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Contribution of the Incorporation of Poultry Litter and Limestone for the Fertility of Sandy Soil in the Brazilian Amazon

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Abstract

Sandy soils have limitations for growing plants. In general, they have low fertility, high toxic aluminum content and low organic matter. The organic matter is responsible for most of the cation exchange capacity of these soils. Added to this, the low clay content and the structure of these soils with large volumes of macropores, determine their low water retention. An alternative is the incorporation of organic waste combined with the practice of liming. Thus, the aim of this study was to evaluate the contribution of the incorporation of poultry litter and limestone in the fertility of sandy soils in the Brazilian Amazon. The experiment was conducted in Colorado do Oeste, RO, on a Quartzipsamment in a completely randomized block design in a 4 × 4 × 2 factorial scheme, corresponding to four doses of poultry litter (0, 5, 10 and 15 mg·ha^{-1}), its incorporation for four times (0, 75, 110 and 145 days) in the presence and absence of 2 mg·ha^{-1} of limestone, with six replications. The incorporation of 15 mg·ha^{-1} of poultry litter combined with 2 mg·ha^{-1} of limestone for 75 days after the merger raises several components of Quartzipsamment fertility, mainly being the availability of phosphorus.

Keywords

Quartzipsamments, Organic Waste, Liming

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1. Introduction

The southern region of Rondônia comprises the transition between the Cerrado and the Amazon. In general both have highly weathered soils, deep, low fertility and high acidity [1]. Added to these characteristics there are areas in this region with soils of sandy texture, classified as Quartzipsamments [2], which, from the agricultural point of view, have problems with the management and conservation of both soils, as well as the local water resources.

The Quartzipsamments of southern Rondônia are formed in geological-environmental domains, predominantly sandstone and have low water and moisture retention capacity as well as retention, fixation and assimilation of nutrients and OM (organic matter). They are lands mechanized in flatter areas and are able to be agricultured, by applying limestone and fertilizer; however, they may respond poorly to fertilization and lose water quickly when the rains cease [3]. These aspects give these soils low productive capacity under natural conditions; one should therefore adopt practices that increase their quality and productivity of the system.

The sandy soils have low natural fertility, frequent presence of Al (aluminum) in toxic form and low OM content. The OM is responsible for most of the CEC (cation exchange capacity) in these soils. Therefore, generally recommended the practice of liming, which aims to eliminate soil acidity and provide a supply of calcium and magnesium for plants, followed by the fertilization of nitrogen, phosphorus and potassium. However, due to the low CEC and high capacity for water infiltration, the leaching of these nutrients can be high, especially N (nitrogen) and K (potassium). P (phosphorus) can also be lost in large quantities, especially when conditions are favorable to the erosion process, but also by the process of leaching of this nutrient because sandy soils have low P adsorption capacity, and the application of fertilizers rich in P, the fast sorption sites are saturated by increasing its availability and its ability to losses to the environment [4].

In this context, to increase the fertility of sandy soils they aren't enough, being the practices of isolated liming and fertilization even risky. Therefore, one should highlight the important role of OM in the soil that among the numerous advantages, it can be shown the retention and availability of nutrients, elevated CEC and the stabilization of soil moisture, avoiding the heat exchanges harmful to the system roots of plants. Thus, the proper functioning of the soil does not occur without a fairly significant amount of organic matter, mainly in the tropics where soils are subject to higher rates of mineralization when compared to temperate regions.

The OM stands out as a key factor for the elevation and/or maintenance of soil quality [5]. The OM has the ability to hold two to three times their volume in water, which in turn, will be supplied to plants and to the fauna in the soil, as well as maintain its temperature under conditions suitable for life. In addition to the nutrients found in the organic fertilizer, plants can absorb large amounts of organic molecules such as amino acids, proteins, enzymes, vitamins, and others. These products promote greater vitality and resistance to plants, and results of soil biological activity and decomposition of OM [6].

