International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 5, No. 2, p. 124-133, 2014

INNSPUB

RESEARCH PAPER OPEN ACCESS

Effect of mineral fertilization on the physicochemical properties of soils in the region of Go and the vegetative behaviour of immature trees of clone PB 235 of *Hevea brasiliensis* in South-Western Côte d'Ivoire

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Article published on August 30, 2014

Key words: Côte d'Ivoire, soil fertility, mineral fertilization, *Hevea brasiliensis*, radial vegetative growth.

Abstract

The effect of mineral fertilization on the physicochemical properties of the soil and the vegetative behaviour of clone PB 235 of *Hevea brasiliensis* has been studied in the Go experimental plantation of San Pedro in south-western Côte d'Ivoire. On that respect, the fertility of soil treated with different doses of complete fertilizer and the vegetative behaviour of rubber trees were assessed from soil samples and measurements of parameters of vegetative growth before and seven years after the establishment of rubber trees. The different doses of fertilizer spread changed from zero to four times the dose used in industrial plantations. The rate of fines (clay and silt) decreased from unfertilized soils those treated with high doses of fertilizer. We noticed a gain of organic matter, carbon and a stability of surface horizons whose maximum is expressed by the treatment fertilized with half-dose. However, the almost constant loss of nitrogen was independent of doses of manure. The rates of exchangeable Ca and Mg decreased from unfertilized soils to those treated with the standard dose and whose values were the lowest, unlike the cationic exchange capacity (CEC) which increased with the same amount of manure. Despite the potassium application at the opening of rubber trees, the loss of exchangeable K and the increasing deficiency of available phosphorus were independent of fertilizer doses. Nevertheless, a constant application of high-doses of phosphorus ensures its availability in soil. Fertilization by half dose of fertilizer leads on the long-term to a stable soil, physically improved. The vegetative behaviour of PB 235 was satisfactory and showed that an application of manure beyond the half dose was not necessary.

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Introduction

Soil fertility is a key factor in the modern and sustainable management of large areas under cultivation, especially in the tropics where it is weakened by the harsh climate. It can be diminished by anthropogenic practices, including agricultural intensification, which generate a pressure on the ecosystem, leading in turn to its decline (Laurence, 1998). Therefore, it appears necessary to consider management methods that enable a rational and sustainable exploitation of lands (Manlay, 2000). This sustainable land management requires that samples be compensated by application, so that the dynamic equilibrium be maintained (Ibrahima *et al.*, 2009). The rational management of soil fertility participates thus in the settlement and crop intensification and, therefore, the control of shifting cultivation, a land-consuming practice. The good management of soil fertility improves labour productivity, speculations of most of the crops cultivated. It therefore contributes to the preservation of significant areas, in particular forest and ecosystem-based ones for various uses including the maintenance and conservation of a good environment. Soil fertility and conservation in tropical areas are, for agronomists, a major concern with respect to the vegetative growth and yield of the crops exploited (Tié Bi and Omont, 1987). To this end, several authors (Noordin *et al.*, 1984; MRB, 2009; Noordin, 2011) consider that the needs of the rubber tree in primary nutrient elements at different stages its growth are nitrogen (N) , phosphorus (P), potassium (K) and magnesium (Mg). In addition to vegetative growth and production data assessed a posteriori, soil physicochemical indicators estimated a priori, may also account for its fertility before and during its development. Also, the previous vegetation may influence the physicochemical status of soils over time. Indeed, the success of the planting or replanting is dependent on the fertility of soils under the previous crop or vegetation. Concerning soils under rubber plantations, numerous studies have highlighted the different balances of chemical components. Thus in 1965, Duchaufour highlighted the significant role of rubber litter in the recycling of minerals and the formation of soil reserves. Tié Bi and Omont showed in 1987 that in south-western Côte d'Ivoire, tertiary sands showed a good balance between calcium and magnesium on the one hand and on the other hand, a low level of total carbon over the forest. Moreover, a beneficial effect of an NP fertilizer on the growth of clone GT 1 was highlighted on the soils of the plantation of Grand Béréby in south-western Côte d'Ivoire. Also, Tié Bi and Omont reported in 1987 that the effect of plots deficient in phosphorus on the vegetative growth and rubber yield can be adjusted by inputs of fertilizers; but it is not the case for the phosphorus content of the soil.

