Composting cow dung enriched with vivianite (phosphocompost) for agricultural use in the Balaza Lawane locality (Far North, Cameroon).

ABSTRACT

Aims: Soils in the Far North of Cameroon are deficient in organic matter and available phosphorus, making it difficult to intensify agricultural production. This affects the yield of several crops.
Study design: a study was carried out to produce cow dung compost enriched with rock phosphate (Vivianite).
Place and Duration of Study: Balaza Lawane in Far North Region of Cameroon. The sowing was done on January 15, 2021 until 20 april 2021.
Methodology: To this end, we produced 3 organic amendments based on cow dung (a compost and two phospho-composts containing 10 and 20% of vivianite, respectively). Monitoring and chemical characterization of each of the three was carried out. A seed germination test was also carried out.
Results: Physico-chemical analyses reveal that the soil at the Balaza Lawane site has a Sandy clay loam granulometry and an acid pH (6.8); it is low in organic matter and available phosphorus. The monitoring of the amendments showed that the temperature, the pH, and even the moisture content of the amendments changed in the same way over time. The application of vivianite powder improved the nitrogen, potassium, and phosphorus content of the phosphocomposts compared to the compost. Phytotoxicity tests showed that our various amendments had no phytotoxic effects. The 20 and 10% phosphocomposts showed higher germination index than the other treatments (157.33±16.32% and 157.01±15.32% respectively). An analysis of variance revealed a significant difference ($p < 0.05$) threshold.
Conclusion: Compost enriched with 20% vivianite produced more available phosphorus, and showed no phytotoxicity. This phosphocompost is proving to be the most effective crop amendment on Balaza Lawane soil.

Keywords: *monitoring, phytotoxicity, compost, phosphocompost, vivianite, Balaza Lawane, Far North, Cameroon.*

1. INTRODUCTION

Land degradation has been a major concern for environmentalists in recent decades [1]. Land degradation is a major factor constraining agricultural production [2]. The decline in the productive capacity of soils affects the yields of African producers, and is much more noticeable in the arid and semi-arid regions of the continent [3]. According to [4], the degradation of agricultural land in sub-Saharan Africa is a complex phenomenon that combines a reduction in the quantity of nutrients and organic matter in soils, and their physical and biological degradation. The soils of the Far North region of Cameroon, which is located in this part of

Africa, also face this problem. The soils in this region have generally low level of organic matter and nitrogen, as well as low levels of available phosphorus [5].

In this part of the country, as in all others in sub-Saharan Africa, the decline in the fertility of cultivated land is due to the increase in the rural population [4]. Thus, the ever-increasing population and its search for fertile land are putting pressure on natural resources. Added to this is the problem of environmental changes, such as water deficits and temperature variations. There is also salinity and soil deficiency in mineral elements (nitrogen and phosphorus) [6]. A lack of available phosphorus (P) in the soil is one of the most important factors limiting crop development and yield [7]. Added to this is the loss of organic matter and soil acidity due to poor farming practices.

The soils of Far North Cameroon consist largely of Vertisols and tropical ferruginous soils. These types of soil sequester phosphorus, making it unavailable to plants. On vertisols, phosphate ions are adsorbed via cations on clay colloids. Heavy metals such as aluminium, iron and calcium present in these (ferruginous) soils cause phosphorus loss by sequestering the free form in the form of precipitates ($AlPO_4$, $FePO_4$, $CaPO_4$) that cannot be absorbed by plants [8]. Soil poor in organic matter and available phosphorus is a constraint to crop development in this region of the country.

Faced with this situation, the use of chemical fertilizers is generally recommended to increase crop yields. But these fertilizers are not always within the reach of farmers, as they are very expensive for farmers in this part of the country, and failure to control their use (fertilizers) leads to environmental risks [9], such as acidity and a reduction in soil microfauna, pollution of the water table, etc. On top of this, mineral fertilizer has no effect on soil organic matter levels, which fall each year unless regular and consistent inputs of organic fertilizer are made, and are washed away more quickly by heavy rainfall [4]. Faced with this situation, agricultural production needs to focus more on fertilizing the soil by biological means, which will make it possible to achieve high crop yields and sustainable soil health at low cost.

