Increasing yields and soil chemical properties through the application of rock fines in tropical soils in the western part of Cameroon, Africa

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Abstract

Rock fines from basalt, trachyte and volcanic pyroclastic materials in addition to limestone and gneiss were applied as fertilizers on tropical soils in several localities in west Cameroon. After harvesting, soil samples from controls and different treatments were collected and analyzed to assess the variation of textures and soil chemical compositions. Cabbage and potatoes as the test crops treated under fines from volcanic pyroclastic materials and basalt yielded the highest and lowest productivities, respectively. The initial loamy sand of the controls moves towards clay textures while initial clay textures remained unchanged, suggesting a loss of sand proportion and an increase in clay particles. For the pH, the slightly, moderately to strongly acidic properties of the local soils (4.8 [?] pH [?] 6.5) were shifted upwards in between the slightly acidic and the slightly alkaline soils (6.6 [?] pH [?] 7.2). However, a sample treated with fines from pyroclastic materials showed a remarkable pH increase from 5.9 to 6.9. The trends of fluctuation of organic carbon and organic matter are parallel with a general increase of these chemicals in soils. Na and K remains constant with a general increase trend for Mg and Ca in most treatments. The highest available phosphorus content of 96.0 ppm was found on the treatment with trachyte fines; followed by 50.9 and 51.5 ppm encountered on treatments with limestone and basalt fines, respectively. Then, this suggests a significant increase of phosphorus in soil after treatments with some rock fines such as trachyte, limestone, gneiss and basalt.

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Rock fines from basalt, trachyte and volcanic pyroclastic materials in addition to limestone and gneiss were applied as fertilizers on tropical soils in several localities in west Cameroon. After harvesting, soil samples from controls and different treatments were collected and analyzed to assess the variation of textures and soil chemical compositions. Cabbage and potatoes as the test crops treated under fines from volcanic pyroclastic materials and basalt yielded the highest and lowest productivities, respectively. The initial loamy sand of the controls moves towards clay textures while initial clay textures remained unchanged, suggesting a loss of sand proportion and an increase in clay particles. For the pH, the slightly, moderately to strongly acidic properties of the local soils (4.8 [?] pH [?] 6.5) were shifted upwards in between the slightly acidic and the slightly alkaline soils (6.6 [?] pH [?] 7.2). However, a sample treated with fines from pyroclastic materials showed a remarkable pH increase from 5.9 to 6.9. The trends of fluctuation of organic carbon and organic matter are parallel with a general increase of these chemicals in soils. Na and K remains constant with a general increase trend for Mg and Ca in most treatments. The highest available phosphorus content of 96.0 ppm was found on the treatment with trachyte fines; followed by 50.9 and 51.5 ppm encountered on treatments with limestone and basalt fines, respectively. Then, this suggests a significant increase of phosphorus in soil after treatments with some rock fines such as trachyte, limestone, gneiss and basalt.

Keywords: yield; rock fines; soil chemicals; soil physico-texture; soil pH and Phosphorus

INTRODUCTION

Soil erosion is a process acting over millions of years. It is known as “geologic” or natural when caused by factors such as climate, soil type and topography, according to Bennett and Chapline (1928). Human also induced soil erosion through activities such as overgrazing, deforestation and agriculture which are the major factors of the soil erosion accounting for 92 % of all activities destroying the soil structure (Mostafa and Osama, 1992). Then, soil erosion is a leading cause of soil infertility with a detrimental impact on the agricultural productivity. In fact, soil productivity depends on a number of physical, chemical, biological and soil properties. The chemical fertility depends on the amount of available nutrients in a soil which is governed by the soil pH, organic matter content and other characteristics. Then, soil erosion leads to the decrease of the chemical fertility through the leaching of some nutrients and the loss of agricultural productivity. This also leads to the economic damage of the income of farmers with alarming damage in sub-Sahara Africa. In Zimbabwe alone, it is estimated that farmers loose three times more nitrogen and phosphorus by erosion than they apply to their fields. Then soil erosion is a burden for agricultural productivity and has rendered soils depleted in essential nutrients necessary for crop growth in Africa. According to Smaling et al. (1996), the average N, P and K balances for Africa in 1983 were -22, -2.5 and -15 Kg ha^{-1} yr^{-1}, respectively. In fact, these nutrients were lost through exported harvested products and erosive processes such as water runoff and wide spread eroding sediments that caused negative balances. Then, adding NPK chemical fertilizers is the common method used by farmers to solve the problem of soil depletion in chemicals in sub-Sahara Africa. This work focuses on an alternative to the use of chemical fertilizers to combat chemical loss in soils. This method is based on the application of fines from different types of rocks to increase chemicals in soils.

