Quality of pot gerbera cultivars in different substrate granulometries[1]

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ABSTRACT

This research was conducted to evaluate the quality of pot gerbera in different granulometries of pine bark substrate. The experiment was carried out in protected environment, in the municipality of Botucatu, São Paulo state, Brazil. The experimental design was randomized blocks, in 5 x 2 factorial scheme (5 substrates and 2 cultivars) and 4 replicates. The substrate was pine bark separated into five granulometries [4-2 mm, 2-1 mm, <4 mm, <2 mm and <1 mm (approximate aeration percentage of 40, 35, 25, 20 and 10%, respectively)]. The utilized cultivars of gerbera (*Gerbera jamesonii*) were Cherry and Golden Yellow. The pots were subjected to quality analysis, in which possible consumers received a form to evaluate the pots regarding the overall aspect of leaves, inflorescences and general aspect of the pot. Then, the following variables were evaluated: number of leaves, plant diameter, stem height, stem diameter, capitulum diameter, number of inflorescences, dry phytomass of shoots and inflorescences and qualitative analysis. Plant quality was directly influenced by the physical and chemical characteristics promoted by the pine bark granulometries, with best results in the substrates with granulometries < 2 mm and < 1 mm.

Keywords: *Gerbera jamesonii* L., sensory analysis, ornamental plant, plant nutrition.

RESUMO

Qualidade de cultivares de gérbera de vaso em diferentes granulometrias do substrato

Esse trabalho foi conduzido com o objetivo de avaliar a qualidade de gérbera de vaso em diferentes granulometrias do substrato casca de pinus. O experimento foi conduzido em ambiente protegido no município de Botucatu, Estado de São Paulo. O delineamento experimental foi em blocos casualizados em esquema fatorial 5 x 2 (5 substratos e 2 cultivares) e 4 repetições. Como substrato utilizou-se casca de pinus separada em cinco granulometrias [4-2 mm, 2-1 mm, <4 mm, <2 mm e <1 mm (porcentagem de aeração aproximada de 40, 35, 25, 20 e 10%, respectivamente)]. As cultivares de gérbera (*Gerbera jamesonii*) utilizadas foram a Cherry e Golden Yellow. Os vasos foram submetidos à análise de qualidade onde possíveis consumidores receberam um formulário para avaliar os vasos quanto ao aspecto geral das folhas, inflorescências e aspecto geral do vaso. Em seguida, avaliou-se o número de folhas, diâmetro de planta, altura de haste, diâmetro da haste, diâmetro do capítulo, número de inflorescências, fitomassa seca da parte aérea e inflorescências e análise qualitativa. A qualidade das plantas foi influenciada diretamente pelas características físicas e químicas proporcionadas pelas granulometrias da casca de pinus, com melhores resultados nos substratos com granulometrias < 2 mm e < 1 mm.

Palavras-chave: *Gerbera jamesonii* L.. análise sensorial. planta ornamental. nutrição de plantas.

1. INTRODUCTION

Commercial floriculture, understood as the professional and business activity of production, market and distribution of flowers and plants cultivated with ornamental purposes, represents one of the most promising segments of the modern Brazilian agribusiness (AGRIANUAL, 2012). In the last years, the commercial cultivation of pot and cut gerbera (*Gerbera jamesonii* L.) has become of great economic importance for floriculture (GUERRERO et al., 2012).

The introduction of gerbera as pot flower is recent in Brazil and many studies are still necessary, especially those related to the determination of physical and chemical properties of the substrate, which contribute to its productive quality (LUDWIG et al., 2014). Due to the reduced space for root growth in pot plants, substrate selection has predominant importance for the productive quality and, on this aspect, Ludwig et al. (2010a) highlight the importance of establishing an adequate ratio between air and water in the substrate. According to the same authors, substrates with high density and promoting greater compaction compromise root growth, which reflects on the reduction of plant development, especially in pots with capacity for 1 L and 11.5 cm of height.

In Brazil, there is a large variety of substrates with different physical and chemical characteristics, which can interfere with the development of gerbera (*Gerbera jamesonii* L.) cultivated in pots. According to Schafer

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et al. (2015), there is a very wide variety in types and proportions of components used as substrates for plants and a considerable lack of technical knowledge on their formulation. Therefore, it is necessary to conduct studies that aim to find ideal conditions for gerbera cultivation, and this information is scarce in the literature.

