Asian Journal of Soil Science and Plant Nutrition

Volume 8, Issue 4, Page 16-33, 2022; Article no.AJSSPN.95869
ISSN: 2456-9682

Effect of Micaschist Powder in Sugarcane (*Saccharum officinarum*) Farming on Ferrallitic Soils of Mbandjock (Cameroon, Central Africa)

Arliane Nicole Tchekambou Tetchou [a*], Josiane Demlabin Sonmo [b], Armanda Nguiffo [b], Jean Pierre Tchouankoue [b], Jean Pierre Nguetnkam [a] and Suzi Huff Theodoro [c]

[a] *Department of Earth Sciences, University of Ngaoundere, P.O. Box 454 Ngaoundere, 7 Cameroon.*
[b] *Department of Earth Sciences, University of Yaounde I, P.O. Box 812 Yaounde, Cameroon.*
[c] *Postgraduate Program at Environmental and Rural Development, University of Brasilia, Brazil.*

Authors' contributions

This work was carried out in collaboration among all authors. Authors ANTT, JPT and JPN did conceptualization, investigated the work and wrote and prepared the original draft of the manuscript. Authors JPT and JPN supervised the study. Authors JDS, AN and SHT wrote, reviewed and edited the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJSSPN/2022/v8i4165

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/95869

Original Research Article

Received: 28/10/2022
Accepted: 30/12/2022
Published: 30/12/2022

ABSTRACT

This study evaluates the fertilizing potential of micaschist powder in sugarcane farming on ferrallitic soils of the Mbandjok area in Cameroon. These soils are poor in exchangeable cations and assimil able phosphorus, very acidic, with low to moderate CEC. An experimental design, which consisted

**Corresponding author: Email: arianetetch@yahoo.fr;*

in a randomized Fischer block, is composed of six replications of five treatments:T0: conventional fertilization (Ureemulticote 39 00, 150 kg ha^{-1}; MAP, 125kg ha^{-1}; KCl,250kg ha^{-1}) T0-M1: T0 + 5 t ha^{-1}of Micaschist powder, T0-M2: T0 + 7 t ha^{-1}of Micaschist powder, NP-M1:N and P supply, conventional dose (no KCl) + 5 t ha^{-1}of Micaschist powder, N-M2: N supply, conventional dose (no P and K) + 7 t ha^{-1}of Micaschist powder. The experiment was carried out between October 2015 and February 2019. During this period, soil samples were collected, sugarcane was planted and monitored with great care in order to determine the parameters indicative of the growth and yield of sugarcane plants. The results indicate an important increase of the sugarcane yield during the three years of experiment, on soils where micaschist powder was added, compared to the control. Concerning the percentage of lift and voids, the T0-M1 treatment had 3% of voids compared to the T0 (9%) treatment which is the reference fertilizer; for Tillers parameter, T0-M1 (338 stems) performs very well during the experiment compared to the T0 (297stems) and for the growth parameter, T0-M1 treatment was good increasing from 182 cm in the first year to 280 cm in the second year. This suggests that micaschist powder has a positive and significant effect on the growth components. For the yield of sugarcane, the best result of tons of sugarcane (TC) was obtained with T0-M1 treatment which increased from 77.15 TC ha^{-1} in the first year to 86.13TC ha^{-1} in the third year**.** The overall results indicate that using micaschist powder as fertilizer can enhance sugar cane yield with a long lasting residual effect of rock powder.

Keywords: Cameroon; Ferrallitic soils; rock powder; sugar cane; sustainable development.

1. INTRODUCTION

Agriculture is one of the pillars of a country's economy and the basis of all food production. However, advanced soil degradation has led many farmers to turn to the use of manures (most of which are in short supply) and chemical fertilizers (their high cost, their availability and their quality are real obstacles to the development of agricultural sector) [1]. In view of these facts, it is important to think of ways and means to overcome these difficulties. Therefore, research was carried out in view to identify and characterize locally available natural fertilizers, such as rocks which can be easily used and at low cost [2-5]. In fact, using rock fertilizers may become an advantageous economic and environmental solution for fertilizing impoverished soils of tropical regions [6,7,8]. It does not require concentration processes and chemical attacks [9]; it may be ready for use (as in the present situation) and production costs are minimal (extraction and crushing costs when needed, will not exceed US$ 10 per ton) [2,4,10]. The technology of rock fertilizers is widely developed in countries such as Brazil, China and Australia [11-16]. In addition, it has been noted that regions covered by recent volcanic rocks are excellence areas of intensive farming. The largest plantations of banana and palm oil are found in the Southern continental part of the Cameroon Volcanic Line, proof that the soils derived from these rock types are naturally very fertile. Nevertheless, more than 60 % of the Cameroon territory is made of ferrallitic soils developed on acidic Precambrian rocks (e.g. [17]. Several field experiments with very satisfactory results have been conducted on the use of rock powder to increase the fertility of these soils (e.g. [18,19,20]).

In this work, micaschists that form large outcrops in South Cameroun (Mbalmayo, Ayos, Bengbis) are tested as rock fertilizer in sugarcane farming on ferrallitic soils of the Mbandjock area, with the aim of evaluating their potential in the increase of sugarcane yield. To carry out this work, physical and chemical parameters of the petrofertilizer and of the experimental soil will be determined, the monitoring of the response of the different treatments on the growth and yield of the sugarcane will be done in order to know which treatment is the most suitable for the sugarcane crop.

2. GEOGRAPHICAL AND GEOLOGICAL SETTINGS

Micaschists samples were collected in a quarry (N03°30’14’’- E11°30’38’’) in the city of Mbalmayo seated on low grade metamorphic rocks which form the southern end of the Yaounde group of Neoproterozoic age, near to the contact with the Congo craton (Fig. 1).

The singularity of low-grade metamorphic rocks to which belongs the Mbalmayo micaschists is due to their position as a nappe straddling the Congo Craton [21,22] and a large E-W extension (over 300km). Geologically, the Mbandjock locality belongs to the Yaoundé group. Its substratum is composed of metamorphic rocks (gneisses, quartzite).