METHODOLOGY

Soil samples were collected from 06 different sites namely Befang (06°20’18”N, 10°02’47”E), Foumbot (05°32’25”N, 10°35’30”E), Batibo (05°45’10”N, 09°45’35”E), Santa (05°47’58”N, 10°09’46”E) Kalong (04°47’30”N, 11°03’53”E) and Bonadale (04°09”36”N, 09°34’34”E) located in west, centre and littoral regions of Cameroon (Table 1). Each site is represented by an experimental plot made up of a control and treated soils replicated three times when growing a test crop. The test crops were chosen based on its growth capacity on a specific site. They were mostly made up of maize (*Zea mays*). However cabbage (*Brassica oleracea*), carrots (*Daucas carota*) and Irish potatoes (*Solanum tuberosum*) were also used as test crops in some sites. Then, fresh rock samples locally collected were crushed into smaller fragments then pulverized several times into fines and sieved with a 1x1mm mesh sieve and used as fertilizers. The rocks used as fines are volcanic such as basalt, trachyte and volcanic pyroclastic materials in addition to gneiss and limestone. Fines of dried *Tithonia Diversifolia* was also used as green manure. Poultry manure or cow dump were also added to some treatments.

After harvesting and yields determined for each crop, soil samples were collected from all the controls and treated soils on 06 different spots of each plot unit and within 0- 25cm of depth, mixed, dried and stored in clean plastic bags and taken for further description and analysis in the Laboratory of Soil Sciences, Faculty of Agronomy, University of Dschang, Cameroon. In the laboratory, soil samples were air-dried at room temperature for one week and passed through a 2-mm polyethylene sieve to remove plant debris and pebbles. Afterwards, they were lightly crushed in an agate mortar into fine powder and passed through a 0.149-mm nylon sieve then stored in glass containers then preserved under ambient conditions pending analysis. The soil samples were subjected to physiological analysis using a standard laboratory procedure for soil analyses (AFNOR). Soil reaction was determined in soil water suspension 1:2.5 using a glass electrode. Organic matter was determined by wet digestion according to Walkley and Black (1934). Total nitrogen was analyzed by the method of Kjeldahl (1883) modified. Exchangeable cations and exchange capacity (CEC) were determined by percolation with 1 M ammonium acetate, and the determination of Ca, Mg, K and Na using a flame photometer and Mg with an atomic absorption spectrophotometer. And pH_{water} (Peech, 1965) was measured with a pH meter at 1:2.5 soil/water.

RESULTS

The results are made up of the yields of each test crops (Table 1) in addition to the textures and chemical compositions of control and treated soils (Table 2 and Table 2 (continued)). The texture was determined based on the percentage composition of each soil sample in sand, silt and clay. Parameters such as pH, OM and OC (%), N (g/Kg), Ca, Mg, Na and K (meq/100 g) and P (ppm) were determined as chemical compositions for the control and treated soils. The variations in chemical contents between controls and treated soils were determined to appraise chemicals'contents in soils after treatments.

Yields

Maize was used as the test crop in the localities of Foumbot, Bonandale and Kalong. However cabbage, carrots and potatoes were also used in Befang, Santa and Batibo, respectively.

Maize as the test crops yielded (after 03 months of growth) 833, 3200 and 4000 Kg/ha for the controls T01, T02 and T03 in the localities of Foumbot, Bonandale and Kalong, which are made up of basalt, sediments and gneiss as country rocks, respectively. Out of the different treated soils where maize was used as the test crop, the best yield was obtained from T23 (= T03 + 3Kg gneiss fines) in the locality of Kalong. This is followed by higher yields of 8300 and 8000 Kg/ha obtained on T22 (= T02 + 2Kg limestone fines) and T13 (= T03 + 3Kg basalt fines) in Bonandale and Kalong, respectively. Yields as low as 5400 and 3200 Kg/ha were obtained on treatments T12 (= T02 + 2Kg basalt fines) and T62 (= T02 + 1Kg limestone fines) in the same locality (Bonandale). The lowest yield comes from T41 (= T01 + 600g basalt fines + 600g poultry manure) cultivated in Foumbot.

Cabbage yielded productivities as high as 15 000 and 11 6666Kg/ha for treatments T24 (= T04 + 200g fines from pyroclastic bombs) and T44 (= T04 + 200g fines from less vesicular pyroclastic materials), respectively. However, the lowest yield of 2444Kg/ha was obtained from the control soil (T04). Intermediate yields of 3578 and 6444Kg/ha were obtained with T14 (= T04 + 200g lapilli fines) and T34 (= T04 + 200g fines from highly vesicular pyroclastic materials), respectively. More details on this work are found in Tetsopgang and Konyuy (2019).

