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RESEARCH ARTICLE

EFFECTS OF SOIL SUBSTRATE QUANTITY AND NITROGEN FERTILIZER ON SOIL CHEMICAL PROPERTIES AND NUTRIENTS UPTAKE BY COCOA (*THEOBROMA CACAO* LINN.) SEEDLINGS IN TOGO

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ABSTRACT

A problem for container tillers is managing container substrate and plant fertility. A comparative study in nurseries on the effects of soil quantity in pot and nitrogen fertilizer on the chemical properties of residual soil and the nutriments uptake by cocoa seedlings were led in a Randomized Complete Block Design. Two types of pots with different capacities (1055 cm^3 and 2021 cm^3) without any contribution and four nitrogen doses applied in pots of 2021 cm^3, were used. The two nurseries were managed under the same conditions. Data were collected on the soil samples at the beginning and the end of experiment then analysed. The results showed that the cocoa seedlings effectively used the soil nutriments reserves but there was no significant difference ($p>0.05$) between the seedlings nutrition in the two types of sachets, nor with the nitrogen application. The major nutriments budget showed that the sold of N, K and Mg were negative whereas those of P and Ca were positive. Calcium profits were so stable whereas P profits were gradual according to the increasing amount of N. Thus, it is possible to grow cocoa seedlings on soil contained in pots of 1055 cm^3 (coffee pot) while ensuring a balanced nutrition of the seedlings.

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INTRODUCTION

The cocoa, known as gods' food *(Theobroma cacao Linn.)* is an exceptional crop in the tropical countries. His cropping requires nursery stage before transplanting on the field. One of the primary concerns for container growers is managing container substrate and plant fertility (Burnett *et al*., 2016). Many works led to the farming conditions of the cocoa seedlings in nurseries. The shading regime of the cocoa seedlings in nursery should be adequate to allow a proper protection of the seedlings against sunlight (Harun and Ismail, 1983). Mohd.Yusoff *et al.* (2007) suggested the control of the shading to only allow 20% of the sunlight. But this shading must be regulated at the time of acclimatization of the cocoa seedlings to allow gradually 50 then 75% of the sunlight. The nutrients such as N, P, K, Ca and Mg are sufficiently essential to soil for plants growth (Mohd.Yusoff *et al.,* 2007).

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Improving the fertility of the soils under the cocoa trees has been subject to several studies (Akanbi *et al*., 2014; Koko, 2014; Oyewole *et al*., 2012; Ayeni, 2010; Ojeniyi, 2010; Koko *et al*., 2009; Koudjega and Tossah 2009; Ayeni, 2008; Ayeni *et al*., 2008; Hartemink, 2005). The studies proposed formulas and combinations of both organic and inorganic fertilizers to ensure a balanced nutrition of the cocoa trees. Most of them are focused on the cocoa trees farming in field. The soils under the cacao trees require particular chemical properties. The organic matter content must be high ($\geq$30g.kg^{-1}), the pH close to neutral (6-7.5) with a Cation Exchange Capacity (CEC) of 20 cmol.kg^{-1} at least. Some contents of major nutrients such as nitrogen ($\geq$1g.kg^{-1}), phosphorus (30-100 ppm), potassium ($\geq$100 ppm or $\geq$1.2cmol.kg^{-1})' calcium ($\geq$5-8cmol.kg^{-1}) and magnesium ($\geq$0.8cmol.kg^{-1}) must be present in the soil for a good production of pods (Aikpokpodion, 2010; Koko, 2014; Akanbi *et al.,* 2014). Adden *et al.* (2015 and 2016) have shown that the cocoa seedlings can be grown in nursery with soil substrate reduced quantities, in pots of 1055cm^3, and a low dose of nitrogen ($\leq$1.5 g.$plant^{-1}$ of Urea-N). But the nutrients dynamic in the potted soil substrates for the cocoa seedlings growing in nursery is not very well known like that carried out in soils under the cocoa trees in field. Therefore, these works aim to study the effects of soil substrate quantity and nitrogen fertilizer on the chemical properties of the residual soil in potting media, the cocoa seedlings nutrients uptake and the nutrients budget in the potted soil substrates in a nursery.