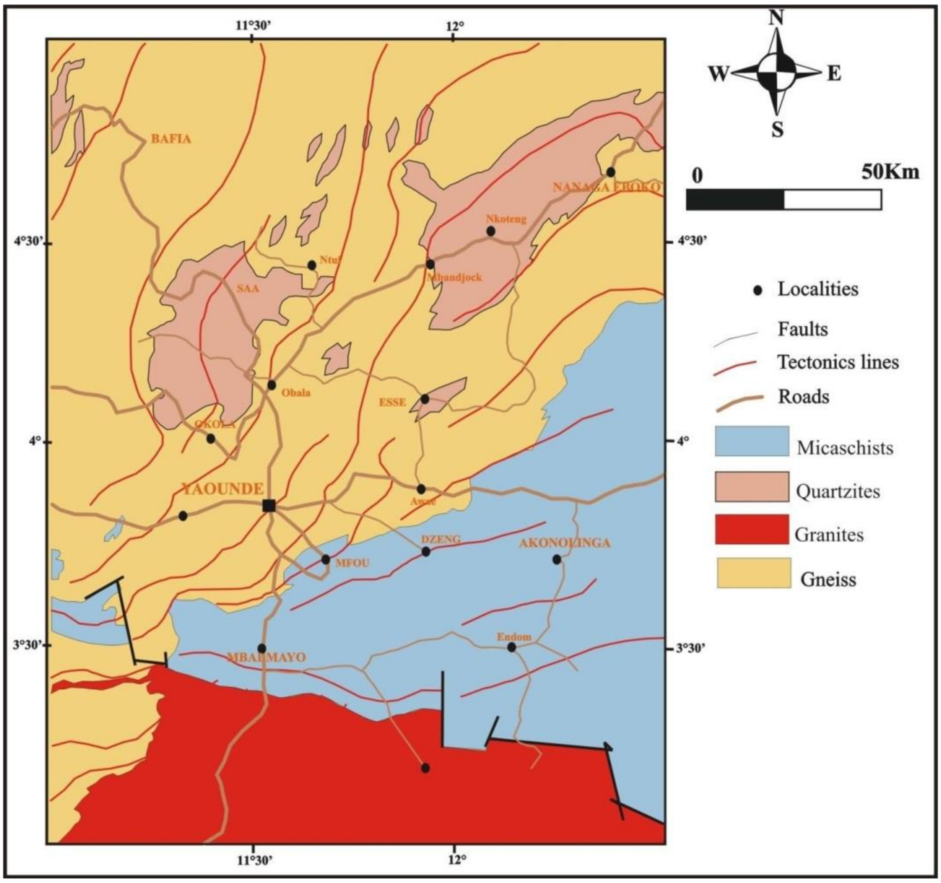
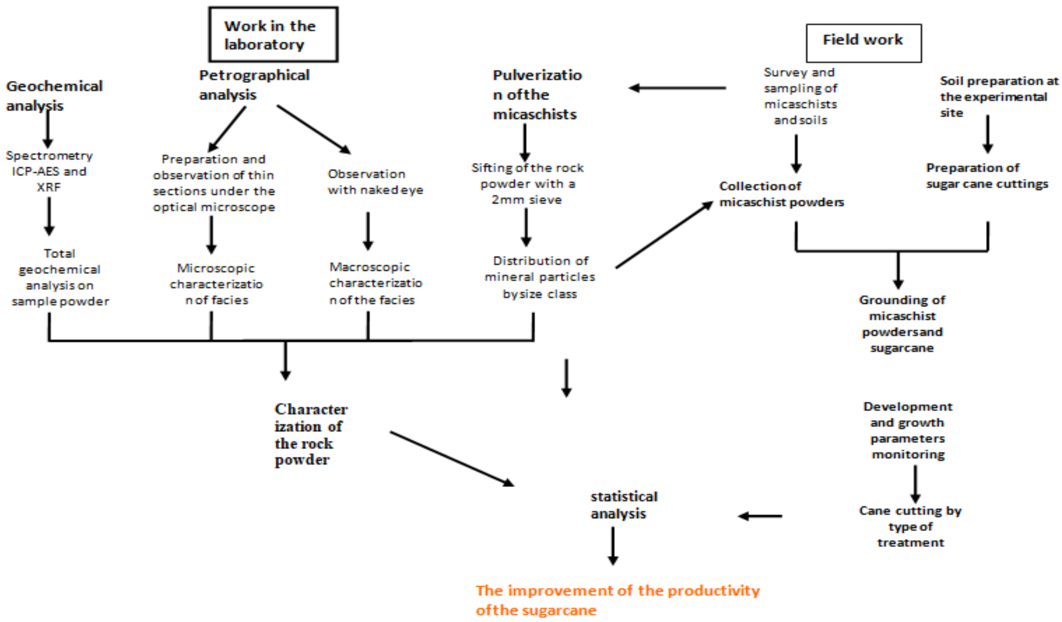


Fig. 1. Geological map of Mbalmayo and Mbandjock

3. MATERIALS

3.1 Flow Chart

The flow chart gives a general idea of the work that will be done in the field and in the laboratory



3.2 Site and Experimental Design

The experimental site is located in a commercial sugarcane farm of the Societé Sucrière du Cameroun (SOSUCAM) that extends on 22.485 ha. The experimental design is a randomized Fischer block with six replications. The usable area of the trial is 0.3 ha (64.5 m wide x 64.6 m long) and the entire plot chosen for the trial measures 1 hectare, of which the remainder outside the trial represents protection area (0.7 ha) (Fig. 2).

Five treatments were tested and considered as growth and yield controls in this trial:

- T0: conventional fertilization (Urea MULTICOTE 39 00, 150 kg ha^{-1}; MAP, 125kg ha^{-1}; KCl, 250kg ha^{-1});
- T0-M1: Conventional fertilization + 5T/ha of micaschist powder (Urea MULTICOTE 39 00, 150kg ha^{-1}; MAP, 125kg ha^{-1}; KCl, 250kg ha^{-1}+5000kg ha^{-1});
- T0-M2: Conventional fertilization + 7T/ha of micaschist powder (Urea MULTICOTE 39 00, 150kg ha^{-1}; MAP, 125kg ha^{-1}; KCl, 250kg ha^{-1}+7000kg ha^{-1});
- NP-M1: N and P contributions in classical doses (no KCl) + 5 t ha^{-1} of Micaschist powder (Urea MULTICOTE 39 00, 150kg ha^{-1}; MAP, 125kg ha^{-1} +5000kg ha^{-1});
- N-M2: Nitrogen supply, classic dose (no P or K) + 7 t ha^{-1} of Micaschist powder (Urea MULTICOTE 39 00, 150kgha^{-1} +7000kgha^{-1}).

3.3 Plant Material

The field experiment is carried out on sugarcane (*saccharum officinarum*) variety FR81258 and originating from Guadaloupe (France overseas). The first sowing took place on October 22, 2015. The second and the third sowing was the regrowth and they took place on February 08, 2017 and February 07, 2018 respectively.

3.4 Rock Powder

The rock used is micaschist. It is a metamorphic rock chosen particularly for its considerable content of SiO_2 (60.288), K_2O (2.388%), Na_2O (2.460%), CaO (5.384%) and MgO (4.958%); in addition to a set of micronutrients that are essential for plant nutrition. This rock was collected and crushed in the Mbalmayo quarry.

3.5 Mineral Fertilizers

The mineral fertilizers used in this work (Urea Multicote 39 00, 150kg ha^{-1}; MAP, 125kg ha^{-1};KCl, 250kg ha^{-1}) were provided by SOSUCAM. The fertilization consists in bringing the elements N, P and K in the form of urea for nitrogen (N), MAP (Mono Ammonium Phosphate) for phosphorus and KCl for potassium (K) respectively. The dose and the number of applications (fractioning) vary according to whether the cane is planted in virgin sugarcane or in regrows.

4. METHODS

4.1 Soil Sampling

Soil samples were taken at a depth of 20cm using an auger. They were composite samples taken in a zigzag pattern on each experimental unit and grouped in blocks. They were preserved in polyethylene bags, then dried in the oven for 24 hours at 40°C and finally sieved with a 2mm mesh sieve in order to have the fraction to be analyzed.

4.2 Cane Planting

Planting of the cane consists of three basic steps (Fig. 3): Cutting and transporting the cuttings: cutting is done at the level of the nursery plot. The canes are cut from top to bottom with the straw Selection and care of the cuttings: once transported to the plot, the cuttings are placed in a pile to be planted and then they are thickened by hand and cut into cuttings of three to four eyes. Regularly, Carbamate is carried out on the cuttings to fight against the diseases or the attacks of insects. Distribution and planting: the cuttings are laid out flat in the bottom of the furrow with the eyes placed laterally to encourage the emergence of the young plantlet. The cuttings are planted at a density of four or three-eyed cuttings per linear meter.

4.3 Maintenance of the Cane

Cane maintenance concerns the fight against weeds, fertilization. To fight against weeds, two types of weeding can be carried out: Hand weeding consists of weeding with hoes fitted with long handles between the rows of cane. It is generally done when the degree of weediness is not important; Chemical weeding is based on the use of selective herbicides with a persistence of at least three months. Fertilization is composed of chemical fertilizer and it consists to bring the elements N, P and K.