The highest yield of carrots with the value of 925Kg/ha was obtained from treatment T35 (= T05 + 1kg basalt fines + 10ml LMO + 0.5Kg Tithonia). Lower yields of 525, 506 and 150Kg/ha were obtained from treatments T45 (= T05 + 1Kg basalt fines + 0.5Kg Tithonia), T25 (= T05 + 1Kg basalt fines + 10 ml LMO) and T15 (=T05 + 1Kg basalt fines), respectively. The control (T05) yielded intermediate productivity with 500Kg/ha. The highest yield of potatoes was from T26 (= T06 + 2Kg basalt fines + 2Kg coal fines) with 20 741Kg/ha, followed by the control (T06) with 14 816Kg/ha. The lowest yield is found on treatment T46 (= T06 + 2Kg trachyte fines +2Kg coal fines) with 13 333Kg/ha.

The performance index (Yi = Yield per treatment/Yield per control) indicates the number of folds increase of each treatment in relation to its control. The higher performances Yi (= 6.13 and 4.77) are found in the locality of Befang with treatments T24 and T44, respectively. This locality also portrayed another high Yi (= 2.63) for treatment T34. Other performances as high as 3, 2.75, 2.59 and 2 are found in treatments T41, T23 and T22 in the localities of Foumbot, Kalong and Bonendale. Other performances are 1 [?] Yi [?] 2 and found sparse in all localities subject to this study. However, the localities of Santa and Batibo showed that treatments T15 and T46 yielded less than their controls with Yi (= 0.30 and 0.89), respectively

Texture and Chemicals

Control soils

The control soils show textures of loamy sand (T01 and T02) to clay (T03) passing through clay loam (T06) and silty clay (T05). The highest pH values (= 7.10 and 6.40) were observed on loamy sandy samples (T01 and T02, respectively). The lowest pH (= 4.60) is portrayed by the silty clayish sample (T05). Intermediate pH values (= 5.92, 5.80 and 5.60) were observed on samples T04, T06 and T03 with clayish affinity. For the organic matters (CO, MO and N), the highest values of CO and MO (= 6.39 and 11.29 %, respectively) were observed on the control T06 collected on a clayish soil in Batibo (Table 2). Samples T03 and T02 show lowest values (= 0.95 and 1.30 %) of CO and MO. Intermediate values of CO and MO (= 2.30; 3.81 and 4.00; 6.57 %) came from samples T04 and T05, respectively. N also exhibits higher values (= 4.62 and 3.06) on T01 and T05, respectively. Lower values (= 0.06, 0.56 and 0.16) were found on T03, T02 and T06. For the exchangeable cations (Ca, Mg, K and Na), Ca exhibits highest values (= 3.84 meq/100g) while lowest values belong to Na and K (= 0.01 meq/100g). K and Mg exhibit values between 3.2 – 0.01meq/100g. The strongest capacity of cationic exchange belongs to T04 and T06 with values of 22.00 and 20.40. Available phosphorus (P) values are between 26.5 and 6.8 ppm for these controls.

Treated soils

The textures of most treated soils fall in the field of sandy loam (T12, T22, T12B, T22B) and clay (T62, T62B, T13, T23 and T45). However, some treated samples presented properties of clay loam (T26 and T46) and laomy sand (T41). This sample exhibits the highest pH (= 7.2) while the lowest pH (= 4.8) belong to T15 and T45. For CO, the highest values (= 7.03, 6.80 and 6.74 %) were encountered on samples T26, T24 and T46, respectively (Table 2). Values of CO as low as 0.21 and 0.34 % were observed on samples T12 and T22, respectively. In fact, most samples show intermediate CO values with values within 1.13 and 6.39 %. Treated soils with lowest values of CO also show lowest MO which are 0.35 and 0.59% for samples T12 and T22, respectively. Samples (T26, T46 and T41) with highest CO also portrayed highest values of MO (= 12.12, 11.62. 11.29%), respectively. N portrays the highest concentration (= 5.46 g/Kg) on T41 followed by lower values (= 3.06, 2.92 and 2.91) encountered on T25, T35 and T15, respectively. For the exchangeable cations (Ca, Mg, K and Na), Mg exhibits the highest values (= 45.76 and 24.00 meq/100g) belonging to T26 and T46. These samples also present higher values of Ca (= 10.24 and 3.20 meq/100g), However samples T13 and T23 also present higher values (= 6.64 and 9.12 meq/100g, respectively) for Ca and Mg (= 3.67 and 4.26 meq/100g, respectively). Then the sum of exchangeable cations are higher on samples T26 (=56.00 meq/100g), T46 (= 27.20 meq/100g), T23 (=14.13 meq/100g) and T13 (= 11.08 meq/100g). The lowest values of exchangeable cations (= 0.1 - 0.0 meq/100g) are those of Na. K also exhibits low values (= 1.08 – 0.0). The strongest and the weakest capacity of cationic exchangeable (= 48.89 and 8.8 meq/100g, respectively) were found on T23 and T25, T35, T45 and T41, respectively. For the available phosphorus (P), the highest value (= 95.96 ppm) was found on sample T46. Samples T22B and T12B also present higher values of 71.37 and 75.80 ppm, respectively. Values as high as 51.50, 50.91 ppm were observed with samples T22 and T62. Other higher values of P are encountered on T23, T24, T44, T13, T12, T34, T26, T15 and T14 with 32.70, 30.11, 28.25, 27.95, 26.65, 26.38, 24.30, 23.56 and 21.49 ppm, respectively. Intermediate values are between 7.24 and 18.45 ppm and 2.07 ppm is the lowest values of P found on T62B (Table 2) and (Table (continued)).