Thus, the previous "forest" vegetation, is assumed to maintain soil fertility (Duchaufour, 1960 ; Tié Bi et Omont, 1987). On that respect, the characteristics the soil having a "secondary forest" previous vegetation were studied for 7 years under clone PB 235 of *Hevea brasiliensis* in the presence of different doses of manure, in south-western Côte d'Ivoire. Simultaneously, the number of tappable trees and the girth at 1 m above the ground were identified. This study aims at assessing the physicochemical status of the soil after development and its effect on the vegetative behaviour of the rubber tree, in the context of providing or not mineral fertilizer.

Materials and methods

Description of the study environment

The study was conducted on the experimental and research station of the Go, located at 50 km north of San Pedro, in the South West (5° 40' North, 6° 43' West) of Côte d'Ivoire. The soils in this area, clayey-sandy by nature, have gravelly horizons. They are ferrallitic, heavily desaturated, with good water retention capacity, but having migmatite and schist origins (Roose et Cherroux, 1966; Perraud, 1967; Tison *et al.*, 1996; Kéli *et al.*, 1997; Brou, 2005). They have a low organo-mineral potential and available phosphorus (DRC, 1968 ; Nguyen, 1982 ; Gabla, 1998). The climate is sub-equatorial with low amplitudes of temperature (30°C), high humidity (80-90 %) and an estimated 1,500 hours sunshine. The average annual rainfall is between 1600 and

2000 mm, and is characterized by a bimodal regime : two rainy seasons, from April to July and from October to November ; and two dry seasons from December to February-March, and from August to September (Kéli *et al.*, 1992; Brou, 2005). The land on which the crops were set was originally occupied by a secondary forest and cocoa trees.

Material and methods

Plant material

Clone PB 235 of *Hevea brasiliensis* planted at a density of 510 trees/ha in 1989, served as plant material. The preparation of the site was carried out mechanically with a 350 hp Bulldozer. *Pueraria phaseoloides* was set as cover crop after the burning of felled trees.

Manure application strategy

The manure was supplied to rubber trees via the planting hole during planting, and at immature stage at the base of the crown of the tree leaves. The spreading was made twice a year, in March-April and October-November. The manure was made up of nitrogenous (urea: 46% N), phosphatized (tricalcium phosphate 33% P_2O_5) and potassic (potassium chloride: 60% K_2O) fertilizer. Doses and quantities were supplied on the basis of the reference scale of mineral fertilization in the ecological conditions of southwestern Côte d'Ivoire (Table 1).

Experimental design

The statistical design used was completely randomized blocks (CRB) with 6 treatments and 4 repetitions, set up on an average area of 4.14 ha. The plantation was established at a density of 510 trees/ha (7 m x 2.80 m). Each elementary plot consisted of 130 trees. The different treatments applied were the following:

1 - 0D. Control, without manure

2 - ½ D. Half dose of manure spread on industrial plantation

3 - 1D. Normal dose of manure spread on industrial plantation

4 - 2D. Double dose of manure spread on industrial plantation

5 - 4DT. Quadruple dose of manure spread on industrial plantation

6 - 4DP. Quadruple dose of manure spread permanently on industrial plantation

Soil fertility

Sampling and soil characterization

Before the first manure spreading, soil samples were collected from the diagonals of each elementary plot within the first thirty cm at the rate of 12 to 17 cores. An average composite sample was designed per elementary plot, from individual samples. Moreover, three (3) soil profiles were dug up-slope (P1), mid-slope (P2) and down-slope (P3) between the row spacing in order to characterize the soil. Seven years after the planting of rubber trees, soil samples were collected in the same way as those made before the establishment of seedlings.

