Scientific Article

Phosphorus rates and use of cattle manure in potted gerbera cultivation[1]

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ABSTRACT

Gerbera can be grown as a cut flower or in pots. However, there is little information on nutrition and fertilization, especially related to phosphorus and the use of organic matter in pots. This study aimed to evaluate the growth and production of potted gerbera under doses of phosphorus and the use of cattle manure. The experiment was carried out in pots, under greenhouse conditions. A randomized block experimental design was used in a 5 x 2 factorial scheme with 4 replications, totaling 40 experimental units. The treatments consisted of 5 P rates: 0, 20, 40, 60 and 80 mg dm^{-3} P, as triple superphosphate powder and use, or not, of cattle manure. Phosphate fertilization and cattle manure in soil with low P contents did not influence the growth and production of potted gerbera. Phosphorus rates improve the nutritional status of potted gerbera, but do not contribute to the commercial quality of the plants. The use of cattle manure increases the availability of phosphorus in the soil for potted gerbera cultivation without, however, contributing to commercial quality. Potted gerbera is poorly responsive to phosphorus addition, supplied by both mineral and organic fertilizers.
Keywords: *Gerbera jamesoni*, phosphorus, organic manure, nutrients.

RESUMO

Doses de fósforo e uso de esterco bovino no cultivo de gérbera de vaso

A gérbera pode ser cultivada como flor de corte ou em vasos, porém há poucas informações sobre nutrição e adubação, especialmente relacionadas ao fósforo e uso de resíduos orgânicos em vasos. O objetivo do trabalho foi avaliar o crescimento e a produção de gérbera em vaso sob doses de fósforo e uso de esterco bovino. O experimento foi conduzido em vasos, em casa de vegetação. Foi empregado delineamento experimental em blocos ao acaso, em esquema fatorial 5 x 2 e 4 repetições totalizando 40 unidades experimentais. Os tratamentos foram constituídos por 5 doses de P: 0, 20, 40, 60 e 80 mg dm^{-3} de P, na forma de superfosfato triplo em pó e uso ou não de esterco bovino. A adubação fosfatada e o esterco bovino, em solo com baixo teor de P, não influencia o crescimento e a produção de gérbera de vaso. As doses de fósforo proporcionam melhorias no estado nutricional da gérbera cultivada em vaso, mas não contribuem para a qualidade comercial das plantas. O uso de esterco bovino aumenta a disponibilidade de fósforo no solo para cultivo de gérbera em vaso, sem, contudo contribuir para a qualidade comercial. A gérbera cultivada em vaso é pouco responsiva às adições de fósforo, fornecido tanto por fertilizante mineral como orgânico.
Palavras-chave: *Gerbera jamesoni*, fósforo, adubação orgânica, nutrientes.

1. INTRODUCTION

Gerbera (*Gerbera jamesoni*) is commercially cultivated as a cut flower or in pots, and has high acceptance in the market of flowers and ornamental plants in Brazil, for presenting flowers with great diversity of colors, good durability and resistance to transportation (MOTA et al., 2014; LUDWIG et al., 2015; SANTOS et al., 2017). In the cultivation of potted gerbera, it is important to look for a high number of flower stems; inflorescences with large diameter; small size; and adequate leaf branching, to form a balanced set between the vegetative and reproductive part (LUDWIG et al., 2010).

An adequate fertilization, both mineral and organic, favors the production and quality of flowers and, with the expansion of the commercial production of flowers and ornamental plants in Brazil, there is a need for more studies on fertilization for this group of plants (LUDWIG et al., 2008; MOTA et al., 2014; SANTOS et al., 2015; SANTOS et al., 2017). In addition, in Brazil, it is common for farmers to manage fertilization empirically, supplying large amounts of nutrients, which are often not required by plants, without following agronomic criteria (LUDWIG et al., 2010; GUERRERO et al., 2013).

Brazilian soils have low P availability, due to high acidity and the presence of high levels of Fe and Al sesquioxides (BROGGI et al., 2010). In highly weathered soils, P has a strong interaction with mineral components of the solid phase, due to the formation of complexes of high energy and of difficult reversibility. Thus, only a part of the P applied to fertilizers will be used by the plants, and the rest will remain in the soil, adsorbed to solid-phase colloids or precipitated as insoluble compounds (RAIJ, 2011; BRAOS et al., 2015). Cattle manure is an organic

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fertilizer frequently used in agriculture. In addition to providing nutrients to plants, such as P and especially N, its use increases CTC, favors particle aggregation, increases porosity, aeration, and soil water retention (SILVA, 2008; PIRES et al., 2008).