The knowledge on these factors contributes to the production of plants with better quality and consequently higher commercial value. The quality of an ornamental plant is intrinsically related to subjectivity and mainly to individual perception, which may hamper the classification of plants with higher or lower quality. In general, the quality criterion attributed to pot plants is directly related to the composition of leaves and flowers, although the morphological features considered as most important from the aesthetic point of view are not recognized in detail (LUDWIG et al., 2011).

Hence, the present study aimed to evaluate the influence of the physical and chemical characteristics of the pine bark substrate, separated into different granulometries, on the quality and consumer preference for the pot gerbera cultivars Cherry and Golden Yellow.

2. MATERIAL AND METHODS

The experiment was carried out in protected environment from November to December 2010, at the Department of Natural Resources - Area of Soil Sciences - FCA - UNESP, in the municipality of Botucatu, São Paulo State, Brazil. The mean temperature during the experimental period was 25 ºC and mean relative air humidity was 78%.

The experimental design was randomized blocks, with a 5 x 2 factorial scheme (5 substrates and 2 cultivars) and four replicates. The utilized substrate was pine bark separated into different granulometries. The granulometries corresponding to the substrates 1, 2, 3, 4 and 5 were respectively 4-2 mm, 2-1 mm, <4 mm, <2 mm and <1 mm (approximate aeration porosity of 40, 35, 25, 20 and 10%, respectively).

Wet and dry densities were determined using the self-compaction method (HOFFMANN, 1970, cited by BRASIL, 2007). Water retention curve (DE BOODT; VERDONCK, 1972) was determined through the application of tensions of 0, 10, 50 and 100 cm of water column, which corresponded to the tensions of 0, 10, 50 and 100 hPa, on a tension table.

Electrical conductivity and pH were determined using the extraction method of 1:5 (substrate volume per water volume), calculated based on the density (BRASIL, 2007). For that, the sample was agitated for 1 h in Wagner agitator with rotation of 40 rpm. The suspension was filtered in white ribbon filter paper, determining the electrical conductivity (EC) with a portable conductivity meter (Horiba B173).

Cation exchange capacity (CEC) was determined following the method proposed for CEC determination in peats by the Association of Official Analytical Chemists (AOAC, 1984), cited by Brasil (2007). The quantification of K, Ca, Mg, Cu, Fe, Mn and Zn was performed through atomic absorption spectrophotometry. NO_3^--N and NH_4^+-N were determined through steam distillation (BREMNER and EDWARDS, 1965) with a modified distiller described by Tedesco and Gianello (1979). These nutrients were determined through the 1:1.5 method (Table 1).

Table 1. Chemical and physical characteristics of the substrates used for gerbera growth and development.

Characteristics	*Substrates*				
	1	2	3	4	5
$EC_{1:5}$ (dS m^{-1})	0.29	0.15	0.34	0.38	0.29
$pH_{1:5\ (inicial)}$	3.47	3.49	4.17	3.49	3.47
$N\text{-}NO_3^-$	0.80	0.12	1.04	1.01	0.17
$N\text{-}NH_4^+$	0.43	0.34	0.57	0.51	0.38
$K_{1:1.5}$ (mg L^{-1})	16.67	5.00	21.67	21.33	6.00
$Ca_{1:1.5}$ (mg L^{-1})	7.33	1.67	10.67	10.67	1.67
$Mg_{1:1.5}$ (mg L^{-1})	4.67	0.33	6.00	6.00	0.00
$Cu_{1:1.5}$ (mg L^{-1})	0.02	0.03	0.02	0.02	0.02
$Fe_{1:1.5}$ (mg L^{-1})	0.22	0.47	0.23	0.20	0.53
$Mn_{1:1.5}$ (mg L^{-1})	0.24	0.48	0.22	0.23	0.54
$Zn_{1:1.5}$ (mg L^{-1})	0.06	0.02	0.10	0.05	0.02
CTC ($mmol_c$ kg^{-1})	646.15	881.67	586.30	740.40	962.08
Total porosity- TP (%)	82.37	80.94	83.08	80.62	79.78
Solids (%)	17.63	19.06	16.92	19.38	20.22
Aeration space - AS (%)	41.55	35.04	25.65	16.80	7.91
Easily available water - EAW (%)	14.76	18.67	28.15	33.92	34.29
Buffering water - BW (%)	1.53	2.55	3.27	5.77	15.31
Available water - AW (%)	16.29	21.22	31.42	39.69	49.60
Remaining water - RW (%)	24.53	24.69	26.00	24.12	22.27
Density wet (kg m^{-3})	391.18	526.00	490.55	463.76	548.04
Dry density (kg m^{-3})	216.38	312.61	239.75	268.38	280.75

Substrates: 1 = 4-2 mm; 2 = 2-1 mm; 3 = <4 mm; 4 = <2 mm and 5 = <1 mm.