Soil physicochemical parameters measured

The soil samples were sent to the CIRAD Laboratory of Soil in Montpellier, France, where the following parameters were determined:

• The exchangeable bases content of the soil (Ca^{2+}, Mg^{2+}, K^+ in meq/100g) ;

• The rates (in %) of sand (S), silt (L), clay (A), carbon (C), organic matter (MO) and total nitrogen (N total), as well as the cationic exchange capacity (CEC, in meq/100g) and the rate of base saturation (V in %);

• The available phosphorus content of (P assimilable in ppm)

• The C/N ratio.

Threshold values of the measured parameters

The different thresholds of chemical parameters of ferrallitic soils of Côte d'Ivoire are listed in Table 1 (Boyer, 1982).

Doses and periods of manure input

The different levels of fertilization tested were compared to the currently recommended dose in industrial plantations in the region of study (Table 2). The phosphatized and nitrogenous fertilizer was spread during the first three years, while potash was supplied in the first year and then at the start of rubber trees exploitation.

Radial vegetative growth of trees

In the second year after planting, the measurement of the girth of rubber trees was made with a measuring tape at 1 m above the ground throughout the immature period, at the end of the physiological cycle, before the start of the annual defoliation between January and March each year. From the measurements of girth, average annual increases were calculated using the following formula:

$Acc_n = Circ_n - Circ_{n-1}$

Acc_n : annual increase in girth

$Circ_n$: girth of trees of the ongoing crop year

$Circ_{n-1}$: girth of trees of the previous crop year.

Statistical Analysis

The physicochemical data of the soil and those of the radial vegetative growth were subjected to analysis of variance using the software StatG. The ranking of averages was conducted according to the Scheffe test at the threshold of 5%.

Results

Soil fertility status

Characterization of soils

The description of soil profiles open in the row spacing, showed that the soil had a sandy to sandy-clayey texture, a dominant massive structure and the presence of a gravelly horizon. The morphology revealed an ABC-type mature soil belonging to the class of slightly desaturated ferralitic soils. Thus, we noticed in the upper-slope and mid-slope a ferrallitic soil slightly desaturated revamped and rejuvenated, then in the bottom of the slope, a slightly desaturated impoverished remoulded ferralitic soil with rejuvenated facies.

Table 1. Threshold values ofchemical parametersofferralliticsoils inCôte d'Ivoire Source : Boyer, 1982.

	C / N	Ca / Mg	pH	Exch. Ca m.eq/100g	Exch. K. m.eq/100 g	Exch. Mg. m.eq/100 g	C.E C m.eq/100 g	S.B.E m.eq/100 g	V (%)
very low						< 0.10	< 5.0	< 1.5	< 20
low	< 9	< 1	< 5.5	< 0.4	< 0.1	0.1-0.17	5-10	1.5-3.0	20-50
average	9-12	1-7.6	5.5-8.0	0.4	0.1-10	0.17-0.25	10-15	3-6	50-90
High	12-25	7.6-11	8-8.5	> 0.4	> 10	0.25-0.4	15-25	6-12	> 90
very high	> 25	> 11				> 0.40	> 25	> 12	

Evolution of the granulometry

The 0-30 cm layer of the soil of plots, initially sandy-clayey in treatment 5 and sandy in all the others at the setting of the experiment, became sandy-clayey in all the treatments after 7 years of cultivation (Table 3). The increase in the rate of fine elements was variable. Concerning clay (5.8 %), it was substantially equivalent to the loss of sand (6.4 %). It was very low (0.7 %) as for silt. The low coefficients of variation (less than 10 %) confirmed the low heterogeneity of treatment, both before and after fertilizer spreading. Figure 1 shows a decrease in the rate of increase of clay in the unfertilized treatment to the pattern which received the highest dose of fertilizer.

Evolution of organic elements

Before manure spreading, the organic matter content (1.48% on average) and total nitrogen (8.90 %) were respectively low and relatively high. However, the C/N ratio (9.95) demonstrates the good mineralization of the organic matter. Seven years after the establishment of the experiment, the organic matter content and total nitrogen became respectively average (8.88 %) and very low (0.56 %). The C/N ratio, which increased slightly downward to a value close to 9.30 (except for treatment 2), remained average and still showed a pretty good mineralization of the organic matter (Table 4). Similarly, there was an increase of the carbon in time. The low coefficients of variation reflected a fairly good homogeneity of the values in time and regardless the treatments.