In view of the above, the objective of this study was to evaluate the growth and production of potted gerbera under doses of phosphorus and the use of cattle manure.

2. MATERIAL AND METHODS

The experiment was conducted in pots, in a greenhouse, in Alfenas, Minas Gerais State (latitude 21º 25' 45" S; longitude 45º 56' 50" W; altitude 881 m), from May to September 2015.

A randomized block design was used in a 5x2 factorial scheme with four replicates, totaling 40 experimental units, with five doses of P: 0, 20, 40, 60 and 80 mg dm^{-3}, and use, or not, of cattle manure. The dose of manure was equivalent to 20 t ha^{-1}, based on the soil volume used in each pot and that of the 0-20 cm layer present in 1 ha (2,000,000 dm^3). The doses of P were defined in order to raise the soil nutrient content of clayey texture from very low to very high, according to the CFSEMG classification (1999).

A 250 dm^3 clayey Oxisol sample of the superficial layer (0-20 cm) was collected, air and shade dried, slashed, passed through a 4-mm sieve and, in a sub-sample, an initial chemical (SILVA, 2009) and granulometric (CAMARGO et al., 2009) characterization was performed, whose values are presented in Table 1.

Table 1. Soil chemical and granulometric characterization of an Oxisol used in potted gerbera cultivation.

pH $CaCl_2$	O.M.	Mehlich-P	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H+Al
	g dm^{-3}	mg dm^{-3}	---------- $mmol_c$ dm^{-3} ----------				
4,5	23	4	2.8	9	6	5	47
SB	CEC	V	m	P-rem	Sand	Silt	Clay
-- $mmol_c$ dm^{-3} --		--------- % ---------		mg L^{-1}	---------- g kg^{-1} ----------		
18	65	28	22	12	350	127	523

O.M.: organic matter; H+Al: potential acidity; SB = sum of bases; CEC: cation exchange capacity at pH 7.0; V: base saturation; m: Al^{3+} saturation; P-rem: remaining phosphorus

The cattle manure used in the experiment was air and shade dried, homogenized, passed through a 4-mm sieve and sampled for determination of moisture, pH and chemical composition on a dry basis (TEDESCO et al., 1995), whose values are presented in Table 2.

Table 2. Water concentration, pH and chemical composition, on a dry basis, of cattle manure used in potted gerbera cultivation.

Parameters	Value
Water content (%)	5.0
pH	7.8
Organic C (g kg^{-1})	252.0
N (g kg^{-1})	24.0
C/N ratio	10.5
P (g kg^{-1})	4.4
K (g kg^{-1})	14.0
Ca (g kg^{-1})	11.8
Mg (g kg^{-1})	6.7
S (g kg^{-1})	3.3
B (mg kg^{-1})	194
Cu (mg kg^{-1})	72
Fe (mg kg^{-1})	2622
Mn (mg kg^{-1})	470
Zn (mg kg^{-1})	251

Soil density (1.10 kg dm^{-3}) was determined, and portions equivalent to 5 dm^3 soil were weighed. Soil portions received dolomitic limestone (CaO = 39%, MgO = 13%, PRNT = 91%), in order to raise soil initial saturation (V%) to 60%, doses of P as triple superphosphate powder, and cattle manure, according to the treatments. These inputs were dry mixed with the soil portions, which were then transferred to 5.5 dm^3 pots, moistened with distilled water at 70% retention capacity and incubated for 30 days.

During incubation, soil moisture was maintained by periodically weighing the pots and replenishing the water. After incubation for 30 days, the soil portions were removed from the pots, air-dried, and a 0.2 dm^3 soil sample was collected from each vase to determine the contents of P extracted by Mehlich-1 (SILVA, 2009). Subsequently, 4.8 dm^3 soil portions were returned to the pots, remoistened at 70% of the retention capacity, and each pot received, on July 15, 2015, a potted gerbera seedling, cultivar Red, with four final leaves. After transplanting the seedlings, the experiment was conducted for 72 days and, during this period, moisture was periodically controlled to maintain soil moisture at about 70% of the water retention capacity.