Regarding the seedlings of gerbera (*Gerbera jamesonii* L.), the experiment used plants with four true leaves of the cultivars Cherry and Golden Yellow belonging to the "Dark eyes" series, which were donated by the company Sakata®, considered as the most cultivated ones in the São Paulo state. The seedlings were planted in pots with capacity for 1 L (height=11.5 cm, upper diameter=13 cm and lower diameter=9 cm), filled with the substrate corresponding to the treatments, according to the wet density.

Gerbera plants were acclimated for 30 days, arranged on a wooden bench (1.2 wide, 12 m long and 0.8 m high) under thermo-reflective screen to maintain light intensity close to 25,000 Lux. After acclimation, the pots were spaced by 25 cm and distributed on two wooden benches with the same previously cited dimensions, remaining under maximum light intensity of 50,000 Lux, with the use of the mobile thermo-reflective screen, installed on the internal upper part of the greenhouse.

Nutrients were supplied through fertigation and daily applied. The nutrient solution had the following composition, in mg L^{-1}: 121 NO_3^--N, 12 NH_4^+-N, 92 K, 24 P, 175 Ca, 27 Mg and 39 S, 0.19 B, 0.08 Cu, 2.74 Fe, 0.19 Mn, 0.04 Mo and 0.08 Zn in the vegetative period and 168 NO_3^--N, 41 NH_4^+-N, 303 K, 35 P, 105 Ca, 45 Mg and 55 S, 0.19 B, 0.08 Cu, 2.74 Fe, 0.19 Mn, 0.04 Mo and 0.08 Zn in the reproductive period (LUDWIG et al., 2011).

Plants were subjected to quality analysis, exposed in a public place for possible consumers to attribute grades, by filling out a form with the following scale: (1) bad, (2) good, (3) very good and (4) excellent, according to the methodology described in LUDWIG et al. (2011). The questions were relative to the overall aspect of leaves, inflorescences and plant in the pot. For this evaluation, the design was completely randomized, in a 5 x 2 factorial scheme (5 substrates and 2 cultivars), with 43 replicates, representing the number of respondents.

Then, plants were evaluated for number of leaves, plant diameter, stem height, stem diameter, capitulum diameter, number of inflorescences, quality analysis, leaf area, shoot dry phytomass and inflorescence dry phytomass, according to the methodology described by Ludwig et al. (2011).

The results were subjected to analysis of variance. The means of the effects of substrates and cultivars were compared by Tukey test at 0.05 probability level, when significant, using the statistical program Sisvar (FERREIRA, 2011). The means of the grades attributed to the plants were compared by Tukey test at 0.05 probability level, with transformation to the logarithm function (Log (X)).

RESULTS AND DISCUSSION

The cultivar Cherry obtained higher grades regarding the aspect of leaves in comparison to Golden Yellow when grown in the substrates 1, 3 and 4 (Table 2). In general, the cultivar Cherry received higher grades in comparison to Golden Yellow, but without differing statistically from it when grown in the substrates 2 and 5. In the substrate 3, both cultivars received lower grades. This result is specifically attributed to the color of the leaves in the plants cultivated in this substrate, in the which they exhibited slight chlorosis between veins, especially in older leaves.

Table 2. Grades attributed to the aspect of the leaves aspect of inflorescences overall aspect of gerbera plants as a function of the substrates and cultivars.

Substrate	Assigned notes					
	Leaves		Inflorescence		General	
	Cherry	GoldenYellow	Cherry	GoldenYellow	Cherry	GoldenYellow
1	2.5 aA	2.0 abB	2.6 aA	2.5 aA	2.5 aA	2.4 aA
2	2.5 aA	2.2 abA	2.6 aA	2.5 aA	2.5 aA	2.3 aA
3	2.0 bA	1.2 cB	2.4 aA	2.4 aA	2.3 aA	1.4 bB
4	2.5 aA	2.1 abB	2.5 aA	2.2 bB	2.5 aA	2.2 aA
5	2.3abA	2.5 aA	2.4 aA	2.5 aA	2.3 aA	2.4 aA
C.V. (%)	33.96		36.15		35.28	

Grade scale: (1) bad. (2) good. (3) very good and (4) excellent. Means followed by the same lowercase letter (substrates) and uppercase letters (cultivars) do not differ by Tukey test at 0.05 probability level. NS: not significant; **, * significant at 0.01 and 0.05 probability levels. respectively. Substrates: 1= 4-2 mm; 2= 2-1 mm; 3= <4 mm; 4= <2 mm and 5= <1 mm. Means followed by the same letter do not differ by Tukey test at 0.05 probability level, being lowercase between substrates and uppercase between cultivars.