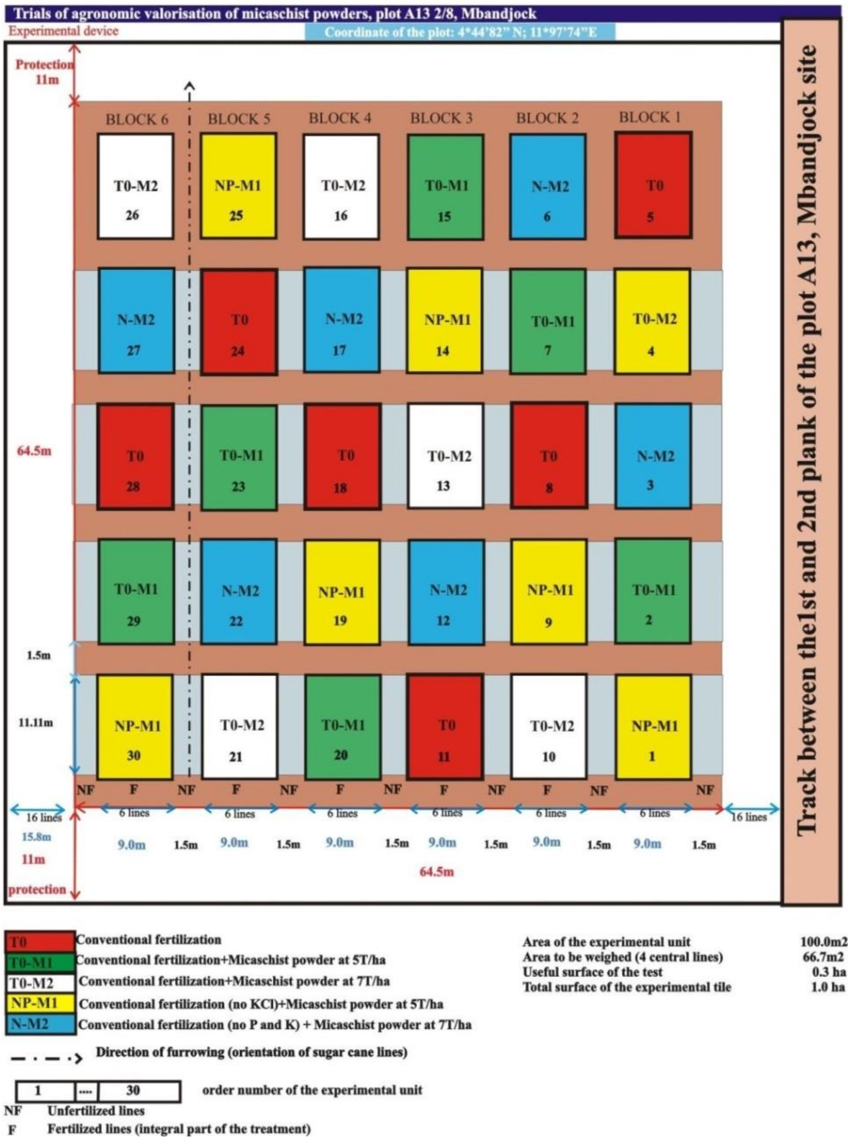


Fig. 2. Experimental set-up of the micaschist powder trial

4.4 Harvest

The three harvests were carried out in a similar way and included: The cutting, preceded by the burning of the plot to be harvested. The cutting is done by hand after having cut and piled up the sugar canes by blocks and by treatment, the machine loaded with dynamo carries and weighs the lots of canes of the whole field Then, these batches are transported by truck to the factory for further analysis The experimentation was rigorously followed in order to avoid inconveniences related to environmental factors. The following agronomic monitoring parameters were taken into account as controls for sugar cane growth and yield: The growth rate of the cane every 2 weeks just for the virgin cane Lifts of sugar cane at 1.5 and 2 months; Tillering at 3, 4.5 and 6 months; Growth from 2 months and every month until 8 months of age or even 10 months if we observe that the cane continues to grow; Diameter measurements from 4 to 5 months until the end of the growth (8-10 months); Weighing of the cane from each plot directly after cutting to assess agricultural yield. Only the four center rows were weighed while the two extreme rows were discarded to limit edge effects and any possible interaction. Weighing was done using an electronic dynamometer attached to a grapple hooked to a tractor. Crop data were analyzed using Excel and ANOVA to highlight differences and benefits induced by one treatment or another.

Fig. 3. Few steps of experimentation. a) Weighing of rock powder, b and e) Spreading of rock powder, c and d) planting the cuttings, f) burning of the plot and piled up the sugar cane by blocks and by treatment, g) the machine loaded with dynamo carries and weighs the lots of cane

5. RESULTS

5.1 Petrography and Geochemistry

Macroscopically, the rock is massive melanocratic and rough to the touch. At the scale of the sample, the rock is biotite dominant (Ca. 40%) with translucent white quartz and milky white feldspar. Beside these minerals, there are also numerous flakes of bluish muscovite and greenish disthene of millimeter size. Calcite was evidenced only under the microscope.

Whole rock geochemical analysis of micaschist (Table 1) shows the following values for major oxides: SiO_2 (60.28%), Al_2O_3 (15.05%), Fe_2O_3 (7.77%), K_2O (2.39%), MgO (4.96%), P_2O_5 (0.26%), CaO (5.38%), Na_2O (2.46%).

The micaschists of Mbalmayo are strongly acidic (60.28%), aluminous (15.05%), magnesiferous (4.96%), potassic (2.39%), sodic (2.46%) and calcic (5.38%). The sum of oxides of K_2O +MgO+CaO+Na_2O gives us 15.19%.

The field experiment using micaschist powder was carried out on sugarcane. The trial was followed during one cycle of virgin cane (first year) and two cycles of regrowth (second and third year). The first sowings in virgin cane took place on October 22, 2015. The two other sowings in regrowth took place on February 08, 2017 and February 7, 2018 respectively.

Table 1. Geochemistry analysis of micaschist of Mbalmayo

SiO2	TiO2	Al2O3	Fe2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	Cr2O3	NiO	H2O	CO2	LoI	Total
60.288	1.036	15.054	7.774	0.000	0.154	4.958	5.384	2.460	2.388	0.255	0.036	0.010	0.000	0.000	0.138	99.934

Rb	Ba	Sr	Nb	Zr	Hf	Y	Ga	Zn	Cu	Ni	Co	Cr	V	Sc	La	Ce	Nd	Pb	Th	U
72.2	965.5	453.2	9.0	240.0	6.1	26.5	17.3	90.3	29.8	75.6	28.3	249.3	155.6	16.5	21.9	78.5	33.1	4.6	8.5	0.9

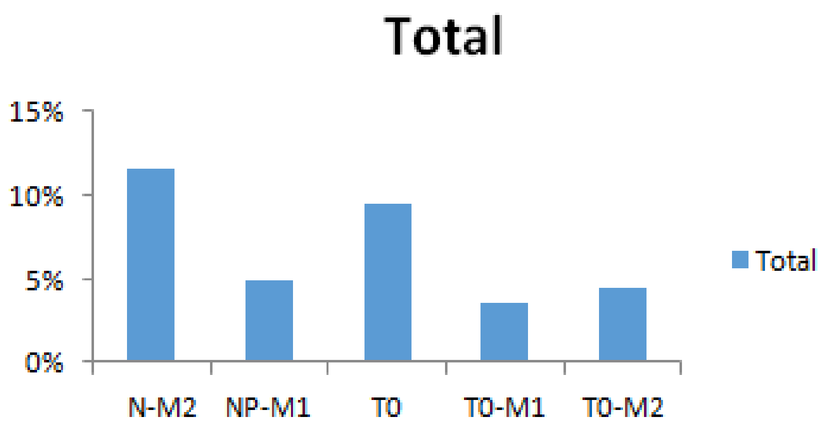


Fig. 4. Lifts and voids

5.2 Lifts and Voids

The average voids were not significant to the whole field. However, the average voids are high in the N- M2 (12%) and T0 (9%) treatments and very low for the T0-M1 plot (3%). In general, we have 7% of voids in the whole cultivable area (Table 2, Fig. 4).

