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Growth and phosphorus absorption by common bean 'Xodó' genotype under effect of glyphosate reduced rates[1]

Crescimento e absorção de fósforo pelo feijoeiro comum ‘Xodó’ sob efeito de subdoses de glyphosate

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Abstract - It was evaluated the effect of glyphosate reduced rates on growth and phosphorus (P) uptake of ‘Xodó’ common bean (*Phaseolus vulgaris* L.) genotype. The experiment was conducted in factorial scheme 4 x 2, in randomized blocks design with four replications, with the first factor constituted by reduced doses of 0, 4.32, 8.64 and 12.96 g ha^{-1} equivalent acid (e.a.) of glyphosate and the second factor consisted of soil P rates (50 and 250 mg dm^{-3}). Evaluations were conducted 30 days after glyphosate application (DAA). The reduced dose of 12.96 g ha^{-1} stimulated common bean cv. Xodó growth as well as increased P concentration in stem and P content in shoot dry mass plants.
Keywords: *Phaseolus vulgaris* L, hormotic effect, herbicide

Resumo - Avaliou-se o efeito de subdoses de glyphosate no crescimento e na absorção de fósforo (P) pelo feijoeiro comum (*Phaseolus vulgaris* L.) cv. Xodó. O experimento foi conduzido em esquema fatorial 4 x 2 em blocos casualizados com quatro repetições, sendo o primeiro fator constituído pelas subdoses de 0; 4,32; 8,64 e 12,96 g ha^{-1} de equivalente ácido (e.a.) de glyphosate e o segundo fator constituído por doses de P no solo (50 e 250 mg dm^{-3}). Avaliações foram realizadas 30 dias após a aplicação do glyphosate (DAA). A subdose de 12,96 g ha^{-1} estimulou o crescimento do feijoeiro comum cv. Xodó, assim como aumentou o teor de P no ramo e o conteúdo de P na parte aérea das plantas.
Palavras-chaves: *Phaseolus vulgaris* L, efeito hormótico, herbicida

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Introduction

Common bean is an important source of protein in Brazilians' diet, considered one of the most consumed foods in the country (Furtini Neto et al., 2000). The crop is demanding in nutrients, sensitive to climatic factors and really susceptible to insects and diseases.

High yields are achieved by the adoption of technologies such as breeding genotypes, adequate preparation of the soil, balanced fertilizing, advanced techniques of irrigation and insects, diseases and weeds control (Zucareli et al., 2011). By other side, weeds interference is considered one of the factors that contribute to low yield of common bean. The crop is usually quite sensitive to weeds interference, what may reduce up to 50-70% its grain yield (Blanco et al., 1969).

Herbicides use for controlling weeds in agricultural areas is an activity widely diffused throughout the world, ranging with the technological level adopted by farmers (Fontes et al., 2001). Among herbicides, glyphosate (N-phosphonomethyl-glycine) is the most used in all over the world (Service, 2007). Its action mechanism is based on the inhibition of 5-enolpiruvil - chiquimate -3-phosphate-sintase (EPSPs) enzyme. This enzyme is critical in shikimic acid pathway and its inhibition results in a reduction in the production of aromatic amino acids, thus injuring metabolic processes such as protein synthesis and photosynthetic process (Eker et al., 2006).

Besides glyphosate interferes negatively in growth of the most vegetal species (Ellis & Griffin, 2002; Yamashita & Guimarães, 2006; Ferreira et al., 2006; Tuffi Santos et al., 2009), some studies have shown that glyphosate reduced rates may stimulate plants growth. Velini et al. (2008) observed that reduced rates between 1.8 and 3.6 g ha^{-1} of this herbicide promote increases in the growth of several species as non transgenic soybean, eucalyptus and corn. In analogous way, Cedergreen et al. (2008) obtained increments in barley growth after glyphosate application.

Nowadays, both in agricultural production sectors as in several subjects of human healthy, the effect of applied chemical products in reduced rates, named hormotic effect, has been widely discussed and searched. This fact has occurred due to the interest of understanding the stimulating and beneficial action mechanism of several substances, initially considered as toxics (Silva et al., 2009). This way, the objective of this work was to evaluate the effect of glyphosate reduced rates over growth and phosphorus absorbtion by common bean crop (*P. vulgaris* L.) Xodó genotype cultivated under two doses of phosphorus.

Material e Methods

The study was conducted under Green house conditions at Universidade Estadual do Norte Fluminense Darcy Ribeiro, located in Campos dos Goytacazes Couty, Rio de Janeiro State (Latitude = 21º19'23"; Longitude = 41º10'40"; Altitude = 14m), in the period between 16/07/2009 to 16/09/2009.