For leaf area, plant diameter and shoot dry phytomass there was significant statistical difference only between the substrates (Table 3). For leaf area, the highest value occurred in the substrate 5 and was 19.02% higher than that of substrate 3. For plant diameter, the value in substrate 5 was 13.5% higher than that obtained in substrate 3. For shoot dry phytomass, the substrates 2 and 5 showed higher values, 8.55 and 8.44 g, representing a mean gain of 39.7% in relation to substrate 3. In general, superior values for these three characteristics were found when plants were cultivated in the substrate 5 (Table 1). Contrary to these results, Ludwig et al. (2011) found difference between

cultivars for these characteristics. These authors also indicate that plants with diameter between 29 and 31 cm and leaf area larger than 10 dm^2 have higher probability of being commercialized. Thus, the obtained plants are adequate according to the indication proposed by these authors.

Table 3. Mean values of leaf area (LA), number of leaves (NL), plant diameter (PD), shoot dry phytomass (SDP) and inflorescence dry phytomass (IDP) in gerbera plants at the commercialization point (CP).

Substrate	Commercialization point				
	LA	NL	PD	SDP	IDP
	cm^2		cm	g	
1	952.73 b	16.88 a	31.13 ab	6.53 b	3.55 a
2	1049.93 ab	18.75 a	34.06 a	8.55 a	3.48 a
3	1017.29 ab	16.75 a	30.50 b	6.04 b	2.94 a
4	1071.45 ab	18.00 a	33.69 ab	7.55 ab	4.06 a
5	1133.93 a	17.25 a	34.63 a	8.44 a	3.48 a
Cultivar					
Cherry	1046.43 A	18.50 A	32.50 A	7.14 A	3.12 B
Golden Yellow	1046.70 A	16.55 A	33.10 A	7.70 A	3.88 A
S	*	NS	**	**	NS
C	NS	NS	NS	NS	**
S*C	NS	NS	NS	NS	NS
C.V. (%)	9.71	18.40	7.06	13.48	22.88

Substrates: 1 = 4-2 mm; 2 = 2-1 mm; 3 = < 4 mm; = 4 < 2 mm = 5 < 1 mm. Means followed by the same letter do not differ by Tukey test at 0.05 probability level. Being lowercase between substrates and uppercase between cultivars.

Plant diameter and leaf dry phytomass were positively and significantly correlated, with correlation coefficient of r: 0.85**. For the other characteristics, there were no significant correlations between the evaluated characteristics and the grades attributed to the leaves. However, it can be observed that the consumer does not consider only the leaf volume as adequate feature for purchase, but also the appearance of the leaves, since there was a high rejection (1.2) for Golden Yellow cultivated in substrate 3, in which the leaves of this cultivar showed different color from the others (Table 2).

The grades attributed to the inflorescences were inferior for the cultivar Golden Yellow when plants were grown in substrate 4 (Table 2). According to Ludwig et al. (2010b), the number of inflorescences in pot plants adds value to the final product and can be decisive in the commercialization, and the market for gerbera plants requires the pot to have at least two open flower buds. Therefore, both cultivars met this requirement, with mean values of 2.5 for Cherry and 3.0 for Golden Yellow (Table 4). Ludwig et al. (2008) did not find significant difference for this characteristic.

The number of inflorescences and their diameter were negatively correlated (r: -0.67*), indicating that the higher the number of inflorescences produced, the lower their diameter. Ludwig et al. (2011) observed this same trend, indicating that this is an expected result, due to the distribution of photoassimilates. Inflorescence diameter and dry phytomass were positively and significant correlated, with correlation coefficient of r: 0.69*.

The quality of pot plants is also based on their height and mainly considers that, for an adequate conformation, the plant must have 1.5 to 2 times the height of the pot (GUERRERO et al., 2013). Thus, all plants were within this qualitative pattern (Table 4).

Table 4. Mean values of stem height (SH), stem diameter (SD), inflorescence diameter (ID), number of inflorescences (NI) and plant height (PH).