The variation of pH and the concentrations of various chemicals between values of different controls and those of corresponding treated soils are presented in Table 3. The highest positive pH variation ([?]pH = + 0.98) was encountered on sample T24 (= T04 + 200g fines from volcanic pyroclastic materials). This sample also exhibits the highest OC and OM variations ([?]OC = 4.50 and [?]OM = 5.11), respectively. A positive [?]pH as high as + 0.80 was observed on a couple of samples, T44 (= T04 + 200g fines from less vesicular pyroclastic materials) and T23 (= T03 + 3Kg gneiss fines). This couple of samples, T44 and T23 also show higher [?]OC (= + 3.30 and = + 1.11) and [?]OM (= + 3.10 and = + 2.48), respectively. Samples T26 (= T06 + 2Kg basalt fines + 0.75Kg green manure) and T12 (= T02 + 2Kg basalt fines) both exhibit negative pH variations (= – 0.60 and = – 0.40), corresponding to negative [?]OC (= - 0.19 and - 1.09) and [?]OM (= - 0.33 and - 1.89), respectively. The highest [?]N (+ 0.84) belongs to sample T41 with manure in his composition.

Most exchangeable cations exhibit low variations with - 0.73 [?] [?]K [?] 0.38, - 0.02 [?] [?]Na [?] 0.75, - 1.48 [?] [?]Ca [?] 2.80 and – 0.76 [?] [?]Mg [?] 1.99. However some higher variations of [?]Ca and [?]Mg are encountered for a couple of samples T23 (= 5.28 and 1.99) and T26 (= 7.04 and 52.56), respectively. [?]Mg is also higher for T46 (= 20.80). The most remarkable variation of chemical concentrations were found on phosphorus contents. Although negative variations are observed on T45 (= – 2.07), T25 (= - 2.62), T62B (= -5.71) and T25 (= -6.70), other samples such as T12, T22, T62, T22B, T12B and T46 exhibit positive phosphorus variations with values as high as 18.87, 43.72, 43.13. 63.59, 68.02 and 76.83, respectively. Positive and low phosphorus contents between 0.42 and 8.65 are observed on samples T41, T13, T23, T14, T34, T15, T26 and T44 (Table 3).