There are several organic ways of increasing agricultural yields. Among these practices, soil fertility can be improved by applying compost as an organic fertilizer. This organic matter contains beneficial compounds that play an important role in improving the physical and chemical properties of the soil, such as increasing soil pores and water retention capacity [10,11]. It also increases pH and improves soil organic matter content [12], total nitrogen content and soil microbial population [13].

The second challenge, which is just as important, is the almost general lack of available phosphorus in these soils. Yet there are sources of phosphorus in Africa, in the form of natural phosphates. In Cameroon, in the locality of Hangloa in the Adamawa region, there is a vivianite deposit. Work by [14], has shown that this rock phosphate can be used to increase agricultural yields. However, these rocks contain high levels of iron and aluminium, leading to phosphorus sequestration, with only a small proportion being available to plants. The use of natural phosphates with low reactivity could be an alternative to soluble phosphate mineral fertilizers if the problem of low solubility is resolved [15]. The solubilization of natural phosphates can be achieved by biological means, such as the use of phosphate-solubilizing microorganisms [16], and the addition of natural phosphate during the composting process. Adding natural phosphates during the composting process produces phosphocomposts, which have the advantage of providing plant-available phosphorus and a source of organic matter for the soil and plants. This is a practical and inexpensive technique for solubilizing rock phosphate.

Deficiencies in available P and organic matter are some of the main factors limiting crop production in Far North Cameroon. A study was conducted in the Balaza Lawane locality in Maroua. The aim of the study was to produce cow dung compost enriched with rock phosphate. Specifically, the aim is to carry out a physico-chemical soil analysis of the Balaza Lawane site, followed by monitoring and physico-chemical characterization of the phosphocomposts, and finally to assess their phytotoxicity.

2. MATERIALS AND METHODS

2.1 Description of the study site

This study was conducted in Sudano-Sahelian Agro ecological Zone of Cameroon. It lies between 8°36" and 12°54" north latitude and 12°30" and 15°42" east longitude. The experimental plot is located at Balaza Lawane (10°66'87" N and 14°42'39" E) in the Maroua 3rd subdivision. It is about 12 Km from the town of Maroua, Cameroon.

2.2 Rock phosphate

The rock phosphate sampled at Hangloa (Adamawa, Cameroon) (Fig. 1) consists of sedimentary formations located between latitudes 7°20 and 7°30 north and longitudes 13°20 and 13°25 easts. It is a vivianite with high solubility and mineralogical composition: Fe_2O_3 (68.72%), P_2O_5 (9.17%): Al_2O_3 (7.72%) and SiO_2 (9.67%) [14]. This rock phosphate is reduced to powder by hammer and then sieved (2 mm mesh sieve) before use.

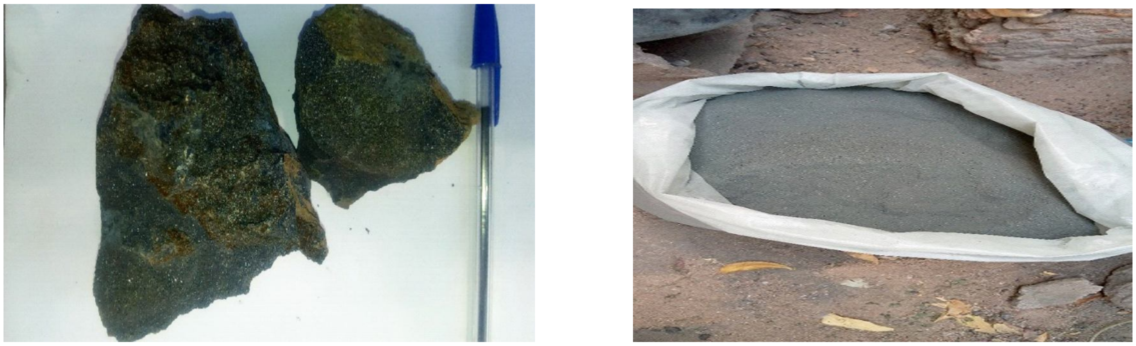

Fig. 1. Rock of Vivianite from Hangloa (A: hard rock, B: rock powder).