MATERIALS AND METHODS

Study zone

Two experiments in nursery on the cocoa seedlings were conducted at Ezimé (Latitude 07°29'31" N, Longitude 0°56'83" E and Altitude 252 m) in the CPMV Centre [Centre de Production de Matériel Végétal] located in Kloto sub-zone, one of three cocoa production lands in Togo. This zone enjoys a rainfall varying between 1200 and 1600 mm.year^{-1} with an average temperature ranging between 20-35°C. The soil in place is described as a silty-clay soil, rich in organic matter (55 g.kg^{-1}), poor in nitrogen (2mg.kg^{-1}) and phosphorus (21.9mg.kg^{-1}). The level of exchangeable bases was low (0.3 meq% K, 13.4 meq% Ca and 5.9 meq % Mg) with a Cation Exchange Capacity (CEC) of 21.1meq % and the pH was 6.7 (Koudjega and Tossah, 2009).

Experimental design

The first experiment was conducted in a Randomized Complete Block Design, repeated four times. The studied factor was the soil quantity contained in pots of different sizes. The pots used were the ordinary polyester black plastic bags with dimensions of 21 x 8 cm² called «coffee pot» (1055 cm^3) and 27 x 10 cm² called « cocoa pot » (2120 cm^3). Each processed plot is made up of 25 pots separated by 20 cm from each other. The second trial was conducted in a Randomized Complete Block Design, repeated three times. The studied factor was the nitrogen fertilizer dose applied to the cocoa seedlings. The plastic pots used were 27 x 10 cm² size called « cocoa plots » (2120 cm^3) with the same characteristics as in the first test. Each plot was made up with 25 pots separated by 20 cm from each other. Three doses of nitrogen, using Urea (46% N), was tested with a control: 1.5 g.plant^{-1}; 3 g.plant^{-1} and 4.5 g.plant^{-1}. The fertilizer was applied once in the potted substrate directly three months after the sowing, this to ensure that the seedlings have already finished using the soil initial reserve in N. These experimental designs have been selected in order to control the spatial variability (van Es *et al*., 2004). Two fresh cocoa beans were sown per pot at the beginning of the test, which were later thinned out to one per pot (the vigorous one), three weeks after the emergence. The watering was carried out regularly every two days in the afternoon at the field capacity. The beans originated from *Ghana Cocoa Board* and were hybrids obtained by crossing and mixing the following parenting: 77 x 42 (33%), 77 x 85 (34%) and 77 x 67 (33%). The surface depleted soil (0-20 cm) in the centre was sampled in early tests, air dried, crushed and sieved manually to be used as substrate in the pots. The sampled soil was properly mixed to ensure good homogeneity and each perforated pot was filled with different capacity, leaving some space for the irrigation water. The whole is placed under a shade house of 4 x 3 x 2 m^3 dimensions controlled to prevent the passage of 80% of sunlight.

Data collection and analysis

In order to calculate the nutrients partial budgets in each pot, the soil initial and final content in major nutrients N, P, K, Ca and Mg, these nutrients uptake by plants and the nitrogen atmospheric deposits were determined. The budget result is calculated as the difference between the inputs and outputs of the system represented by a type of pot with all its contents. The inputs are obtained by adding the quantities of specific nutrients in the initial soil to the input fertilizers and the atmospheric deposits of N. The outputs are calculated by adding the specific nutrients uptake exported by the cocoa plant and the residual quantity of the specific nutrients contained in the potted final soil. To achieve this, soils samples, plants and rainwater were collected during the two studies. The composite soil samples were collected at the beginning and the end of each test. The plant samples were collected at the end of the tests. The water sample was directly collected in a jar in the open air during the tests.