DISCUSSION

The texture and physico-chemical properties of soils treated with fines from different rock types +- manure were assessed in several localities of Cameroon. There is general variation of textures and physico-chemical parameters of treated soils in relation to the controls: the initial loamy sand texture of the controls moves to sandy loam and clay laom textures; sandy clay texture moves to clay texture and initial clay textures remained unchanged. This suggests that a soil treated with rock fines +- manure losses sand proportion while increasing mostly in clay and somehow in silt particles. In respect to the pH, the slightly, moderately to strongly acidic properties of the local soils were shifted upwards in between the slightly acidic and the slightly alkaline soils (Figure 1). This suggests a general increase of pHs after treatments. For example, in the locality of Santa, a pH (= 4.60) of a control T05 increases to pH (= 4.80 and = 4.90) corresponding to treated soils T15, T45 and T25, T35, respectively. In fact, there is a general positive increase of pHs between +0.10 and +0.98) (Table 3). However, a couple of samples exhibit negative pH variations ([?]pH = - 40 and [?]pH = - 60) on samples T12 (= T02 + 2Kg basalt fines) and T26 (= T06 + 2Kg basalt fines + 2Kg caol fines) in the locality of Bonandale and Batibo, respectively. This implies the potential of these treatments to increase or decrease soil pHs. The organic carbon (OC) and organic matter (OM) also showed variations after the application of different treatments. The trends of fluctuation of OM and OC are parallel throughout all control and treated soils (Figure 2). Some samples exhibit positive [?]OM and [?]OC while other show negative [?]OM and [?]OC (Table 3). This implies that these soils showed increasing or decreasing OC and OM after treated with rock fines +- manure. The highest values of [?]OM (= + 5.11) and [?]OC (= + 4.50) were found on sample T24 (= T04 + 200g fines from pyroclastic bombs) which also showed the highest [?]pH (= + 0.98) and yield index (Yi= 6.13). The second highest Yi (= 4.77) from the sample T44 (= T04 + 200g fines from less vesicular pyroclastic bombs) also exhibit higher [?]pH (= +0.80), [?]OM (= + 3.10) and [?]OC (= +3.30). This suggests that fines from pyroclastic materials increase pH, OM and OC contents in different treatments. This is also observed on treatments with fines from basalt. However negative [?]pH is observed on samples T12 and T26 which were treated with fines from basalt. These samples also showed negative [?]OM and [?]OC. This suggests that a decrease of pH implies as decrease in OM and OC. Regarding other soil nutriments, N contents remained very weak [?] 1.00g/Kg except some higher values between 2.77 and 3.06 g/Kg encountered for sample T15, T25, T35 and T45. These samples were treated with basalt fines + green manure. Then, added N may come from the manure. Na remains unchanged and K values slightly increase to 0.8 - 1.1 meq/100g. However, there is a remarkable high values of Mg and Ca on some samples with treatment of basalt and trachyte fines. This suggest these rocks as a source of Ca and Mg in soils. For P, there is a general increase in relation to the controls in most soil samples after treatment (Figure 4). The highest values of 96.0, 51.5 and 50.9 ppm were found on soils treated mostly with trachyte and limestone, respectively. Higher P contents of 32.7 and 30.1 came from treatments with fines of gneiss and volcanic pyroclastic materials.

CONCLUSION

Fines from different rock types such as basalt, trachyte, volcanic pyroclastic materials in addition to limestone and gneiss applied as fertilizers, indicate a slight increase of pH in all samples in several localities in Cameroon. However there is a remarkable pH increase in a treatment with basalt fines. Then the application of the fines from basaltic rocks may be used to manage the soil acidity. These basalt fines also increase significantly the soil contents in MO, CO, Mg and Ca. There is a good and parallel correlation of MO and CO contents in all treated soils. The higher values of P suggests the application of these rock fines as good potential sources of phosphorus in tropical soils.

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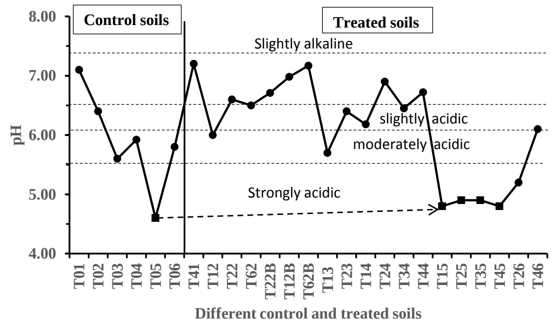
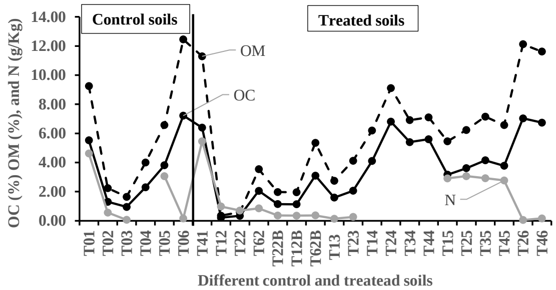

Control soils
Treated soils
Slightly alkaline
slightly acidic
moderately acidic
Strongly acidic
8.00
7.00
6.00
5.00
4.00
pH
T01 T02 T03 T04 T05 T06 T41 T12 T22 T62 T22B T12B T62B T13 T23 T14 T24 T34 T44 T15 T25 T35 T45 T26 T46
Different control and treated soils

Figure 1


Control soils
Treated soils
OM
OC
N
OC (%) OM (%), and N (g/Kg)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
T01
T02
T03
T04
T05
T06
T41
T12
T22
T62
T22B
T12B
T62B
T13
T23
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T46
Different control and treatead soils

Figure 2

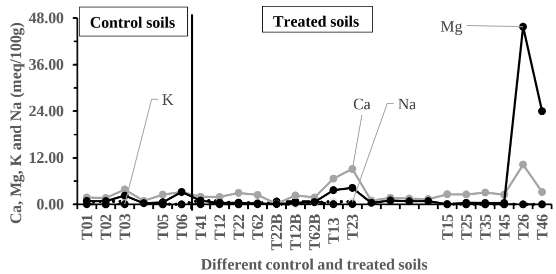
Control soils
Treated soils
Ca, Mg, K and Na (meq/100g)
48.00
36.00
24.00
12.00
0.00
K
Ca
Na
Mg
T01
T02
T03
T05
T06
T41
T12
T22
T62
T22B
T12B
T62B
T13
T23
T15
T25
T35
T45
T26
T46
Different control and treated soils

