

FLOWER PRODUCTION OF GERBERA CULTIVARS IN TWO SOILLESS SUBSTRATES

UTJECAJ KULTIVARA I HIDROPONSKIH SUPSTRATA NA PRINOS CVJETOVA GERBERE

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ABSTRACT

The effect of two hydroponic substrates (organic mix with perlite and rockwool) on the flower production of three gerbera cultivars ('Bordorex', 'Dalma' and 'Goldy') was studied from August 2005 through March 2007. Flower production was higher in organic substrate compared to rockwool in Dec. 2005 (34%), Apr. 2006 (12%) and Mar. 2007 (20%). Interaction between type of substrate and cultivars for flower production was found in Jan., Sep. and Nov. 2006.. Production of flowers of 'Goldy' in organic substrate was higher compared to other combinations, except in Jan. 2006. when the production was the same as of 'Bordorex' on organic substrate. Through experimental period cultivars had more influence on production of flowers than substrate. Diameter of flower stalk and diameter of inflorescence were influenced by cultivar as well. Under the conditions of our study there was not much influence of substrate type on flower production or on flower stem quality, however choice of cultivar had a significant effect.

Key words: *Gerbera jamesonii*, soilless substrate, yield

SAŽETAK

Istraživan je utjecaj dvaju hidroponskih supstrata; organskog s perlitom i anorganskog (kamenja vuna), te triju kultivara gerbere 'Bordorex', 'Dalma' i 'Goldy' na prinos cvjetova gerbere u razdoblju od kolovoza 2005. do ožujka 2007.

U usporedbi prinos cvjetova gerbere uzgojenih na kamenoj vuni u odnosu na prinos cvjetova na organskom supstratu, bio je viši za 34% u prosincu 2005.,

za 12% u travnju 2006., te za 20% u ožujku 2007. Interakcija supstrata i kultivara došla je do izražaja u siječnju, rujnu i studenom 2006.

U usporedbi s drugim kultivarima, prinos cvjetova gerbere bio je najveći kod kultivara 'Goldy' na organskom supstratu, osim u siječnju kada je 'Goldy' imao izjednačen prinos s kultivarom 'Bordorex'. U eksperimentalnom razdoblju kultivari su imali veći utjecaj na prinos cvjetova nego supstrat.

Pod utjecajem kultivara bili su promjer cvjetne stapke i promjer cvjetne glavice. Rezultati pokazuju da nije bilo velike razlike u prinosu kao ni u kakvoći cvjetova gerbere uzrokovane vrstom supstrata (organskog i kamene vune), no izbor kultivara ima značajan utjecaj

Ključne riječi: *Gerbera jamesonii*, hidroponski supstrati, prinos

INTRODUCTION

Gerbera jamesonii is an ornamental plant grown for the cut flower market on a large scale (Teeri et al., 2006); flowers are available in a wide range of colors, including yellow, orange, pink, crimson, red, purple, and white (Emongor, 2004). *Gerbera* could have a potential in Mediterranean areas owing to the prevalent economic and ecological conditions (Issa et al. 2001).

In Mediterranean countries soilless techniques have been used for several years and they have intensified production of floricultural crops (Maloupa et al., 1992). The cost, local availability and experience with substrate use, are usually the determining factors for choosing a particular substrate type (Samartzidis et al., 2005). Experiments carried out to assess the physical and chemical properties of substrates, nutrient supply, water availability and their relation to particular plant characteristics contribute to the optimization and productivity in intensive culture methods (Issa et al., 2001). The main advantages of soilless systems are more accurate control over the supply of water, nutrients, and pH compared to soil culture. Reduction of labor requirement, higher yields, and better uniformity of quality due to easier and more accurate control of production factors are some additional benefits. In these systems there is no need for soil sterilization and more crops per year are possible (Olympios, 2005).

Rockwool (inorganic substrate) and organic mix of corn peat, fiber peat, coco fiber, and rice husk with perlite (organic substrate) are the commonest soilless substrates in gerbera production in Croatia.

Organic substrates of a moderate or low biostability will release available nutrients and vary in their chemical properties, such as pH, electrical conductivity (EC) and cation exchange capacity, as a consequence of the decomposition of the substrate's organic matter (Lemaire, 1997). Rockwool is a chemically inert substrate, obtained from diabase, a volcanic rock, with porosity of about 96% (Jørgensen, 1975). It is an artificial substrate, which offers a high degree of water permeability and high water content at low suction (Bogoul and Boulard 2006).