The management of OM in cropping systems has increased substantially in Brazil [7] and organic fertilizers have become vital for supplying nutrients to plants. Among the different organic wastes currently used as a source of OM. The poultry litter is a good alternative for improving the physical, chemical and biological soil properties. This occurs because of its physic-chemical characteristics and the expressiveness of the poultry industry in Brazil that produces large amounts of waste, making its application to soil a practical and economical method [4]. However, a waste-based organic fertilization should not be done randomly, because high doses of organic fertilizers with C/N and N/P can result in an unbalanced availability of nutrients [8] and fertilizers rich in P applied to sandy soils may lead to environmental pollution [4]. Therefore, it is necessary to evaluate the effect of doses of organic manure on soil fertility.

The concept of soil fertility, proposed by Liebig in the mid-nineteenth century, is inefficient in several contexts. Soil fertility, conceptually, is the ability of soil to provide nutrients in adequate quantity and proportion to the plants in the absence of toxic elements for their development and productivity. The ineffectiveness of this concept is demonstrated when comparing direct and conventional planting systems [9].

For sandy soils, it is also extremely dangerous to treat fertility only in the mineral point of view, because nutrient availability within a farm crop in a soil with low buffering capacity may be easy, but keeping these nutrients in a cycle can become much more complex. Thus, it is an interesting strategy to incorporate indicators of fertility, microbiological variables, which act directly on nutrient cycling [10]. Microorganisms can be used as indicators for recovery of soils of different textures and the absence of microbial biomass in sandy soils indicates the irreversible nature of human disturbance [11].

Besides the management of OM for maintaining the fertility of sandy soils, it is important to work with the concept of the agricultural capability of the land. Because, the lack of land use planning based on its limitations and potential has often caused negative environmental impacts [12]. In this manner, classifying the agricultural capability of the land is as important as knowing the soil fertility and recommending the appropriate fertilizer for the plant and soil. The Quartzipsamments have low agricultural potential. However, after 1970, these soils were incorporated into the agricultural exploration, primarily for the grazing system and subsequently for the grain production [13].

Given the above, the present study aimed to evaluate the contribution of the incorporation of poultry litter and limestone in the fertility of sandy soils in the Brazilian Amazon, as guidance for further cultivation of *Brachiaria* pasture.

2. Materials and Methods

The experiment was conducted in municipality of Colorado do Oeste located in the southern region of Rondônia, in the Brazilian Amazon, Line 155, Gleba Corumbiara, Lot 96-A, 28 km (latitude—13˚00'08.43"S and longitude—60˚34'23.82"). The regional climate is classified as Aw (hot and humid tropical with well-defined dry and rainy season) according to Köppen's Climate Classification with a mean annual rainfall of 2400 mm [14]. The local vegetation was classified as Tropical Savanna (Cerradão tropical subperinifólio) [15] and the soil as Neossolo Quartzarênico Órtico típico [16], which amounts in soil classes of high-level categorical to Quartzipsamments in the Soil Taxonomy [16].

The design of the experiment was a completely randomized block design (RBD) in a 4 × 4 × 2 factorial scheme, corresponding to four doses of poultry litter (0, 5, 10 and 15 $mg \cdot ha^{-1}$), four times of incorporation (0, 75, 110 and 145 days) in the presence and absence of 2 $mg \cdot ha^{-1}$ of limestone, with six replications. Each plot had a size of 3 m^2.

Poultry litter had the following attributes: pH 7.01; 251.3 $g \cdot kg^{-1}$ organic carbon; 39.8 $g \cdot kg^{-1}$ calcium; 10.5 $g \cdot kg^{-1}$ Mg; 6.9 $g \cdot kg^{-1}$ K; 33.8 $g \cdot kg^{-1}$ C and 31.2 $g \cdot kg^{-1}$ P.

The incorporation of the different doses of poultry litter in a 20 cm deep soil layer occurred in November 2013. As the experiment was installed, the first sampling was held, which consisted at 0 at the time. Once the area was left fallow, sampling was held again at 75, 110 and 145 days after incorporation. In all samples it was collected in each plot three simple random samples in a zigzag pattern for the formation of a composite sample, for the variables to be determined. The time of 75 days was chosen for the limestone reaction and the primary mineralization of the OM.