Table 2. Lifts and voids

Line label	Average of % blanks
N-M2	12%
NP-M1	5%
T0	9%
T0-M1	3%
T0-M2	4%
General total	7%

5.3 Growth

In virgin cane (CV), the behavior of the sugarcane of all treatments, from the 2nd to the 5th month, is similar. At this stage, the curve shows that as time goes by, the sugar cane gets bigger. From the 5th to the 9th month, the growth of the sugarcane in the whole field is very appreciable however; the curve (Fig. 5) shows that the growth in the N-M2 treatment is below the average of the others treatments. During the regrowth and based on the different average heights per treatment, the N-M2 treatment plants are the shortest (177.24 cm) followed by the T0 treatment (177.84 cm) and finally the T0-M1 treatment plants (179.58 cm) which are the longest (Table 3).

5.4 Diameter

In virgin cane (CV), from the 5th to the 6th month, the crops of the T0 treatment stand out for their size while those of the other treatments still have a diameter of less than 20 cm. between the 6th and 8th month, we notice a clear evolution of the canes of the whole field. between the 8th and 9th month, the canes of treatments N-M2, NP-M1, T0-M2 do not increase in volume remaining respectively at 20 cm, 22cm, and 21 cm. while the canes of T0-M1 and T0 evolve lightly (from 22 to 23 cm for T0-M1 and from 21 to 22 cm for T0). For the first regrowth (R1), from the 5th to the 8th month, it should be noted here that the N-M2 and NP-M1 treatments that did not perform well in virgin cane are resurfacing. In the last month, the biggest crops are successively those of treatments T0-M1 (20cm), NP-M1, T0 and N-M2 (19cm), T0-M2 (18cm) (Table 4, Fig. 6).

5.5 Tillers

At 2 months, we notice that the N-M2 treatment has fewer tillers compared to the others. At the 3rd month, we note a boom concerning the tillers for all the canes and of all the treatments increased each one of the tillers. From 4 months onwards, there was a sharp decrease in tillers in all treatments. The crops of treatments N-M2, NP-M1 lost more tillers, respectively 24 and 19 tillers and the T0-M1 lost less tillers (4 tillers) (Table 5, Fig. 7).

5.6 Rate of Cane per Hectare

As for the rate of cane per hectare, with the help of Fisher's test that analyzes the differences between the groups, percentages of cane per hectare increase after each harvest and this applies to all treatments. Micaschist dust application showed respectively increases in rate of cane per hectare of 3% and 4% for the T0-M1 treatment. In virgin cane, the most successful treatment was T0-M1 (77.15TC/ha), followed by T0 (74.99TC/ha), T0-M2 (73.15TC/ha), N-M2 (73.32TC/ha) and finally NP-M1 (66.46TC/ha)). In first growth, T0-M1 (85.8TC/ha) produced the most, followed by T0-M2 (82.7TC/ha), T0 (82.7TC/ha), NP-M1(77.7) and N-M2 (76.9TC/ha). At the second regrowth, T0-M1 (86.13TC/ha) performed best, followed by T0 (84.03TC/ha), T0-M2 (83.93TC/ha), N-M2 (78.99TC/ha) and NP-M1 (77.14TC/ha) (Table 6, Fig. 8).

5.7 Sugar Yield

The percentage of sugar changes in an increasing way during the experiment. Micaschist dust application showed respectively increases in sugar yields of 6% and 9% for the T0-M1 treatment. In virgin cane (CV), T0-M1 (10.84TS/ha) performed best, then T0 (10.24TS/ha) and finally N-M2 (8.8TS/ha). In first regrowth (R1), T0-M1 (11.1TS/ha) is the best, followed by T0 (10.7TS/ha) which remained stable and finally N-M2 (10.6TS/ha) which has relatively increased. At the second regrowth (R2), T0 (11.74TS/ha) performed best followed by T0-M1 (11.64TS/ha) and finally N-M2 (10.77TS/ha). It can be seen that, still using Fisher's test, the T0- M1 treatment has a considerable sugar content followed respectively by T0 and N-M2. (Table 7, Fig. 9)

Table 3. Evolution of sugar cane Growth

Averageof L2			**CV**			**General Total**			**R1**			**General Total**
Line label	**N- M2**	**NP- M1**	**T0**	**T0- M1**	**T0- M2**		**N- M2**	**NP- M1**	**T0**	**T0- M1**	**T0- M2**	
2	11	13	12	13	12	**12**	51	52	55	57	54	**54**
3	17	18	19	18	19	**18**	131	130	140	142	136	**136**
4	22	23	23	23	24	**23**	186	185	184	183	187	**185**
5	28	29	30	31	32	**30**	221	215	214	212	214	**215**
6	51	62	62	58	61	**59**	240	240	239	238	236	**239**
7	83	103	99	99	97	**96**	258	258	257	258	256	**257**
8	119	145	135	139	139	**135**	277	275	273	280	273	**276**
9	162	188	176	182	179	**177**						
General total	**61**	**73**	**69**	**70**	**70**	**69**	**177**	**176**	**177**	**179**	**176**	**177**

Table 4. Evolution of sugar cane diameter

			CV					**R1**				
Average diameter	**N- M2**	**NP-M1**	**T0**	**T0-M1**	**T0-M2**	**Generaltotal**	**N- M2**	**NP-M1**	**T0**	**T0-M1**	**T0-M2**	**General total**
5	18	17	20	17	18	18	20	19	22	21	20	20
6	19	19	20	20	19	19	20	20	20	20	19	20
7	20	21	21	21	20	21	19	19	19	20	18	19
8	20	22	21	22	21	21	20	20	20	21	19	20
9	20	22	22	23	21	22	20	20	20	20	19	20
10							19	19	19	20	18	19
Generaltotal	**20**	**21**	**21**	**21**	**20**	**21**	**20**	**19**	**20**	**20**	**19**	**20**

Table 5. Evolution of sugar cane Tillers

Average ofNber of stems/plots			**Column labels**			
Line label	**N-M2**	**NP-M1**	**T0**	**T0-M1**	**T0-M2**	**Generaltotal**
2,0	250	353	318	345	332	320
3,0	260	373	331	371	345	336
4,4	235	318	275	321	296	288
6,0	211	299	264	317	284	274
General total	**239**	**338**	**297**	**338**	**314**	**305**