The experiment was conducted in factorial scheme 4 x 2, in randomized complete blocks with four replications. The first factor was constituted by glyphosate reduced rates: 0; 4.32; 8.64 and 12.96 g ha^{-1} , corresponding to 0; 0.3; 0.6 e 0.9% from recommended rate of 1440 g ha^{-1} in ammonium salt form of Roundup WG® commercial product and the second factor was represented by two doses of phosphorus (P) in the soil (50 e 250 mg dm^{-3}), by using simple superphosphate. Experimental plot was constituted by just one vase containing four plants. These vases with capacity of 5 dm^{-3} were filled with Yellow Argisoil (Table 1).

Table 1. Soil chemical characteristics. Campos dos Goytacazes, Rio de Janeiro State, 2009.

K	Ca	Mg	Na	BS	Al	t	H+Al	T
				$mmol_c\ kg^{-1}$				
2,8	7,7	3,6	0,2	14,3	1	15,3	29,9	44,2
P	**Zn**	**Mn**	**Cu**	**Fe**	**pH***	**V**	**M**	**OM**
		$mg\ dm^{-3}$			(H_2O)	(%)	(%)	$g\ kg^{-1}$
8,85	0,97	22,6	0,39	61,6	4,28	32,29	2,26	10,4

*H_2O (1:2,5).

Seeds of common bean (*P. vulgaris* L.) Xodo genotype, from Viçosa County, Minas Gerais State were used, sowing eigth seeds per vase and tem days after, it was conducted a thinning out, keeping the four most vigorous plants in each vase.

Hydrated lime [Ca $(OH)_2$] was used in order to rase bases saturation to 70%. After hydrated lime mixture, vases were incubated for 15 days maintaining moist during this period. A nitrogen fetilization was conducted at 30 and 50 days after sowing (DAS), by using 40 mg dm^{-3} and 20 mg dm^{-3} of nitrogen (N), respectively, in ammonium nitrate form. Phytosanitary control was achieved through Vertimec 18 CE® (0,6 g dm^{-3}) and Cercobin 700 WP® (0,7 g dm^{-3}) sprayers at 40 and 50 DAS, respectively. Plants were irrigated with deionized water throughout the experiment.

Glyphosate application was conducted with a costal sprayer, pulverizador costal pressurized in carbon dioxide, with constant pressure of 3,0 kgf cm^{-2}, equipped with bar and spray nozzles Turbo Teejet 100.015, considering a spray volume of 230 dm^{-3} $ha^{-1.}$

Herbicide was applied at 30 DAS, when plants were in V_4 development stage, with the third trifoliate leaf fully expanded. At application time, climatic conditions were: 29°C air temperature, relative humidity 65% and 2.5 km h^{-1} wind speed.

Thirty days after glyphosate application (DAA), plants were collected and separated into leaves, branches and roots. These materials have been dried in an oven with forced air circulation, at 72ºC, during 48 hours and weighted in order to determine dry mass. Dried leaves and branches were ground up and stored in airtight jars, for later determination of P content. Roots were extracted from the vases by washing with water on sieve. Phosphorus content determination was accomplished through súlfur digestion, by molybdenum blue colorimetric method in atomic absorption spectrophotometer (Malavolta, 1997).

Assessed characteristics were: leaves number, leaf dry mass (MS), branch, root and dossel (MS leaf + MS branch), phosphorous content in leaf and branch and phosphorus content dossel plant. Results were submitted to variance analysis by using F test and regression analysis ($p > 0.05$) to glyphosate rates. All analysis were performed with the use of SAEG 7.0 software.

Results and Discussion

Leaves dry mass production of common bean Xodo genotype increased linearly with the rise of glyphosate reduced doses (Figure 1A), reaching the maximum value around 34.14% of increase in leaves dry mass acumulation for the glyphosate subdose of 12.96 g ha^{-1}. Similar result was found by Mechede et al. (2008) when authors observed growth stimulus in leaves of *Commelina benghalensis*, with greater length and leaf area for all reduced doses used.

In relation to branches dry mass, the effect of glyphosate reduced doses was dependent on the phosphorus levels adopted (Figure 1B). For the lowest phosphorus dose (50 mg dm^{-3}), it was observed increase in branch dry matter production with the increase of glyphosate reduced doses (Figure 1B).

However, when using 250 mg dm^{-3} of phosphorus, branch dry matter was not significantly affected by glyphosate reduced doses. In addition, it was observed that for 0 and 4.32 g ha^{-1} of glyphosate reduced doses, there was higher branch dry matter production when compared to 50 mg dm^{-3} phosphorus dose.