On these samples, some physicals and chemicals analyses were performed. On the soil samples, the organic matter (OM) content, the total N content, available P, exchangeable K, exchangeable Ca and exchangeable Mg were determined. The C/N ratio was calculated. On the plants samples, the dry matter (DM), N, P, K, Ca and Mg content were determined. On the water samples the N content was determined. Nitrogen was determined using the Kjeldahl method as described by Jackson (1965). The Bray-1 method (Bray and Kurtz, 1945) was used for the determination of P dosage while the exchangeable bases K, Ca and Mg were determined by the extraction with ammonium acetate 1N and photometric flame titration for K and by spectrophotometry for Ca and Mg. The organic matter content is determined using the Walkley-Black method (Nelson and Sommers, 1982). The CEC is determined by continuous flow colorimetric with the ammonium dosage contained in the exchange solution obtained with ammonium acetate 1N. The particle size distribution was determined by sedimentation according to the scale of Atterberg after destruction of the organic matter and the ultra sound specific treatment with an automatic particle size analyser. The pH was determined in water with a pH-meter. The organic carbon (C) content is calculated by dividing the organic matter content by 1.724 (CIRAD, 2004). The C/N ratio is obtained by dividing the organic C content by the total N content. To calculate the weight of the potted soil, soil bulk density of 1.324 was used with the specific volume of each perforated pot (1055 cm^3 or 2120 cm^3). The cocoa seedlings uptakes were calculated based on the content of their specific nutrient and the yield in dry matter per cocoa seedling. The initial and final quantity of a specific nutrient is obtained by multiplying the weight of the potted soil by the initial or final content of the nutrient expressed in mg.kg $^{-1}$ of soil. The Analysis of Variance (ANOVA) and the Duncan multiple range test were carried out on the collected data using the STATISTICA version 5.5 software (StatSoft Inc, 1999) at 5% threshold.

RESULTS

Effects on the soil chemical properties

The physicals and chemicals characteristics of the initial soil (Table 1) show that the soil has a silty-clay texture with

Table 1. Physical and chemicals characteristics of initial potted soil

Parameters	Initial soil
OM ($g.kg^{-1}$)	26.0
N ($mg.kg^{-1}$)	1.60
P_2O_5 ($mg.kg^{-1}$)	18.4
K_2O ($mg.kg^{-1}$)	0.51
CaO ($cmol.kg^{-1}$)	9.20
MgO ($cmol.kg^{-1}$)	3.70
C/N	9.40
CEC ($cmol.kg^{-1}$)	22.0
pH	6.70
Clay content (%)	44.0
Sand content (%)	15.0
Silt content (%)	41.0
Soil texture	Silty-clay

OM: Organic Matter

Table 2. Effects soil substrate quantity on residual potted soil chemical properties

Parameters	1055 cm^3 (Coffee pot)		2120 cm^3 (Cocoa pot)		Means	SD	F	p
	Means	SD	Means	SD				
OM ($g.kg^{-1}$)	24.0	1.00	23.7	0.58	23.8	0.75	0.250	0.643
N ($mg.kg^{-1}$)	1.10	0.10	1.07	0.15	1.08	0.12	0.100	0.768
P_2O_5 ($mg.kg^{-1}$)	14.9	0.20	15.2	0.25	15.0	0.25	2.065	0.224
K_2O ($mg.kg^{-1}$)	0.44	0.04	0.44	0.04	0.44	0.04	0.011	0.923
CaO ($cmol.kg^{-1}$)	8.03	0.15	8.17	0.25	8.10	0.20	0.615	0.477
MgO ($cmol.kg^{-1}$)	3.13	0.21	2.93	0.15	3.03	0.20	1.799	0.251
C/N	12.7	1.46	13.0	1.63	12.9	1.39	0.057	0.824
CEC ($cmol.kg^{-1}$)	20.9	0.10	20.7	0.36	20.8	0.26	0.857	0.407
pH	6.70	0.10	6.73	0.06	6.72	0.08	0.250	0.643