2.3 Organic fertilizers

03 types of organic fertilizers were used: mixed compost with vivianite powder at a ratio 1:9, mixed compost with vivianite powder at a ratio 1:8, and no mixed compost. Composting was carried out in 2021 (January-April) at Balaza Lawane. Heap composting method was used [17,18]. Produced compost derived cow dung. 03 types of compost were used.

2.4 Soil preparation for physico-chemical analysis

At the Balaza Lawane site, the soil was sampled at a depth of between 0 and 25 cm. Soil samples were taken from the edges and diagonals of the plot in order to obtain a representative mixture. This quantity of collected soil was mixed to obtain composite samples. After quartering, a quantity of soil (1 kg) was taken for physico-chemical analysis.

2.5 Monitoring changes

The process is monitored by measuring temperature, humidity, and pH. These parameters have been used to monitor the composting process throughout the maturing process over a period of approximately 16 weeks. Temperature and pH are measured using a TenYua 4-in-1 thermometer (humidity, light, pH, and temperature). The measurements are taken weekly, at different points in the pile and at different depths. For the determination of the water content, there was a weekly sampling from each compost heap. A 100 g sample was taken at a rate of 3 per heap and placed in a ventilated dryer at 70°C until a constant dry mass was obtained. Moisture content (MC) is calculated as the difference in mass before and after drying, expressed as a percentage of the original wet mass. The moisture content is determined as follows: MC (%) =100 × (Wm-Dm)/Wm, where Wm= Mass of fresh sample; Dm= Mass of dry sample.

When the soil was ripe, we proceeded to quarter the different amendments, which gave us composite samples (1kg), which we packaged and sent to the Soil Analysis and Environmental Chemistry Research Unit of the FASA (Faculty of Agronomy and Agricultural Sciences) at the University of Dschang. The main analyses carried out on these samples were: organic carbon content (OC); total nitrogen content (Ntot); exchangeable base content (Ca, Mg, K, and Na); cation exchange capacity (CEC); available and total phosphorus content (Bray **II**). The physicochemical parameters included in these amendments were determined following the international methods used in the laboratory of the Research Unit on Soil Analysis and Environmental Chemistry (URASCE) of the University of Dschang, as recommended by [19].

2.6 Phytotoxicity test

The principle is as follows: seeds are placed in a series of Petri dishes soaked with increasing doses of compost extract, together with a control series (without compost extract). The method used in our experiment was that of [20]. An aqueous extract of each amendment was prepared by mixing 80 g of each amendment with 800 mL of distilled water. A liquid/solid ratio of 1:10 (g/L) was maintained. The different mixtures were agitated in a test tube at 180 rpm for two hours and then allowed to settle for a few hours. The supernatant was filtered through a coffee filter. Dilutions were then made of the aqueous extract of each preparation. The different dilutions were 25%, 50%, 75%, and 100% aqueous extract of each amendment in 75%, 50%, 25%, and 0% distilled water respectively. Then 5 ml of each dilution was added to the soya beans (10 beans per compartment as we used Petri dishes divided into 2 compartments) and 5 ml of distilled water for the control treatment. This procedure was repeated three times. The design was a randomized complete block (RCBD). After 72 hours of incubation (Fig. 2), total germination (TG) and germination index (GI) were assessed. The following formula was used to calculate total germination. TG = (number of germinated seeds in each treatment)/(total number of seeds)*100. The germination index was evaluated by combining the percentage of relative seed germination (GR) and the percentage of relative root length (LR). The formula was as follows. Relative seed germination (GR) = (total number of germinated seeds in the sample)/ (total number of germinated seeds in the control)*100. Relative root length (RL) = (sample root length)/(control root length)*100. Germination index (GI) = (GR*LR)/100

Fig. 2. Soybean seeds after 72 hours of incubation.

2.7 Data analysis.

The results were statistically analyzed using the software 'Stratigraphic plus version 5.0', which carried out an analysis of variance (ANOVA) to determine the interactions between the treatments. Duncan's test was used to assess the difference between the means of the treatments. The correlation test was also used to investigate the relationship between the different parameters.

3. RESULTS AND DISCUSSION

3.1 Physico-chemical parameters of the soil at the study site

Table 3 shows the results of the physico-chemical parameters of the soil at the study site. The table shows that the soil has a high sand content (56%), followed by clay (27.5%) and silt (16.5%). Projections onto the granulometry triangle (Fig. 3) reveal that the soil has a Sandy clay loam granulometry.