Figure 3

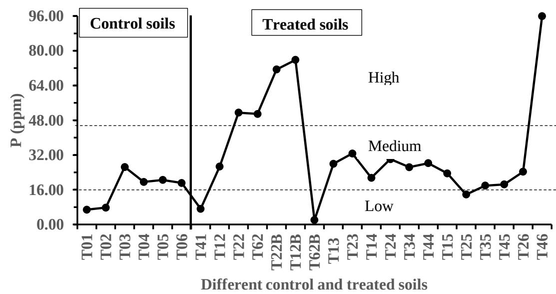

Figure 4

Hosted file

Figure Legends.docx available at https://authorea.com/users/303010/articles/433079-increasing-yields-and-soil-chemical-properties-through-the-application-of-rock-fines-in-tropical-soils-in-the-western-part-of-cameroon-africa

Samples	Soil types	Composition	crop	Yield (Kg/ha)	Yi	Growth Period (months)	Localities (Basement)	Coordinates	
T01	control	Local soil	maize	833	1	3	Foumbot (basalt)	05°32'25"N	10°35'30"E
T41	treated soil	T01 + 600g basalt fines +600g poultry manure		2500	3	3			
T02	control	local soil	maize	3200	1	3	Bonandale (sediments)	04°09"36"N	09°34'34"E
T12	treated soil	T02 + 2Kg basalt fines		5400	1.70	3			
T12B				/	/	6			
T62		T02 + 1Kg limestone fines		4000	1.25	3			
T62B				/	/	6			
T22		T02 + 2kg limestone fines		8300	2.59	3			
T22B				/	/	6			
T03	control	Local soil	maize	4000	1	3	Kalong (gneiss)	04°47'30"N	11°03'53"E
T13	treated soil	T03 + 3Kg basalt fines		8000	2				
T23		T03 + 3Kg gneiss fines		11000	2.75				
T04	control	Local soil	cabbage	2444	1	3	Befang (volcanic pyroclastic materials)	06°20'18"N	10°02'47"E
T14	treated soil	T04 + 200g lapilli fines		3578	1.50				
T24		T04 + 200g fines from pyroclastic bombs		15000	6.13				
T34		T04 + 200g fines from highly vesicular pyroclastic materials		6444	2.63				
T44		T04 + 200g fines from less vesicular pyroclastic materials		11666	4.77				
T05	control	Local soil	carrots	500	1	3	Santa (basalt)	05°47'58"N	10°09'46"E
T15	treated soil	T05 + 1Kg basalt fines		150	0.3				
T25		T05 + 1Kg basalt fines + 10ml LMO		506	1.01				
T35		T05 + 1Kg basalt fines + 10ml LMO + 0.5Kg Tithonia		925	1.85				
T45		T05 + 1Kg basalt fines + 0.5Kg Tithonia		525	1.05				
T06	control	Local soil	potatoes	14815	1	3	Batibo (basalt)	05°45'10"N	09°45'35"E
T26	treated soil	T06 + 2kg basalt fines + 2Kg caol fines		20741	1.4				
T46		T06 + 2kg trachyte fines + 2Kg coal fines		13333	0.89				

LMO: Light Organic Matrix; Yi = Performance Index (= Yield per treatment/Yield per control)

Table 1: Localities of soil samples with their compositions, test crops and yields in the west, centre and littoral regions of Cameroon.

