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RESPONSE TO SIMPLE SUPERPHOSPHATE AND TOP-PHOS FERTILIZER ON WHEAT IN AN OXISOIL

[RESPUESTA A LA FERTILIZACIÓN CON SUPERFOSFATO SIMPLE Y TOP-PHOS EN TRIGO EN OXISOL]

P. V. D. Molin[1], L. Rampim[1*], F. Fávero[1], M. do Carmo Lana[1], M. V. M. Sarto[1], J. S. Rosset[1], D. Mattei[1], P. S. Diel[1] and R. N. D. Molin[1]

[1] State University of West Paraná, Unioeste, CCA/PPGA, Pernambuco Street No. 1777, P.O. Box 9, Zip Code 85960-000, city of Marechal Cândido Rondon, Paraná state, Brazil. E-mail: paulo_vi7or@hotmail.com; rampimleandro@yahoo.com.br
**Corresponding author*

SUMMARY

The limitation of natural resources coupled with growing demand for fertilizers to sustain increased crop productivity ally to meet world demand for food intensifies the search for greater efficiency in fertilizer use. The objective of this study was to evaluate the response of phosphorus fertilization on wheat plants, noting its influence on the agronomic and nutritional characteristics of wheat and chemical attributes soil. The experiment was conducted in a greenhouse with two sources of single superphosphate (P - 18% P_2O_5 and top-phos - 22/28% P_2O_5) and P_2O_5 five doses (0, 50, 100, 150 and 200 kg ha^{-1}), in 2 dm^3 pots. Shoot dry matter give maximum point buildup dose of 151.25 kg ha^{-1} P_2O_5 and root dry matter point is the maximum dose of 165 kg ha^{-1} P_2O_5 independent of fertilizer used. Application of P_2O_5 levels with superphosphate fertilizer and top-phos increase levels of pH and available soil P and P content, K and S in the leaf tissue. Recommend both, simple superphosphate with 18% P_2O_5 as top-phos, considered with 28% P_2O_5 for phosphate fertilizer in wheat crop, by selecting the fertilizer that provide best value for money, in this case the superphosphate.

Key words: *Triticum aestivum*; Available phosphorus; Adsorption of phosphorus; Fertilizer; Organomineral.

RESUMEN

La limitación de los recursos naturales, junto con el aumento de la demanda de fertilizantes para mantener el aumento de la productividad de los cultivos, para satisfacer la demanda mundial de alimentos intensifica la búsqueda de un uso más eficiente de los fertilizantes. El objetivo de este estudio fue evaluar la respuesta de la fertilización con P en plantas de trigo en Oxisol, y su influencia en las características agronómicas y nutricionales de los cultivos de trigo y las propiedades químicas del suelo. El experimento se realizó en un invernadero, instalado en un diseño completamente al azar con dos fuentes de P (superfosfato - 18% de P_2O_5 y top-phos - 22/28% P_2O_5) y cinco dosis de P_2O_5 (0, 50, 100, 150 y 200 kg ha^{-1}) en el recipiente 2 dm^3. Se obtuvo la producción de materia seca al punto de máxima acumulación con dosis de 151.25 kg ha^{-1} de P_2O_5 y el peso seco de la raíz al punto máximo fue en con dosis de 165 kg ha^{-1} de P_2O_5 independiente del fertilizante utilizado. La aplicación de dosis de P_2O_5 en fertilizante superfosfato y top-phos aumento de pH y los niveles de P disponibles en el suelo y el contenido de P, K y S en las hojas. Se recomienda tanto el superfosfato simple 18% de P_2O_5 como la top-phos, considerado con un 28% de P_2O_5, para la fertilización con fósforo del trigo cultivado, el fertilizante que presenta la mejor relación calidad-precio, en este caso fue el superfosfato simple.

Palabras-chave: *Triticum aestivum*; Fósforo disponible; adsorción de fósforo; Fertilizantes; Organomineral.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a cereal widely used in food and feed. Due to its ease of adaptation is much cultivated in subtropical regions as tropical, with the most cultivated cereal in production volume (Caierão, 2009), with approximately 651 million tons of grain (Usda, 2012).

To keep the food supply, the increase in productivity of existing agricultural areas is one of the (Pinto-Zevallos and Zarbin, 2013) solutions. Thus, it becomes important to conduct studies which will help minimize the effect of the factors causing yield loss and depreciation of the quality of the wheat, as the occurrence of pests and diseases (Gallo *et al*., 2002; Kimati *et al*., 1997), problems with soil fertility (Raij, 2011) and mineral nutrition (Fernandes, 2006; Malavolta, 2006).

Among the nutritional factors stand positive responses to the use of nitrogen (N) (Freitas *et al*., 1994, 1995) and phosphorus (P) (Oliveira *et al*., 1984; Camargo and Merriman, 1987; Clark, 1990; Souza, 1996). In the case of P, is cited as responsible for achieving high productivity of wheat (Gargantini *et al*., 1958) and is essential in the early stages of plant growth (Malavolta, 2006), the adequacy of the pH with liming. (Bataglia *et al*., 1985, Souza, 1996). According to Lopes and William (2000), 50% of P is assimilated by plants when at pH 6.0 and 100% at pH 6.5 and 7.0. In other words, soil pH can influence the efficiency of use of applied P, and consequently affect the productivity and profits of the farmer.

