Journal of Agriculture and Environmental Sciences
December 2015, Vol. 4, No. 2, pp. 153-163
ISSN: 2334-2404 (Print), 2334-2412 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jaes.v4n2a18
URL: http://dx.doi.org/10.15640/jaes.v4n2a18

Natural Phosphate and Humic Substances Applied In Quartzipsamment and Kandiudult Cultivated with Sugar Cane

Paulo Sergio S. Bezerra[1], Renato M. Prado[2]&FranciroseShigaki[3]

Abstract

It is known that use of natural reactive phosphate associated with humic substances will be able to increase phosphorus absorption the the efficiency of phosphate fertilization in the production of sugar cane.Objective of this study is to evaluate the effects of phosphorus levels in the absence and presence of enriched peat extract with humic substances. The study was conducted in a greenhouse in the municipality of Chapadinha, in the state of Maranhão, Brazil, in an entirely randomized 2x2x3+2 delineation with three repetitions in Quartzipsamment and Kandiudult, in the absence and presence of 520 L ha^{-1} of the peat extract, three doses of phosphorus (75, 150 and 300 mg dm^{-3}) in the natural reactive phosphate form and two controls. The experimental unit consisted of a vase filled with 20kg of soil containing a RB867515 of sugar cane. The accumulation of phosphorus and dry matter on the aerial part of the sugar cane were evaluated, 180 days after planting and 120 days after the first cutting. The associated natural phosphate and humic substances demonstrated greater increments in the sugar cane for the two cycles and different soils compared to the isolated phosphate.

Keywords: Organic matter; Phosphate fertilization; Phosphorus accumulation; *Saccharum*spp.

1. Introduction

Greater crop productivity depends, among other factors, on the adequate supply of nutrients, especially phosphorus. Research with sugar cane indicates that phosphate constitutes one of the most limiting factors in its production in the majority of Brazilian soils, making necessary the practice of phosphate fertilization in order to supply the needs of the plant (Santos et al., 2009).

The high-solubility phosphate sources correspond to more than 90% of the P_2O_5 in the Brazilian agriculture and present a greater efficiency in a short time period, when compared to the natural phosphates that come from igneous and metamorphic rocks (Novais et al., 2007). In tropical soils, with a high capacity for absorption of phosphorus, the nutrient arising from the soluble source is converted to less available forms, thus reducing its efficiency. The phosphorus, in spite of being little-required by vegetables, is one of the nutrients applied in greater quantities in Brazilian soils thanks to its low natural availability and its affinity with the mineral fraction (Bastos et al., 2008).

[1]Federal University of Maranhão ,Center of Exact Sciences and Technology - Department of Chemistry, Avenue of the Portuguese 1966, CEP 65080-805, Bacanga , São Luis-MA-Brazil, phone: (+55) 98 – 3272-8228, e-mail: paulossbezerra@hotmail.com.
[2]Paulista State University, College of Agrarian and Veterinarian Sciences, Vegetal Production Department, Jaboticabal Campus, Via de acesso Prof. Paulo DonatoCastellane, s/n, CEP 14884-900,Jaboticabal-SP-Brazil.
[3]Federal University of Maranhão, Center for Agrarian Sciences and Environmental, BR 222 s/n, CEP 65500-000, Chapadinha-MA-Brazil.

Due to the probable scarcity of raw material for the production of mineral fertilizers, it is important to study a way of minimizing the use of phosphorus in the soil without diminishing the absorption of this nutrient by the plant (Stamford et al., 2006). One alternative to better the utilization of this nutrient is the use of natural reactive phosphates which, due to their origin in sedimentary rocks (soft phosphates), have the capacity of freeing phosphorus in a progressive and continuous manner, with a greater residual effect, less subject to absorption, yet more efficient in perennial crops (Novais et al., 2007).

Besides this, mineral fertilizers can be associated with organic fertilizers, so that, due to the presence of a higher content of organic matter, there is an increase in the efficiency of phosphorus absorption by the plants. Some studies have demonstrated that the increase in organic matter can induce a reduction in the absorption of phosphorus in the soil, increasing its availability (Stamford et al., 2006), due to the presence of denominated stable fractions of humic substances in the organic material.There is research indicating that the use of organic materials, rich in humic substances, incorporated in the soil increase the production of sugar cane, highlighting the filter cake on containers at a dosage of 28.3 t ha^{-1} (Almeida Júnior et al., 2011), filter cake incorporated in the soil in field conditions for second-cycle sugar cane at a dosage of 70 t ha^{-1} (Fravet et al., 2010; Prado et al, 2013), vinasse at a dosage of 150 m^{-3} ha^{-1} (Prado et al. 2013), sewage sludge at a medium dosage of 10 t ha^{-1} (Tasso Júnior et al., 2007) and peat at a dosage of 25 t ha^{-1} (Matias, 2010). It can be observed that this these studies indicate relatively high dosages of organic material that raise the costs of the applied product, affecting its economic viability.

One way to diminish the quantity of organic material in agriculture would be to utilize the extract of these materials containing concentrated solutions of humic substances. One study carried out by Gullo (2007), associated mineral fertilization and a commercial extract drawn from peat with a high concentration of humic acid in sandy soil of a low fertility, and utilized 350 L ha^{-1} in first-cycle sugar cane and 600 L ha^{-1} in second-cycle sugar cane, obtaining a significant increase in the productivity. In light of this, the hypothesis can be made that the use of humic substances in the cultivation of sugar cane can contribute to the increase in efficiency of phosphate fertilization in the form of natural phosphate beginning with the increment of the absorption of phosphorus by the plant. In this way, the object of this study is to evaluate the effect of natural phosphate in the absence and presence of humic substances in the accumulation of phosphorus and in the production of dry matter in sugar cane, cultivated in Quartzipsamment and Kandiudult.

