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Alternative substrates for growth and production of potted chrysanthemum (cv. Funny)

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ABSTRACT. The identification of alternative substrates that are suitable for the production of potted plants is very important. To this end, we studied the influence of different substrates on the growth and production of potted chrysanthemum (*Dendranthema grandiflora* Tzvelev cv. Funny). A completely randomized design with four treatments and twelve replicates was used. Each treatment consisted of the following substrates: i) carbonized rice husks; ii) commercial substrate; iii) mixture of vermiculite and carbonized rice husks in a 1:1 proportion; and iv) mixture of vermiculite and washed sand in a 1:1 proportion. Satisfactory results were obtained with alternative substrates, indicating that rice husks can be used as a sole or partial substrate for potted chrysanthemum cultivation, creating a possible new use for this regional agro-industry waste product. Using rice husk as a substrate promoted bud diameters 6% larger than the commercial substrate usually used in Brazil.

Keywords: *Dendranthema grandiflora* Tzvelev, rice husk, growing media.

RESUMO. Substratos alternativos para o crescimento e produção do crisântemo (cv. Funny) em vaso. A indicação de substratos alternativos, que sejam viáveis para a produção de plantas em vaso é de grande relevância. Neste sentido, estudou-se a influência de diferentes substratos no crescimento e produção do crisântemo. (*Dendranthema grandiflora* Tzvelev cv. Funny). Foi adotado o delineamento inteiramente casualizado com quatro tratamentos e 12 repetições. Cada tratamento consistiu dos seguintes substratos: i) casca de arroz carbonizada; ii) substrato comercial; iii) mistura de vermiculita e casca de arroz carbonizada na proporção 1:1; e iv) mistura de areia lavada e vermiculita na proporção 1:1. Resultados satisfatórios foram obtidos com os substratos alternativos estudados, demonstrando que a casca de arroz carbonizada pode ser usada no cultivo do crisântemo de vaso como substrato ou parte desse, tornando possível o reuso desse rejeito agroindustrial. A casca de arroz carbonizada como substrato promoveu diâmetro do botão 6% maior em relação ao substrato comercial, geralmente, usado no Brasil.

Palavras-chave: *Dendranthema grandiflora* Tzvelev, casca de arroz, substratos.

Introduction

During the last several decades, peat has been used as the main floriculture substrate around the world (HORN, 1996; SCAGEL, 2003). However, due to rising costs and uncertain future availability of peat moss, there is a need, especially in the floriculture industry, of alternative commercial potting substrate components (BACHMAN; METZGER, 2008; PIVETTA et al., 2008; WAGNER JÚNIOR et al., 2007).

Increasing awareness of environmental issues, as well as the need to dispose of or re-use the everincreasing amounts of waste and reduce the consumption of non-renewable resources, such as peat, has encouraged the study of alternative composts (GRIGATTI et al., 2007), biosolids (PAPAFOTIOU et al., 2004), biofertilizers (CAVALCANTE et al., 2008), coconut fiber and pinus bark (LONE et al., 2008), composting sugar-cane bagasse (CATUNDA et al., 2008), and the use of products like carbonized rice husks (GUERRINI; TRIGUEIRO, 2004; KENNEDY et al., 2004, 2005; SCHMITZ et al., 2002) as substrates for commercial horticultural activity.

Carbonized rice husk is widely available in regions where rice is produced and processed, such as South Brazil. It has been used as an organic fertilizer, but the amount produced by industries that process rice for human consumption is greater than the options currently available for its re-use, so the remainder becomes a residue, which could be used for agricultural purposes, as to use as substrate.

Several studies about carbonized rice husks, like the ones by Faria et al. (2001) and Trigueiro and Guerrini (2003), have concluded that this product has the potential to be used as a sole or partial substrate for plant cultivation. Nevertheless, no standardized parameters for floriculture and pot chrysanthemum have been recommended. These activities intensively use available substrates and are particularly economically and environmentally important in South Brazil (VENCATO, 2006).

Substrates affect plant growth, root systems and plants nutritional status (LEINFELDER et al., 1991; BECKMANN-CAVALCANTE et al., 2009). Thus, a good substrate should be pathogen-free, have high levels of soluble nutrients, and have adequate pH, bulk density, pore space, electrical conductivity and C/N-ratio (HORN, 1996). It must also maintain an adequate water availability and proportion of air over time (VILLAGOMEZ et al., 1979). In spite of the importance of the substrate for plant growth and nutrition, Walker (1990) and Galbiatti et al. (2007) reported extremely high concentrations of nitrate-N in commercial greenhouses in the United States, underscoring the importance of previous studies about commercially recommended alternative substrates.