From these samples, it was determined in laboratories the variables that are consisted of: $CaCl_2$ pH, TOC (total organic carbon), available P and K, Ca (calcium), Mg (magnesium), H (hydrogen) and Al contents; and calculation was used to determine the CEC, the V% (base saturation) and the m% (Al saturation) [17]. The following were determined as microbiological variables: the MBC (carbon from the soil microbial biomass) [18], BSR (basal soil respiration) [19], and by calculation, the qMIC (microbial quotient) [20] and quotient qCO_2 (metabolic) [19].

Land suitability classification [21] and fertilizer recommendation for the harvest of *Brachiaria* was also performed. As there isn't a manual for recommendations of fertilizers for the state Rondônia, it was used as base the fertilizer recommendation for the State of Acre [22], which is also in the Amazon biome.

The statistical analysis consisted in checking outliers by the Grubbs test, followed by the Bartlett and Shapiro-Wilk test to test the homogeneity of variances and normality of residuals, respectively. The normal data obtained was analyzed using the ANOVA (analysis of variance) technique. The Tukey's test, with a probability level of 0.05, was used to determine significant differences between treatment means of the variables that were isolated or double effect interaction. For the variables that showed the effect of the triple interaction the Scott-Knott test was applied. For variables with non-normal distribution of the data a transformation was performed. For P, K, Ca, Mg and MBC the transformation was performed with the equation $x = \sqrt{x}$. For Al, m% and qMIC constructed the data with the equation $x = x + 1$. qCO_2 for the metabolic transformation the equation $x = x + 10$ was used.

3. Results and Discussion

Regarding the isolated effects of treatment, the dose of 10 $mg \cdot ha^{-1}$ of poultry litter increased ($p < 0.05$) the content of Mg and CEC in the soil, though the latter did not differ ($p > 0.05$) from the dose of 0. The 5 mg·ha^{-1} dose decreased ($p < 0.05$) the m%. However, pH, K, BMC, qMIC and BSR were not affected ($p > 0.05$) by different doses of poultry litter incorporated (**Table 1**). Soil pH and Mg were increased ($p < 0.05$) at 75 days after incorporation, while the m% decreased ($p < 0.05$). The content of K only increased ($p < 0.05$) at 145 days after incorporation. The effective CEC was higher ($p < 0.05$) at day 0. The BMC increased ($p < 0.05$) after 110 days of incorporation, while BRS declined ($p < 0.05$) in the same period (**Table 2**). The presence of limestone increased ($p < 0.05$) the pH, the content of Mg and V%, and its absence provided greater ($p < 0.05$) concentration of K (**Table 3**).

For P there was a significant interaction between doses of poultry litter applied and its time of incorporation and between the incorporation of doses of poultry litter and the application of 2 mg·ha^{-1} of limestone (**Table 4**). The incorporation of 10 and 15 mg·ha^{-1} of poultry litter at 75 days of incorporation was effective ($p < 0.05$) to raise the level of P to 57.53 and 79.08 mg·dm^{-3}, respectively, without statistical difference between them. The presence of limestone was superior ($p < 0.05$) to its absence in the dose of 15 mg·ha^{-1} of poultry litter, increasing the P concentration to 54.05 mg·dm^{-3} (**Table 4**).

Table 1. Means of chemical and microbiological attributes of a Quartzipsamment due to the effect of different doses of poultry litter, obtained in the Brazilian Amazon, 2014.

Doses of poultry litter	$CaCl_2$ pH	K	Mg	CEC	m%	MBC	qMIC	BSR
mg·ha^{-1}		mg·dm^{-3}	---------cmol$_c$·dm^{-3}---------		%	mg·kg^{-1}	%	*
0	4.13a	5.95a	0.28b	6.36a	12.87b	79.21a	0.71a	2.35a
5	4.25a	7.88a	0.29b	5.53b	7.91ab	91.78a	0.96a	2.42a
10	4.19a	7.00a	0.45a	6.03ab	8.79ab	92.31a	0.88a	2.25a
15	4.33a	9.69a	0.41ab	5.87ab	6.98a	77.43a	0.79a	2.33a

Means followed by different letters in columns don't differ significantly from the Tukey test at 5% probability. *mg $C\text{-}CO_2$ kg·soil^{-1}·h^{-1}.