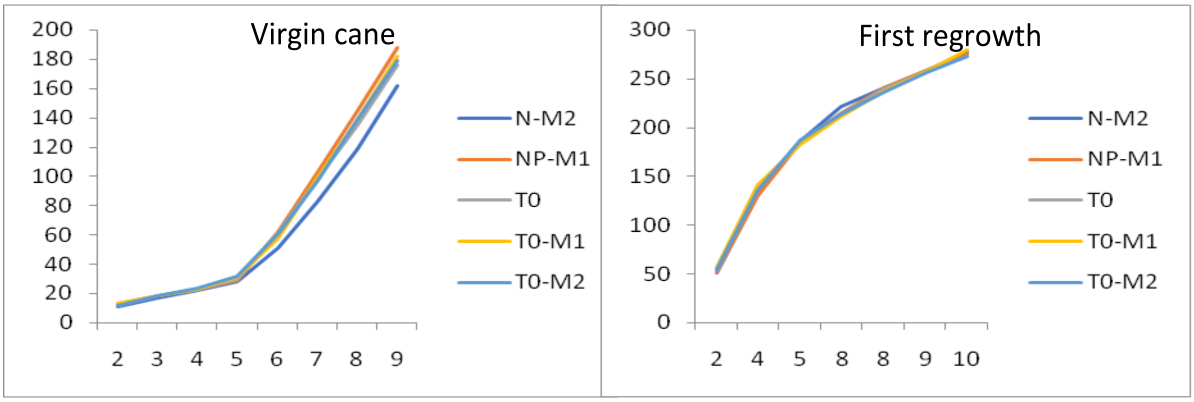


Fig. 5. Evolution of growth by treatment and by campaign

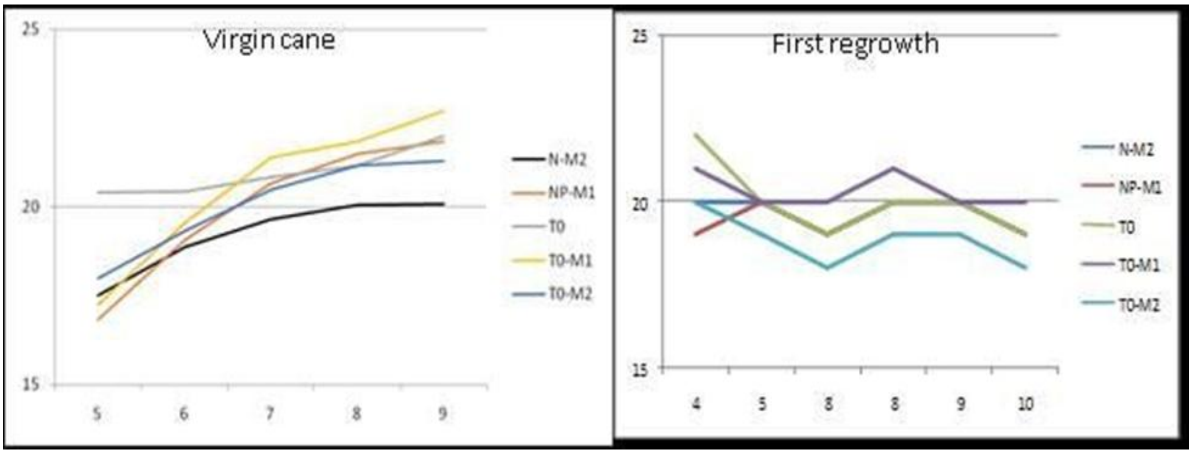


Fig. 6. Evolution of diameter by treatment and by campaign

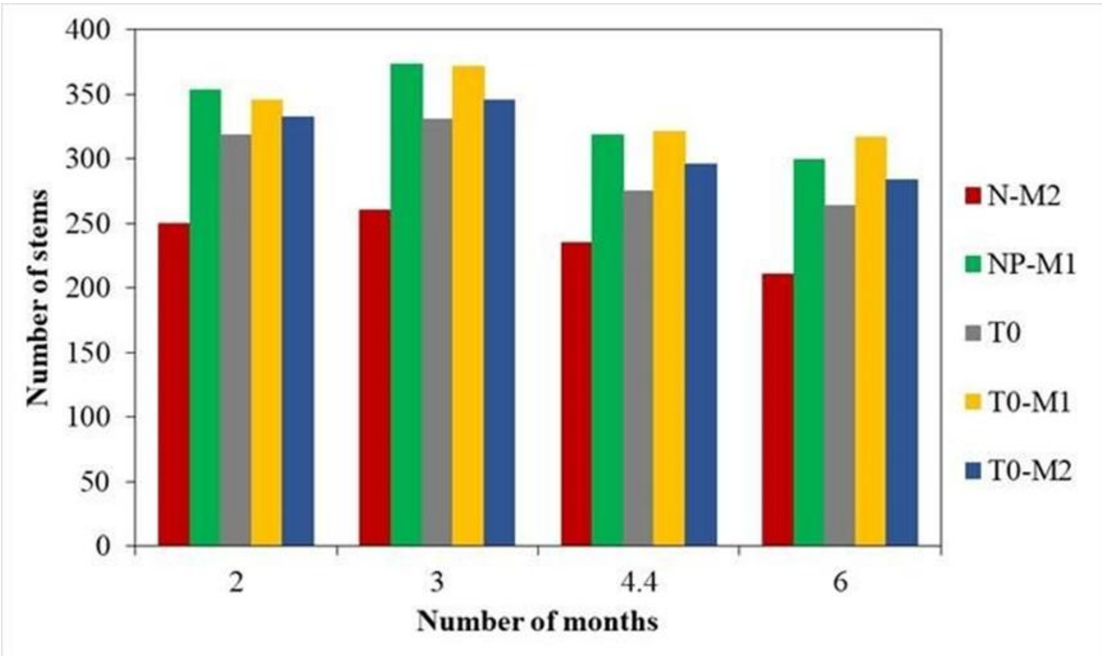


Fig. 7. Evolution of Tillers by treatment

Table 6. Rate of cane per hectare

Cut:		**08/02/17**				**07/02/18**				**14/02/19**		
Age		15.6				12.0				12.2		
		CV				R1				R2		
Treatment	**TC/ha**	**Tc/ha/months**	**ANOVA**	**% Witness**	**TC/ha**	**Tc/ha/months**	**ANOVA**	**% witness**	**TC/ha**	**Tc/ha/months**	**ANOVA**	**% witness**
T0-M1	**77.15**	**5.5**	**B**	**3%**	**85.8**	**6.45**	**A**	**4%**	**86.13**	**7.04**	**A**	**3%**
T0-M2	73.15	5.4	B	-1%	83.7	6.11	AB	1%	83.93	6.86	AB	0%
T0	74.99	5.3	B	0%	82.7	6.27	A	0%	84.03	6.87	AB	0%
NP-M1	66.46	5.0	B	-6%	77.7	5.55	B	-5%	77.14	6.31	B	-8%
N-M2	73.32	4.9	B	-1%	76.9	6.13	AB	-1%	78.99	6.46	AB	-6%
Test F												
Interraction												
C.V	6%				9%				9%			
Average	73.5				81.5				82.1			

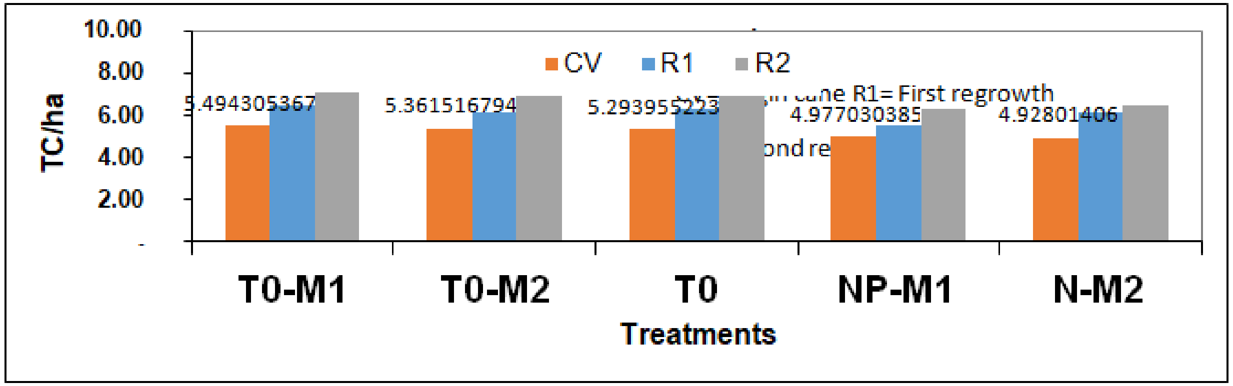


Fig. 8. Evolution of rate of cane per hectare

Table 7. Sugar yield

Cut		**08/02/17**				**07/02/18**				**14/02/19**		
Age		**15.6**				**12.0**				**12.2**		
		CV				**R1**				**R2**		
Treatment	**TS/ha**	**Ts/ha/months**	**ANOVA**	**% witness**	**TS/ha**	**Ts/ha/months**	**ANOVA**	**% witness**	**TS/ha**	**Ts/ha/months**	**ANOVA**	**% witness**
T0-M1	**10.84**	**0.89**	**A**	**6%**	**11.1**	**0.91**	**A**	**9%**	**11.91**	**0.99**	**A**	**+2%**
T0-M2	9.76	0.67	AB	-3%	10.5	0.82	B	-5%	11.66	0.95	A	-1%
T0	10.24	0.77	AB	0%	10.7	0.87	AB	0%	11.74	0.96	A	0%
NP-M1	8.98	0.62	BC	-5%	9.7	0.75	C	-12%	10.45	0.85	B	-11%
N-M2	8.8	0.56	C	-9%	10.6	0.86	AB	-1%	10.77	0.88	AB	-8%
Test F Interraction	NS											
C.V	8%				8%				9%			
Average	10.06				10.1				11.26			