1. Materials And Methods

The experiment was developed in a greenhouse of the Federal University of Maranhão in the municipality of Chapadinha, in the state of Maranhão, Brazil. Samples of the top layer (0 – 20 cm of depth) of two distinct soils were used, relative to the capacity for absorbing phosphate: Quartzipsamment and Kandiudult, medium/medium texture, both classified according to the methodology described in Embrapa (2013). The chemical analysis of the soil samples for fertility purposes was carried out according to the methodology described in Raij et al., (2001), and granulometric (physical attributes**)** analyses were done according to the procedure described in Embrapa (1999). The results are shown in the following table:

Table1: Characterization of the chemical and physicalattributes of QuartzipsammentandKandiudult, the depth 0-20 cm.

Chemical attributes												
SOILS	pH	P(resin)	OM	Ca^{+2}	Mg^{+2}	K^{+}	Al^{+3}	H+Al	SB	CEC	V	M
	$CaCl_2$	mg dm^{-3}	g dm^{-3}	---------------------- $mmol_c$ dm^{-3}----------------------							-----%------	
Quartzipsamment	4.0	5	17	8	3	0.3	0.9	15	11.3	26.3	43	8
Kandiudult	4.1	6	19	19	10	0.6	1.7	31	29.6	60.6	49	6

	Physicalattributes			**Micronutrients**				
	Clay	Silt	Sand	Cu	B	Mn	Fe	Zn
	g kg^{-1}			mg kg^{-1}				
Quartzipsamment	139	91	770	0.1	0.2	0.9	79	0.3
Kandiudult	185	204	611	0.1	0.3	3.6	136	0.7

Organic matter = OM; cation exchange capacity = CEC; base saturation = V%; aluminum saturation = m. sum of bases = SB.

The maximum capacity of absorption of phosphorus (MCAP) was determined in soil samples, with 319 mg kg^{-1} for Quartzipsamment and 660 mg kg^{-1} for the Kandiudult, using the Langmuir Isotherm according to the method described by Olsen and Watanabe (1957).

For the source of humic substances a liquid extract of peat with the following characteristics was used: density of dry base = 0.21 g dm^{-3}, organic matter = 770 g dm^{-3}, fluvic acid = 37.2%, humic acid = 26.7%, total carbon = 56.7%, nitrogen = 3.09%, C/N relation = 17/1, soluble phosphate = 7.5 mg dm^{-3}, soluble potassium 16.7 mg dm^{-3}, pH factor 5.3 e CEC = 420 $mmol_c$ dm^{-3} (Raij et al., 2001). The dose of peat extract was determined in a preliminary experiment of soil incubation for 30 and 60 days, containing doses of peat extract and a fixed dose of phosphate in the form of natural reactive phosphate, the dose being determined at 520 L ha^{-1} which allowed for a greater supply of phosphorus available in the soil.

30 days before the installation of the experiment, the soils were collected, sifted, and situated into containers with a capacity for 20 dm^{-3} of soil. To elevate the base saturation by 60% calcined limestone (PN = 95%, RE= 105.2% e PRNT = 100%) was incorporated in the soil, according to the indications of Raij and Cantarella (1997).

The experimental delineation was entirely randomized with three repetitions, in a factorial scheme of 2x2x3+2. The treatments were obtained from the moment of the combination of the two soils (Quartzipsamment e Kandiudult) in the absence and presence of 520 L ha^{-1} of the peat extract, three doses of P (75, 150, 300 mg dm^{-3}) utilizing natural reactive Bayóvar phosphate (14% de P_2O_5 soluble in citric acid) and a control treatment of each soil (without phosphate and without peat). The basic fertilization consisted of broadcast application, incorporated in the soil, of 200 mg dm^{-3} of N in the form of urea (44% de N), 150 mg dm^{-3} de K in the form of potassium chloride (60% de K_2O). The micronutrients Cu and Zn were employed in a superficial way on the soils as a solution, according to the recommendations contained in Raij and Cantarella (1997).

The RB 867515 variety of sugar cane was used in the experiment. The hydric management was carried out using daily watering to maintain adequate vegetative development in the sprouting and tillering stages of the sugar cane, in conformity with the recommendations described in Machado et al. (2009).

After 15 days of fertilization the planting was carried out by manually placing four buds of sugar cane per vase, and 20 days after planting the thinning began, leaving only the most vigorous plant. 180 days after planting the cut of the plant at soil level for evaluation of the dry matter of the aerial part and accumulation of P was carried out. The vegetal matter was washed, dried in a kiln at 65ºC until achieving constant mass. Afterward the matter was ground, and determination was made as to the supply of P following the method described by Bataglia et al. (1983).

Fifteen days after cutting the first-cycle sugar cane a covering of 300 mg dm^{-3} of N in the form of ureia and 150 mg dm^{-3} in the form of potassium chloride was added. At 120 days after the cutting the sugar cane the second cut was carried out for the evaluation of dry matter and the accumulation of second-cycle P, according to the procedure utilized in the first cycle of the sugar cane.