The present study was aimed at evaluating the effect of different substrates on the growth and production of potted chrysanthemums (cv. Funny) cultivated in South Brazil.

Material and methods

Plant material and growth conditions

Chrysanthemum (*Dendranthema grandiflora* Tzvelev, cv. Funny) plants propagated by cuttings were used in this study.

The experiment was carried out from May to September (120 days) in a greenhouse at the Federal University of Pelotas, Rio Grande do Sul State, Brazil. Plants were grown in 0.6 L capacity polyethylene pots of (11 cm in height, 11 cm in upper diameter and 6.4 cm in base diameter). The pots were arranged into twelve blocks with randomized substrates (36 plants per substrate) and placed in a greenhouse. The substrates studied were as follows: carbonized rice husks (CRH); commercial substrate Plantmax® (COM) composed of carbonized rice husks, composted pinus bark, bovine vermicompost and vermiculite; a mixture of vermiculite and carbonized rice husks in a 1:1 proportion (MIX_1); and a mixture of vermiculite and washed sand in a 1:1 proportion (MIX_2). Burned carbonized rice husks from industries in Rio Grande do Sul State (Brazil) were used in this study.

Each pot contained three chrysanthemum plants, 5 to 8 cm in height and with 3 to 4 leaves, which were submitted to long-day regimes during the first four weeks. Twenty-one days after planting, the plants underwent tip pruning, and B-nine growth regulator was applied according to technical recommendations for commercial planting (GRUSZYNSKI, 2001).

The flowering induction began 5 weeks after the vegetative time, when plants measured 6 to 7 cm in height. During this phase, photoperiodic control was not necessary because there was less than
13 hours of environmental light per day.

Watering was done manually according to plant requirements in an attempt to keep the substrates as close as possible to field condition. Water was applied once daily after root time, with 90 mL of nutritive solution applied directly to the substrate; the leaves were not washed. The pH was kept between 5.5 and 6.0, and the electrical conductivity was 2.0 mS cm^{-3}. The applied solution was recommended by Schwarz (1995) and was composed of i) macronutrients (mmol L^{-1}): 10.50 of NO_3^-, 1.0 of $H_2PO_4^-$, 1.0 of SO_4^{2-}, 0.5 of NH_4, 5.0 of K^+, 3.0 of Ca^{2+} and 1.0 of Mg^{2+}; and ii) micronutrients (μmol L^{-1}): 30.0 of Fe, 5.0 of Mn, 4.0 of Zn, 0.75 of Cu, 0.5 of Mo and 30.0 of B.

Determination of the main physical and chemical characteristics of the substrate

Both the physical and chemical characteristics of each substrate are listed in Table 1. Physical characteristics were determined by methods proposed by De Boodt and Verdonck (1972) and Wilson (1983), which included: (i) bulk density; (ii) total porosity: percentage of air compared to the total volume; (iii) aeration space: difference between total porosity and the volume of water retained under a 10 hPa tension; and (iv) available water: water volume between 10 and 100 hPa tensions. Chemical characteristics included pH, C, C/N, N, P, K, Ca and Mg and were determined according to recommendations from Tedesco (1995). A suspension of 5 g fresh sample and 50 mL distilled water was stirred for 30 min. at 25°C and then filtered and used for measuring pH.

Table 1. Physical and chemical characteristics of the studied substrates.

Substrate	Chemical characteristics								Physical characteristics			
	pH	C/N	C	N	P	K	Ca	Mg	BD	TP	AS	AW
			(g kg^{-1})						(g L^{-1})	%		
CRH	7.0	25	22	0.9	1.5	2.1	2.4	1.6	265.9	98.4	66.1	21.5
COM	5.5	57	126	2.2	4.6	7.1	27.6	9.7	329.4	64.2	21.7	9.1
MIX_1	7.2	-	13	-	1.6	4.7	7.7	10.9	190.5	75.4	36.2	9.8
MIX_2	7.5	-	0.2	-	0.6	1.6	29.5	8.8	871.3	46.0	21.7	3.0

CRH = carbonized rice husks; COM = commercial substrate; MIX_1 = vermiculite + CRH; MIX_2 = vermiculite + washed sand; BD = bulk density; TP = total porosity; AS = aeration space; AW = available water.