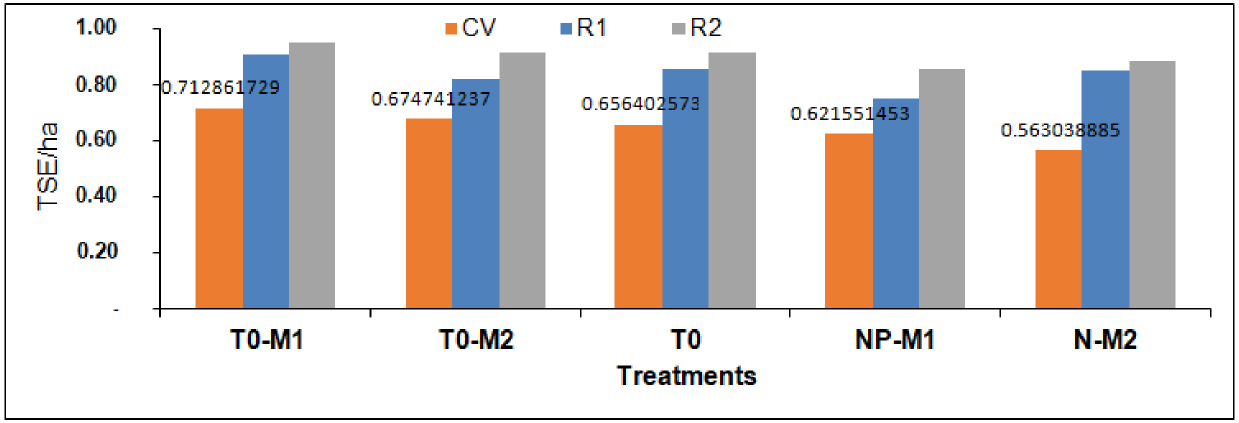


Fig. 9. Evolution of sugar yield

Table 8. Extracted sugar

Cut	08/02/17			07/02/18			14/02/19		
Age	15.6 CV			12.0 R1			12.2 R2		
Treatment	SE%C	%witness		SE%C	ANOVA	% witness	SE%C	ANOVA	% witness
T0-M1	**13.0**	**A**	**5%**	**14.05**	**A**	**3%**	**14.53**	**A**	**+3%**
T0-M2	12.6	A	2%	13.36	B	-2%	13.90	**A**	-1%
T0	12.4	A	0%	13.65	AB	0%	13.98	A	0%
NP-M1	12.5	A	1%	13.50	AB	-1%	13.59	A	-3%
N-M2	11.4	B	-8%	13.88	AB	2%	13.65	A	-2%
Test F									
Interraction									
C.V	6.9			4%			6%		
Average	9.7			13.69			13.73		

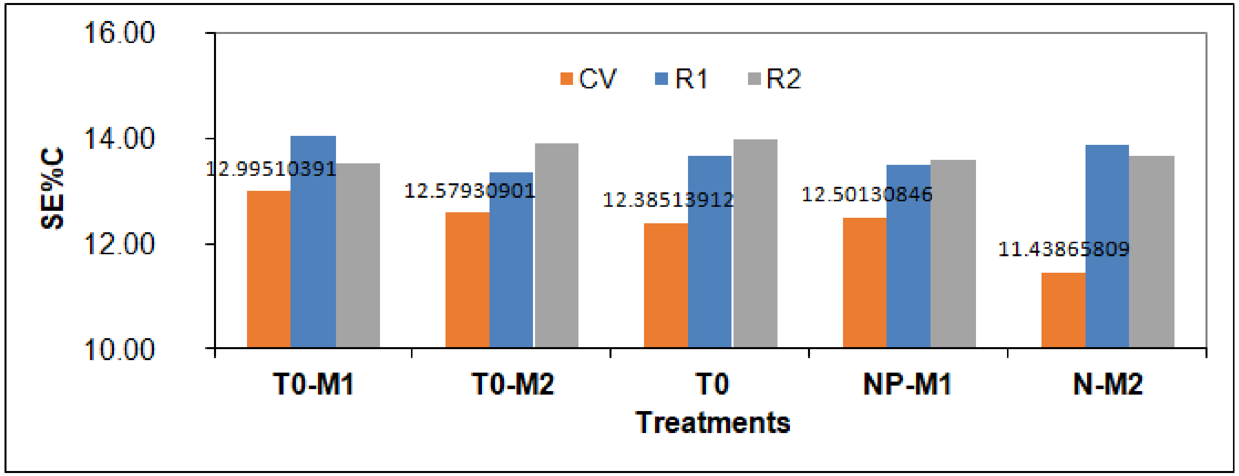


Fig. 10. Evolution of extracted sugar

5.8 Extracted Sugar

The percentage of sugar extracted during the experiment will rise and fall for the T0-M1 treatment from 13.01SE%C in virgin cane to 14.05SE%C in the first regrowth and falls again to 13.53SE%C in the second regrowth. The percentage of sugar for the T0 treatment goes from 12.4SE%C in virgin cane, increases in the first regrowth (13.65SE%C) and continues to increase until it reaches 13.98SE%C in the second regrowth. The N-M2 treatment increases as the experiment progresses. The sugar percentage for this treatment increases from 11.4SE%C in virgin cane, then increases to 13.88SE%C in the first growth and decreases slightly (13.65SE%C) in the second growth. Micaschist dust application showed increases in extracted sugarcane of 5% and 3% for the T0-M1 treatment. (Table 8, Fig. 10).

6. DISCUSSION

6.1 Micaschist Petrology

Microscopic study shows that the micaschists of Mbalmayo contain biotite (which releases magnesium, potassium), muscovite (releases potassium), orthoclase (releases potassium), calcite (releases Calcium) and quartz. When these nutritive elements (Mg, P, and K) are released into the soil, they promote the rapid growth of plants [23,24,25,26]. Analyses of the geochemical data of micaschist powder from Mbalmayo show some essential macronutrients for plant nutrition such as K_2O (2.39%), MgO (4.96%), P_2O_5 (0.26%), CaO (5.38%), Na_2O (2.46%). All this demonstrates that micaschist powder can be used as a fertilizer to enhance or regenerate the fertility of the soils, which has already lost part of its nutrients by leaching processes. In addition, the use of these materials, added to soils with different granulometric ranges, could change their physical restructuring [27,28] and brings benefits to the increase of biological activity in the rhizosphere as well [29].