The data were submitted to a variance analysis by way of the F test and comparison of averages by the Tukey test, with a 5% probability level, using the AgroEstat software (Barbosa; Maldonado Jr., 2011).

2. Results And Discussion

The treatments (with the presence of phosphorus) were highlighted in relation to the control treatment (without phosphate) in two cycles of sugar caneare described in the following Table 2.

Table 2: Accumulation of Phosphorus (AcP) and dry matter of the aerial part (DMAP) by the sugar cane in the first and second cycle in function of the treatments.

Treatments	first-cycle		second-cycle	
	AcP mg per vase	DMAP g per vase	AcP mg per vase	DMAP g per vase
Soil (S)				
Quartzipsamment	389.6	186.5	250.1	122.4
Kandiudult	345.9	192.6	248.8	140.9
Test F	10.28**	13.87**	0.01 ns	62.89**
PeatExtract (T)				
Absence	234.4	172.8	154.6	103.3
Presence	501.0	206.2	344.4	160.0
Test F	382.0**	414.4**	149.03**	593.30**
Dosages of P (D), mg dm^{-3}				
75	224.6 c	177.4 b	101.9 b	93.8 c
150	3037 b	195.4 a	303.7 a	145.1 b
300	456.6 a	195.9 a	342.8 a	156.2 a
Test F	112.21**	54.87**	92.15**	272.54**
Factorial (F)	61.04**	52.46**	33.99**	116.26**
Control (C)				
Quartzipsamment	142.9	62.3	117.8	40.5
Kandiudult	138.4	60.1	120.2	43,3
Test F	0.01 ns	0.30 ns	0.01 ns	0.24 ns
F versus C	334.37**	3487.37**	125.56**	849,19**
S x T	8.56**	0.43 ns	9.33**	31.98**
S x D	3.92*	1.16 ns	1.98 ns	19.60**
T x D	17.82**	9.67 **	12.32**	3.04 ns
S x T x D	1.33 ns	8.47**	1.32 ns	0.19 ns
CV(%)	14.2	2.9	21.5	5.9

ns, not significant;** significant (p<0,01) and *significant (p<0,05). Averages followed by the same letter do not differ statistically from each other by Tukey's test at 5%. CV= variation coefficient

3.1 First cycle of sugar cane

There was an interaction in the variable accumulation of phosphorus (P) among all the sources of variation, demonstrating that the response of the plant to the absorption of P can be different in the soils, in the absence and in the presence of peat and also in the different doses of P in the first cycle of sugar cane (Table 2).