Table 2. Means of chemical and microbiological attributes of a Quartzipsamment due to the effect time of incorporation of poultry litter, obtained in the Brazilian Amazon, 2014.

Time of incorporation	$CaCl_2$ pH	K	Mg	CEC	m%	MBC	qMIC	BSR
Days		mg·dm^{-3}	------cmol$_c$·dm^{-3}-------		%	mg·kg^{-1}	%	*
0	3.83b	4.06c	0.06c	6.69a	18.95b	65.24b	0.76b	1.54b
75	4.33a	8.63b	0.44ab	6.03b	5.82a	71.33b	0.58b	1.94b
110	4.41a	2.70c	0.58a	5.94b	5.99a	124.95a	1.27a	0.30c
145	4.33a	15.13a	0.35b	5.14c	5.78a	79.22ab	0.73b	5.58a

Means followed by different letters in columns don't differ significantly from the Tukey test at 5% probability. *mg $C\text{-}CO_2$ kg·soil^{-1}·h^{-1}.

Table 3. Means of chemical and microbiological attributes of a Quartzipsamment due to the effect of the incorporation of 2 mg·ha^{-1} of limestone, obtained in the Brazilian Amazon, RO, 2014.

Limestone	pH $CaCl_2$	K	Ca	Mg	H	Al	CTC	V%	m%	CBM	qMic	RBS	qCO_2
		mg·dm^{-3}	----------------cmol$_c$·dm^{-3}------------------					------%-----		mg·kg^{-1}	%	*	**
Presence	4.09b	9.66a	0.66a	0.24b	4.38a	0.62a	5.92a	16.37b	9.89a	103.40a	1.00a	2.20b	45.17b
Abscence	4.35a	5.60b	0.82a	0.48a	4.14a	0.53a	5.97a	22.48a	8.39a	66.96b	0.66b	2.47a	85.72a
CV (%)	7.12	28.56	20.36	24.81	11.66	16.85	10.30	37.78	28.44	41.58	19.11	37.33	20.34

CV: coefficient of variation. Means followed by different letters in columns differ significantly by the F test at 5% probability. *mg $C\text{-}CO_2$ kg·soil^{-1}·h^{-1}; **mg $C\text{-}CO_2$ g^{-1}·BMC·h^{-1}.

Table 4. Means of phosphorus content ($mg \cdot dm^{-3}$) Quartzipsamment due to the effect of the interaction between doses of poultry litter and its time of incorporation, and of the interaction between doses of poultry litter and incorporating 2 $mg \cdot ha^{-1}$ limestone, obtained in the Brazilian Amazon, 2014.

Doses of poultry litter $mg \cdot ha^{-1}$	Time of incorporation ---days---			
	0	75	110	145
0	1.40aA	2.55bA	1.40aA	2.48aA
5	1.25aA	18.60bA	26.43aA	17.13abA
10	1.40aB	57.53aA	24.18aAB	24.78abAB
15	1.45aC	79.08aA	32.15aBC	45.43aAB

Doses of poultry litter $mg \cdot ha^{-1}$	Limestone	
	Presence	Absence
0	1.70bA	2.21bA
5	16.75bA	14.95abA
10	20.64bA	33.03aA
15	54.05aA	25.00abB

Means followed by the same letters, uppercase on the rows and lowercase on the columns, don't differ significantly from the Tukey test at 5% probability.

The content of Ca, H, Al, V% and qCO_2 were influenced by the significant interaction between the doses of poultry litter applied and its time of incorporation (**Table 5**), being that with the application of 5 $mg \cdot ha^{-1}$ of poultry litter followed by 75 days of its incorporation achieved a higher ($p < 0.05$) content of Ca and V% and lower levels of H and Al. This dose did not differ statistically from 10 and 15 $mg \cdot ha^{-1}$. The highest levels of qCO_2 were obtained with the application of the smallest doses of poultry litter, 0 and 5 $mg \cdot ha^{-1}$, and with the highest time of incorporation, 145 days.