Evolution of the adsorption complex

At the establishment of the experiment, the soils were relatively supplied in exchangeable bases (high exchangeable Ca and Mg; average exchangeable K) and more or less homogeneous on the plots of study. The cationic exchange capacity (CEC) and the base saturation percentage (V) were very low but homogeneous. After 7 years of experimentation, the Ca and Mg contents remained high and medium, the K one became very low, the CEC and the saturation percentage increased slightly (Table 5). We noticed a decrease of Ca and Mg and gain in CEC under the rubber trees. These decrease and gain fell from the unfertilized treatment to the normal dose. The increase of manure beyond the normal dose resulted in a decrease of the CEC rate.

Table 2. Doses andtype of fertilizerappliedonindustrialrubber tree plantations.

Fertilizers	Year 1	Year 2	Year 3	**At** tapping
PCa3	294 g /a	156 g / a	156 g / a	-
-	150 kg / ha	80 kg / ha	80 kg / ha	-
KCl	98 g / a	-	-	80 g/ a
-	50 kg / ha	-	-	50 kg / ha
Urée	68 g / a	68 g / a	68 g / a	-
-	35 kg / ha	35 kg / ha	35 kg / ha	-

Table 3. Status of the granulometry of the soils of plots (%) at the establishment and after 7 years of fertilizer treatments of the rubber tree plantation, clone PB 235.

Components	*period*	*Treatments*						*average*	**CV %**
		1	2	3	4	5	6		
clay	establishment	10.6	10.1	10.6	10.7	12.1	10.5	10.8 ± 0.6	5.8
	under rubber tree	17.8	16.4	16.9	16.0	17.9	14.5	16.6 ± 1.2	7.0
silt	establishment	10.4	11.2	10.9	11.4	11.0	10.5	10.9 ± 0.4	3.4
	under rubber tree	11.7	10.6	12.0	11.9	12.8	10.3	11.6 ± 0.9	7.4
sand	establishment	79.0	78.8	78.5	77.8	76.8	79.0	78.3 ± 0.8	1.0
	under rubber tree	70.6	73.0	71.3	72.1	69.3	75.3	71.9 ± 1.9	2.6

1 - Control, without manure

2 - Half dose of manure spread on industrial plantation

3 - Normal dose of manure spread on industrial plantation

4 - Double dose of manure spread on industrial plantation

5 - Quadruple dose of manure spread on industrial plantation

6 - Quadruple dose of manure spread permanently on industrial plantation

Evolution of available phosphorus and acidity

The acid soils (pH 5.54) of the experimental area had a very low available phosphorus content (12 ppm on average) and homogeneous (CV <8 %) at the implementation of the trial (Table 5). Seven years later, we noticed a slight increase in soil acidity and an increase in the deficiency of available phosphorus (7 ppm) except in the fertilized treatment continuously at high doses (11.22 to 19.50 ppm).

Vegetative behaviour of Hevea brasiliensis clone PB 235

Number of tappable rubber trees at their tapping start

At the start of tapping the rubber trees of clone PB 235 five years after planting, all the treatments had at least 300 trees/ha, higher than the 200 trees/ha necessary to start the exploitation of a rubber tree plot. Therefore, all the patterns started to be tapped simultaneously, though the number of trees at the first opening differed significantly according to doses of mineral manure spread. The number of tappable rubber trees of the treatment which was not supplied with manure was much lower (Table 6) than that of all the other fertilized treatments.

Table 4. Rate (%) of organic matter (OM), carbon (C), total nitrogen (N) andvalues of C/Nof the soil ofrubber tree plantation of clonePB235,at establishment andafter 7 years of fertilizertreatments.