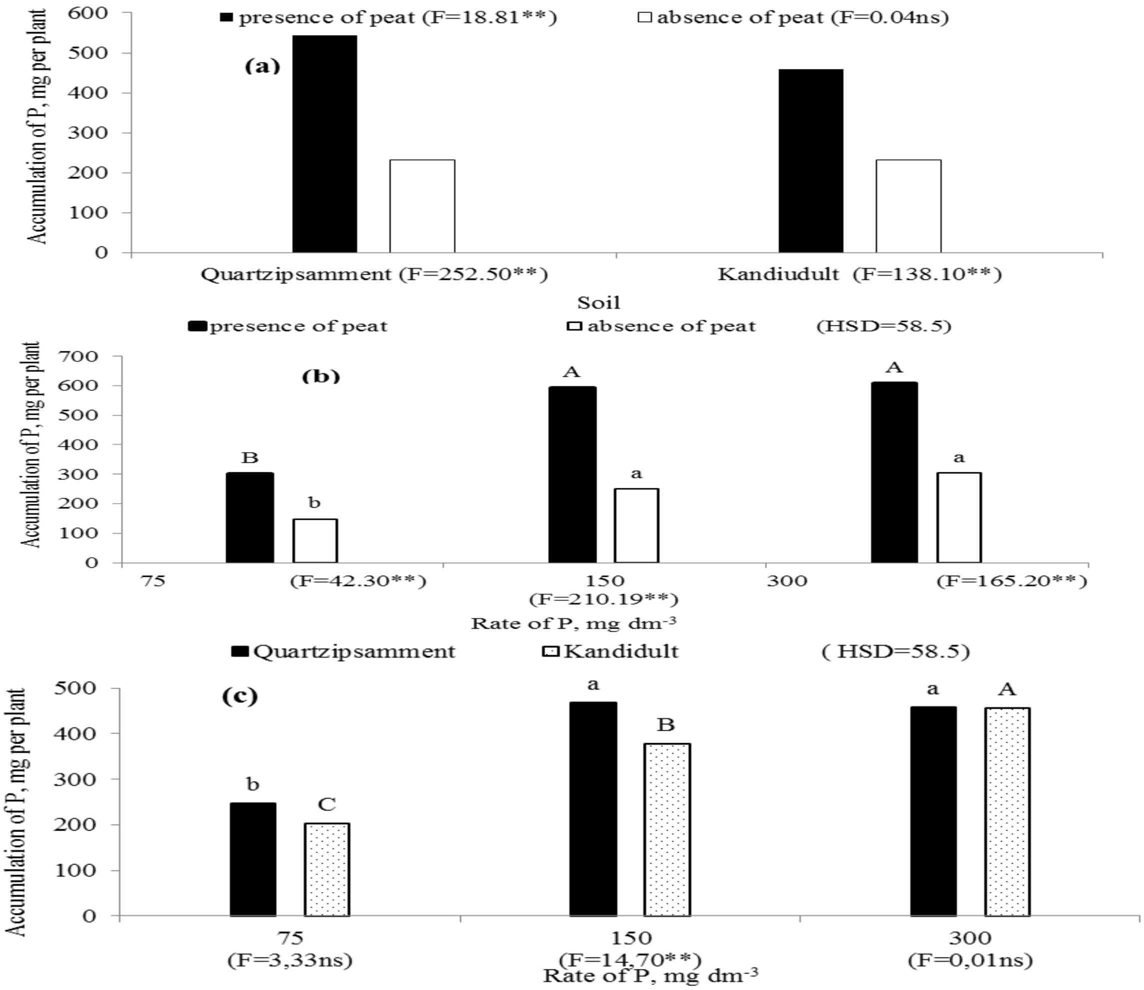


Figure 1: Accumulation of P in the sugar cane (first cycle) in function of the two soils at different levels of peat (a); in function of the dosages of P in different soils (b); and in function of the dosages of P in different levels of peat (c). ns, not significant;** significant ($p<0,01$) e *significant ($p<0,05$). Averages followed by the same letter do not differ statistically from each other by Tukey's test at 5%. (HSD=58,5); lower case letters compare the dosages of the phosphate in the Quartzipsamment (b) and absence of peat (c); upper case letter compare the dosages of P in the Kandiudult (b) and presence of peat (c).

For the interaction of soils and peat it can be verified that the presence of peat brought about a greater accumulation of this nutrient in the plan, in relation to the treatment in the absence of peat (Figure 1a). It can also be observed that there was a greater increment in the accumulation of phosphate in the plant cultivated in the Quartzipsamment for the treatment in the presence of peat, and in the absence of peat extract there was no difference between the soils (Figure 1a). The greatest accumulation of P by the plant cultivated in Quartzipsamment, is possibly related to the low absorption capacity of P in this soil (319 mg kg^{-1}) in relation to Kandiudult (660 mg kg^{-1}) reflected in greater absorption of this nutrient by the plant. This greater accumulation of P in the plant cultivated in Quartzipsamment in relation to Kandiudult occurred only with the moderated dose of P, that is, the 150 mg dm^{-3} dose (Figure 1b).

The presence of peat incremented the accumulation of phosphorus (AcP) in the plant in relation to its absence, irrespective of the dose of P that was used (Figure 1c). This result demonstrates the importance of the application of liquid peat associated with the natural reactive phosphate in the increment of the absorption of P by the plant, possibly given by the fact that it favors the availability of phosphorus in the soil.

The organic fertilization brings about a greater accumulation of phosphorus in the plant, due principally to the increase of organic acids, which compete with phosphorus absorption sites, diminishing the potential of positive charges (Mielniczuc, 2008) and increasing the availability of phosphorus for the plant. What's more, the organic acids free up H^+ (protons), these protons act in the solubilization of natural phosphate, increasing the availability of the in phosphate in the soil (Matias, 2010).

The increase in the absorption of phosphorus by the plant with the use of peat extract incremented the production of dry matter in the aerial part of the plant, independent of the dosage of phosphorus utilized in the soil. However, the greater quantity of dry matter was found in the plant that was cultivated with the presence of peat associated with the dosage of 150 mg dm^{-3} of phosphorus (Figure 2).

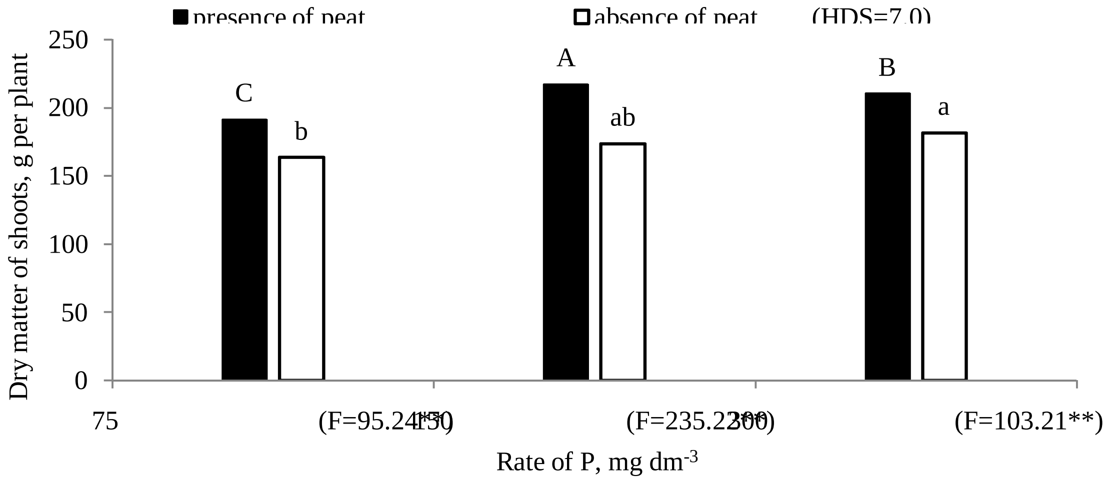


Figura 2. Dry matter from the aerial part of the sugar cane (first cycle) in function of the dosages of phosphate in the different levels of peet;** significant ($p<0,01$) e *significant ($p<0,05$). Averages followed by the same letter do not differ statistically from each other by Tukey's test at 5%. (HSD=7.0); lower case letters compare the dosages of phosphate within the treatment in the absence of peat, and capital letters compare the dosages of P within the treatment in the presence of peat.