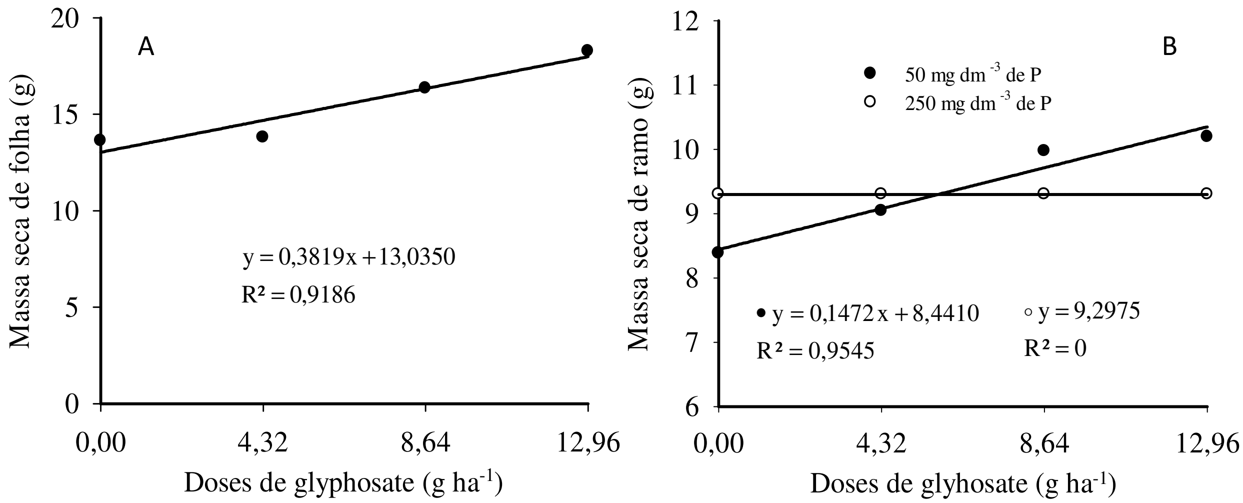

Figure 1. Leaf dry mass (A) (obtained by the average from P doses) and branch dry mass (B) of common bean Xodo genotype cultivated in Yellow Argisoil. Campos dos Goytacazes, Rio de Janeiro State, 2009.

For dossel dry mass, authors noted increasing linear behavior while occurred increase in glyphosate reduced dose, with maximum increment of 36.27% for the highest reduced dose used (12.96 g ha^{-1}) (Figure 2).

Increments in dossel dry mass production in non transgenic soybean crop after application of glyphosate reduced doses also were observed by Velini et al. (2008). These researches concluded that there was a raise of 28% in soybean dossel dry mass production for 14.2 g ha^{-1} of glyphosate reduced dose. Similar results were obtained by Silva et al. (2009) too. However, Perim et al. (2011) observed that glyphosate reduced doses: 0; 1.5; 2; 6 and 12 g ha^{-1} did not promote increasing in dossel dry mass production of soybean Valiosa RR genotype.

Leaves number raised linearly with the increment of glyphosate reduced doses (Figure 3). Overspring due to the death of apical cells has been one of the visual symptoms observed after plants intoxication with glyphosate. Results have been observed in cotton, passion-flower and eucalyptus crop (Yamashita & Guimarães, 2005; Tuffi Santos et al., 2007; Wagner et al., 2008). However, in the present study it was not noted the death of apical cells, with the highest leaves number observed, a result of increased plant growth provided by glyphosate.