Component	*Period*	*Treatments*						*average*	**C V %**
		1	2	3	4	5	6		
C %	establishment	0.84	0.79	0.88	0.84	0.94	0.88	0.86±0.05	5.80
	under rubber tree	5.29	5.35	5.17	5.00	5.43	4.72	5.16±0.24	4.65
M.O %	establishment	1.44	1.36	1.52	1.45	1.61	1.52	1.48±0.08	5.39
	under rubber tree	9.10	9.20	8.89	8.60	9.34	8.12	8.88±0.41	4.62
N total %	establishment	8.50	8.70	9.40	9.00	9.80	7.80	8.90±0.64	7.22
	under rubber tree	0.57	0.55	0.57	0.56	0.58	0.50	0.56±0.03	5.10
C/N	establishment	10.10	9.27	9.57	9.68	9.63	11.43	9.95±0.70	7.04
	under rubber tree	9.28	9.73	9.07	8.93	9.36	9.44	9.30±0.22	2.37

1 - Control unfertilized

2 - Half dose of manure spread on industrial plantation

3 - normal dose of the fertilizer spread on industrial plantation

4 - Double dose of manure spread on industrial plantation

5 - Quadruple dose of manure spread on industrial plantation

6 - Quadruple dose of fertilizer spread on permanently on industrial plantation.

Vegetative growth of rubber trees

The rubber trees girth measurements at immature stage revealed that only the trees of the unfertilized pattern showed values significantly lower than those from all the other treatments; the latter being statistically identical to each other (Table 6).

Table 5. Status of adsorbent complex, available phosphorus and acidity of soils of rubber tree plantation of clone PB235, at the establishment and after 7 years of fertilizer treatments

Components	*Period*	*Treatments*						*Average*	**C.V %**
		1	2	3	4	5	6		
Exch.Ca meq/100g	establishment	1.06	1.57	1.50	1.57	1.37	1.26	1.39±0.18	12.97
	under rubber tree	0.34	0.58	0.89	0.48	0.56	0.71	0.59±0.17	7.77
Exch. Mg meq/100g	establishment	0.35	0.45	0.47	0.47	0.46	0.43	0.44±0.04	9.13
	under rubber tree	0.11	0.19	0.26	0.19	0.25	0.19	0.20±0.05	25.21
Exch.K meq/100g	establishment	0.17	0.23	0.26	0.32	0.20	0.21	0.23±0.05	21.58
	under rubber tree	0.06	0.05	0.08	0.06	0.07	0.05	0.06±0.01	16.22
C.E.C meq/100g	establishment	1.83	2.21	2.35	2.35	2.08	1.97	2.13±0.19	8.91
	under rubber tree	4.00	3.00	2.95	4.00	3.40	2.80	3.36±0.49	14.59
V %	establishment	0.92	0.98	0.99	1.02	1.03	0.98	0.99±0.03	3.04
	under rubber tree	13.00	26.30	42.30	26.50	20.50	37.50	27.68±9.82	35.48
	establishment	5.15	5.75	5.61	5.91	5.38	5.43	5.54±0.25	4.51
pH water	under rubber tree	4.61	4.73	5.21	5.01	5.00	5.23	4.97±0.23	4.63
Avail. P meq/100g	establishment	13.82	12.48	11.05	12.85	12.70	11.22	12.35±0.96	7.77
	under rubber tree	2.50	5.00	3.50	11.50	4.25	19.50	7.71±6.02	78.10

1 - Control, without manure

2 - Half dose of manure spread on industrial plantation

3 - Normal dose of manure spread on industrial plantation

4 - Double dose of manure spread on industrial plantation

5 - Quadruple dose of manure spread on industrial plantation

6 - Quadruple dose of manure spread permanently on industrial plantation.

Discussion

Effect of mineral manure on soil fertility under rubber trees

The results show that soils under rubber trees gradually improve towards a finer structure (clay, silt) in contrast to coarse materials (sand) which reduction is inversely proportional to the gain in clay. The phenomenon appears stronger especially as the plot is not supplied with fertilizer. Moreover, in the fertilized plots, at half-dose spread on industrial plantations, the gain in carbon and organic matter, carbon restoration of litter, is optimum.