The beneficial effect of phosphate fertilization associated with humic substances compared with the isolated use of mineral fertilizer in sugar cane fertilization (first cycle), was also reported by other authors. Rosset et al. (2014) obtained increase in the culm productivity in sugar cane of different varieties cultivated in Hapludox soil using 15 L ha^{-1} of humic substances applied in furrows. Gullo (2007) obtained a significant response utilizing a dosage of 350 L ha^{-1} of humic substances in sandy soil. BenzoniNeto (2006) applied 20 L h^{-1} of the mixture of 12% of humic acids e 3% of fluvic acids, in the furrow of sugar cane cultivated in Hapludox soil, seeing significant gains in culm production and in greater development of the root system.

However, Stamfordet al., (2006), evaluating the budding of some varieties of sugar cane, applied 3 kg ha^{-1} of humic substances associated with mineral fertilizers in furrows and observed that this treatment did not produce gains, that is, did not improve the budding and did not stimulate the initial development of the plant.

3.2 Second cycle of sugar cane

The presence of peat resulted in greater increments of P absorption by the plant cultivated in the two soils in comparison with the absence of peat (Figure 3a). In the comparison of the two soils, in can be noted that greater increments of P accumulation are found in plants cultivated in Quartzipsamment than in those cultivated in Kiundiudult (Figure 3). Similar results have been found in this experiment for first-cycle sugar cane.

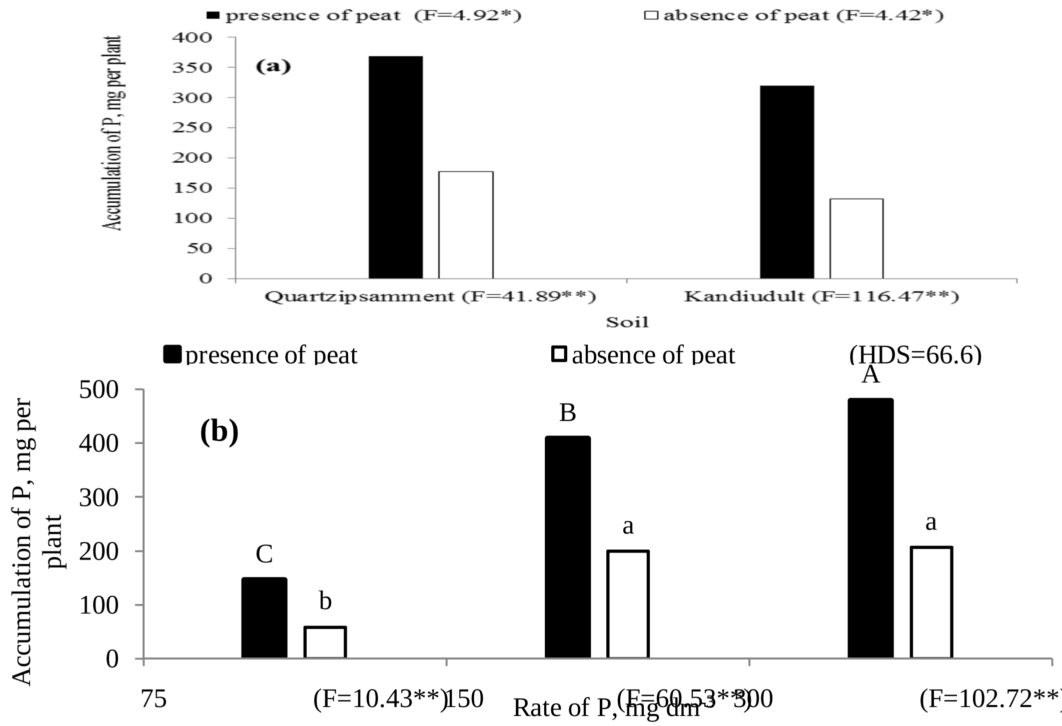


Figure 3.Accumulation of P in sugar cane (second cycle) in function of the soils (a) and in function of the phosphate (b) in different levels of peat.ns, not significant;** significant ($p<0,01$) and *significant ($p<0,05$). Averages followed by the same letter do not differ statistically from each other by Tukey's test at 5%. (HSD=66,6); lower case letters compare the dosages of phosphate within the treatment in the absence of peat, and capital letters compare the dosages of P within the treatment in the presence of peat.

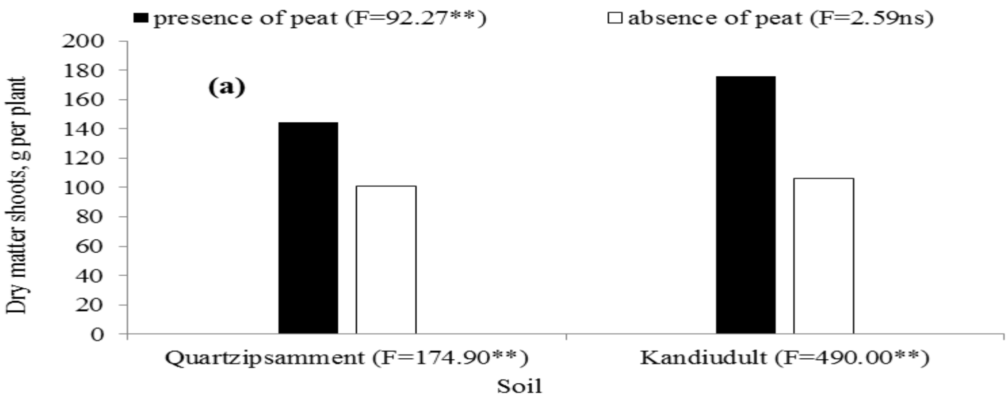
The presence of peat extract in all the dosages of P brought about greater increments in the absorption of P by the second-cycle sugar cane plant in comparison with the treatment without the application of peat, demonstrating that the addition of this organic compost associated with natural reactive phosphate increases the residual effect of phosphate in the soil (Figura 3b).