Among the essential macronutrients for plants, P is one of the least required by plants, but it is the most used in fertilization by low levels available in the soil and also for being the one that most often limits crop production (Faquin, 2005). The low availability to the plants is due to high content of aluminum and iron oxides in the soil, which has a high phosphorus adsorption capacity (Kliemann and Santos, 2005), mainly evidenced in acidic soils. Different answers for the use of soil P and fertilizer among cultivars have been reported, so that Coimbra et al. (2014) identified different behavior between corn hybrids with tolerance to low soil P for some hybrids, while others are more responsive to phosphorus fertilization, an increase in productivity.

The site of application of fertilizer in the soil can also influence fertilization, since the greater the dilution of P in the soil, the greater its interaction with soil particles, which is observed when performing broadcast fertilization, reduced condition with the application localized fertilizer at sowing (Resende *et al*., 2007). In the case of the P, localized application is most suitable, not only due to its interaction with the oxides of iron and aluminum in the soil, but its way of absorption, diffusion (Lopes and Guilherme, 2000), related to their low mobility in soil. To Vilar and Vilar (2013) the plants have several ways to alleviate the problems arising from P deficiency, such as changes to obtain, absorb and retain P to be used, as well as the symbiotic mycorrhizal associations increasing the area of land use and releasing phosphatases acting on solubilization of P.

Single superphosphate is obtained by reaction between finely ground rock phosphate and sulfuric acid. P low solubility of phosphate present in the natural undergoes changes in its chemical structure, giving product of the highest water solubility and highest agronomic efficiency. This immediately makes available P in soil in adequate amounts from the start of the crop cycle, providing the conditions for correct formation of the root system of the plants (Novais *et al*., 2007). Sandy soils have higher P availability after phosphate fertilizers compared to soils with increasing levels of clay (Machado *et al*., 2011).

Top-phos is present in a complex formulation that protects the P element fixing with aluminum, iron and calcium, making this nutrient more available and usable for the plants, with the complex provides greater root development. Thus, the top-phos can also benefit from the absorption of water and other nutrients, particularly P, due to the larger contact area with the roots (Timac Agro, 2012).

Thus, the aim of this study was to evaluate the response of phosphorus fertilization on wheat plants using two phosphate fertilizer superphosphate and top-phos in Oxisoil, noting its influence on the agronomic and nutritional characteristics of wheat and chemical attributes soil.

MATERIAL AND METHODS

The experiment was conducted in a greenhouse at the Horticulture and Protected Cultivation Mário César Lopes Station, belonging to the State University of West Paraná – Unioeste, campus Marechal Cândido Rondon - PR, with geographical coordinates 54º 22' W and 24º 46' S, and an average altitude of 420 meters.

The experimental design was completely randomized, with four replications in a factorial scheme 2 x 5, with two sources of single superphosphate (P - 18% P_2O_5, 18% Ca and 10% of S and top-phos - 22/28% P_2O_5, 17% Ca and 5% S) and five P rates (0, 50, 100, 150 and 200 kg ha^{-1} P_2O_5). For the top-phos was considered the ratio of 28% P_2O_5 which includes the total concentration of P fertilizers, since 6% is considered slow release (TIMAC AGRO 2012).

The experiment was conducted in pots and deployed for up to 5 dm^3 of soil. Fertilizer application was done before planting by mixing the ground fertilizer with the soil contained in pots. The soil was collected in the municipality in Jesuítas - PR, ranked Oxisoil clayey (Embrapa, 2013) with the following chemical properties: pH in $CaCl_2$ = 4.92; COT = 5.43 g dm^{-3}, P = 2.40 mg dm^{-3}, K^+ = 0.70 $cmol_c$ dm^{-3}, Ca^{2+} = 5.84 $cmol_c$ dm^{-3}, Mg^{2+} = 2.22 $cmol_c$ dm^{-3}, H + Al = 2.51 $cmol_c$ dm^{-3}, Al^{3+} = 0 $cmol_c$ dm^{-3}, SB = 8.76 $cmol_c$ dm^{-3}, CEC = 11.27 $cmol_c$ dm^{-3} and V = 77.73%.

Sowing was held on June 14, 2011, using supervised seeds of wheat cultivar Mirante. Six seeds per pot of wheat, subsequently performing thinning, leaving four plants per pot were sown. The control of soil moisture was through irrigation of the plants keeping the soil at field capacity. There was no need for fungicide application in shoots. To control thrips (*Thrips* sp.), The application of the insecticide thiamethoxam + lambda cyhalothrin at a dose of 40 mL ha^{-1} performed on August 5, 2011.