Throughout the experiment, four fertilizations were carried out with N and three with K, in all pots, through nutrient solution. In each fertilization with nitrogen and potassium, 15 mg dm^{-3} N, as urea, and 15 mg dm^{-3} K, as KCl, were supplied (NOVAIS et al., 1991).

72 days after transplanting, at the gerbera marketing time, defined according to Guerrero et al. (2013), the following parameters were evaluated: largest shoot diameter of the plants, measured with the aid of a tape measure at two points perpendicular to the end of opposite leaves; number of stems; stem length; inflorescence diameter and stem weight, according to the procedures described in Ludwig et al. (2010) and Muniz et al. (2013). Subsequently, a fully expanded leaf was collected from each pot, according to Tombolato et al. (1997); they were washed, dried in a forced air oven at about 60 °C, and milled to determine P contents in the leaf tissue (TEDESCO et al., 1995).

The results concerning the contents of P in the soil and leaf tissue of gerbera; the mean values of stem length and inflorescence diameter; shoot diameter; the number and fresh weight of stems per plant, were submitted to analysis of variance, mean comparison test (Tukey, $p < 0.05$) and polynomial regression, using the Agroestat software (BARBOSA and MALDONADO JÚNIOR, 2015).

3. RESULTS AND DISCUSSION

Phosphorus doses (P) and the use of cattle manure altered the P content of the soil in an isolated and significant way ($p<0.01$) before transplanting. The contents of P in the soil, extracted by Mehlich-1, increased linearly with P doses, and ranged from 4 to 25 mg dm^{-3}, respectively, in the control treatments and at the highest P dose (Figure 1A), which are interpreted, respectively, as very low and very high, for clayey soils (CFSEMG, 1999). Regarding organic fertilization, it was verified that the application of the equivalent of 20 t ha^{-1} cattle manure increased the contents of P in the soil by 23% (Figure 1B) and, therefore, the contents ranged from medium to high, according to the interpretation of the CFSEMG (1999).

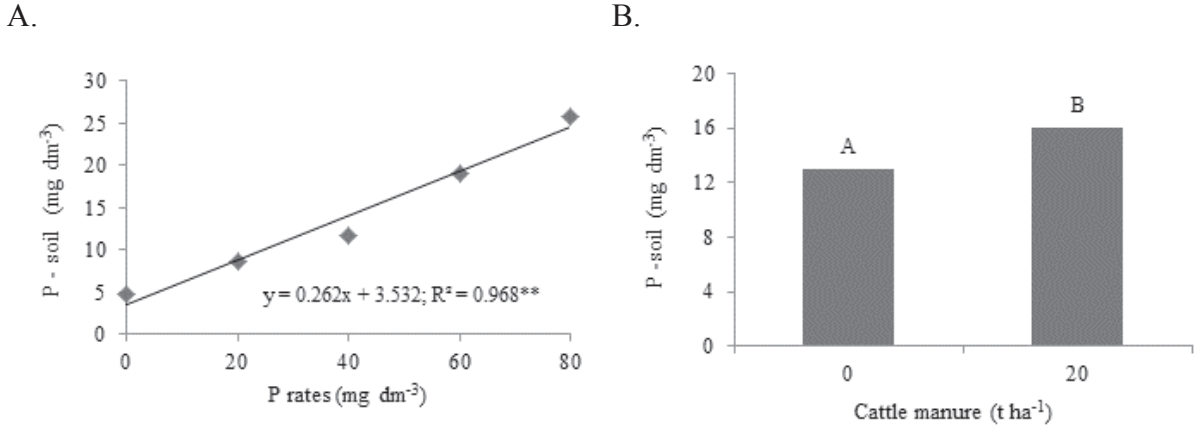

Figure 1. Contents of P in the soil, extracted with Mehlich, under doses of phosphorus (A) and use of cattle manure (B).

The increase in the P contents of the soil with the application of cattle manure is due to the presence of the nutrient in the composition of the organic fertilizer, and the decrease in P fixation reactions in the soil with organic fertilization (BRAOS et al., 2015). Still according to these authors, most of the P present in the cattle manure passes quickly to the available form, after the application of this organic fertilizer in the soil. However, as a general recommendation, it is common to assume in fertilization calculations that the P mineralization rate from organic sources is 60 to 70% in the first year after organic fertilization (CFSEMG, 1999; RAIJ et al., 1997).