Considering the components of potential soil acidity, Al and H, the incorporation of 5 $mg \cdot ha^{-1}$ for a period of 75 days, would be a good alternative to reduce it, and besides, this combination increased the Ca and V% contents (**Table 5**). The exchangeable aluminum content was reduced to 0.27 $cmol_c \cdot dm^{-3}$, below the level toxic to most crops 0.30 $cmol_c \cdot dm^{-3}$ [23]. The addition of organic waste is often related to the decrease of the phytotoxic effects of Al [23] [24].

The incorporation of 2 $mg \cdot ha^{-1}$ of limestone has managed to increase ($p < 0.05$) the pH, Mg and V% (**Table 3**), although the latterdid not reach very high levels (22.48%) improved fertility has been achieved. Thus, combining the incorporation of poultry litter with limestone would be an interesting strategy.

The adoption of soil management systems aiming for higher activity of soil microbes and increased OM and soil pH, can reduce P adsorption [25]. These affirmations are corroborated by the results of this work.

The incorporation of limestone combined with 15 $mg \cdot ha^{-1}$ of poultry litter was able to raise the level of P to 54.05 $mg \cdot dm^{-3}$. Handling this, which could be replaced by the incorporation of 10 and 15 $mg \cdot ha^{-1}$ of poultry litter at 75 days of incorporation, which was effective ($p < 0.05$) to raise the level of P to 57.53 and 79.08 $mg \cdot dm^{-3}$, respectively, with no statistical difference between them (**Table 4**). According to the interpretation of the level of P with relation to clay content, these yields available are considered high [26]. As P is a nutrient that limits crop productivity in many regions of the world, particularly in areas with highly weathered acidic soils [27] these results are of paramount importance for the fertility and productivity of the soil.

The TOC was the only variable influenced by the interaction of the three factors. The best combination was the application of 15 $mg \cdot ha^{-1}$ of poultry litter with 75 days of incorporation in the presence of limestone (**Table 6**).

The significance of the OM on many soil properties is evidenced in the presence of macro and micro-organisms whom affect the formation of the aggregates in the soil, because in conjunction with root fungi and filaments, they segregate and exude the mucilage that stick the soil particles, and the smaller aggregates, thus becoming larger aggregates, which makes the soils stable for several years, preventing leaching and erosion from occurring [28]. The application of poultry litter can contribute to soil aggregation in the order of 34% after three years of implementation [29]. The greater stability of aggregates in water and larger size aggregates are desirable

Table 5. Means of the content of calcium, hydrogen, aluminum ($cmol_c \cdot dm^{-3}$), base saturation (%) and metabolic quotient (mg $C\text{-}CO_2$ $g^{-1} \cdot BMC \cdot h^{-1}$) Quartzipsamment due to the effect of the interaction between doses of poultry litter and its time of incorporation, obtained in the Brazilian Amazon, 2014.

Doses of poultry litter $mg \cdot ha^{-1}$	Calcium Time of incorporation ----------------------------------days----------------------------------			
	0	75	110	145
0	0.29aA	0.58bA	0.42cA	0.49bA
5	0.29aB	1.01abA	0.53bcAB	1.05aA
10	0.29aB	1.36aA	0.98abA	0.79abA
15	0.30aB	1.38aA	1.34aA	0.74abAB
Doses of poultry litter $mg \cdot ha^{-1}$	**Hidrogen Time of incorporation ----------------------------------days----------------------------------**			
	0	75	110	145
0	4.98aAB	5.36bB	4.45aAB	4.39cA
5	4.99aB	3.92aAB	4.20aBC	3.02aA
10	4.96aB	3.37aA	4.30aAB	4.01bcAB
15	5.30aB	3.87aA	3.76aA	3.30abA
Doses of poultry litter $mg \cdot ha^{-1}$	**Aluminium Time of incorporation ----------------------------------days----------------------------------**			
	0	75	110	145
0	1.21aB	0.77bAB	0.64aA	0.64bA
5	1.20aB	0.27aA	0.30aA	0.13aA
10	1.46aB	0.25aA	0.25aA	0.24abA
15	1.21aB	0.14aA	0.22aA	0.21abA
Doses of poultry litter $mg \cdot ha^{-1}$	**Base saturation Time of incorporation ----------------------------------days----------------------------------**			
	0	75	110	145
0	5.68aA	12.55bA	16.90bA	11.87bA
5	5.47aC	25.26abAB	16.34bBC	30.40aA
10	5.41aB	33.59aA	26.49abA	22.58abA
15	5.29aB	32.61aA	34.08aA	26.25aA
Doses of poultry litter $mg \cdot ha^{-1}$	**Metabolic quocient Time of incorporation ----------------------------------days----------------------------------**			
	0	75	110	145
0	46.45aB	56.47aB	11.17aB	216.40abA
5	22.34aB	25.20aB	5.11aB	249.40aA
10	24.41aB	29.32aB	4.40aB	138.31bcA
15	50.46aA	69.64aA	10.10aA	87.96cA