Phenological stage of elongation of wheat plants, four plants per pot were cut at ground level, with a separate shoot of the root system. The roots were washed to remove adhering soil, then the mass of shoots and roots were placed in an incubator at 60°C with forced air until constant mass, so that the shoot dry matter was determined (SDM, grams) and root dry matter (RDM, grams).

Subsequently, the SDM was ground and subjected to the nitric-perchloric digestion and determination of the levels of P, K, Ca, Mg and S (g kg^{-1}), according to the method described by EMBRAPA (2009). Content of P in shoots depending on the RDM, obtained by multiplication between the SDM and the P levels obtained in shoots was calculated. With the collection of plants, three samples were remove of soil from each pot for later determination of pH_{CaCl2} and P exchangeable (mg dm^{-3}) (EMBRAPA, 2009).

Data by treatments were subjected to analysis of variance for variables, and regression for P doses when significant, selecting higher R^2 to linear and quadratic effect. When required fertilizer sources was significant, the comparison of means was performed by F-test, that conclusion for just two levels by factor doses (top-phos and single superphosphate). Statist analysis was used SAEG 8.0 software (SAEG, 1999).

RESULTS AND DISCUSSION

Growth characteristics

For the growth characteristics in Table 1, the mean effect was observed only for doses tested independent of superphosphate fertilizer or top-phos, no difference between the fertilizers for both shoot dry matter (SDM) and root dry matter (RDM).

The SDM showed quadratic growth with maximum point to the dose of 151.25 kg ha^{-1} P_2O_5 independent of the use of SFS or top-phos, since there was no interaction between fertilizer. Accumulation was 1.073 g shoot dry matter of wheat plants in the elongation phase (Figure 1a). Thus the application of P through different products did not affect the response of plants to accumulate dry matter, corroborating data presented in a study by Resende *et al*. (2007), which tested the application of different P sources, different solubilities and different methods of application on corn plants, a similar increase in production was observed.

For RDM, seen in Figure 1b, was found similar to the SDM behavior with quadratic growth, the point of maximum dry matter accumulation was obtained with the dose of 165 kg ha^{-1} P_2O_5, independent of fertilizer used. Zanini *et al*. (2009) to use the form of triple superphosphate as P for forage species also found quadratic response to fertilization with the point of maximum accumulation of RDM with the dose of 170 mg kg^{-1} soil P to *Brachiaria brizantha*.

Both SDM increased as the RDM with the application of superphosphate and top-phos observed in the elongation stage of wheat plants are related to the immediate immediate effects of these phosphate fertilizers, since they exhibit high solubility (Kliemann and Santos, 2005), showing the use of both phosphorus deficient soils on the ground. On the other hand, when reaching limit accumulation of SDM and RDM probably exceeded the critical level of P for plants, primarily occurring luxury consumption by P (Figure 2a) without passing in increased dry matter in wheat, indicating the limit doses of fertilizer to perform a correction. This was, from the optimal doses of P, the phosphorus can adversely affect the sustainability and cost-effectiveness of fertilizer recommendation.

The point of maximum accumulation of SDM showed levels five times higher compared to the control without applying P. Cunegato *et al*. (2011) studied the application of P levels on SDM of wheat, observed that the treatments without P addition had reduced growth in Planosolo compared to plant growth with higher doses of up to 512 mg kg^{-1} of P soil, starting plateau accumulation of SDM close to 100 g kg^{-1} of P soil.

Table 1. F values, coefficient of variation (CV%), production of shoot dry matter (SDM) and root dry weight (RDM) in the elongation of wheat crop, and pH $CaCl_2$, phosphorus exchangeable (P) and P content in soil in terms of levels of phosphorus (P_2O_5) with fertilizer super simple (SFS) and top-phos. Marechal Cândido Rondon – PR, 2011

Fertilizer doses	SDM	RDM	pH $CaCl_2$	P exchangeable	P content
Top-phos	--------------- g	----------------	------------	--- mg dm^{-3} ---	---- mg ----
--- kg P_2O_5 ---					
0	0.179	0.194	4.71	4.74	0.0004
50	0.507	0.415	5.72	6.03	0.0015
100	1.036	0.680	5.28	9.30	0.0038
150	1.054	0.573	5.45	17.76	0.0055
200	1.062	0.599	5.44	19.79	0.0071
Simple superphosphate					
--- kg P_2O_5 ---					
0	0.253	0.245	5.23	4.27	0.0005
50	0.891	0.693	5.18	6.17	0.0028
100	1.110	0.686	5.57	9.86	0.0044
150	1.040	0.609	5.64	14.90	0.0056
200	0.957	0.607	6.11	15.41	0.0057
Fertilizer					
Top-phos	0.7676	0.4922	5.32	11.52	0.004
Simple superphosphate	0.8502	0.5680	5.55	10.12	0.004
Medium values					
	0.81	0.53	5.43	10.82	0.004
F values					
Fertilizer	1.07 ^{ns}	2.56 ^{ns}	3.63 ^{ns}	0.19 ^{ns}	0.23 ^{ns}
Doses	16.76 **	11.55 **	5.08 **	23.50 **	60.49 **
Linear	47.32 **	23.02 **	4.18 *	45.14 **	237.69 **
Quadratic	18.75 **	19.16 **	4.31 *	0.17 ^{ns}	3.33 ^{ns}
Fertilizer x Doses	1.07 ^{ns}	1.17 ^{ns}	3.02 *	0.44 ^{ns}	2.54 ^{ns}
C.V. (%)	31.11	28.23	6.79	22.18	23.67

* e **: significant at 5% and 1%, respectively, by F test; ^{ns}: not significant at the 5% level by F test.