OM: organic matter; SD: standard deviation

Table 3. Effects of nitrogen fertilizer on residual potted soil chemical properties

Parameters	Treatments, g of Urea-N											
	0		1.5		3		4.5		Means	SD	F	p
	Means	SD	Means	SD	Means	SD	Means	SD				
OM ($g.kg^{-1}$)	26.0	1.00	24.7	1.15	26.0	1.00	25.7	0.58	25.5	0.58	1.303	0.339
N ($mg.kg^{-1}$)	1.27	0.15	1.35	0.18	1.35	0.26	1.48	0.10	1.35	0.17	0.718	0.568
P_2O_5 ($mg.kg^{-1}$)	13.6	1.21	13.2	1.29	13.7	0.97	12.8	0.71	13.3	1.07	0.431	0.736
K_2O ($mg.kg^{-1}$)	0.42	0.03	0.41	0.05	0.43	0.05	0.40	0.03	0.41	0.03	0.344	0.795
CaO ($cmol.kg^{-1}$)	8.00	0.00	7.83	0.35	7.90	0.30	7.80	0.36	7.90	0.29	0.272	0.844
MgO ($cmol.kg^{-1}$)	2.93	0.06	2.90	0.26	2.87	0.12	2.80	0.26	2.88	0.17	0.248	0.860
C/N	11.2	1.84	11.6	1.30	11.3	1.83	10.4	0.55	11.1	1.48	0.336	0.800
CEC ($cmol.kg^{-1}$)	20.9	0.31	20.7	0.52	20.7	0.40	20.5	0.06	20.7	0.36	0.422	0.742
pH	6.70	0.10	6.63	0.25	6.60	0.10	6.57	0.12	6.60	0.13	0.402	0.755

OM: organic matter; SD: standard deviation

Table 4. Effects soil substrate quantity on nutrients uptakes in the pots

Parameters	1055 cm^3 (Coffee pot)		2120 cm^3 (Cocoa pot)		Means	SD	F	p
	Means	SD	Means	SD				
DM/plant (%)	75.0	1.00	76.7	2.08	75.8	1.18	4.000	0.116
N ($mg.plant^{-1}$)	1.92	0.11	1.87	0.11	1.89	0.11	0.285	0.621
P_2O_5 ($mg.plant^{-1}$)	0.96	0.11	1.01	0.16	0.98	0.13	0.200	0.678
K_2O ($mg.plant^{-1}$)	2.20	0.20	2.22	0.11	2.21	0.14	0.036	0.859
CaO ($mg.plant^{-1}$)	1.39	0.19	1.43	0.08	1.42	0.14	0.182	0.692
MgO ($mg.plant^{-1}$)	2.37	0.11	2.47	0.11	2.42	0.11	1.143	0.345

DM: dry matter; SD: standard deviation

Table 5. Effects of nitrogen fertilizer on nutrients uptakes in the pots

Treatments, g of Urea-N	DM/plant (%)		N ($mg.plant^{-1}$)		P_2O_5 ($mg.plant^{-1}$)		K_2O ($mg.plant^{-1}$)		CaO ($mg.plant^{-1}$)		MgO ($mg.plant^{-1}$)	
	Means	SD	Means	SD	Means	SD	Means	SD	Means	SD	Means	SD
0	74.33	0.58	2.14	0.26	1.39	0.35	2.31	0.05	1.53	0.08	2.33	0.08
1.5	76.33	1.15	2.17	0.28	1.34	0.34	2.26	0.16	1.49	0.11	2.33	0.12
3	74.67	1.53	2.04	0.12	1.20	0.16	2.35	0.07	1.43	0.08	2.30	0.04
4.5	76.67	1.15	2.28	0.16	1.44	0.27	2.32	0.12	1.44	0.13	2.27	0.16
Means	75.50	1.45	2.16	0.20	1.34	0.26	2.31	0.10	1.47	0.10	2.31	0.10
F	3.083		0.630		0.368		0.355		0.613		0.212	
p	0.090		0.616		0.770		0.787		0.625		0.885	