Means followed by different letters, uppercase and lowercase lines in columns, differ significantly by the Tukey test at 5% probability.

Table 6. Means content of total organic carbon ($g \cdot kg^{-1}$) Quartzipsamments due to the effect of the interaction between doses of poultry litter, its incorporation time and presence and absence of 2 $mg \cdot ha^{-1}$ of limestone, obtained in the Brazilian Amazon, 2014.

Doses poultry litter ($mg \cdot ha^{-1}$)	Time of incorporation (dias)	Limestone	
		Absence	Presence
0	0	9.52dA	8.96eA
0	75	11.28cA	11.28cA
0	110	11.16cA	10.57dA
0	145	11.86bB	15.73bA
5	0	7.67eB	9.65dA
5	75	12.23bA	11.95cA
5	110	8.94dA	8.39eA
5	145	8.48eB	11.50cA
10	0	9.41dA	8.40eA
10	75	11.03cB	14.92bA
10	110	10.10dA	10.46dA
10	145	12.08bA	10.94cB
15	0	7.79eA	6.96fA
15	75	15.79aB	17.53aA
15	110	10.83cA	7.67fB
15	145	11.06cA	10.27dA

Means followed by different letters, uppercase and lowercase lines in columns, differ significantly by the Scott-Knotttest at 5% probability.

properties in cultivated soils, since they are directly linked to erosion. Thus, besides being a source of nutrients, OM protects the soil against erosion.

The nutrient cycling is fully linked to the quantity of microorganisms present in the soil, and these, the quantity and quality of OM. BMC is the living soil fraction consisting of bacteria, fungi, actinomycetes, algae and protozoa. The BMC can be used as a biological indicator, or as an index of sustainability adequacy for a production [20] system. The qMIC indicates the availability of TOC for microbial biomass [30]. The soil microbiota acts in the process of decomposition of OM, participating directly in the biogeochemical cycling of nutrients, thereby mediating its availability in the soil [10]. Thus, raising the level of nutrients available to plants without increasing microbial biomass tends to the rapid loss of fertility and the unsustainability of cultivation.

There was no effect ($p > 0.05$) of increased doses of poultry litter in content BMC and qMIC (**Table 1**), only the time of incorporation (**Table 2**). This is probably due to the effect of the soil texture on soil microbial biomass, which shows to be more significant than planted vegetables substrates [30]. Therefore, the same could be true for increasing the amount of organic waste. Considering that the studied soil is sandy, the increased microbial biomass, corresponds to the greater nutrient cycling and reduced losses of soil/plant system, these results demonstrate that the added nutrients by the poultry litter will be cycled through the microbial biomass. Increases in BMC is 28% higher with the application of poultry litter when compared to fertilization with urea were obtained on a clay soil [31]. Increased BMC is usually accompanied by a decrease in metabolic activity [32], represented by BSR (**Table 2**), which was found by [10] and also in this work.

Where as increasing doses of poultry litter did not decrease the level of any component of fertility (**Table 1**), and that the incorporation of 10 and 15 $mg \cdot ha^{-1}$ increased the P content without differing statistically from each other at 75 days incorporation (**Table 4**), and that 15 $mg \cdot ha^{-1}$ increased the amount of TOC (**Table 6**) also after 75 days of incorporation, it is recommended the application of the highest dose, since it is not logistically impracticable, because its cost is low and its benefits go beyond soil fertility.