Leaf tissue of nutrients

For the levels of foliar nutrients in Table 2, significant effects for the independent tested doses of superphosphate fertilizer or top-phos was observed with no difference between fertilizer for both the concentration of the nutrients P, K and S as to the contents of P in shoots of wheat plants. However, for Ca and Mg nutrients, a significant effect for fertilizers.

P concentration in leaf tissue, observed in Figure 2a, was influenced positively with the addition of P_2O_5 levels with fertilizer. Can evaluate that until the dose of 200 kg ha^{-1} P_2O_5 gave the highest content of foliar P, proving the plant uptake of P added. However, has not reached the point of maximum accumulation in leaf tissue, other words, would be able to use higher dose to evaluate the content of P. Frandoloso *et al.* (2010) in an experiment with corn to test two types of phosphate fertilizers, found an increase in foliar P concentration up to a dose of 247 kg ha^{-1} of P_2O_5 for triple superphosphate and until the dose of 194 kg ha^{-1} P_2O_5 for phosphate rock.

Rosolem and Nakagawa (2005) evaluating nutrient content in leaves and grains of oat due fertilization with phosphorus and potassium, also found increased levels of nutrients flag leaf with phosphate. This increase may be a reflection of the increase in plant development provided by the addition of P in soil with low content of element (Nakagawa *et al*., 2003), as in this work with 2.4 mg dm^{-3} in the soil and may result in greater root formation (Malavolta *et al*., 2006), thus favoring the absorption and accumulation of nutrients.

For the P content in shoots (Figure 2a), linear growth with the doses for both fertilizer was observed, demonstrating that the phosphorus, regardless of its source, made available soil P (Figure 4b), being absorbed by plants wheat. Thus, even while a reduction of SDM (Figure 1a) remained linear increase of P content in the tested doses, because the increase in the availability of soil P (Figure 4b) has kept the P uptake by wheat plants identified by the P content in the leaf tissue (Figure 2a), without reaching maximum level with available soil P provided with doses up to 200 kg ha^{-1} de P_2O_5.

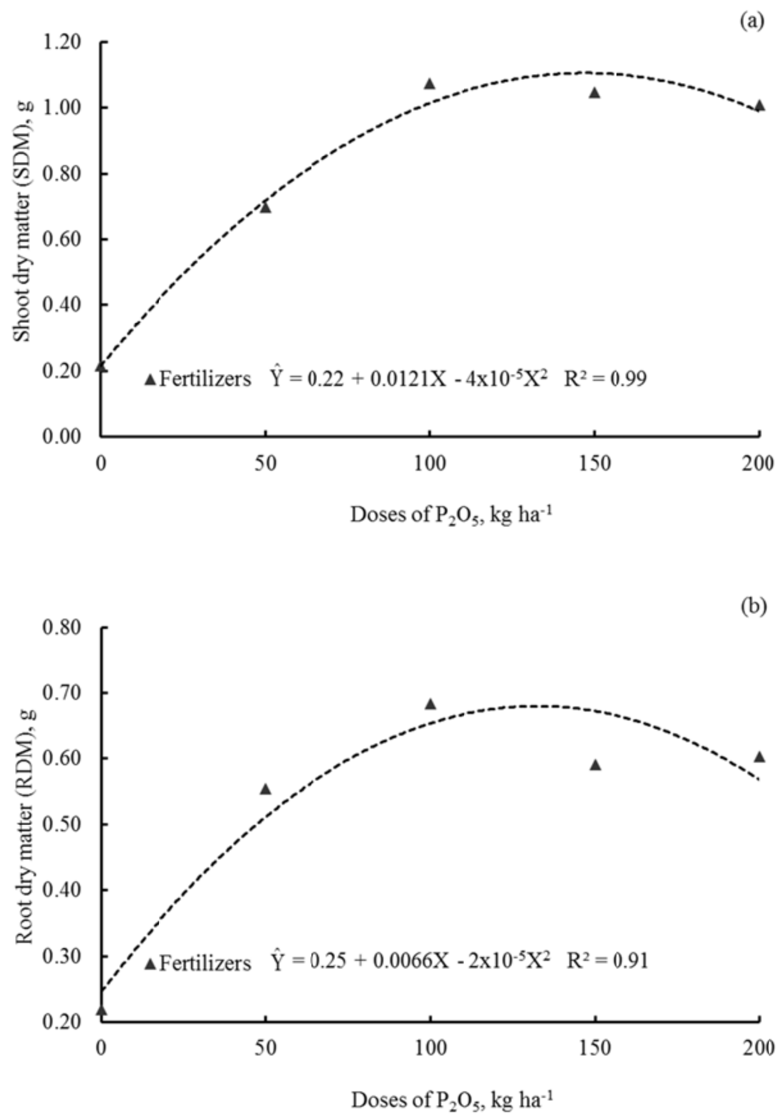

Figure 1. Production of shoot dry matter (SDM) (a) and root dry matter (RDM) (b) the elongation of wheat crop in function of P rates applied to average superphosphate fertilizer and top-phos. Marechal Cândido Rondon – PR, 2011.