6.2 Growth Components

There is no significant difference in the result of growth and diameter for all the treatments in this study. It seems that quantity and quality of fertilizer used during the experiment had almost the same effect on sugarcane growth and diameter. In this paper, the treatments used affect the percentages of lifts and tillers. The T0-M1 treatment had 3% of voids compared to the T0 (9%) treatment which is the reference fertilizer. For the population of sugarcane (Tillers), the crops of treatments N-M2, NP-M1 lost more tillers, respectively 24 and 19 tillers and the T0-M1 lost less tillers (4 tillers), means that T0-M1(338 stems) performs very well during the experiment compared to the T0 (297 stems). The same result has been obtained by Priyono et al. [26] and Crusciol et al. [25] who used silicate rocks in sugarcane culture. According to Priyono et al. [26], the percentage of germinating seed buds was significantly affected by the application of different fertilizer package. However, for the same parameters (Growth, diameter) the T0-M1 treatment is slightly better than the others. Rock fertilizer mixed with conventional fertilizer gives very good results.

The treatment with rock powder (N-M2) shows more and more considerable evolution towards the end of the experiment, suggesting that the elements contained in the rock fertilizer are progressively released and stay several years in the soil before being renewed. This shows that applications of this input to the soil can be spaced more widely [1], since soil regeneration occurs over time as the nutrients from the rocks and the soils react with the intermediation of the regenerated biota.

The T0 treatment is considered as a control treatment and behaves well but much less than the combined treatment of rock fertilizer with conventional fertilizer. These results obtained corroborate well with those obtained by Leonardo and Theodoro [30] and Ramos et al. [4].

Leonardos and Theodoro [30] showed the results of a comparative study on the effects of using ground meal rock (stonemeal), soluble fertilizers (NPK) and the mixture of both for the growth of eucalyptus trees over more than 10 years. According to the authors, crushed rock + NPK showed better germination and growth results. Theodoro and Leonardos [7] suggested that mixtures of NPK with crushed rocks could become a transition mechanism from the conventional model to a more sustainable production model.

6.3 Sugar Yield

Considering the N-M2 treatment; it is clear that micaschist powder brings nutritive elements that plants need for growing. Concerning the rate

Table 9. Comparative data on the effects of rock powder (N-M2), soluble fertilizers (NPK) and the mixture of both on the yield (T0-M1)

Treatment / Time(years)	1	2	3
T0-M1	85.8	77.15	86.13
T0	82.7	74.99	84.03
N-M2	76.9	73.32	78.99

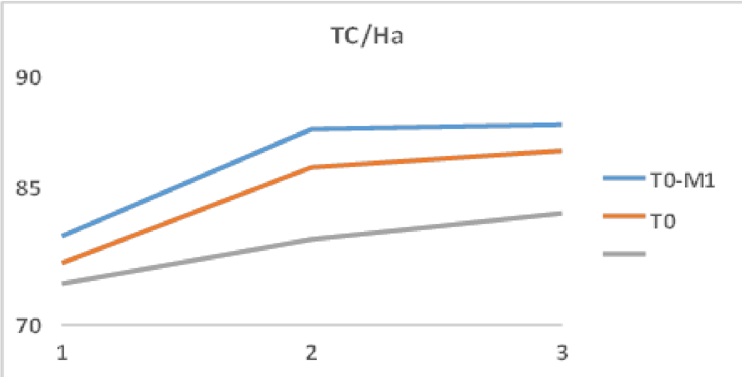


Fig. 11. Effects of rock powder, soluble fertilizers (NPK) and the mixture of both on the yield

of cane per hectare (Table 9, Fig. 11), N-M2 treatment performs very well during this study passing from 73.32TC/ha in virgin cane to 78.99TC/ha in second regrowth. Silverol et al., [31], used rock dust instead of synthetic fertilization for maize, found that rock dust treatments provided adequate crop development results compared to that provided by the control, but rock dust was inferior to inorganic fertilization, probably due to higher fertilizer solubility, thus highlighting the importance of long-term rock dust use [4].

According to Theodoro et al. [32], maize and bean crops showed improvements in yield of approximately 20% in both grain crops and in tuber yield by approximately 30%. Similarly, Tarumoto [33] applied basalt rock dust on sugar cane and found that sugarcane yield improved by up to 9.2 and 9.1% in the first and second year respectively. In this work, micaschist dust application showed increases in sugar yields of 6% in the first year and 9% in the second year for the T0-M1 treatment.

7. CONCLUSIONS

The main conclusions of this study can be summarized as follows:

- Micaschist powder contains essential macro and micronutrients for plant nutrition;
- The use of micaschist powder significantly increases the growth and yield of sugarcane;
- Among the treatments used in the present work, T0-M1 has performed very well: it displays best results in growing parameters and yield, compared to the control;
- It was also noted that the mixture of rock fertilizer and chemical fertilizer not only boosts the growth and yield of the plants but also induces a positive and durable effect in the soil.

SOSUCAM's historical average agricultural yield is around 65TC/ha, for sugar yields of about 7TS/ha. In the trial carried out in the present study, T0-M1 treatment agricultural yield is 86.13TC/ha, for sugar yield of about 11.61TS/ha.

Sosucam produces on average 7TS/ha and in the present work, 11.61TS/ha were obtained, corresponding to a significant increase of 4.61TS/ha. In Cameroon, a ton of sugar is about 800,000 francs, which means that when 7TS/ha is marketed, Sosucam obtains an amount of 5,600,000 francs. The marketing of the 11.61TS/ha obtained in the present work will give 9,288,000 francs, indicating a gain of 3,688,000 francs for the company

Micaschist powder is suitable to supply sugarcane requirement and from the second year of planting, the agrominerals, resulting from micaschist powder, can completely replace chemical fertilizer. The overall results indicate that the micaschist powder has a long duration in soil and its fertilizing effects increase with time.

ACKNOWLEDGEMENTS

Authors thank the Société Sucrière du Cameroun (SOSUCAM) for providing land and funds for field experimentation. This work is a part of the PhD thesis of A. N. T. Tetchou.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Manning DA, Theodoro SH. Enabling food security through use of local rocks and minerals. Ext. Ind. Soc. 2020;7(2):480–487. DOI: 10.1016/j.exis.2018.11.002
2. Van Straaten P. Farming with rocks and minerals: challenges and opportunities. Acad. Bras. De Cienc. 2006;78(4):721-730. Available: https://doi.org/10.1590/S00001-376520060004000009
3. Stamford NP, Simoes Neto DE, Freitas ADS, de Oliviera WS, Cruz L. Rock biofertilizer and earthworm compost on sugarcane performance and soil attributes in two consecutive years. Sci. Agric. 2016; 73:29-33. Available:https://doi.org/10.1590/0103-9016-2015-0005
4. Ramos CG, Dalmora AC, Kautzmann RM, Hower J, Dotto GL, Oliveira LFS. Sustainable release of macronutrients to black oat and maize crops from organically- altered dacite rock powder. Natural Resources Research. 2021;30(3): 1941-1953. Available: https://doi.org/10.1007/s11053-021-09862-0
5. Rodrigues M, Everson C, Glaucio Leboso ADS, Silveira A, Renato HF, Roney O, Roberto CA, Marco RN. Estimating technological parameters and stem productivity of sugarcane treated with rock powder using a proximal spectroradiometer. Industrial crops & products. 2022;186. DOI:https://doi.org/10.1016/j.indcrop.2022.115278
6. Leonardos OH, Theodoro SH, Assad ML. Remineralization for sustainable agriculture:A tropical perspective from a Brazilian viewpoint. in:nutrient cycling in agroecosystms. Formerly Fertilizer Research. 2000;56:3–9. Available:https://doi.org/10.1023/A:1009855409700
7. Theodoro SH, Leonardos OH. Sustainable farming with native rocks: the transition without revolution. Anais Acad. Bras. Ciências. 2006;78(4):715–720. Available: https://doi.org/10.1590/S0001-37652006000400007
8. Munsanje. Directly applied Chilembwe phosphate rock for enhanced leaf concentration in Tithonia diversifolia. Unpubl.MSc. thesis, university of Guelph. 2007;194.
9. Ramos CG, Querol X, Oliveira MLS, Pires K, Kautzmann RME, Oliveira LFSA. Preliminary evaluation of volcanic rock powder for application in agriculture as soil a remineralizer. Science of the Total Environment, Amsterdam. 2015;512:371–380.
10. Silva RC, Beneton K, Ieda JC, Azevedo AC, Marcos Gervasio Pereira MG. Use of agromineral as substrate for growth of eucalyptus seedlings. FLORESTA, Curitiba, PR. 2021;52(1):025-034. jan/mar/2022. ISSN eletrônico 1982-4688 DOI:10.5380/rf.v52 i1. 73752
11. Leonardos OH, Fyfe WS, Kronberg BI. The use of ground rocks in laterite systems: an improvement to the use of conventional soluble fertilizers? Chem Geol. 1987; 60:361-370. Available: https://doi.org/10.1016/0009-2541(87)90143-4
12. Silva TR, Cazetta JO, Carlin SD, Telles BR. Drought-induced alterations in the uptake of nitrogen, phosphorus and potassium, and the relation with drought tolerance in sugar cane. Ciênc. agrotec. 2017;41(2). Available: https://doi.org/10.1590/1413-70542017412029416
13. Gillman GP, Buekket DC, Coventry RJ. A laboratory study of application of basalt dust to highly weathered soils: effects ion soil cation chemistry. Austr J. Soil Rest. 2000;39:799-811.
14. Swoboda P, Thomas FD, Martin H. Remineralizing soils? The agricultural usage of silicate rock powders:A review. Sciences of the Total Environment; 2022.