The time of 75 days of incorporation was effective to raise the pH, Mg (**Table 2**), P (**Table 4**) Ca and V% (**Table 5**), demonstrating the rapid mineralization effect of OM in tropical environments. Studies with less time of incorporation are needed to recommend the planting of crops before that period. Because in the beginning of decomposition of the OM there can be acidification of soil and immobilization of the nutrients, with productivity losses for the implanted harvest.

The presence of limestone did not demonstrate impressive results in fertility, but increased pH, Mg and V% (**Table 3**), and still had significant interaction with P availability (**Table 4**), being so that it is recommended its implementation. With surface application of limestone, similar results were obtained only after 18 months of application [33].

In the area being studied *Brachiaria brizantha* cv. Marandu cultivated. No evaluation was made of the effect of treatments on the cultivate of *Brachiaria*, just the grazing was eliminated and after application of poultry litter and limestone the area was left fallow. However in possession of the results regarding soil fertility and based on the recommendation for the formation of new pasture for the State of Acre [22], inferences about the culture can be made.

The fertility requirement of the forage is considered average and the recommended bases saturation is 40%. With the incorporation of 15 $mg \cdot ha^{-1}$ of poultry litter for 75 days V% was elevated to 32.61% (**Table 5**), close to the recommended level. As the P concentration was increased to the range of high availability, it would require the application of only 10 $kg \cdot ha^{-1}$ of P_2O_5. However, considering the very poultry litter as a source of input P, P fertilization would not be necessary. It is recommended the application of nitrogen and potassium in pasture establishment [22].

The undesirability of phosphate fertilizers is due to concerns about the rising level of available P levels that cause environmental impacts. With the incorporation of poultry litter in sandy soils under grassland, weak bonds with the surface of the P microaggregates are formed, which can be easily lost by leaching occurrences, as well as the erosion losses that inorganic P and labile organic P linked to these microaggregates suffer [34]. All these forms can reach the water. Leaching and P loss of fertilizers applied to the soil may exceed the water extractable from source material amounts, because of organic P mineralization and competitive adsorption of the dissolved organic carbon [35]. The high loss of P occurs due to low binding energy of sandy soils, organic C increased and decreased exchangeable aluminum, so high application rates of poultry litter, or continuous applications can lead to desorption of P and percolation of the same, being that the tillage system allows longer applications than the conventional ones [4].

According to the recommendation of fertilization [22] and the results of this study for Quartzipsamment the application of 15 $mg \cdot ha^{-1}$, combined 2 $mg \cdot ha^{-1}$ of limestone with incorporation of 75 days provides conditions for the establishment of a new pasture formed with the *Brachiaria brizantha* species. However, for the maintenance of fertilization from poultry litter or other sources new experiments must be conducted. With respect to nitrogen, for example, it is known that both broiler freshly applied as residual contribute to the supply of this element in grasses [36]. Therefore it is likely that doses of poultry litter can be reduced over time.

For the land suitability classification [21] it must be taken into account the agricultural practices adopted by farmers in order to diagnose the behavior of land in different technological levels. Thus, the studied soil was inserted in the land suitability classification, as the management level B (undeveloped), and group 4 subgroup P (land belonging to the class of good agricultural potential for planted pasture). Therefore, it is noticed that the use of the property is appropriate for its class agricultural capability, being able to improve soil fertility through the application of poultry litter and limestone.

4. Conclusion

The incorporation of 15 $mg \cdot ha^{-1}$ of poultry litter combined with 2 $mg \cdot ha^{-1}$ of limestone for 75 days of incorporation raises various components of fertility for Quartzipsamment, mainly being the available phosphorus. This management allows deployment of the cultivation of *Brachiaria brizantha* cv. Marandu replacing the fertilization formation. In sandy soils the concern about soil fertility is its lifting and handling, with the microbial biomass rising after 110 days of incorporation of the treatments, favorable conditions occur for nutrient cycling. However, the results correspond only to the first year of implementation in pasture fertilization.

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