Table 2. F values, coefficient of variation (CV%) and phosphorus (P), potassium (K), sulfur (S), calcium (Ca) and magnesium (Mg), and P content in shoots in wheat during elongation of wheat crop in terms of levels of phosphorus (P_2O_5) with superphosphate fertilizer (SFS) and top-phos. Marechal Cândido Rondon – PR, 2011

Fertilizer doses	P	K	S	Ca	Mg
Top-phos	---------- g kg^{-1} ----------				
--- kg P_2O_5 ---					
0	1.08	18.67	2.56	47.77	17.32
50	1.33	22.15	2.91	34.21	12.61
100	1.58	26.09	1.96	33.64	12.53
150	2.12	28.69	2.47	29.32	10.69
200	2.79	31.20	4.82	31.64	13.25
Simple superphosphate					
--- kg P_2O_5 ---					
0	0.88	17.62	2.01	30.42	11.76
50	1.35	23.64	2.32	32.23	10.39
100	1.64	25.16	2.53	26.04	10.85
150	2.27	28.94	2.89	32.14	12.12
200	2.50	31.25	3.23	28.66	9.85
Fertilizer					
Top-phos	1.78	25.36	2.94	35,32 a	13,29 a
Simple superphosphate	1.73	25.32	2.60	29,90 b	11,00 b
			Medium values		
	1.75	25.34	2.77	32.61	12.14
			F values		
Fertilizer	0.84 ^{ns}	0.01 ^{ns}	1.28 ^{ns}	5.28 **	8.96 **
Doses	11.91 **	11.12 **	4.46 **	2.15 ^{ns}	2.49 ^{ns}
Linear	92.50 **	43.80 **	10.60 **	5.98 *	-
Quadratic	0.90 ^{ns}	0.54 ^{ns}	4.83 *	2.27 ^{ns}	-
Fertilizer x Doses	0.39 ^{ns}	0.11 ^{ns}	1.62 ^{ns}	2.09 ^{ns}	2.24 ^{ns}
C.V. (%)	44.79	17.11	35.12	22.86	19.93

* e **: significant at 5% and 1%, respectively, by F test; ^{ns}: not significant at the 5% level by F test. Means followed by the same capital letter in the line do not differ by the F test.

In Figure 3 it can be seen that the dose from 56,8 Kg ha^{-1} de P_2O_5 was no increase in foliar S content, probably due to both fertilizers having sulfur in the formulation (Figure 3b), with a concentration of 16% the super simple, and 5% in the top-phos. In fact, according Novais *et al*. (2007), superphosphate can be recommended to provide sulfur fertilization in the row for annual crops in soils with chemical deficiency in this attribute. The presence of S in both fertilizer and increase of S in the leaf tissue, evidence the possibility to use them to provide part or all of the need for S to wheat crop. On the other hand, according to Raij (2011) and Rampim et al. (2013), the need for high doses of S can be provided through the gypsum being recommended dose of this product to clay soils with high P adsorption capacity (Vilar *et al*., 2010).

Concentration of K in the sheet was affected at doses of P_2O_5, increase being detected through the use of phosphate fertilizers doses (Figure 3a). This may be related to the establishment of more appropriate nutritional conditions, resulting in an increase in SDM and RDM (Figure 1a and Figure 1b), and leaf P content (Figure 2a). Since, P is predominantly absorbed and translocated in plants under anionic form ($H_2PO_4^-$), the absorption of positive companion ion to the charge balance in the plant making required and potassium (K^+) (Faquin, 2005). Moreover, it may have been an increased uptake of K in the soil before the increased metabolic activity in the higher P levels, reflecting mainly the increase of SDM and RDM. According Faquin (2005), K acts on cell expansion and P in metabolic processes, increased metabolism to occur has consequently increased cellular growth, increased photosynthetic activity and increased formation of ATP, raising the application K.