Table 6. Girth (cm) of the trunk at 1 m above the ground and number of tappable trees of clone PB 235 after fertilizer treatments.

	Treatments					
Years	1	2	3	4	5	6
Year 2	13.50 b	16.30 a	16.40 a	16.2 a	16.4 a	15.2 a
Year 3	27.00 b	31.60 a	31.70 a	31.6 a	31.1 a	30.0 a
Year 4	40.10 b	44.80 a	44.90 a	44.8 a	44.0 a	43.2 a
Year 5	48.60 b	53.00 a	53.1 a	52.9 a	52.4 a	51.7 a
Tappabletrees/ha	309 c	436 a	421 a	414 ab	387 ab	383 ab

On the row.the values assigned with the sameletter are notsignificantly different(Scheffe 5%)

1 - Control, without manure

2 - Half dose of manure spread on industrial plantation

3 - Normal dose of manure spread on industrial plantation

4 - Double dose of manure spread on industrial plantation

5 - Quadruple dose of manure spread on industrial plantation

6 - Quadruple dose of manure spread permanently on industrial plantation.

All these remarks (gain in fines and loss of sand, gain in carbon and organic matter), contribute to improve soil water characteristics (permanent wilting point, field capacity, available water) and, probably, to limit erosion (Boyer, 1982). In industrial plantation, the profit is significant especially as fertilization is performed at half dose of mineral manure. Thus, it appears that high doses of nitrogenous, phosphatized and potassic fertilizer activate on the one hand, the degradation of sand, while increasing clay and silt content, and on the other hand, favour litter decomposition in the soils of the field.

Furthermore, nitrogen, an important component of plants, undergoes regardless of fertilizer doses, a significant loss under rubber trees. This loss is probably the result of a high consumption of nitrogen by the fast growing and vigorous clone that is PB 235 (Obouayeba *et al.*, 2000 ; Obouayeba, 2005). It may also be the result of leaching, because of the sandy-clayey texture of the soil and certainly the abundance of rainfall in the region, as noted by Ibrahima *et al.,* (2009). The calcium and magnesium content of the soil, two elements linked by their Ca/Mg ratio to indicate some structural stability (Boyer, 1982), undergo a downward evolution in non or partially fertilized plots, with a minimal loss at normal dose spread on industrial plantations. This loss of exchangeable bases causes more acidification of soils which deficiency in available phosphorus increases despite the input of this component even at high dose. However, a permanent high dose supply (four times the dose spread on industrial plantations), may possibly tend to adjust this deficiency. The representativeness of the soils of the study site compared to those in the South West of Côte d'Ivoire (DRC, 1968) could enable to extrapolate these results to the entire region. Indeed, the spreading of nitrogenous, phosphatized and potassic fertilizers on slightly desaturated remoulded or impoverished ferralitic soils in the study area (Nguyen, 1982; Gabla, 1998), at a dose reduced by half compared to the previous recommendations, seems to contribute, at a lower cost, to the durability of rubber tree plantations. At the end of the exploitation cycle of the first plantations carried out by clearing the natural forest, some replanting would certainly benefit from a chemically impoverished, but stable and physically improved soil; which is most important for rubber plantations (Yew, 1991).

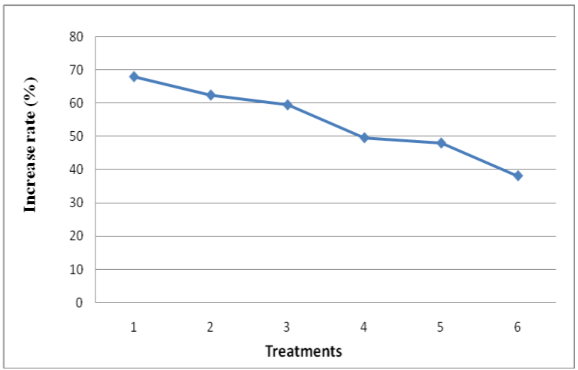

Fig. 1. Increase rate of clay in the surface horizon (0-30 cm)after 7 years of fertilizer treatments of rubber tree plantations.