Variables analyzed

The variables were recorded during (a) and at the end (b) of the experiment, as described below:

a_1) Time to produce buds with diameter up to 0.3 cm (in days); a_2) bud diameter [obtained with a digital paquimeter (0.01-300 mm, Digimess®) when 70 to 80% of the hermaphroditic flowers were identified in the center of the inflorescence]; b_1) dry weight of shoots (DWS), roots (DWR) and buds (DWB): plants of each substrate were brought to the laboratory and dried at 70°C for 48 hours, and the weight of each plant part was determined in a Sartorious® brand precision balance (0.01 g precision) and expressed as g plant^{-1}; b_2) root length (cm): determined using a millimeter ruler; b_3) canopy height (cm): measured from the base of the plant to the main bud.

Statistical analysis

Treatments followed a completely randomized statistical design, and each treatment had twelve replicates. Three plants in each pot were analyzed. Each treatment was represented by one of the substrates. Statistical analysis included analysis of variance (ANOVA), mean separation on substrate data using the Tukey test (FERREIRA, 2000) and correlation analysis between substrate characteristics and the dependent variables studied. SAS software was used, and terms were considered significant at $p < 0.01$.

Results and discussion

Dry weight and root length

As seen in Table 2, the commercial substrate had a greater statistically significant influence on the dry weight of shoots and on root length. In addition, the MIX_2 substrate produced the lowest dry shoot weight (nearly 37% less than COM), which could be caused by the high bulk density (Table 1) and, consequently, the low aeration capacity of this substrate.

In spite of the lack of statistical difference, the dry weight of roots had a large range between the lowest (CRH) and the highest (COM) averages, almost 49%, which can strongly influence plant development (SINGH; SINJU, 1998; TAIZ; ZEIGER, 2004) because plants, especially potted chrysanthemums, obtain the majority of their nutrients and water via the root system. Accordingly, root variables (dry weight of roots and root length) had the same decreasing sequence of substrates, i.e., COM>MIX_1>MIX_2>CRH (Table 2), indicating that the substrate influenced root growth and development because substrates with the longest roots also had highest dry root weight, in agreement with the study by Fogain and Gowen (2005).

A basic condition for root growth and development is an adequate supply of oxygen because O_2 deficiency causes plant reaction and accumulation of deleterious compounds, which reduces plant growth and development (STROJNY et al., 1998). In the present study, the COM substrate (with the second lowest total porosity (64.2%, Table 1) presented the highest values for root variables. This can be attributed to the chemical composition of COM, as chrysanthemums are exigent in nutrients and, additionally, the physical and chemical characteristics of the substrate are equally important for this flower crop (BARBOSA, 2003).

As can be seen in Table 1, the COM substrate had pH values in the ideal range for the chrysanthemum, i.e., between 5.0 and 6.0 (BARBOSA, 2003; GRUSZYNSKI, 2001; HORN, 1996), while the other substrates had higher pH values. According to Marschner (2005), inappropriate pH values could cause physiological imbalance in plants, affecting the availability of nutrients and reducing the cation and anion uptake. Although the chemical properties of the substrate, such as the pH value, are very important for root growth and mineral nutrient availability, the conditions in the rhizosphere and the extent to which roots can modify these conditions play a critical role in mineral uptake. Taiz and Zeiger (2004) found that root growth is usually increased by slightly acidic conditions (pH 5.5 and 6.5).

Adequate substrate aeration is critically important for plants grown in pots (HEISKANEN, 1993). Thus, pot substrates are saturated to pot capacity when air space is at least 10% of total substrate volume (BUGBEE; FRINK, 1986).

The quantitative results of the dry weight of roots (Table 2) grown in all substrates except for the COM substrate are below the average weight reported by Farias et al. (2003) in a study also conducted on potted chrysanthemums.

Table 2. Average dry weight of buds (DWB), shoot (DWS) and roots (DWR), root length (RL), time to produce buds (TPB), bud diameter (BD) and canopy height (CH) of chrysanthemum plants as a function of substrate.