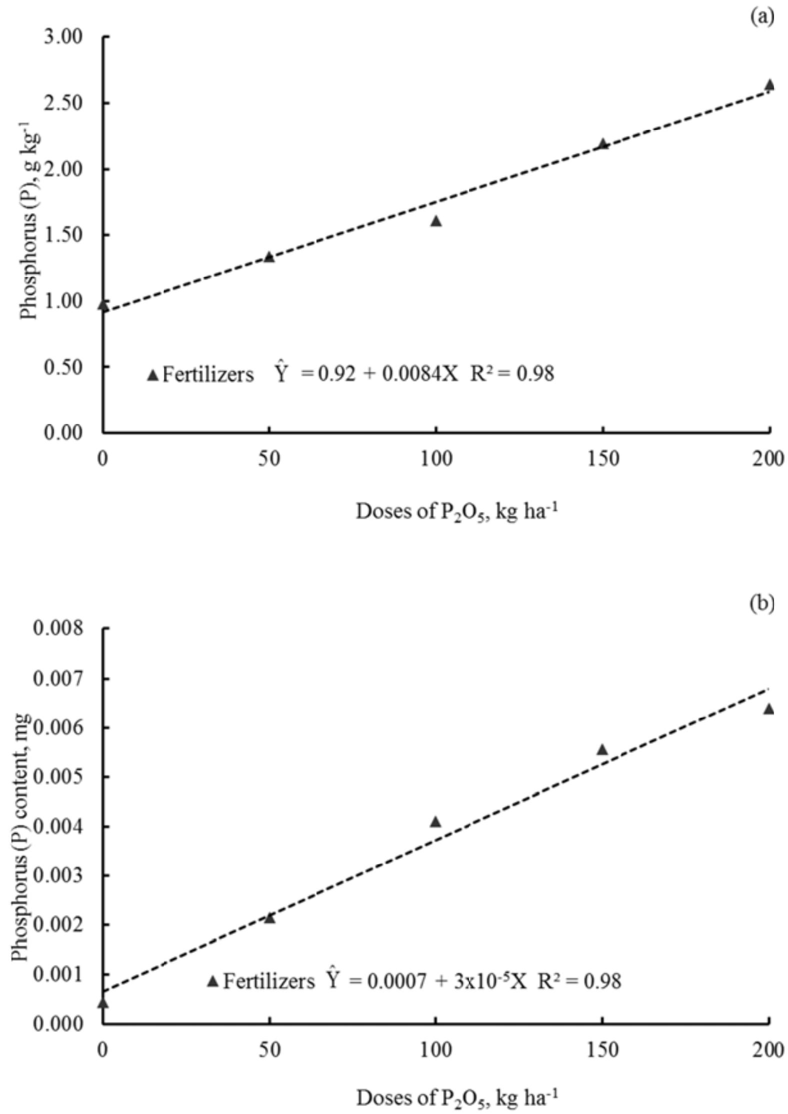

Figure 2. P (a) leaf tissue foliar and P content (b) in shoot elongation in wheat crop in terms of rates of phosphorus fertilizer applied to the average of superphosphate and top-phos. Marechal Cândido Rondon – PR, 2011.

For the calcium and magnesium leaf, there was significant difference between the tested products, and in both cases, the top-phos fertilizer increased concentration of Ca and Mg higher than superphosphate (Table 2). The uptake of Ca and Mg fertilization provided by the top-phos may be related to complexing present in the fertilizer. When the linear absorption of P with doses of P_2O_5 occurs may be due to increased Ca absorption, which can originate both fertilizer as soil and Mg in the soil that the complexing may have increased plant uptake because keeping the soil moisture at field capacity, and at work, enhances the absorption of P (Costa *et al*., 2006.; Costa *et al*., 2009) found in Figure 2a. Thus, moisture can facilitate the mobility of complexes of Ca and Mg in the soil and can be absorbed into the transport stream (Novais *et al*., 2007).

Chemical properties in the soil

For soil chemical properties, it was found a significant effect for the interaction between fertilizer and the doses for variable soil pH, while for the P exchangeable in the soil was a significant effect only for independent fertilizer doses tested, not being observed difference between them (Table 1).

In Figure 4a we observed a linear increase in soil pH with doses of phosphate fertilizers for both the SPS and for the top-phos; so that the SFS showed higher increase in pH per unit of added fertilizer in the top-phos. Thus, with the increase of phosphorus fertilization on soil acidity reduction was observed and may be related to the presence of calcium in the formulation, which can raise the base saturation and consequently minimize the effect of the acidity due to the dilution effect, aimed at reducing the hydrogen ion activity in the soil (Novais *et al*., 2007; Raij, 2011).