	Control soils						Soils treated with different rock fines ± manure								
	T01	T02	T03	T04	T05	T06	T41	T12	T22	T62	T22B	T12B	T62B	T13	T23
Texture															
Sand	86.00	82.50	18.00		5.00	40.00	83.00	75.00	70.00	77.50	62.00	76.00	75.00	27.00	38.00
Silt	10.00	5.00	24.00		40.00	28.00	13.00	10.00	20.00	15.00	31.00	10.00	10.00	28.00	34.00
Clay	4.00	12.50	58.00		55.00	32.00	4.00	15.00	10.00	7.50	7.00	14.00	15.00	45.00	43.00
	LS	LS	C		SC	CL	LS	SL	SL	C	SL	SL	C	C	C
Soil reaction															
pH water	7.10	6.40	5.60	5.92	4.60	5.80	7.20	6.00	6.60	6.50	6.71	6.98	7.17	5.70	6.40
Organic matter															
CO(%)	5.52	1.30	0.95	2.30	3.81	7.22	6.39	0.21	0.34	2.05	1.14	1.13	3.10	1.59	2.06
MO(%)	9.25	2.24	1.64	4.00	6.57	12.45	11.29	0.35	0.59	3.54	1.97	1.95	5.35	2.74	4.12
N (g/Kg)	4.62	0.56	0.06		3.06	0.16	5.46	0.98	0.70	0.85	0.36	0.35	0.37	0.14	0.26
C/N	11.60	23.00	15.00		12.00		11.62	2.00	5.00	24.00	32.00	32.00	88.00	11.00	9.00
Exchangeable Cations (meq/100g)															
Ca	1.76	1.64	3.84	0.90	2.52	3.20	1.96	1.92	2.96	2.44	0.16	2.32	1.78	6.64	9.12
Mg	0.88	0.84	2.27	0.30	0.52	3.20	0.96	0.40	0.44	0.24	0.08	0.40	0.60	3.67	4.26
K	0.70	0.80	0.73		0.07	0.01	1.08	0.80	0.20	0.62	0.07	0.07	0.45	0.73	0.67
Na	0.04	0.01	0.06		0.02	0.00	0.06	0.04	0.02	0.06	0.76	0.76	0.76	0.04	0.08
Sum of exchangeable bases (meq/100g)															
	3.38	3.29	6.90	1.90	3.13	6.40	4.06	3.16	3.62	3.36	1.07	3.55	3.59	11.08	14.13
Capacity of cationic exchange (meq/100g)															
	7.40	15.00	15.27	22.00	8.80	20.40	8.80	15.20	13.60	14.20	18.25	19.25	19.50	33.18	48.89
Phosphorus Assimilable (ppm) Bray II															
	6.82	7.78	26.48	19.60	20.52	19.13	7.24	26.65	51.50	50.91	71.37	75.80	2.07	27.95	32.70

T01, T02, T03, T04, T05 and T06 are control soils collected in the localities of Foumbot, Bonandale, Kalong, Befang, Santa and Batibo in Cameroon, respectively. Treated soils were collected in the same localities, respectively. T41 = T01 + 600g basalt fines + 600g poultry manure; T12 = T02 + 2Kg basalt fines; T22 = T02 + 2Kg limestone fines; T62 = T02 + 1Kg limestone; T22B = T22 after 06 months of growth period; T12B = T12 after 06 months of growth period; T62B = T62 after 06 months of growth period; T13 = T03 + 3Kg basalt fines; T23 = T03 + 3Kg gneiss fines. Abbreviations: LS = Loamy sand; C = Clay; SC = Silty clay; CL = Clay loam; SL = Silty laom. pHw = pH water. The letter "B" indicates soil samples collected after 06 months of plant growth.

Table 2: Physico-chemical properties of controls and soils treated with different rock fines ± manure collected in different localities in Cameroon.

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Soils treated with different rock fines ± manure (continued)										
	T14	T24	T34	T44	T15	T25	T35	T45	T26	T46
Texture										
Sand					5.00	8.00	6.00	4.00	40.00	39.00
Silt					40.00	34.00	40.00	36.00	25.00	27.00
Clay					55.00	58.00	54.00	60.00	35.00	34.00
					SC	SC	SC	C	CL	CL
Soil reaction										
pH water	6.18	6.90	6.45	6.72	4.80	4.90	4.90	4.80	5.20	6.10
Organic matter										
CO %	4.10	6.80	5.40	5.60	3.16	3.61	4.15	3.77	7.03	6.74
MO %	6.20	9.11	6.91	7.10	5.45	6.23	7.15	6.57	12.12	11.62
N (g/Kg)					2.91	3.06	2.92	2.77	0.05	0.16
C/N					11.00	12.00	14.00	14.00		
Exchangeable Cations (meq/100g)										
Ca	0.96	1.70	1.50	1.36	2.60	2.56	3.04	2.54	10.24	3.20
Mg	0.40	1.02	0.81	0.86	0.03	0.42	0.36	0.36	45.76	24.00
K					0.07	0.09	0.09	0.07	0.01	0.01
Na					0.03	0.02	0.02	0.02	0.01	0.00
Sum of exchangeable bases (meq/100g)										
	2.07	3.64	3.09	2.94	3.08	3.09	3.51	2.99	56.00	27.20
Capacity of cationic exchange (meq/100g)										
	23.00	28.00	24.40	23.60	10.70	8.80	8.80	8.80	24.16	21.20
Phosphorus Assimilable (ppm) Bray II										
	21.49	30.11	26.38	28.25	23.56	13.82	17.90	18.45	24.30	95.96