With regard to the chemical parameters, it also emerges that the soil studied has a pH = 6.8, which means that it is an acid soil. The sum of exchangeable bases is 9.12 meq/100g. The organic carbon content is low at 1.38%; for good agricultural productivity, [21] show that a productive soil should have at least 2.3% organic carbon. This soil is also low in total nitrogen (0.02%), which is less than 1%. The available phosphorus content is low 27.96 mg/Kg, compared to the total phosphorus present in this soil 140.19 mg/Kg.

The soil pH value shows that the soil is slightly acidic. This result is in line with that obtained by [22], who worked on cotton growing in the far north of Cameroon, at Kodek to be precise, where the soil had a pH of 6.8. The Kodek and Balaza Lawane areas border each other, which could explain why the pH levels are so close. The work of [23] and [24], also revealed that the soils in this region are generally acidic. [25] reported that the average pH of soils in the Far North of Cameroon is around 6. This soil acidity may be due to poor soil management and the use of chemical fertilizers, which further contribute to soil acidification. The low level of CEC can be explained by the fact that the soil contains more sand than clay (this soil contains twice as much sand as clay, which is the main element in the soil on which cations are fixed).

The results on the phosphorus content in the soil show that the total P content is five times higher than the available P, which could be explained by the fact that a large proportion of the phosphorus is sequestered by the cations present in the soil, such as aluminium (Al), iron (Fe) and calcium (Ca) [8], and also by the adsorption of phosphate ions via the cations on the clay colloids.

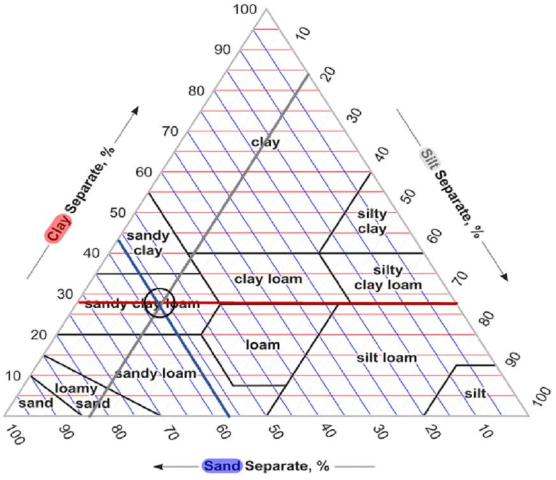

Fig. 3. Projection of soil texture onto the triangle.

Table 1: Physico-chemical characteristics of the soil.

Parameters		Soil
Particle size	clay (%)	27,5
	loam (%)	16,5
	sand (%)	56
pH		6,8
CO (%)		1,38
MO (%)		2,38
Ntot. (%)		0,02
Ca^{2+} (méq/100g)		8,40
Mg (méq/100g)		0,08
K (méq/100g)		0,31
Na (méq/100g)		0,34
S (base sum) (méq/100g)		9,12
CEC (méq/100g)		25,00
P tot. (mg/Kg)		140,19
P av. (mg/Kg)		27,96

pH: hydrogen potential; CO: organic carbon; OM: organic matter; N tot.: total nitrogen; Ca^{2+}: calcium; Mg: magnesium; K: potassium; Na: sodium; CEC: cation exchange capacity; P tot.: total phosphorus; P av.: available phosphorus.

3.2 Changes of temperature

Fig. 4 shows the evolution of temperature over time. This figure shows that the compost and the 10 and 20% phosphocomposts have the same appearance from the beginning to the end of the process (maturation). At the beginning of the process, the temperatures are low (32°C). They then increase over time and reach their maximum on day 28. At this time, the compost and 10% phosphocompost reached temperatures of 70.66±3.05°C and 70.33±3.21°C respectively, and the 20% phosphocompost reached a temperature of 66.66±3.78°C. We then observed a gradual decrease in the temperature of the different piles, which reached 37°C on the 91st day of composting. Furthermore, we observed that the temperature curves of the compost and 10% phosphocompost were slightly higher than those of the 20% phosphocompost throughout the process.