The aim of the present study was to investigate the influence of two hydroponic substrates, organic mix and rockwool on flower production of gerbera cultivars in a non heated greenhouse.

MATERIAL AND METHODS

The experiment was conducted in a non heated greenhouse located in Split, in the Mediterranean area (lat. 43°30'N, long. 16°25' E) of Croatia. The experiment lasted from August 2005 through March 2007. Air temperature during the experiment was measured daily with min/max thermometer. Minimum temperatures were under optimum temperature for flower production in the cold period of the year (from December to mid February) whereas the day/night temperatures were 15/12 °C. Gerbera seedlings were received from a commercial nursery in rockwool plugs (ø 4.6 x 5 cm) and were transplanted on 7th July 2005 at the stage of the third true leaf.

Three gerbera cultivars 'Bordorex', 'Dalma' and 'Goldy' (Florist De Kwakel b.v., Aalsmeer, Netherlands) and two growing media (rockwool slabs and organic substrate) were tested in open hydroponic systems under natural photoperiod.

Plants were potted into 3.5 L pots (20 cm diameter x 16 cm height) filled with commercial substrate (EGO Potgrondbedrijf Bleiswijk BV, Bleiswijk, Holland) consisting of corn peat, fiber peat, cocofiber EGO-production, black peat fiber, rice husk, and perlite (organic substrate with perlite). The second

substrate (inorganic), were rockwool cubes (10 x 10 x 6.5 cm) and slabs (100 x 15 x 7.5 cm) (Agroban, Batka, Slovakia). Gerbera plants had previously been inserted in a rockwool cube, perforated in the centre, and then put on the saturated rockwool slab. Plants in pots were placed on benches at 40 x 40 cm space (density of 6 plants m⁻²); the same density was provided on benches with rockwool slabs.

Table 1. Effect of substrate and cultivar on flower production per plant of gerbera in 2005.

Tablica 1. Utjecaj supstrata i kultivara na proizvodnju cvjetova gerbere po biljci u 2005.

Treatments	Flower production per plant			
	Sept.	Oct.	Nov.	Dec.
Substrate (S)				
Organic	1.23	1.18	1.44	1.69 a
Rockwool	1.33	1.22	1.43	1.26 b
Cultivar (Cv.)				
Bordorex	1.08 b	1.09 b	1.32 b	1.30
Dalma	1.32 a	1.17 b	1.38 b	1.54
Goldy	1.43 a	1.32 a	1.57 a	1.53
<i>Significance</i> ^a				
Substrate (S)	NS	NS	NS	***
Cultivar (Cv.)	**	**	**	NS
S X Cv.	NS	NS	NS	NS

^a Means within columns for substrate or cultivar followed by different letters are significantly different at $P \leq 0.05$ by Fisher's protected LSD test.

^a Različita slova u stupcima pokazuju značajne razlike kod supstrata i kultivara ($P \leq 0.05$) kod Fisherova LSD testa

Table 2. Effect of substrate and cultivar on flower production per plant of gerbera in 2006.
 Tablica 2. Utjecaj supstrata i kultivara na proizvodnju cvjetova gerbere po biljci u 2006.

Treatments	Flower production per plant											
	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Substrate (S)												
Organic	1.5 a	1.5	1.5	1.9 a	1.6	2.2	2.1	2.1	1.9	1.5	2.3 a	1.5
Rockwool	1.1 b	1.4	1.5	1.7 b	1.6	2.1	2.0	1.9	1.7	1.5	1.6 b	1.7
Cultivar (Cv.)												
Bordorex	1.2 b	1.1 b	1.4	1.5 b	1.4 b	1.9	1.7 b	1.8 b	1.4 b	1.3	1.6 b	1.3 b
Dalma	1.1 ab	1.4 ab	1.5	1.9 a	1.5 ab	2.2	1.9 b	1.7 b	1.6 b	1.5	1.9 b	1.7 ab
Goldy	1.4 a	1.7 a	1.6	1.9 a	1.7 a	2.3	2.4 a	2.4 a	2.1 a	1.6	2.1 a	1.9 a
<i>Significance^a</i>	**	NS	NS	*	NS	NS	NS	NS	NS	NS	***	NS
Substrate (S)	**	**	NS	**	**	NS	***	**	***	NS	***	*
Cultivar (Cv.)	*	NS	NS	NS	NS	NS	NS	NS	**	NS	***	NS

^a Means within columns for substrate or cultivar followed by different letters are significantly different at $P \leq 0.05$ by Fisher's protected LSD test
^b Različita slova u stupcima pokazuju značajne razlike kod supstrata i kultivara ($P \leq 0.05$) kod Fisher's LSD testa

Table 3. Effect of substrate and cultivar on flower production per plant of gerbera in 2007.