DOI: 10.1016/j.scitotenv.2021.150976

15. Theodoro SH, Leonardos OH. The use of rocks to improve family agriculture in Brazil. An. Acad.Bras.Ciênc. 2006;78:721-730.
Available: https://doi.org/10.1590/S0001-37652006000400008
16. Theodoro SH, Medeiros FP, Ianniruberto M, Jacobson TKB. Soil remineralization and recovery of degraded areas: An experience in the tropical region. J. S. Am. Earth. Sci. 2020;103014.
Available:https://doi.org/10.1016/j.jsames.2020.103014
17. Kamguia Kamani MS, Wang W, Tchouankoue JP, Huang SF, Yomeun B, Xue EK, Lu GM. Neoproterozoic syn-collision magmatism in the Nkondjock region at the northern border of the Congo craton in Cameroon: Geodynamic implications for the Central African orogenic belt Precambrian Research. 2021;353:106015.
DOI: 10.1016/j.precamres.2020.106015
18. Nkouathio D, Wandji P, Bardintzeff JM, Tematio P, Kagou Dongmo A, Tchoua F. Utilisation des roches volcaniques pour la reminéralisation des sols ferralitiques des régions tropicales. Cas des pyroclastites basaltiques du graben de Tombel (Ligne Volcanique du Cameroun). Bull. Soc. Vaud. Sc. Nat. 2007;91(1):1-14.
Available: http://doi.org/10.5169/seals-282141
19. Tchouankoue JP, Tetchou Tchekambou AN, Abossolo Angue M, Ngansop C, Theodoro SH. Rock fertilizers as an alternative to conventional fertilizers: The use of basalt from the Cameroon Volcanic Line for maize farming on ferralitic soils. Geotherapy. 2015;26:445-458.
DOI: 10.1201/b13788-27
20. Fodoue Y, Nguetnkam JP, Tchameni R, Basga SD, Penaye J. Assessment of the Fertilizing effect of Vivianite on the growth and yield of the Bean ‘‘Phaseolus vulgaris’’ on oxisoils from Ngaoundere (central North Cameroon). International Research Journal of earth Sciences. 2015;3(4):18-26.
21. Mvondo H, Owona S, Mvondo Ondoa J, Essono J. Tectonic evolution of the Yaoundé segment of the Neoproterozoic Central Africa Orogenic Belt in southern Cameroon. Canadian Journal of African Earth. 2007;44:433–444.
Available: http://dx.doi.org/10.1139/e06-107
22. Metang V, Nomo N.E, Ganno S, Takodjou WJD, Teme MAE, Teda SAC, Fossi DH, Mbakam NMD, Tchameni R, Nkoumbou C, Nzenti JP. Anatexis of metadiorite from the Yaoundé area, Central African Orogenic Belt in Cameroon: implications on the genesis of in-source granodiorite leucosomes. Arab J Geosci. 2022;15:35.
Available:https://doi.org/10.24018/ejgeo.2022.3.5.321
23. Van Straaten, P. Rocks for crops in the world. Remineralize the Earth Organic Gardening Resource Centre; 2017. Website: www.groworganic.com. Accessed on 08/11/20
24. Ramos LA, Lana RMQ, Korndörfer GH, Da Silva AA. Effect of organo-mineral fertilizer and poultry litter waste on sugarcane yield and some plant and soil chemical properties. Afr. J. Agri. Res. 2017;12:20–27.
DOI: 10.5897/ajar
25. Crusciol CAC, Campos M, Martello JM, JoséAlves C, Nascimento CA, Reis Pereira JC, Cantarella H. Organomineral Fertilizer as Source of P and K for Sugarcane. Scientific report; 2021.
Available: https://doi.org/10.1038/s41598-020-62315-1
26. Priyono J, Sulis Nur Hidayati D, Ikhlas Suhada SG. Silicate Rock-Based Fertilizers Improved the Production of Sugarcane Grown on Udipsamments Kediri, East Java, Indonesia. International Journal of Applied Agricultural Sciences. 2020;6(2):16-20.
DOI: 10.11648/j.ijaas.20200602.11
27. Paz CG, Rodríguez TT, Behan-pelletier VM, Hill SB, Vidal- torrado P, Cooper M. Ferralsols. In: Chesworth W. (eds) Encyclopedia of Soil Science. Encyclopedia of Earth Sciences Series. Springer, Dordrecht; 2008.
28. Martins, Silva, Marchi DRG, Leite G, Martins MCA, De E, Gonçalves, S., Guilherme LRG, ASF. Effect of alternative multinutrientsources on soil chemical properties. Rev. Bras. Ciencia do solo. 2015;39:194-204.
Available:https://doi.org/10.1590/01000683rbcs20150587.
29. Doumer ME, Giacomini SJ, Silveira CAP, Weiler DA, Bastos lM, Freitas lD. Microbial and enzymatic activities in the soil after

application of retorted oil shale. Pesquisa Agropecuária Brasileira. 2011;46:1538-1546.

30. Leonardos OH, Theodoro SCH. Fertilizer tropical soils for sustainable development. In: Proceedings of International workshop on Science for Sustainable development in Latin America and Caribe, Rio de Janeiro; 1999.

31. Silverol AC, Machado, Filho l. Utilização de pó de granito e manto de alteração depiroxenito para fertilização de solos. Revista Brasileira de Agroecologia. 2007; 02(01):703- 707.

32. Theodoro SCH, Tchouankoue JP, Goncalves AO, Leonardos OH, Harper JA. Importância de uma Rede Tecnológica de Rochagem para a Sustentabilidade em Países Tropicais. Revista Brasileira de Geografia Física. 2012;5:1390-1407. 2012; 06:1390-1407

33. Tarumoto MB. Basalt rock in sugarcane grown in ferralsols: changes in soil chemistry, mineralogy, and microbiology and in crop yiel. Thesis submitted to College of Agricultural Sciences, Unesp, Botucatu Campus to obtain the degree of Doctor of Philosophy in Agronomy; 2019.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/95869