The low temperature values of the phosphorus composts compared with the composts are explained by the natural addition of phosphorus, causing poor oxygen circulation necessary for proper microbial development [26]. The increase in temperature at the beginning of the process is due to the biodegradation of organic matter by mesophilic microorganisms, which attack readily degradable compounds very quickly. As this degradation is exothermic, an increase in temperature is observed. When the temperature exceeds 45°C, thermophilic microorganisms develop to the detriment of mesophilic ones [27], so the degradation of organic matter by the latter releases heat and leads to an increase in temperature that reaches 65 to 70°C (hygienization of the compost). This temperature is within the recommended range for pathogen elimination [28]. Due to the lack of readily biodegradable compounds, microbial activity decreases, leading to a drop in temperature, which reaches 37°C. At this stage, the temperature no longer changes and humification processes take place. The results on the evolution of windrow temperatures are in line with those of [29,30].

Fig. 4. Temperature changes during composting.

3.3 Changes in pH

Fig. 5 shows the evolution of the pH value over time for the different types of soil amendments. For the 3 types of amendments the curves are identical. At the beginning there was a decrease in the pH value during the first 14 days. The pH increased and stabilized at around 7 after day 14. During the whole process, the pH values of the composts were slightly higher than those of the phosphocomposts. On day 91, all amendments had a pH above 7, with the compost and the 10% phosphocompost having the most basic pH values of 7.83±0.53 and 7.66±0.28 respectively, compared to the 20% phosphocompost which had a value of 7.33±0.28.

pH decreases early in composting due to strong microbial activity involved in material degradation during early stages of composting, leading to production and release of organic acids, which acidify [31]. After day 14, the pH increases again due to the consumption of acids and the production of ammonium resulting from the degradation of protein amines during the ammonification process. In addition, it can be used to reduce acidity in soil [32]. The pH values of the composts are slightly higher than those of the phosphocomposts (10% and 20%), which could be due to the fact that the rock powder activates the phosphate-solubilizing microorganisms in the heaps to a greater extent. pH can be used as an indicator of compost maturity and normal pH values are between 7 and 8. Normal pH values are between 7 and 8. Our amendments can therefore be considered to be mature, although pH is not the only parameter for the determination of compost maturity.

Fig. 5. Changes in pH over time

3.4 Moisture content variation

The variation of the moisture content over time is shown in Fig 6. From this figure we can see that the 3 curves show the same trend. At the beginning of the composting process, they are close to 70%, then they gradually decrease to reach final values of less than 40%. It should be noted that the slight increase in the moisture content on days 21 and 35, compared to days 14 and 28 respectively, is due to the addition of water (sprinkling) after the turning (which allows aeration) of the heaps on days 14 and 28. On these dates the samples were taken before the heaps were turned. During the whole process, these values were slightly higher in the compost heaps than in the different phosphocomposts.

The loss of moisture during the composting process can be explained by the production of steam during the decomposing of organic material, which evaporates under the combined action of aeration and high temperatures due to intensive microbial activity, leading to the drying of the compost [33]. The results of the curves are in agreement with the studies of [29].

Fig. 6. Changes in water content over time.

3.5 Physico-chemical parameters

Table 2 shows the agronomic characteristics of the different soil improvers. The table shows that the composition of organic matter (CO, OM, total N and C/N) varies according to the natural phosphate added. The organic carbon content, organic matter and C/N ratio decrease with the addition of rock powder. These parameters decrease with increasing vivianite content in the composts. At the same time, the total nitrogen content increased with the addition of vivianite powder. It increased from 0.63% in the untreated compost to 0.66% and 0.67% in the 10% and 20% phosphocomposts, respectively. The C/N ratio also decreased as a function of natural phosphate dose, from 10.85 in compost to 10.07 and 9.17 in composts receiving 10% and 20% vivianite doses.

This table also shows the nutrient content of the different amendments. The sum of bases (calcium, potassium, sodium, magnesium) increased with the addition of rock phosphate. It increased from 31.75 meq/100 g in the compost without Vivianite to 61.85 and 57.50 meq/100 g in the composts with 10% and 20% Vivianite, respectively. Adding natural phosphate increased the potassium content from 8meq/100g in the untreated compost to 32.61 in the 20% phosphocompost. This content increased as a function of the doses of natural phosphate in the soil improvers. The same logic as for the CEC applies to the variation of the amounts of exchangeable bases in the soil improvers. Their values are almost identical to those of the exchangeable bases, depending on the addition of vivianite powders.