Tablica 3. Utjecaj supstrata i kultivara na proizvodnju cvjetova gerbere po biljci u 2007.

Treatments	Flower production per plant		
	Jan.	Feb.	Mar.
Substrate (S)			
Organic	1.5	1.3	1.8
Rockwool	1.4	1.5	1.5
Cultivar (Cv.)			
Bordorex	1.4	1.5	1.5
Dalma	1.4	1.3	1.7
Goldy	1.6	1.3	1.8
<i>Significance</i> ^a			
Substrate (S)	NS	NS	**
Cultivar (Cv.)	NS	NS	NS
S X Cv.	NS	NS	NS

^a Means within columns for substrate or cultivar followed by different letters are significantly different at $P \leq 0.05$ by Fisher's protected LSD test.

^a Različita slova u stupcima pokazuju značajne razlike kod supstrata i kultivara ($P \leq 0.05$) kod Fisher's LSD testa

Plants in both substrates were irrigated with the same nutrient solution (pH 5.5, EC 1.5 -2.0 dSm⁻¹). Following macronutrients were applied in the first 6-8 weeks of cultivation (mM): 11.25 NO₃-N, 1.0 NH₄-N, 1.25 P, 3.5 Ca, 4.5 K, 1.25 SO₄ and 1.2 Mg; and micronutrients (in μM): 5.0 Mn, 4.0 Zn, 40.0 B, 0.75 Cu, 0.6 Mo and 50 Fe as Fe-EDTA. After the first 6-8 weeks, when the first flowers appeared, the final nutrient solution containing the same concentration of micronutrients as previously and the following macronutrients (mM) 11.4 NO₃-N, 0.9 NH₄-N, 1.5 P, 4.0 Ca, 5.2 K, 1.8 SO₄, and 1.2 Mg was used. Nutrient solution was delivered via drip system with four-outlet emitters of 3

Table 4. Effects of substrate and cultivar on rosette height and diameter (on 12th, 20th and 28th Aug and on 5th Sept. 2005).

Tablica 4. Utjecaj supstrata i kultivara na visinu i promjer rozete (dana 12., 20. i 28.08. i 5.09.2005.)

Treatments	Height of rosette (cm)				Diameter of rosette (cm)			
	12.08.	20.08.	28.08.	05.09.	12.08.	20.08.	28.08.	05.09.
Substrate (S)								
Organic	14.2 a	19.0 b	25.0 b	27.4	26.5 b	39.6 b	50.7 b	56.0
Rockwool	16.6 b	22.6 a	27.3 a	28.8	35.3 a	48.8 a	55.5 a	60.2
Cultivar (Cv.)								
Bordorex	14.4 b	19.3 b	25.4 b	27.2 b	30.8	42.5	52.1	56.0 b
Dalma	14.6 b	19.8 b	25.1 b	26.8 b	30.5	46.1	55.9	61.9 a
Goldy	18.2 a	24.8 a	28.9 a	31.2 a	33.4	45.7	51.7	56.8ab
<i>Significance</i> ^a								
Substrate (S)	*	**	NS	NS	***	***	*	NS
Cultivar (Cv.)	**	**	**	***	NS	NS	NS	*
S X Cv.	NS	NS	*	**	NS	**	NS	NS

^a Means within columns for substrate or cultivar followed by different letters are significantly different at $P \leq 0.05$ by Fisher's protected LSD test.

^{a)} Različita slova u stupcima pokazuju značajne razlike kod supstrata i kultivara ($P \leq 0.05$) kod Fisher's LSD testa.

L·h⁻¹ capacity (Toro Company, El Cajon, Calif.) with one spigot placed in each pot and in each cube on rockwool slabs. The irrigation rate depended on the plant size and the environmental conditions in the greenhouse. The amount of applied nutrient solution ranged from 0.5 L to 2.0 L per plant daily with leaching fraction of 15 to 25%.