In relation to the parameters evaluated in gerbera plants, phosphate fertilization and cattle manure did not significantly alter ($p > 0.05$) shoot diameter, mean inflorescence diameter, mean number of stems per plant and stem weight per plant, and the mean values obtained in the experiment for these parameters were, respectively, 29.4 cm; 9.4 cm; 2.1 and 18.9 g pot^{-1} (Table 3).

Table 3. Shoot diameter (SD), inflorescence mean diameter (ID), mean stem number (SN) and stem weight (SH) of potted gerbera, under doses of phosphorus and use of cattle manure.

P rates (mg dm^{-3})	SD	ID	SN	SH
	---------- cm ----------			------ g ------
0	27.1	9.2	2.4	18.3
20	27.5	9.1	1.8	19.6
40	30.9	10.5	2.1	20.2
60	31.1	9.1	2.0	18.6
80	30.5	8.9	2.3	17.9
Cattle manure (t ha^{-1})				
0	28.8	9.5	2.0	18.2
20	30.1	9.2	2.2	19.7
F Test				
P rates (P)	1.81^{NS}	1.77^{NS}	1.08^{NS}	0.46^{NS}
Cattle manure (CM)	1.72^{NS}	0.83^{NS}	0.93^{NS}	1.37^{NS}
P x CM	0.48^{NS}	1.13^{NS}	1.37^{NS}	0.86^{NS}
CV (%)	13.89	11.90	21.20	20.11

NS = not significant by the F test ($p > 0.05$)

Gerbera plants with two open, well-formed flowers per pot are classified for commercial use in class II (IBRAFLOR, 2016). Thus, considering these classification parameters, the gerbera plants of all treatments in the experiment had a quality standard for commercialization in class II.

Ludwig et al. (2010) found in potted gerbera cultivars fertigated with nutrient solutions that the shoot and inflorescence diameter ranged, respectively, from 31.4 to 35 cm, and from 8.8 to 9.3 cm, and that the plants had, on average, 2.8 inflorescences per pot. Guerrero et al. (2013) obtained potted gerbera plants (cultivar Red) with 27.2 cm of mean shoot diameter, with 8.6 cm mean inflorescence diameter, and, on average, 2.9 inflorescences per pot, in an experiment using substrate and nutrient solution. The differences in the results of plant evaluations in this experiment, in relation to those obtained by the different authors mentioned, can be possibly explained by the use of soil instead of substrate and by the experiment period (winter/spring instead of spring/summer).

During the experiment, no P deficiency symptoms were observed in potted gerbera plants, including in the control treatment. P deficiency in cut flowers causes dark green coloration on older leaves; lower shoot growth; decrease in the number and size of leaves and flowers; lower shoot growth; damage to the formation of reproductive organs, which delays flower initiation; and lower flower quality (BARBOSA et al., 2009; FRAZÃO et al., 2009).

Phosphate and organic fertilization with cattle manure did not favor the growth and production of potted gerbera plants, possibly due to the fact that the initial P content in the soil, although low, was sufficient to meet the requirements of the plants. This result evidences the high efficiency of gerbera in absorbing soil P and/or using it.

The variation in the efficiency of P absorption among plants is due to the difference in number and length of root hairs; establishment of symbiotic associations; expression of high affinity transporters and changes in the rhizosphere region (ZAMBROSI et al., 2012). As for the efficiency of P use, some plants have a greater capacity to redistribute and reuse nutrients from an older, senescent organ for biomass production (ROZANE et al., 2007).

Santos et al. (2017) observed that organic fertilization with industrial waste did not increase shoot and inflorescence diameters of potted gerbera, in relation to mineral fertilization. Ludwig et al. (2013) found that P was the fifth macronutrient most required by the Red potted gerbera, and the accumulated amount of nutrient in the plant shoot was 42 mg plant^{-1}. According to the authors, this value was 12.5; 8.0; and 2.8 times lower than the accumulated amounts of K, N, and Ca by plants. The authors still report that the period of greatest P accumulation by gerbera plants occurred from 29 to 43 days after acclimatization.

