (2017). Effet des apports d'écume de sucrerie sur la disponibilité du phosphore assimilable et les rendements d'un essai de culture cannière à Zuénoula, Centre-Ouest de la Côte d'Ivoire. Afrique SCIENCE 13(6) : 125 – 133.

Yao K, Gala BTJ, Bouadou OBF, Affi BJ, Yao-Kouamé A(2015). Gestion durable de la fertilité des sols à travers l'impact de l'écume de sucrerie sur la minéralisation de la matière organique dans un Cambisol au Centre-Ouest de Côte d'Ivoire.International J. Innovation and Appl. Studies. 13 (1) : 190-197.

Yèhouénou E, Pazou A, Toko AI, Houndantodé JZ (2016).Variabilité des éléments chimiques du sol sableux du littoral amendé avec des sous-produits d'épuration des eaux usées à Sèmè-Podji au Sud-Bénin.Bulletin de la Recherche Agronomique du Bénin. 64 (2009) : 27-33.