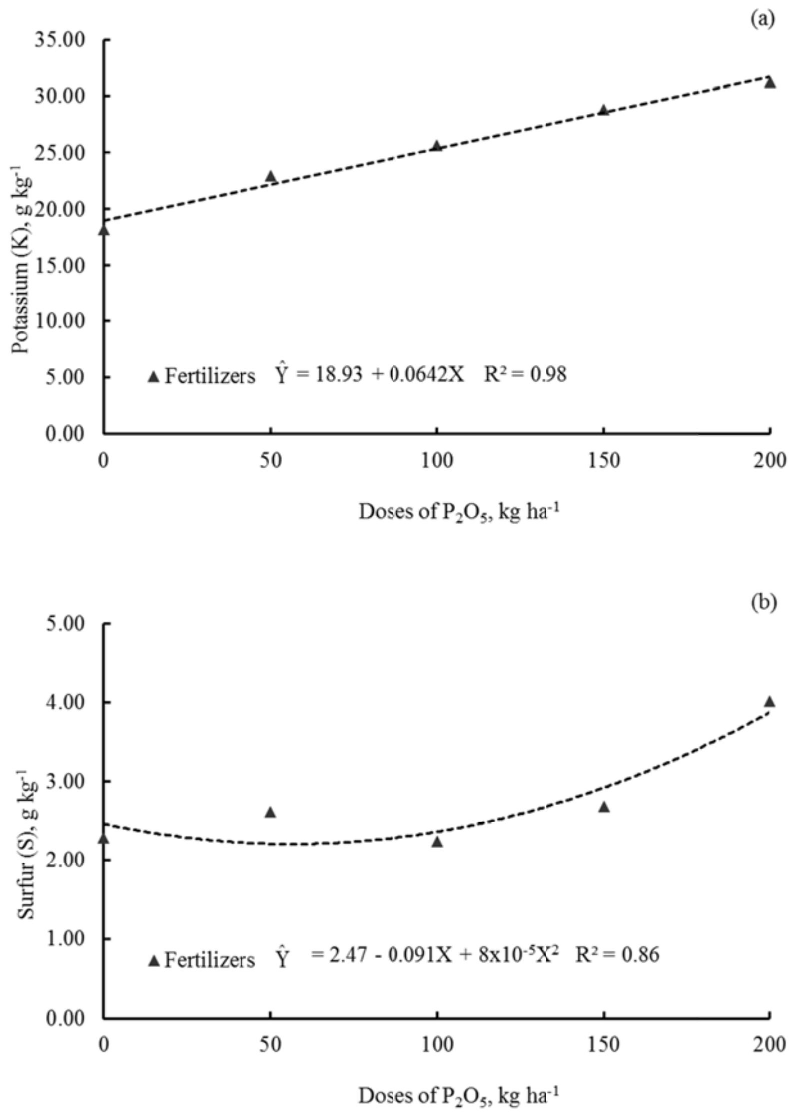

Figure 3. K (a) and S (b) leaf tissue foliar in shoot elongation in wheat crop in terms of rates of phosphorus fertilizer applied to the average of superphosphate and top-phos. Marechal Cândido Rondon – PR, 2011.

With increasing doses of P_2O_5, showed an increase in the amount of available P in soil (Figure 4b), other words, at the dose of 200 kg ha^{-1} was higher P_2O_5 concentration of P in soil, but not reaching the point of maximum increment in soil, regardless of fertilizer applied, since P exchangeable in soil was 2.40 mg dm^{-3}. Dallamea *et al*. (2005) studying the source of P, triple superphosphate, found that the treatments had very low initial concentrations of P, had a lower response in the construction of P levels in the soil. This is due to the soil, possibly because they possess a greater number of sites for immobilization of P, which were not fulfilled, so part of P added to the soil binds to iron and aluminum oxides, remaining adsorbed and not expressing the same increase so pronounced in the levels of P (Vilar *et al*., 2010). In the same study, in treatments that had high initial concentrations of P, were more responsive in available soil P with increasing doses of P_2O_5. This fact, as this paper demonstrates the direct relationship between P added to the soil by fertilization, providing direct increase in soil P and contribute to enhance the foliar P, requiring doses higher than those used to achieve the optimal level in the soil.

Fontoura *et al*. (2010) also found that the phosphorus in wheat, oats, corn, barley and soybeans with different sources (single superphosphate, triple superphosphate and rock phosphate) increased P exchangeable in the soil that had initially 6.9 mg dm^{-3} P in the middle of the layers 0-0.10 and 0.10-0.20 m depth in Oxisol alumínico. Moreover detected maximum productivity with the dose of 135 kg ha^{-1} P_2O_5 using triple superphosphate and increase linear in soil with rock phosphate to test the dose of 160 kg ha^{-1} of P_2O_5.