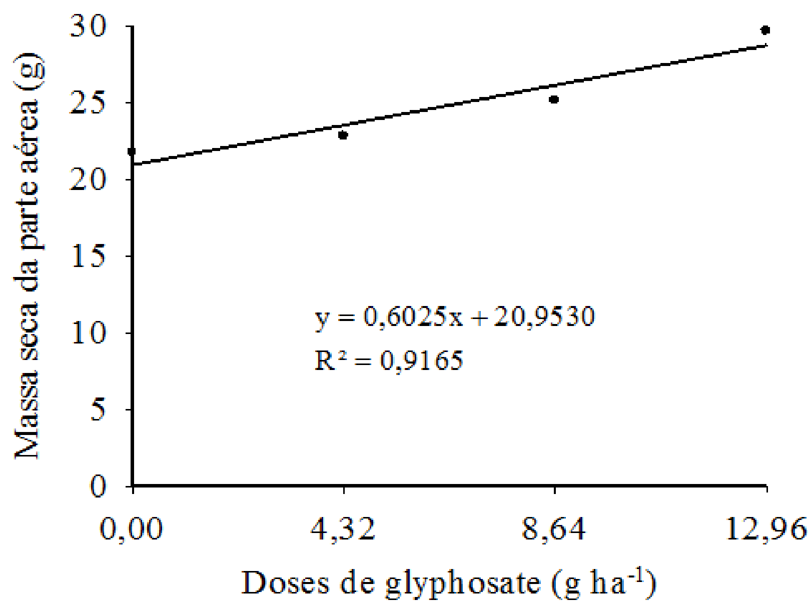

Figure 2. Dossel dry mass of common bean Xodo genotype cultivated in Yellow Argisoil (obtained by the average from P doses). Campos dos Goytacazes, Rio de Janeiro State, 2009.

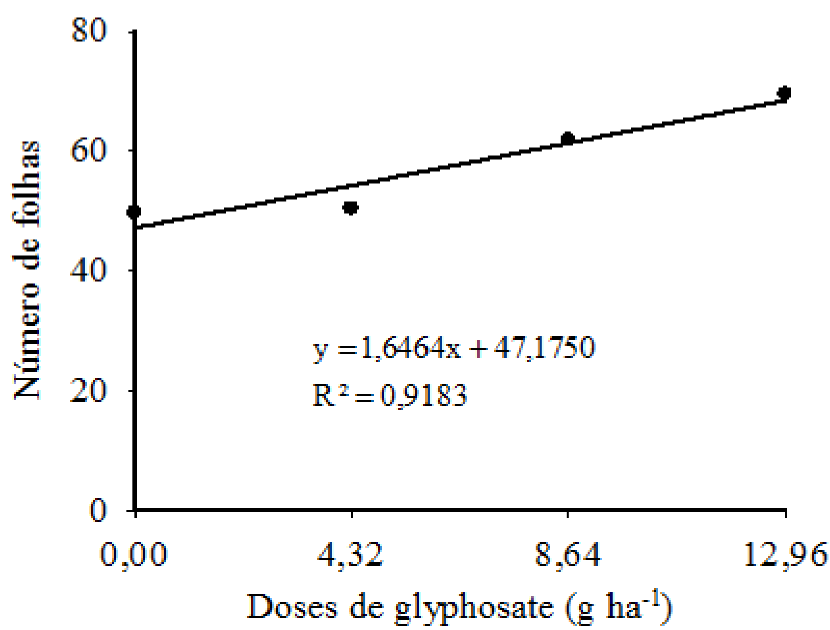

Figure 3. Leaves number of common bean Xodo genotype cultivated in Yellow Argisoil (obtained by the average from P doses). Campos dos Goytacazes, Rio de Janeiro State, 2009.

Plant growth stimulus provided by substances considered toxic has already been known (Godoy, 2007, Velini et al., 2008; Cedergreen, 2008). Among herbicides, glyphosate stands out as the one that presents the most promising effects. However there is no information yet, about what is the real mechanism by that glyphosate may interfere positively in crops growth and development.

Results obtained by Cedergreen & Olesen (2010) in barley crop indicated increase in photosynthetic rate, provided by the major efficiency in carbon fixation. According to these authors, glyphosate may also have stimulated rubisco activity with positive consequences over photosynthetic rate. Besides it, has been associated to glyphosate a major assimilates translocation (Su et al., 1992), what could also support plants growth. These results could explain the increased leaves number and dry mass production observed in the present work.

Glyphosate reduced doses influenced in P content in branches and dossel. There was no effect of glyphosate reduced doses over P content in leaf (3.37 g kg^{-1}). However, Godoy (2007) and Cakmak et al. (2009), applying similar reduced doses to the one used in this work, obtained increments in P content of eucalyptus young leaves and P total content of soybean crop, respectively. Since phosphorus carrier system is responsible for glyphosate absorption (Pipke et al., 1987; Fitzgibbon & Braymer, 1988, Morin et al., 1997), it is considered that glyphosate reduced doses applied in plants may conduct to genes induction that encoding proteins involved in the process of phosphorus absorption, resulting in raising of this nutrient. However, little is known about P transportation (Versaw & Harrison, 2002) and glyphosate transportation in plants (Perim et al., 2011).