Substrate	Qualitative analysis					
	40 DAA					
	SH	SD		ID	NI	PH
		Cherry	Golden Yellow			
	--cm--	------cm------		--mm--		--cm--
1	14.88 a	4.75 bA	5.04 abA	75.17 a	3.12 a	19.19 a
2	16.75 a	4.96 aA	4.58 bA	81.15 a	2.50 a	20.88 a
3	15.70 a	4.86 aA	4.68 bA	77.80 a	2.50 a	19.83 a
4	16.91 a	4.47 bB	5.25 abA	73.05 a	3.13 a	21.32 a
5	15.75 a	4.76 bB	6.06 aA	80.37 a	2.63 a	20.42 a
Cultivar						
Cherry	15.62A			78.15 A	2.50 B	19.82 A
Golden Yellow	16.38A			76.87 A	3.05 A	20.84 A
S	NS	*		NS	NS	NS
C	NS	*		NS	*	NS
S*C	NS	**		NS	NS	NS
C.V. (%)	17.8	8.39		10.71	29.24	16.78

Substrates: 1 = 4-2 mm; 2 = 2-1 mm; 3 = < 4 mm; = 4 < 2 mm = 5 < 1 mm. Means followed by the same letter do not differ by Tukey test at 5 % probability being lower between substrates and capital between cultivars.

Stem height and plant height were not significantly different between treatments. However, these two characteristics were positively and significantly correlated, with correlation coefficient of r: 0.92**.

Stem diameter was higher for the cultivar Golden Yellow when cultivated in the substrates 1, 4 and 5, and for the cultivar Cherry in the substrates 2 and 3 (Table 3). Ludwig et al. (2011) found higher values of stem diameter for the cultivar Cherry, also highlighting the importance of this feature, which is mainly related to the support of the inflorescences, avoiding the possible fall and loss of quality, particularly during the transport and handling.

It was observed that 40 and 95% of the respondents would not buy the cultivars Cherry and Golden Yellow, respectively, if cultivated in the substrate 3, which indicates a rejection of the plants grown in this substrate, in a more accentuated way for the cultivar Golden Yellow, a fact attributed to the color of the leaves, which was a decisive factor for the rejection by the respondents. The cultivar Cherry, regardless of the substrate, had greater acceptance by the respondents, with emphasis on plants cultivated in the substrates 2 and 4 (Figure 1).

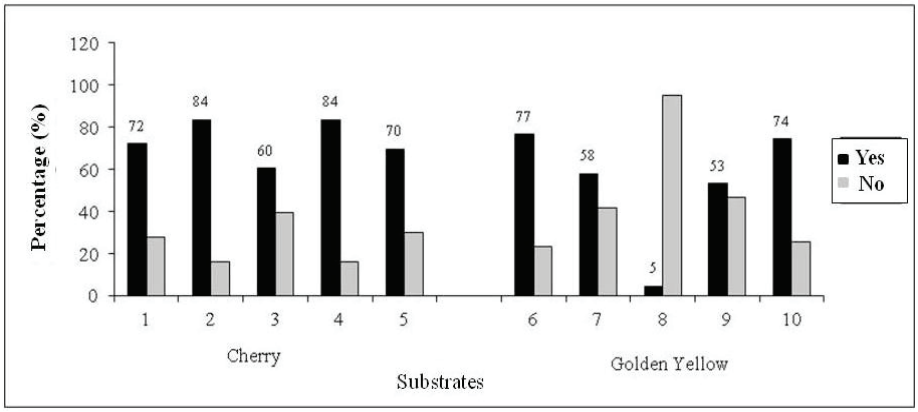

Figure 1. Reaction of the respondents when questioned about the purchase of the cultivars Cherry and Golden Yellow produced in the different substrates.

CONCLUSIONS

It was concluded that the cultivar Cherry has greater acceptance by the consumer in comparison to Golden Yellow. The quality of the plants was directly influenced by the physical and chemical characteristics promoted by the pine bark granulometries, with better results in the substrates with granulometries < 2 mm and < 1 mm, with aeration spaces of 20% and 10%, respectively.

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AUTHORS CONTRIBUTIONS

A.C.G.: The article refers to a part of the thesis of the author who conducted the experiment together with the doctoral student **F.L**. **G.A.F.:** trainee and student of scientific initiation, his project was part of the experiment of the doctoral thesis. **D.M.F.:** professor doctor, adviser of the three authors cited. All collaborated in the discussion of the data to make the articles.

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