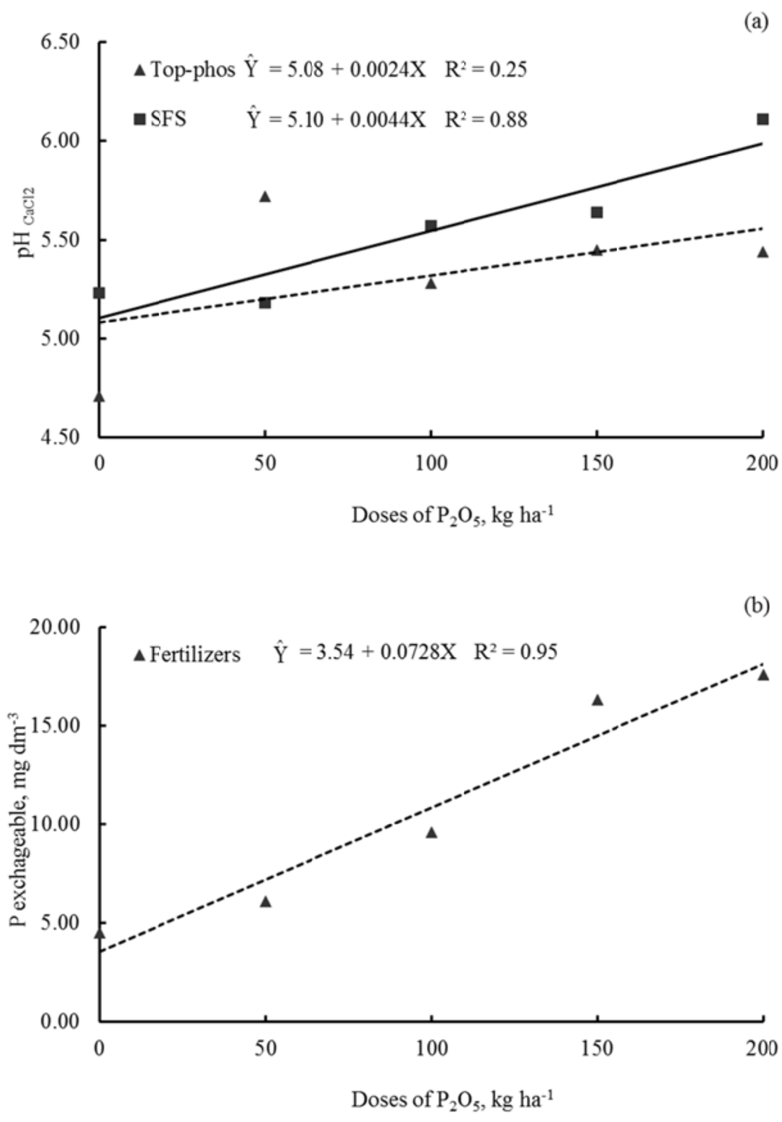

Figure 4. pH in $CaCl_2$ and phosphorus (P) exchangeable in the soil in elongation of wheat crop in terms of rates of phosphorus applied to single superphosphate fertilizer and for top-phos. Marechal Cândido Rondon – PR, 2011.

To achieve high levels of available P in the soil at the higher doses of fertilizers, considered above those required by the wheat crop (Embrapa, 2009), was observed decreasing effect on the accumulation of yield dry matter from the dose of 151.25 kg ha^{-1} P_2O_5 independent of the use of SFS or top-phos. Which may indicate the dose that reached P concentrations in soil that may be feasible to perform only maintenance fertilization. Pavinato and Cereta (2004) showed a low response in grain yield to fertilization with P and K in soil with high levels of these nutrients, showing that under these conditions, the application to launch or online, the winter crop, would be used to fertilize in assembly need to culture in succession summer, optimization and concentration occurring in just one application during cultivation.

At high levels of soil chemical attributes, Altmann (2012) suggests the use of fertilizer system, increasing operational efficiency in systems with succession or rotation with wheat culture, directing the necessary fertilizer for crops used for the application only in the winter season, performing the supply deficient nutrients to increase productivity and enhance the production of waste (Fonseca *et al*., 2011), and thus increase the cycling of nutrients and consequently improve systems such as tillage, making it more sustainable.

In soil with low P concentrations, as seen in the soil of this study, according to Freitas *et al.* (1995), use of tolerant genotypes to acidity, more responsive to the application of lime and phosphorus, can make possible the wheat crop in soils low in P, with smaller investments. Thus, the increase in the concentration of P in the soil (Figure 4b) and consequently leaf P (Figure 2a), may give rise in productivity, as evidenced by the response observed in dry matter, both in shoots and in roots (Figures 1). Above all, the fertilization correction can be performed either with single superphosphate as with top-phos, and obtained similar level of available soil P (Figure 4b).

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Viability of fertilizer use

Considering the results of this work can make a comparison of the economic viability of these two fertilizers. The top-phos cost was R$ 1,600.00 a ton while superphosphate cost R$ 824.00. Considering that the top-phos has 28% P_2O_5 in their formulation and superphosphate has 18% P_2O_5 and also that the dose of greater accumulation of SDM (Figure 1) was 151.25 kg ha^{-1} P_2O_5: for top-phos would require 539 kg ha^{-1}, totaling R$ 858.00 per hectare for single superphosphate would require 838 kg ha^{-1} to R$ 701.00 per hectare. Thus, it was recommended to use fertilizer more cost-effective, which may vary according to the cost of each fertilizer in each region of cultivation of wheat.

CONCLUSION

Shoot dry matter gave maximum point build up dose of 151.25 kg ha^{-1} P_2O_5 and root dry matter point was the maximum dose of 165 kg ha^{-1} P_2O_5 independent of fertilizer.

Application of P_2O_5 levels with superphosphate fertilizer and top-phos increased levels of pH and available soil P and P content, K and S in the leaf tissue.

Recommend both, simple superphosphate with 18% P_2O_5 as top-phos, considered with 28% P_2O_5 for phosphate fertilizer in wheat crop, by selecting the fertilizer that provide best value for money, in this case the superphosphate.

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