Total and available phosphorus levels increased in the phosphocomposts compared to the compost without additives. They increased from 495.45 mg/kg compost to 1733.79 mg/kg 20% phosphocompost for total phosphorus and from 98.43 mg/kg compost to 345.78 20% phosphocompost for available phosphorus. These phosphorus levels increased with the addition of rock powder. This corresponds to an increase of 193.15 % and 249.94 % respectively for the 10 % and 20 % phosphocompost in relation to the total compost. In terms of available phosphorus, the increases were 194.29% and 251.29% for the 10% and 20% phosphocompost, respectively.

The increase in natural phosphate content in the composts leads to a decrease in organic matter. This could be due to the amount of organic matter added at the beginning of the process, which is higher in the compost (100%) than in the two phosphocomposts (90 and 80%). The loss of carbon thus reflects the intensity of organic matter degradation [34]. The decrease in organic matter content is the result of the mineralization of organic matter by microorganisms that use C for their metabolism. The difference in C/N is explained by the higher nitrogen content in enriched compost compared to unamended compost. The microorganisms present during composting consume more carbon (the main component of organic molecules) than nitrogen [29].

In general, total nutrient concentrations tend to increase in the final product as a result of the concentration effect generated by mass loss, as is the case for total nitrogen [35,36]. Unlike carbon, which undergoes a net loss, nitrogen undergoes less loss due to the partial reorganization of mineralized nitrogen [37]. The final C/N ratio of all our amendments varies between 10 and 15, with values established by different authors [38,39] as an indicator of substrate maturity. Our results are consistent with those of [40], who showed that organic carbon and C/N ratio were higher in compost than in phosphocompost.

The variation in the amounts of exchangeable bases in the soil improvers follows the same logic as the CEC, that is it increases as a function of the natural phosphate doses in the soil improvers. Their values are almost identical to those of the exchangeable bases, depending on the addition of vivianite powders. This could be explained by the release of mineral salts such as phosphorus and ammonium ions by the degradation of organic matter [41]. Conductivity values are higher in phosphocomposts, indicating that they contain large amounts of ions that may be necessary for plant growth [26].

With regard to total and available phosphorus, the addition of vivianite increases total and available phosphorus levels due to the action of organic anions (citrates and oxalates) resulting from the decomposition of OM after a certain degree of humification [42]. Our results confirm those obtained by [43,26,15], who worked respectively on mango residues, the combination of catering waste, household waste, manure and cow dung. They showed that the addition of rock phosphate increased the total and available phosphorus content of phosphocomposts in comparison to composts without natural phosphate additives. [44], also showed that these contents varied according to the dose of natural phosphate that was added.

Table 2: Physico-chemical parameters of compost and phosphocomposts 10 and 20%.

Parameters	Differents amendments		
	C	**PC10**	**PC20**
CO (%)	6,84	6,65	6,15
MO (%)	11,79	11,28	9,40
N tot. (%)	0,63	0,66	0,67
C/N	10,85	10,07	9,17
Ca^{2+} (meq/100g)	10,00	10,00	6,00
Mg (meq/100g)	12,96	25,05	14,40
K (meq/100g)	8,00	23,45	32,61
Na (meq/100g)	0,79	3,36	4,49
S (base sum) (meq/100g)	31,75	61,85	57,50
CEC (meq/100g)	35,00	63,00	58,00
P tot. (mg/Kg)	495,45	1452,43	1733,79
P av.	98,43	289,67	345,78

C: compost, PC10: phosphocompost containing 10% rock phosphate, PC20: phosphocompost containing 20% rock phosphate, pH: hydrogen potential; CO: organic carbon; OM: organic matter; N tot.: total nitrogen; Ca^{2+}: calcium; Mg: magnesium; K: potassium; Na: sodium; CEC: cation exchange capacity; P tot.: total phosphorus; P av.: available phosphorus.