T14 = T04 + 200g lapilli; T24 = T04 + 200g fines from volcanic pyroclastic materials; T34 = T04 + 200g highly vesicular pyroclastic materials; T44 = T04 + 200g fines from less vesicular pyroclastic materials; T15 = T05 + 1Kg basalt fines ; T25 = T05 + 1Kg basalt fines + 10ml LMO (Light Organic Material); T35 = T05 + 1Kg basalt fines + 0.5Kg green manure (Tithonia); T45 = T05 + 1Kg basalt fines + 0.5Kg green manure; T26 = T06 + 2Kg basat fines + 0.75Kg green manure; T46 = T06 + 2Kg trachyte fines + 0.75Kg green manure. Abbreviations: LS = Loamy sand; C = Clay; SC = Silty clay; CL = Clay loam; SL = Silty laom. pHw = pH water

Table 2 (continued): Physico-chemical properties of controls and soils treated with different rock fines ± manure collected in different localities in Cameroon.

	T41	T12	T22	T62	T22B	T12B	T62B	T13	T23	T14	T24	T34	T44	T15	T25	T35	T45	T26	T46
ΔpH	+0.10	-0.40	+0.20	+0.10	+0.31	+0.58	+0.77	+0.10	+0.80	+0.26	+0.98	+0.53	+0.80	+0.20	+0.30	+0.30	+0.20	-0.60	+0.30
Variation Organic matter																			
ΔOC	+0.87	-1.09	-0.96	+2.05	-0.16	-0.17	+1.8	+0.64	+1.11	+1.80	+4.50	+3.10	+3.30	-0.65	-0.20	+0.34	-0.04	-0.19	-0.48
ΔOM	+2.04	-1.89	-1.65	+1.30	-0.27	-0.29	+3.11	+1.10	+2.48	+2.20	+5.11	+2.91	+3.10	-1.12	-0.34	+0.58	0.00	-0.33	-0.83
ΔN	+0.84	+0.42	+0.14	+0.29	-0.20	-0.21	-0.19	+0.08	+0.20					-0.15	0.00	-0.14	-0.29	-0.11	0.00
Variation Exchangeable cations																			
ΔK	+0.38	0.00	-0.60	-0.18	-0.73	-0.73	-0.35	0.00	-0.06					0.00	+0.02	+0.02	0.00	0.00	0.00
ΔNa	+0.02	+0.03	+0.01	+0.05	+0.75	+0.75	+0.75	-0.02	+0.02					+0.01	0.00	0.00	0.00	0.00	0.00
ΔCa	+0.20	+0.28	+1.32	+0.80	-1.48	+0.68	+0.14	+2.80	+5.28	+0.06	+0.80	+0.60	+0.46	+0.08	+2.55	+0.52	+0.02	+7.04	0.00
ΔMg	+0.08	-0.44	-0.40	-0.60	-0.76	-0.44	-0.24	+1.40	+1.99	+0.10	+0.72	+0.51	+0.56	-0.49	-0.10	-0.16	-0.16	+42.56	+20.80
Variation Assimilable Phosphorus																			
ΔP	+0.42	+18.87	+43.72	+43.13	+63.59	+68.02	-5.71	+1.47	+6.22	+1.89	+10.51	+6.78	+8.65	+3.04	-6.70	-2.62	-2.07	+5.17	+76.83

Δ: Difference between 02 values. T41 = T01 + 600g basalt fines + 600g poultry manure; T12 = T02 + 2Kg basalt fines; T22 = T02 + 2Kg limestone fines; T62 = T02 + 1Kg limestone; T22B = T22 after 06 months of growth period; T12B = T12 after 06 months of growth period; T62B = T62 after 06 months of growth period; T13 = T03 + 3Kg basalt fines; T23 = T03 + 3Kg gneiss fines; T14 = T04 + 200g lapilli; T24 = T04 + 200g fines from volcanic pyroclastic materials; T34 = T04 + 200g highly vesicular pyroclastic materials; T44 = T04 + 200g fines from less vesicular pyroclastic materials; T15 = T05 + 1Kg basalt fines ; T25 = T05 + 1Kg basalt fines + 10ml LMO (Light Organic Material); T35 = T05 + 1Kg basalt fines + 0.5Kg green manure (Tithonia); T45 = T05 + 1Kg basalt fines + 0.5Kg green manure; T26 = T06 + 2Kg basalt fines + 0.75Kg green manure; T46 = T06 + 2Kg trachyte fines + 0.75Kg green manure (Tithonia);. Tithonia = Tithonia diversifolia

Table 3: Variation of the chemical parameters between controls and treated soils collected in the different localities of Cameroon.