Substrate	DWB	DWS	DWR	RL	TPB	BD	CH
	(g)			(cm)	(days)	(mm)	(cm)
CRH	4.57 a	14.62 a	1.78 a	10.78 b	11.25 ab	3.51 a	21.22 a
COM	4.87 a	16.07 a	3.50 a	12.47 a	13.00 a	3.30 b	21.15 a
MIX_1	4.75 a	13.75 a	2.43 a	11.78ab	10.00 b	3.37 ab	21.17 a
MIX_2	4.55 a	10.50 b	2.30 a	11.00 b	10.00 b	3.46 ab	18.58 b
smd	0.45	5.01	1.65	1.30	1.77	0.17	2.75

CRH = carbonized rice husks; COM = commercial substrate; MIX_1 = vermiculite + CRH; MIX_2 = vermiculite + washed sand. Averages followed by same letter, in the column, are not different according to Tukey test ($p \leq 0.01$); smd = significant minimum difference.

The high percentage of CRH aeration space is crucial for root growth and plant development due to its promotion of an adequate balance between water and air during plant cultivation, consequently leading to better yields. Additionally, De Boodt and Verdonck (1972) and Boertje (1984) found that substrate total porosity up to 85% was ideal, which classifies CRH as a good substrate (98.4%) for chrysanthemum production.

Root length was positively and significantly correlated with the phosphorus concentration; i.e., the substrates with higher phosphorus concentrations (Table 1) promoted longer roots (Table 2), with a significant ($p \leq 0.01$) correlation coefficient (r) of 0.86 (Figure 1). This result indicates that the substrate phosphorus concentration influences directly chrysanthemum root growth. This was previously suggested, since phosphorus is an important nutrient for root formation (MARSCHNER, 2005), it has a profound effect on root system architecture (WILLIAMSON et al., 2001), and it is often the limiting nutrient for plant growth because of its low mobility in the soil.

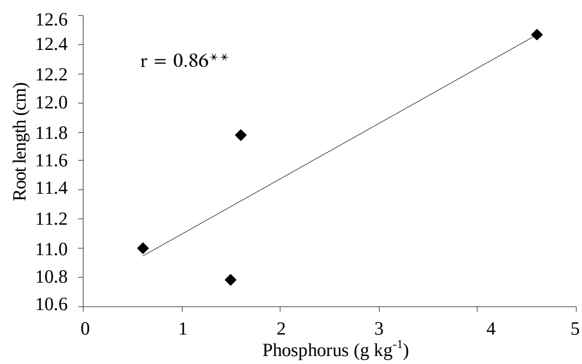

Figure 1. Root length of 'Funny' chrysanthemum as a function of substrate phosphorus concentration.

The dry weight of buds (Figure 2) was positively correlated with the substrates' phosphorus and potassium concentrations, indicating that these elements are important for this variable. These results could be explained by a study done by Gruszinski (2001), who argued that both phosphorus and potassium are crucial for chrysanthemum budding and that an excess or deficiency in P or K can negatively affect budding and the post-harvest quality of flowers. According to Marschner (2005), there is a relationship between phosphorus deficiency, the number of flowers and the delay in flower initiation, suggesting that P participates in the balance of substances that regulate plant growth. Wachowicz and Serrat (2006) found that *Gypsophila paniculata* plants cultivated without phosphorus did not form flower stems.

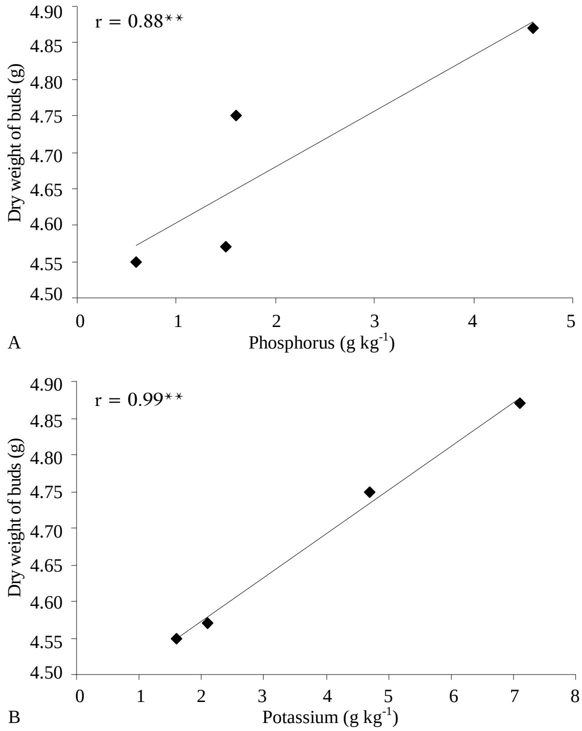

Figure 2. Dry weight of 'Funny' chrysanthemum buds as a function of phosphorus (A) and potassium (B) concentration in the substrate.