The greater superiority of the response of the plant after the application of the peat extract in the soil could possibly result in the increase of culms productivity, for the increase in the accumulation of P in the plant makes possible a greater production of dry matter.

Results in the literature demonstrate that the application of organic compost in the sugar cane crop is viable, irrespective of the type of soil, to improve the residual effect of phosphate, and thus bring about better responses in the plant, consequently increasing the production of culm in ratoon. (Fravet et al., 2010).

The treatment in the presence of peat produced greater responses in the plant for the variable dry matter in the aerial parts in both soils in comparison to the treatment without the application of peat (Figure 4a). However, the presence of peat in the plant cultivated in the Kandiudult produced a greater amount of dry matter in the aerial part (Figura 4a), in spite of the fact that the plant cultivated in the Quartzipsamment made possible a greater accumulation of P by the plant. This result could be related to the better use of phosphate by the plant, for the plant optimizes the use of P available in the soil, absorbing less P and using it more efficiently in the transformation of dry matter. The quantity of P in the soil after the application of phosphate fertilizer can directly influence the response of the plant, the crops being capable of adapting according to the quantity of this nutrient in the soil solution (Oliveira el al., 2011). Similar results have been reported in the literature, some researches like Oliveira et al. (2012), studying soils with different P absorption capacities reported that the plant absorbs less P in soil with a greater quantity of clay in comparison to a sandy soil, because of the greater competition between the soil and the plant for the nutrient (P), the plant perfects the use of P in the production of dry matter.

The increase in dosages of phosphate brings about a greater response in the plant in relation to the dry matter, in that the 150 mg dm^{-3} dosage (moderate dosage) the production of dry matter was not affected by the soil (Figure 4b). The greater responses in the plant we found in the 150 e 300 mg dm^{-3} dosages for sugar cain cultivated in Quartzipsamment and Kandiudult in the two cycles, demonstrating that this section could be characterized as an adequate level of phosphate for the plant.



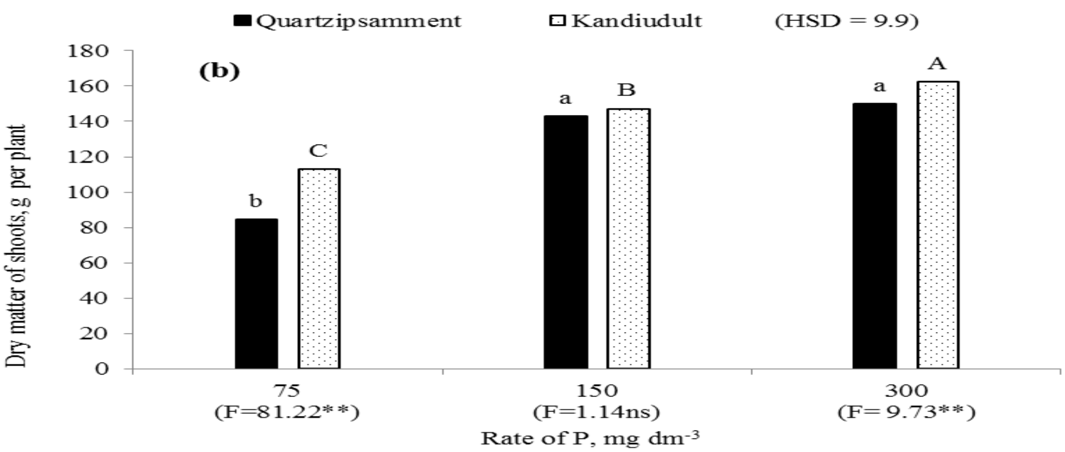


Figure 4.Dry matter of the aerial part (DMAP) of sugar cane (second cycle) ein function of the two soils (a) and in function of the doses of phosphate (b) in different levels of peat.ns, not significant;** significant ($p<0,01$) e *significant ($p<0,05$). Averages followed by the same letter do not differ statistically from each other by Tukey's test at 5%. (HSD= 9,9); lower case letters compare the dosages of phophate within the Quartzipsamment and capital letters comare the doses of P within the Kandiudult.

In analysis of the results found in the second-cycle sugar cane for the variables, accumulation of phosphorus and dry matter, it can be observed that greater increments were found when the dosages of phosphorus were increased in the presence and in the absence of peat, demonstrating that the residual effect of the phosphate is affected by the addition of the natural phosphate. Kifuko et al. (2007) reported that there is a positive relationship between dosages of natural reactive phosphate and quantity of available P in an experiment of field incubation demonstrating that the dissolution of the FNR was favored by the time of experimentation. It can be noted as well that the response of the plant is increased when the dosages of natural reactive phosphate are associated with the peat extract, is probably occurs because the association makes possible a significant increase in the residual effect of the phosphate, bringing about greater absorption of this nutrient by the plant and consequently reflecting in a greater quantity of dry matter in the two soils.