DM: dry matter; SD: standard deviation

Table 6. Nutrients partial budgets in residual soil in the pots

Parameters	Coffee pot (1055 cm^3)	Cocoa pot (2120 cm^3)	Dose of Urea-N in cocoa pot (2120 cm^3)			
			0 g.plant^{-1}	1.5 g.plant^{-1}	3 g.plant^{-1}	4.5 g.plant^{-1}
Unit	----------------------------------mg.plant^{-1} --------------------------------					
NITROGEN						
Initial soil content (+)	2.23	4.49	4.49	4.49	4.49	4.49
Mineral fertilizer (+)	0.00	0.00	0.00	0.69	1.38	2.07
Atm. deposit (+)	0.00	0.00	0.00	0.00	0.00	0.00
Final soil content (-)	1.54	3.00	3.09	3.93	4.21	3.93
Nutrient uptake (-)	1.92	1.87	1.89	2.20	2.12	2.42
Sold	*-1.22*	*-0.38*	*-0.49*	*-0.95*	*-0.46*	*0.21*
PHOSPHORUS						
Initial soil content (+)	25.70	51.65	51.65	51.65	51.65	51.65
Mineral fertilizer (+)	0.00	0.00	0.00	0.00	0.00	0.00
Atm. deposit (+)	0.00	0.00	0.00	0.00	0.00	0.00
Final soil content (-)	20.80	42.58	41.26	35.93	37.89	34.24
Nutrient uptake (-)	0.96	1.01	1.06	1.21	1.36	1.74
Sold	*3.94*	*8.06*	*9.32*	*14.51*	*12.39*	*15.66*
POTASSIUM						
Initial soil content (+)	0.71	1.43	1.43	1.43	1.43	1.43
Mineral fertilizer (+)	0.00	0.00	0.00	0.00	0.00	0.00
Atm. deposit (+)	0.00	0.00	0.00	0.00	0.00	0.00
Final soil content (-)	0.61	1.24	1.29	1.07	1.15	1.12
Nutrient uptake (-)	2.20	2.22	2.27	2.42	2.35	2.20
Sold	*-2.10*	*-2.02*	*-2.13*	*-2.06*	*-2.07*	*-1.89*
CALCIUM						
Initial soil content (+)	7.20	14.46	14.46	14.46	14.46	14.46
Mineral fertilizer (+)	0.00	0.00	0.00	0.00	0.00	0.00
Atm. deposit (+)	0.00	0.00	0.00	0.00	0.00	0.00
Final soil content (-)	6.28	12.84	12.57	11.79	12.89	12.42
Nutrient uptake (-)	1.39	1.43	1.52	1.36	1.44	1.59
Sold	*-0.47*	*0.19*	*0.37*	*1.31*	*0.13*	*0.45*
MAGNESIUM						
Initial soil content (+)	2.07	4.15	4.15	4.15	4.15	4.15
Mineral fertilizer (+)	0.00	0.00	0.00	0.00	0.00	0.00
Atm. deposit (+)	0.00	0.00	0.00	0.00	0.00	0.00
Final soil content (-)	1.75	3.29	3.26	3.03	3.14	3.48
Nutrient uptake (-)	2.37	2.47	3.10	2.90	3.00	3.20
Sold	*-2.05*	*-1.61*	*-2.20*	*-1.78*	*-1.99*	*-2.53*