3.6 Germination rate

Fig. 7 shows the germination rate of soya beans as a function of the different aqueous extracts of soil improvers. It shows that the highest rates after 72 hours were obtained in the treatments that received 25% phosphocompost 20 and 10% (93.33±5.57% and 90.00±10% respectively), which were higher than those of the control that received only distilled water (86.66±5.77%). Analyses of variances shows a significant difference (*P* = .05) between treatments. Overall, the 25%, 50% and 75% of the different amendments gave germination rates equal to or greater than 80%, while the 100% dilutions of the aqueous extract of these different amendments had percentages lower than 80%. Soya bean germination was slightly affected by the 100% diluted additions. In the study of [20], the effect of compost on seed germination should be assessed. [45], also showed that the level of toxicity of composts that inhibit seed germination is higher than that of composts that inhibit radicle elongation, so it is necessary to evaluate the germination index taking into account the radicle elongation.

3.7 Germination index

Fig. 8 shows the germination index as a function of the different aqueous extracts of the soybean amendments. It shows that the 25% phosphocompost 10 and 20% had the highest indices (157.01±15.32 and 157.33±16.32% respectively). The lowest germination indices were observed in the 100% amendment dilutions. Analyses of variances shows a significant difference ($P < 0.05$) between treatments. The 50 and 75% dilutions gave intermediate values. It was also observed that the phospho-composts had higher germination indices than the compost, regardless of the extract content. This shows that the composition of the initial substrate can have an effect on the GI. Analysis of variance showed a significant difference at the 5% level. According to the criteria of [20] and [46], based on the percentage of the germination index, none of the three amendments used is phytotoxic. According to these authors, GI values below 50% indicate high phytotoxicity, values between 50% and 80% indicate moderate phytotoxicity and values above 80% indicate no phytotoxicity. If the index exceeds 100%, the compost can be considered a phytonutrient or phytostimulant.

First, the presence of certain nutrients in our soil conditioners resulted in longer radicle development in the treatments receiving them than in the control (distilled water only), leading to the high germination indices obtained in this study. Secondly, our soil improvers may contain very few substances that inhibit seed germination and root growth. The phytotoxic effect of immature compost is due to the emission of ammonia [47], a substance that is toxic to seed germination even at low levels. The presence of certain organic acids, such as acetic acid, is probably the most harmful organic acid released by immature composts, although there are other compounds (acetaldehyde, ethanol, acetone, ethylene, etc.) that contribute to phytotoxic effects [48]. However, the organic amendments based on cow dung and vivianite that we have produced are not toxic. Therefore, we can say that they were mature. Furthermore, these results indicate that the effect of the aqueous extracts varies according to the dilution of the added compost.