1 -Control, without manure

2 -Half dose of manure spread on industrial plantation

3 -Normal dose of manure spread on industrial plantation

4 -Double dose of manure spread on industrial plantation

5 -Quadruple dose of manure spread on industrial plantation

6 -Quadruple dose of manure spread permanently on industrial plantation.

Effect of mineral manure on the number of tappable rubber trees and the radial vegetative growth of the trunk

The vegetative behaviour, notably the radial vegetative growth of the trunk and the density of tappable rubber trees, is particularly satisfying, whatever the treatment, fertilized or not. Indeed, the average girth measured at 1 m above the ground varied from 48.6 (unfertilized control) to 53.1 cm (pattern fertilized at the dose spread on industrial plantations). This result indicates that the increase in vegetative growth of clone PB 235 is clear and corroborates the works of several authors (Obouayeba et Boa, 1993; Obouayeba *et al.*, 2000; Obouayeba, 2005) which show that the trunk of the rubber trees of clone PB 235, which has a quick growth, reaches about 50 cm girth measured at 1 m from the ground at 5 years of age. Now this result is similar to that of the unfertilized control which is significantly lower than that of the trees of all the fertilized treatments whose girth at the start of tapping is of the same order. This good vegetative growth of the trees of clone PB 235 accounts for the fact that at the start of tapping (opening), regardless of the treatment, there are at least 300 tappable rubber trees. This number is significantly higher than the 200 trees/ha required for the first tapping of rubber tree plot as recommended by professionals (Obouayeba, 1995). The increase in growth is thus due to the input of mineral manure. However, this advantage is annihilated by the loss of rubber trees by uprooting during heavy rains because of the physical characteristics of the soil. Indeed, despite the subsoiling of the planting row, the taproot of the rubber tree hardly penetrates the soil, grows and plays its anchorage role lesser than on deeper and loose soil (Gabla, 1998) role. It appears then an imbalance between the root part (taproot and lateral roots) and the shoot part consisting of the air vegetative biomass (Chaudhuri *et al.*, 1995) of PB 235 generally bulkier, as observed with fertilizer treatments. The data concerning the physicochemical characteristics of soils and the vegetative growth of the trees of clone PB 235 according to doses of manure spread raise a problem relating to the input of fertilizers on the soils of South-western Côte d'Ivoire. Indeed, these results enable us to consider the slightly fertilized (half dose) pattern as the one offering the best compromise between the soil characteristics and the vegetative behaviour of the rubber trees that grow on it. Finally, many studies have shown the advantage of the input of manure over the first three years of a rubber tree plantation: homogeneous plantation, maximum number of trees at the first opening. However, the input of manure under rubber trees having a quick growth such as PB 235, PB 260, IRCA 130 etc., may not be necessary when the previous cover was forest, fallow or exhausted land, and when dealing with deep and loose soil.

Conclusion

Surface horizons of desaturated ferrallitic soils in the region of San Pedro (South-West Côte d'Ivoire), previously covered by secondary forest, fertilized or not with different doses of nitrogenous, phosphatised and potassic fertilizer, undergo an evolution of their organo-mineral status under rubber trees. The gain in fines (clay and silt), added to loss of sand, gain in carbon, in organic matter and thus the improvement of water features (permanent wilting point, field capacity and available water) and resistance to erosion, are better when we supply half dose of mineral manure spread on industrial plantations. The nitrogen loss, via plant nutrition and/or via leaching, is independent of the doses of manure. We notice an aggravation of the deficiency of soils in available phosphorus, unless this component is supplied permanently and at very high doses. There is no clear relationship between the level of fertilization and the evolution adsorption complex. However, we note that the lowest losses in exchangeable Ca and Mg and the lowest gain in cationic exchange capacity (CEC) are obtained with the fertilized treatment at normal dose. An application of manure beyond the half dose has no beneficial effect either on the physicochemical characteristics of the soil or on the radial vegetative growth of rubber trees.

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