deficiencies in organic matter (26 g.kg^{-1}), nitrogen (1.6 mg. kg^{-1}), phosphorus (18.4 mg.kg^{-1}) and potassium (0.51 mg.kg^{-1}). The level of Ca and Mg are acceptable (respectively 9.2 cmol.kg^{-1} and 3.7 cmol.kg^{-1}) with a pH close to neutrality (6.7) and a CEC of 22 cmol.kg^{-1}. The C/N ratio of the soil is quite low (9.4). The analysis of the residual soil contained in both types of pots shows that (Table 2) the organic matter content is 23.8±0.75 g.kg^{-1}, the C/N ratio gives 12.9±1.39, the pH is 6.72±0.08, the CEC gives 20.8±0.26 cmol.kg^{-1}, the nitrogen content shows 1.08±0.12 mg.kg^{-1}, the phosphorus content is 15.0±0.25 mg.kg^{-1} and the potassium content is 0.44±0.04 mg.kg^{-1}. There is no significant difference ($F_{(1, 6)}$ = 0.011-2.065; p = 0.224-0.923) between the nutrient contents of the final soil contained in the cocoa pot (2120 cm^3) and the coffee pot (1055cm^3). The use of nitrogen in the cocoa pots resulted in very little change in nutrient contents of the residual soil at the end of the test (Table 3). The organic matter content 25.5±0.58 g.kg^{-1} with the input of the different doses of nitrogen fertilizer. The nitrogen content gives 1.37±017 mg.kg^{-1}. The residual phosphorus content is 13.3±1.07 mg.kg^{-1}. The exchangeable bases (K, Ca and Mg) content have not significantly varied versus their initial soil content.

The ratio C/N remains 11.1±1.48 with an average CEC of 20.7±0.36 cmol.kg^{-1} and a pH of 6.6±0.13. Of course, there is a net decrease of the contents in various major nutrients with relation to the initial soil but there is no significant difference ($F_{(3, 12)}$=0.248 - 1.303; p = 0.339 – 0.860) between the nutrient contents in the residual soils contained in pots of 2120 cm^3 and fertilized with nitrogen. Overall, the residual soils in the different types of pots or with the N input have fairly similar chemical properties.

Effects on the cocoa seedlings nutrients uptake

The cocoa seedlings nutrition on the soil substrates in the different types of pots or with the nitrogenous fertilizer input is revealed by the various major nutrients uptakes by the plants. Comparing the coffee pots to the cocoa pots (Table 4), it is noticed that the dry matter represents 75.8±1.18% of the weight of the seedlings. The contents in N, P, K, Ca and Mg in the tissues of cocoa seedlings reveal N uptake of 1.89±0.11 mg.plant^{-1}, P uptake of 0.98 ±0.13 mg.plant^{-1}, K uptake of 2.21±0.14 mg.plant^{-1}, Ca uptake of 1.42±0.14 mg.plant^{-1} and Mg uptake of 2.42±0.11 mg.plant^{-1}. There is no significant difference ($F_{(1, 6)}$ =0.248 - 1.303; p=0. 339 - 0.860) between the various nutrients uptakes in both types of pots. Comparing the nitrogen doses in the cocoa pots (Table 5), it notices that the dry matter represents 75.5±1.45 % of the weight of seedlings. The nutrients uptakes reveal that N uptake is 2.16±0.20 $mg.plant^{-1}$, P uptake is 1.34±0.26 $mg.plant^{-1}$, K uptake is 2.31±0.10 $mg.plant^{-1}$, Ca uptake is 1.47±0.10 $mg.plant^{-1}$ and Mg uptake is 2.31±0.10$mg.plant^{-1}$. There is no significant difference ($F_{(3, 12)}$ = 0.212 -3.083; p=0 090 - 0.885) between the various treatments with nitrogen. The cocoa seedlings nutrition is not different both in the coffee pots and the cocoa pots. This reflects the absence of a nutritional imbalance in the pots with the nitrogen input.