Favorable results were encountered by Gullo (2007) emratoons treated with association of mineral fertilizer and dosages of 300 and 600 L ha^{-1} of humic substances applied in first-cycle sugar cane in sandy soil, obtaining as a result an increase in culm productivity. Rosset et al. (2014) applied in lines of ratoons cultivated in medium texture Hapludox soil 10 kg ha^{-1} of humic substances (12% humic acid and 3% of fluvic acid), and obtained a significant response in the diameter of the culm and increments in culm productivity. According to Silva et al. (2007), the effect of the phosphated fertilization associated with the organic fertilizer brings about an increase in the absorption of phosphorus by the plant and in the tillering of the second cycle, these results will probably be reflected in greater culm productivity (Santos et al., 2009).

In addition, the absorption of phosphorus by the second cycle sugar cane is benefited by the dissolution of the natural reactive phosphate, which, because it is a low-velocity source in the freeing-up of P in relation to the soluble sources in water, synchronizes the mineralization of the organic matter with its solubilization with the passing of time, having the effect of diminished absorption and consequently increasing its P residual effect bringing about greater use of this nutrient by the plants (Resende et al., 2006).

The results obtained in this experiment utilizing a dosage of peat extract(520 L ha^{-1}) as a source of humic substances, associated with phosphated fertilizers in sugar cane, could become a more viable way of obtaining the greater productivity of sugar cane culm in first-cycle and second-cycle sugar cane. Considering also that the application of peat in its liquid form is relatively easier and less costly than peat in its solid state, especially due to the difference in volume--for in order to obtain significant results with the application of solid peat it would be necessary to use about 25 t ha^{-1} in sugar cane crops(Matias, 2010). However, it is still necessary to complement this study with field work, to enable more conclusions with respect to the use of this peat extract in sugar cane cultivation.

3. Conclusions

The adequate level of phosphate for the plant occurred between the 150 - 300 mg dm^{-3} dosages;The associated natural phosphate and peat extract brought about greater increments in the sugar cane in the two cycles than the isolated phosphate in all the studied variables;

The plant cultivated inQuartzipsamment obtained a greater accumulation of P in the first cycle, however, greater increment of dry matter was found in the plant cultivated in Kandiudultin the two cycles of sugar cane. However, the use of the humic substance enhances the development of self-soil culture media used.

4. Acknowledgements

I acknowledge Laboratory of Plant Nutrition in Vegetal Production Department/College of Agrarian and Veterinarian Sciences, Coordinated by Prof. Dr. Renato de Mello Prado. The Higher Education Personnel Training Coordination (CAPES) Higher Education Personnel Training Coordination (CAPES) for granting the scholarship.

5. LiteratureCited

Almeida Júnior, A. B., C. W. A. Nascimento, M. F. Sobral, F. B. V. Silva and W. A. Gomes. 2011. Soil fertility and uptake of nutrients by sugarcane fertilized with filter cake. Revista Brasileira de Engenharia Agrícola e Ambiental. Campinas. 15 (10), 1004–1013.doi.org/10.1590/S1415-43662011001000003.

Barbosa, J. C. and W. Maldonado Jr. 2011. AgroEstat - System for Analysis Testing of Statistics Agronomic. Version 1.1.0.626.

Bastos, A. L., J. P. V. Costa, I. F. Silva,R. W. C. Raposoand J. S.Souto. 2008. Influence of doses and phosphorus in the diffusive flux in Alagoas soil. Revista Brasileira de Engenharia Agrícola e Ambiental, 12, 136-142.doi.org/10.1590/S1415-43662008000200005.

Bataglia, O. C., A. M. C.Furlani, J. P. F. Teixeira, P. R.Furlaniand J. R. Gallo. 1983. Métodos de análise química de plantas. Campinas: Instituto Agronômico, 8-10 (Boletim técnico no 78).

Benzoni neto, A. 2006. Programa tradecorp. In: Novas tendências da nutrição organo-mineral em cana-de-açúcar, 1, 2006, Araçatuba. Disponível em: <http:www.udop@udop.com.br >. Acesso em: 10 ago.2013.

Embrapa: Empresa Brasileira de Pesquisa Agropecuária - Centro Nacional de Pesquisa de Solos. 1999. Manual de métodos de análise de solo. 2a.ed. Revisada e atualizada. Rio de Janeiro-RJ, 212p.

Embrapa. Empresa Brasileira de Pesquisa Agropecuária - Centro Nacional de Pesquisa de Solos. 2013. Sistema brasileiro de classificação de solos. 2ª ed. Rio de Janeiro: Embrapa Solos, 300 p.

Fravet, P. R. F., R. A. B. Soares, R. M. Q Lana and G. H. Korndörfer.2010.Effect filter cake doses and mode of application on yield and technological quality of stumps of cane sugar.Ciência e agrotecnologia, Lavras, 34, 618-624.maio/jun 2010.

Gullo, M. J. M. 2007 Use of the foundation soil conditioners humic acid in sugar cane crop (Saccharum spp.). Piracicaba, 2010. 174 p. graduate schoolDissertacion (MSc in Agronomy - Area of Concentration: Crop Science). Escola Superior de Agricultura "Luiz de Queiroz".