Variables of bud and canopy height

The different substrates had a significant statistical influence on the time required to produce buds, bud diameter and canopy height (CH) (Table 2).

The commercial substrate promoted the lowest bud diameter, although it produced the best results for root variables. This result could be a function of the physical properties of the COM substrate, which had the second lowest total porosity and aeration space and, consequently, the second highest bulk density, as seen in Table 1. When compared to the recommendations of a study by Kämpf (2000), COM and MIX_2 substrates had a total porosity below the recommended 75-90% range, which is important to promote good plant growth and development. Additionally, total porosity values are higher in the substrate than in soil due to the greater amount of water used on plant cultivation in substrates.

De Boodt and Verdonck (1972) reported that higher substrate compactation promotes lower structure and total porosity and, consequently, makes plant development more difficult. In a study about chrysanthemum cultivation in expanded clay, Barbosa et al. (1999) observed a close relationship between canopy height and aeration space, which agrees with the results of this study, as seen in Figure 3, which shows that as the total porosity (A, r = 0.92**), the aeration space (B, r = 0.71**) and the available water (C, r = 0.88**) of the substrate increases the canopy height increase The MIX_2 substrate had a statistically lower canopy height (Table 2), a very important commercial variable for potted ornamental plants.

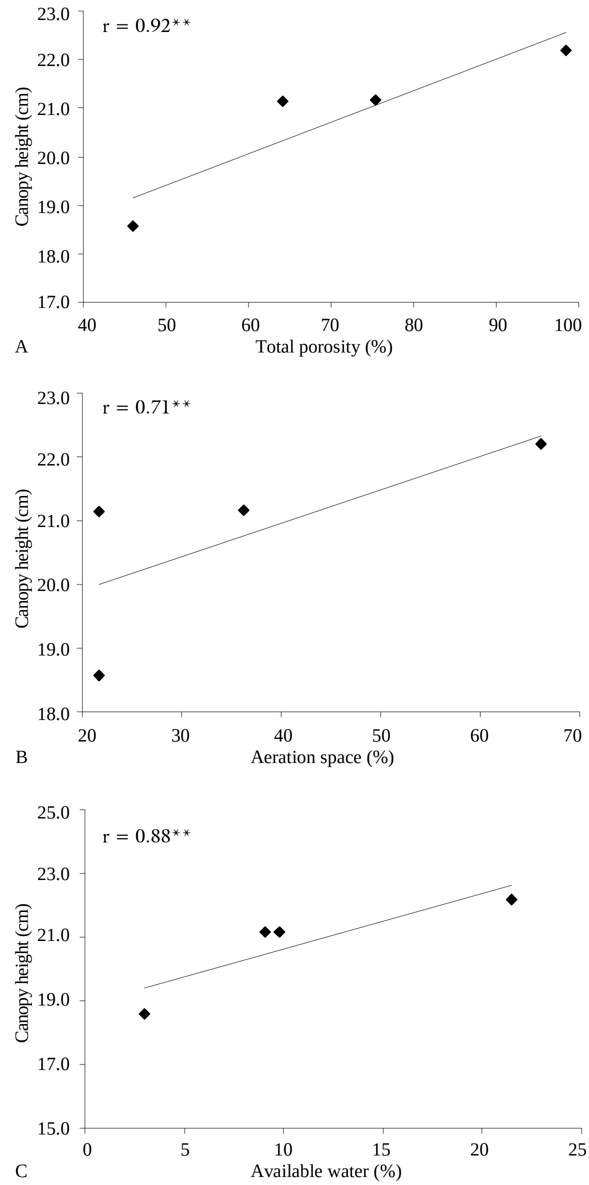

Figure 3. Canopy height of 'Funny' chrysanthemum as a function of total porosity (A), aeration space (B) and available water (C) in the substrate.

Despite significant differences between the substrates, all of them presented a relationship between canopy height and pot height in the range described by Noordegraaf (1994) as satisfactory, i.e., between 1.5 and 2.0.

Conclusion

Our study demonstrates that i) the alternative substrates studied here had different effects on the growth of potted 'Funny' chrysanthemums; ii) satisfactory results were obtained with alternative substrates, showing that rice husks could be used as a sole substrate or part of a substrate for potted chrysanthemums. This suggests that the re-use of this waste product from regional agroindustry is possible.

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