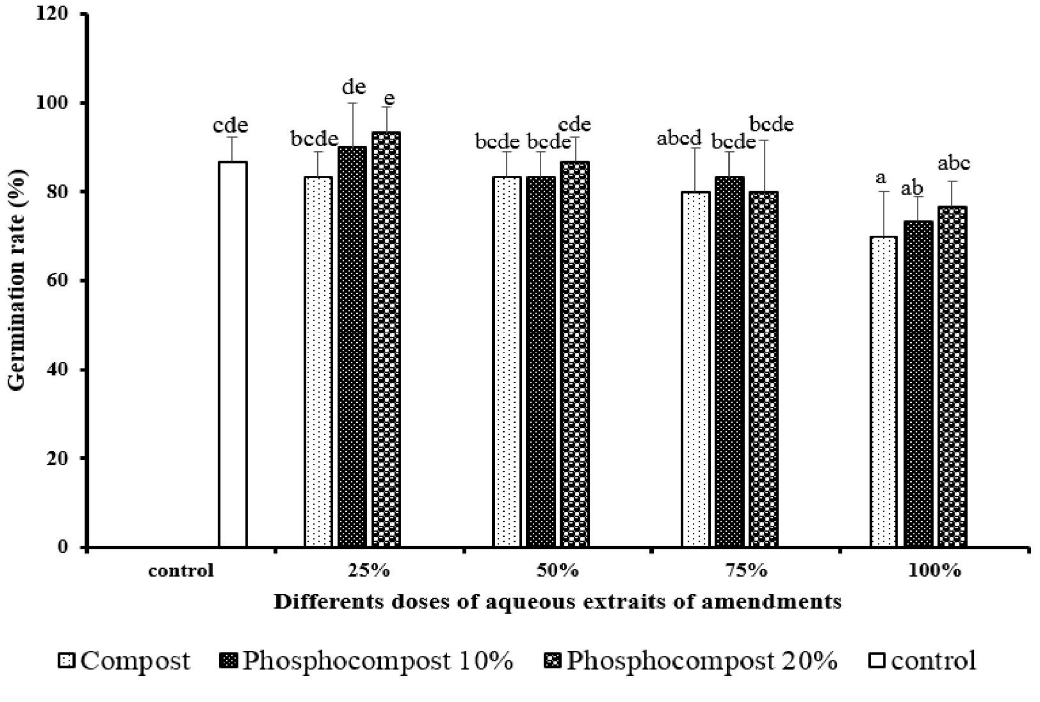

Fig. 7. Germination rate as a function of the different aqueous extracts of soil improvers.

Means with different letters are considered significantly different at $p < 0.05$

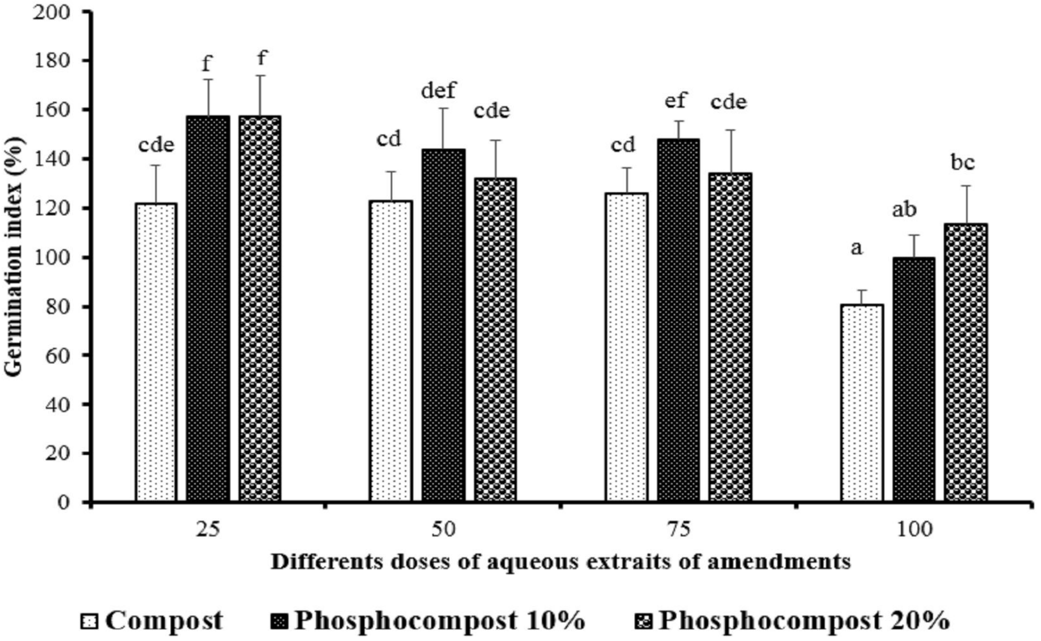

Fig. 8. Germination index as a function of different aqueous extracts of soil improvers.
Means with different letters are considered significantly different at $p < 0.05$

4. CONCLUSION

The objective of this study was to produce cow dung compost enriched with rock phosphate. The study revealed that the soil at the Balaza Lawane (Far North, Cameroon) has a slightly acidic pH (pH=6.8), is low in organic matter and contains few nutrients that are favorable to crop development. Available phosphorus is also very low. Monitoring of the different amendments shows that they all have the same appearance, with a slight increase in compost compared with phosphocomposts. The application of vivianite powder at the time of composting improved the quality of the latter compared with compost without additives in terms of nitrogen, potassium, total and available phosphorus content. Also, the phytotoxicity test carried out on soya beans shows that our phosphocomposts are not phytotoxic and can be used to amend crops. These amendments are recommended for use in soils low in organic matter and available phosphorus, such as Balaza Lawane, to improve the yield of crops requiring phosphorus, such as grasses and legumes.

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