Kifuko, M. N., C. O. Othieno, J. R.Okalebo, L. N.Kimenye, K. W.Ndung'uand A. K. Kipkoech.2007. Effect of combining organic residues with minjingu phosphate rock on sorption and availability of phosphorus and maize production in acid soils of Western Kenya.Experimental Agriculture, Bangor, 43, 51-66. doi.org/10.1017/S0014479706004121

Machado, R. S., R. V. Ribeiro,P. E. R. Marchiori, D. F. S. P Machado, E. C. Machado and M. G. A. Landell. 2010. Biometric and physiological responses to water deficit in sugarcane at different phenological stages. Pesquisa Agropecuária Brasileira. Brasilia. 44 (12). doi.org/10.1590/S0100-204X2009001200003.

Matias, G. C. S. 2010. Agronomic efficiency of phosphate fertilizers in soils with different phosphorus adsorption capacity and organic matter content.Doctoralthesis.Escola Superior de Agricultura "Luiz de Queiroz", Piracicaba- SP, 174 p.

Mielniczuc, J. 2008. Matéria orgânica e sustentabilidade de sistema agrícola. In: Santos, G. A., L. S. Silva, G. A.Canellasand F. A. O. Camargo. Fundamentos da matéria orgânica do solo: ecossistemas tropicais e subtropicais. 2.ed. Porto Alegre: 2008. Metrópole. pp: 1-18.

Novais, R. F., V. H. Alvarez, N. F. Barros, R. L. F. Fontes, R. B. Cantaruttiand J. C. Neves. 2007.Fertilidade do solo. Sociedade Brasileira de Ciência do Solo, Viçosa-MG, 1017 p.

Oliveira, F. M., I. Aspiazú, M. K.Kondo, I. D. Borges, R. F.Pegaroroand E. J. V. Vianna. 2011. Crescimento e produção de variedades de cana-de-açúcar influenciadas por diferentes adubações e estresse hídrico. Revista Trópica – Ciências Agrárias e Biológicas. V. 5- 1, 56-67.

Oliveira, P. S. R., B. B.Deminicis, D. D. Castagnaraand F. C. N. Gomes. 2012. agronomical characteristics of the mombaça grass fertilized with phosphorus in sandy and loamy soils. Archivos de Zootecnia. 61 (235), 397-406.doi: 10.4321/S0004-05922012000300008

Olsen, S. R.andF. S.Watanabe. 1957. A method to determine a phosphorus adsorption maximum of soils as measured by the Langmuir Isotherm.Soil Science Society America Proceedings. 21, 144-149.

Prado, R. M., G. Caioneand C. N. S Campos. 2013. Filter Cake and Vinasse as Fertilizers Contributing to Conservation Agriculture. Applied and Environmental SoilScience. Id:581984, 8pages .doi.org/10.1155/2013/581984.

Raij, B. van and H. Cantarella.1997.Milho para grãos e silagem. In: Raij, B. van; Cantarella, H.; Quaggio, J. A.; Furlani, A. M. C. Recomendações de adubação e calagem para o Estado de São Paulo. Campinas, Instituto Agronômico, 1997, 285p. (Boletim Técnico, 100).

Raij, B. van, J. C. Andrade,H. Cantarellaand J. A.Quaggio. 2001. Análise química para avaliação da fertilidade de solos tropicais. Campinas: Instituto Agronômico. 2001. 285p.

Resende, A. V., A. E. Furtini Neto, V. M. C. Alves, J. A. Muniz, N. Curi and F. J. Lago. 2006. Match response to phosphorus sources and application methods during three successive crops in soil of the cerrado region. Ciência e Agrotecnologia, Lavras, mai/jun. 30, 458-466.

Rosset, J. S., J. A. Schiavoand R. A. R Atanázio. 2014. Chemical attributes, total organic carbon stock and humified fractions of organic matter soil submitted to different systems of sugarcane management. Ciências Agrárias, Londrina, v. 35, n. 5, p. 2351-2366, set./out. 2014.doi: 10.5433/1679-0359.

Santos, V. R. dos, G. Moura Filho, A. W.Albuquerque,J. P. V. Costa, C. G. Santos and A. C. I. Santos. 2009. Crescimento e produtividade agrícola de cana-de-açúcar em diferentes fontes de fósforo. Revista Brasileira de Engenharia Agrícola e Ambiental. 13(4), 389–396.

Silva, M. A., G. J. C. Gava, M. M. Caputo, R. P.Pincelli, E. M. Jerônimo and J. C. S. Cruz. 2007. Uso de reguladores de crescimento como potencializadores do perfilhamento e da produtividade em cana-soca. Bragantia, Campinas, 66, 545-552.doi:S0006-87052007000400003

Stamford, N. P., C. E. R. S. Santos, W. P. J. Stamfordand S. H. L. Dias. 2006. Rock biofertilizers with Acidithiobacillus on sugarcane yield and nutrient uptake in a Brazilian soil.GeomicrobiologyJournal. 23, 261-265.doi:119017336001.

Tasso Júnior, L. C.,M. O. Marques, A. Franco, G.A.Nogueira, F. O.Nobile, F.Camilottiand A. R. Silva. 2007. Yield and quality of sugar cane cultivated in sewage sludge, vinasse and mineral fertilization supplied soil. EngenhariaAgrícola, Jaboticabal, 27 (1), 276-283.doi.org/10.1590/S0100-6916/2007/000100022.