Only phosphate fertilization provided a significant change in the P contents of the leaf tissue and the mean length of gerbera stems, with a linear increase with the application of P doses (Figure 2). Leaf P contents ranged from 2.8 to 4.1 g kg^{-1}, and the mean length of potted gerbera stems ranged from 16.3 to 19.5 cm, when comparing the extreme treatments (0 and 80 mg dm^{-3} P). Therefore, the increase obtained with phosphate fertilization was 50 and 20%, respectively.

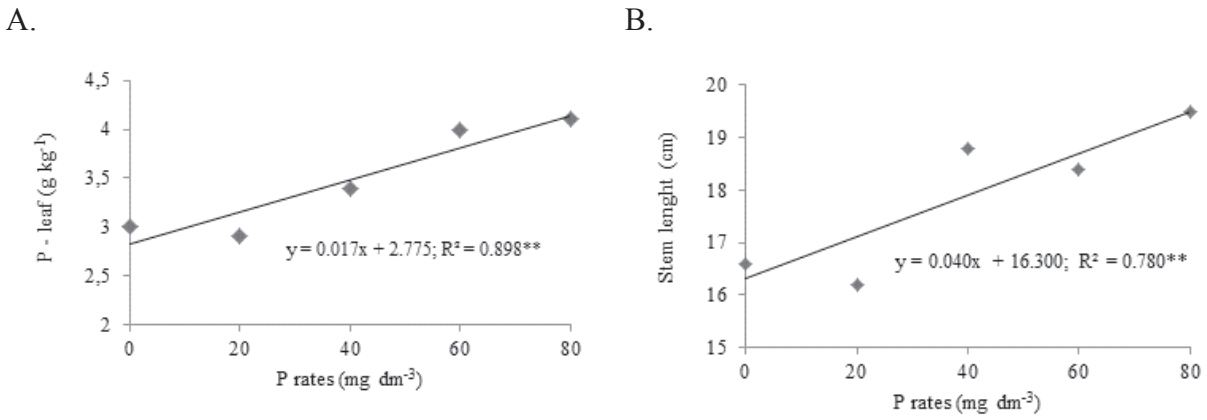

Figure 2. Leaf contents of P (A) and stem length (B) of potted gerbera, under doses of phosphorus and use of cattle manure.

The contents of P in gerbera leaf tissues were within the range of leaf contents considered appropriate by Tombolato et al. (1997) for ornamental plants. In an experiment with potted gerbera using substrate and nutrient solution, Mota et al. (2016) showed that the increase in the concentration of P and other macronutrients in the nutrient solution resulted in an increase in P leaf contents and other macronutrients, but did not alter the production parameters evaluated in the plants (shoot diameter, number of inflorescences and inflorescence diameter). According to these authors, P leaf contents in gerbera in the experiment ranged from 2.4 to 5.7 g kg^{-1}. In an experiment with different cultivars of potted gerbera and two nutrient solutions as nutrient sources, Ludwig et al. (2008) obtained an average content of 2.6 g kg^{-1} P in the plant leaf tissue.

For the commercialization of potted gerbera, plant height must be from 14 to 30 cm (IBRAFLOR, 2016). Thus, considering the values obtained for stem length, the gerbera plants of this experiment showed a quality standard for commercialization. In an experiment using fertilization with potassium chloride and silicate, Guerrero et al. (2013) verified values of gerbera stem length that ranged from 14.5 to 16.4 cm. According to these authors, very tall and thin stems in potted gerbera may not have sufficient support and cause tipping. Santos et al. (2017) obtained a stem length for potted gerbera ranging from 17.6 to 23.3 cm, in an experiment in which organic fertilization from agribusiness waste and mineral fertilization were used.

4. CONCLUSIONS

Doses of phosphorus improve the nutritional status of potted gerbera, but do not contribute to the commercial quality of the plants. The use of cattle manure increases phosphorus availability in the soil for potted gerbera cultivation, without, however, contributing to commercial quality. Potted gerbera is poorly responsive to phosphorus addition, supplied by both mineral and organic fertilizers.

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AUTHORS CONTRIBUTION

J.R.M.: orientation of the work, conception and design of the research, writing and discution of the manuscript**. L.G.S.:** installation, conduction and evaluation of the experiment, data collection**. P.R.C.L.:** important suggestions incorporated to the manuscript. **A.R.S.:** installation and conduction of the experiment. **B.S.C.:** installation and conduction of the experiment.

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