Partial budget of the major nutrients in the pots

To understand the nutrient dynamics in the different types of pots and with the nitrogenous fertilizer input, the partial budgets of the key nutrients N, P, K, Ca and Mg were calculated (Table 6). The N balance indicates that the result is negative (0.55±0.49 $mg.plant^{-1}$). The atmospheric deposits of N per plant are negligible (4.02 x 10^{-5} $mg.plant^{-1}$). The N losses are higher in the coffee pots (1.22±0.0 $mg.plant^{-1}$) than in the cocoa pots (0.44±0.08 $mg.plant^{-1}$). The N input increased slightly the N absorption by the cocoa plants but these needs can validly be covered by the intrinsic capacity of the initial soil. The balance of P is positive regardless of the type of the pots and the doses of Urea-N (10.65±4.39 $mg.plant^{-1}$). The gain is higher in the cocoa pots (8.69±0.90 $mg.plant^{-1}$) than in the coffee pots (3.94±0.0 $mg.plant^{-1}$). It realizes that the higher the N dose is the higher the P gain is. The input of N doses seems to be beneficial for the mineralization of P. The balance of the exchangeable bases is quite varied. The balance of K is negative but fairly stable regardless of the type of pot or N input dose (2.05±0.09 $mg.plant^{-1}$). The balance of Ca is positive in the cocoa pots (0.28±0.13 $mg.plant^{-1}$) while in the coffee pots, the balance is negative (0.47±0.0 $mg.plant^{-1}$). The result of the balance of Mg is everywhere negative (2.03±0.32 $mg.plant^{-1}$). It is trivial to note that the cocoa seedlings nutrition is guaranteed regardless of the type of pots (coffee pot or cocoa pot).

DISCUSSION

The plant nutrition must be balanced for the optimum growth. For cocoa tree, the ratio N/P must be equal to 1.5 to 2 and this is trivial for a balanced nutrition of the plant (Snoeck and Jardin, 1992). The N and P uptakes in this study gives values of 1.39 to 1.99 for the N/P ratio in the cocoa seedlings. It reflects a perfect balance between N and P when the nitrogenous fertilizer dose is between 0 and 3 $g.plant^{-1}$ regardless of the type of pot. A dose of 4.5 $g.plant^{-1}$ results in an imbalance of the system with a too low N/P ratio of 1.39. Between the two types of pots (pot of 1055 cm^3 and pots of 2120 cm^3), the balance between N and P is good with fairly similar values (1.99 and 1.86 respectively). Furthermore, the Diagnostics-Soil Software was developed and used to predict the nutrient requirements for cocoa orchards (Snoeck *et al.,* 2006; Snoeck and Jardin 1992; Jardin and Snoeck 1985; Jardin, 1976). According to this software, the balance between nitrogen (N) and the sum of exchangeable bases (SBE) in the analysed soil must be less than or equal to 8.9 for a good growth and production of the cocoa tree. In light of this study, the balance between SBE and N is 5.83 and 7.22 on the soil used. This demonstrates once again that the soil in the both pots is ready to ensure a balanced nutrition for the cocoa seedlings. The realization of a cocoa seedlings nurseries in smaller sized pots (pot of 1055 cm^3) could be achieved validly with a balanced nutrition of the cocoa seedlings in the cocoa farming sub-zone Kloto in Togo. An additional N input could be carried out with fairly moderate doses.

Conclusion

These works reveal the effects of the soil quantity and the nitrogen input on the chemical properties of potted soil then the nutrients uptakes by the cocoa seedlings and the partial budget of key nutrients in the nursery. The chemical properties of the potted residual soil do not seem to be different in both coffee pots (1055cm^3) and cocoa pots (2120 cm^3).
The nitrogen input has no effect on the quality of the potted residual soil. The cocoa seedlings nutrition in the various pots or with the input of nitrogen is not different. The nutrient budget reveals the dynamics of the major nutrients in the potted soil content. The results of N, K and Mg balances are negative while those of P and Ca are positive with relatively stable gains for Ca and the increasing gain for P based on the N increasing dose. It is possible to grow the cocoa seedlings on soil contained in smaller size pot like that of coffee (1055 cm^3) while ensuring a balanced nutrition of the plants.

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