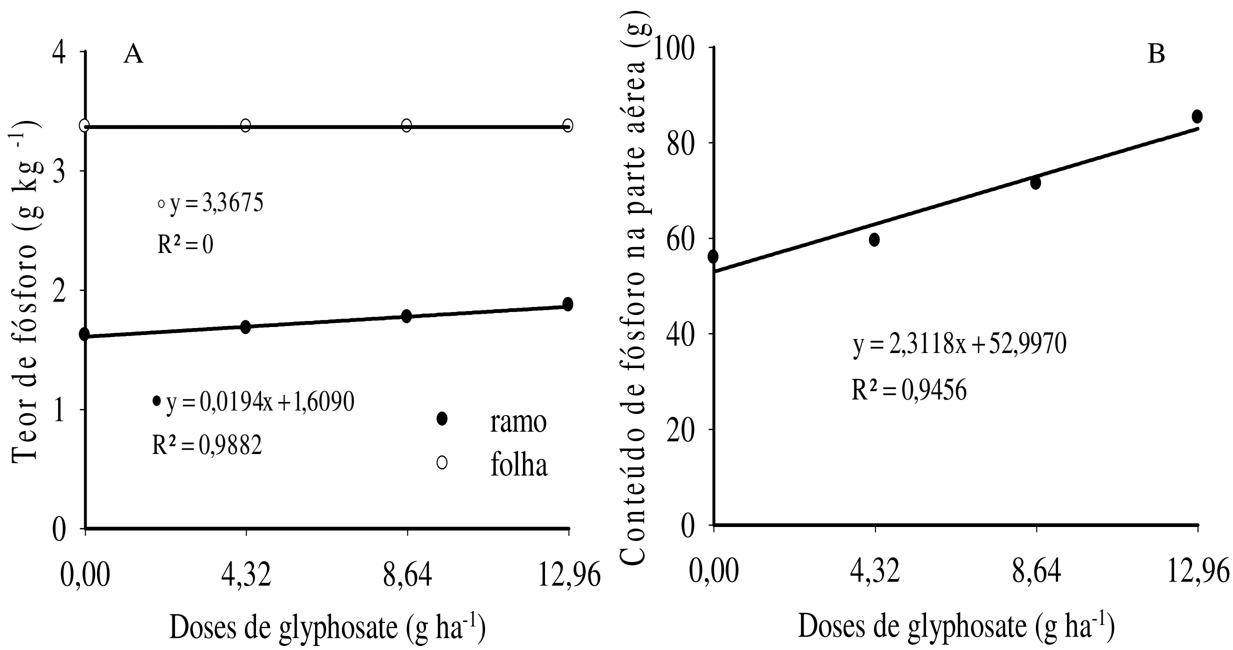

Figure 4. Phosphorus content in leaf and branch (A) and phosphorus content in dossel (B) (obtained by the average from P doses). Campos dos Goytacazes, Rio de Janeiro State, 2009.

Growth characteristics evaluated were not influenced by P used doses (Table 2). However, the highest P dose applied promoted major P content in common bean leaves and branches (Table 3). Besides the highest P dose have provided higher P content in leaves and branches of common bean Xodo genotype (Table 3), the increment absence in common bean growth may be due to the low efficiency of phosphorus utilization by common bean Xodo genotype in this condition. Second to Fageria (1998), Xodo is a genetic material inefficient as P use.

Table 2. Common bean Xodo genotype growth submitted to two P doses. Campos dos Goytacazes, Rio de Janeiro State, 2009.

P Dose (mg dm^{-3})	Leaf dry mass (g)	Branch dry mass (g)	Dossel dry mass (g)	Root dry mass (g)
50	16,5	9,40	25,9	4,31
250	14,5	9,30	23,8	3,94
Average	15,5	9,35	24,85	4,12
CV (%)	18,58	16,11	14,93	18,58

Tabela 3. Phosphorus content in leaf and branch in common bean Xodo genotype submitted to two P doses. Campos dos Goytacazes, Rio de Janeiro State, 2009.

P Dose (mg dm^{-3})	P content in leaf (g kg^{-1})	P content in branch (g kg^{-1})
50	2,05 b	1,24 b
250	4,69 a	2,23 a
Average	3,4	1,73
CV (%)	26,2	23,1

The results obtained in this study demonstrated that glyphosate influenced in beneficial form, common bean growth. However, more researches are needed with different plant species to know what and in what conditions, plants species may be benefited by glyphosate use, besides obtaining useful knowledge for understanding this phenomenon.

Conclusions

Glyphosate reduced dose of 12.96 g ha^{-1} stimulated an increase in leaves number, leaf, dossel and branches dry mass of common bean Xodo genotype, when cultivated with 50 mg dm^{-3} of P.

Glyphosate reduced doses increased P content in branches and, consequently, P content in dossel.

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