Flower harvesting was recorded weekly and yield was expressed as a number of flowers per plant per month. Flowers were picked before the development of the second tubular ring and only well developed flower were taken into consideration.

Table 5. Effects of substrate and cultivar on flower stalk diameter, diameter of disk floret and diameter of gerbera central disk floret on 22nd Feb. 2006.

Tablica 5. Utjecaj supstrata i kultivara na promjer cvjetne stabljike, promjer cvjetne glavice te promjer centralnog diska cvjetne glavice cvjetova gerbere 22.02.2006.

Treatments	Diameter of flower stalk (mm)	Diameter of inflorescence (mm)	Diameter of disk florets (mm)
Substrate (S)			
Organic	5.8	86.1	24.4
Rockwool	5.6	97.2	21.6
Cultivar (Cv.)			
Bordorex	5.7 b	86.3 b	29.3 a
Dalma	6.7 a	133.8 a	28.9 a
Goldy	5.2 c	73.9 b	17.0 b
<i>Significance^a</i>			
Substrate (S)	NS	NS	NS
Cultivar (Cv.)	***	**	***
S X Cv.	NS	NS	***

^a Means within columns for substrate or cultivar followed with different letters are significantly different at $P \leq 0.05$ by Fisher's protected LSD test.

^a Različita slova u stupcima pokazuju značajne razlike kod supstrata i kultivara ($P \leq 0.05$) kod Fisher's LSD testa

Height (from the substrate surface to the top of the highest leaf) and diameter of rosette were measured on all plants from 12th Aug. to 5th Sept. 2005 on a weekly basis. Height of rosette, diameter of inflorescence (capitulum), diameter of disk florets as well as the flower stalk diameter, were measured on all plants on 22nd Feb. 2006.

During winter (from Nov. to Feb.) and spring of 2006-2007 (Feb. and Mar.) samples of drainage solution were collected to determine pH and electrical conductivity (EC). In all the cases, three samples per cultivar per substrate were collected.

The experiment was set up as a completely randomized block design in three replications. All data were subjected to analysis of variance (ANOVA) using PROC GLM of the SAS software package (SAS Institute, 1989) to determine the significance of mix organic substrate with perlite and inorganic substrate as well as their interaction. When the effects were significant mean separation was performed by Fisher's protected LSD at $P \leq 0.05$.

RESULTS AND DISCUSSION

In Dec. 2005, flower production in organic substrate was 34% higher compared to rockwool (Table 1). From Sept. to Dec. 2005 'Bordorex' had the lowest number of flowers per plant, and compared to 'Goldy' it produced 25% less flowers in Sept. and 17% in Oct. and Nov. (Table 1). On Apr. 2006, organic substrate had 11% higher production of flowers compared to rockwool (Table 2). Cultivar 'Bordorex' had 17-35% lower production of flowers compared to 'Goldy' in Feb., Apr., May, Jun., Aug., Oct., Sep., and Dec. 2006 (Table 2).

During the whole period cultivar 'Goldy' had a higher number of flowers per plant compared to the other cultivars. This difference in flower production is due to the fact that 'Goldy' belongs to the type of mini cultivars (7-9 cm flower diameter), and 'Dalma' and 'Bordorex' to standard cultivar types (10-14 cm flower diameter). Previous research on gerbera cultivars also showed that production level of mini cultivars was 500 stems m^{-2} per year and that of the standard ones 250 stems m^{-2} per year (Evans, 2005).

Flower production was higher in organic substrate in Dec. 2005 (34%), Apr. 2006 (12%), and Mar. 2007 (20%) compared to rockwool (Table 1, 2 and 3). Interaction between type of substrate and cultivar was found for flower production in Jan., Sep. and Nov. 2006. Production of flowers of 'Goldy' in organic substrate was highest compared to other cultivars, except in Jan. when the production was the same as for 'Bordorex' in organic substrate (Fig 1). Van Labeke and Dambre (1998) also found that organic substrate (coir) and rockwool had no influence on the number of flower stems. At the start of cultivation (12th Aug. to 5th Sept. 2005.) the height and diameter of rosette were affected by both the substrate and cultivar (Table 4). On 28th Aug. and 5th Sept. 2005. 'Bordorex' and 'Dalma' had a higher rosette on rockwool than on organic substrate, but "Goldy" had higher rosette on organic

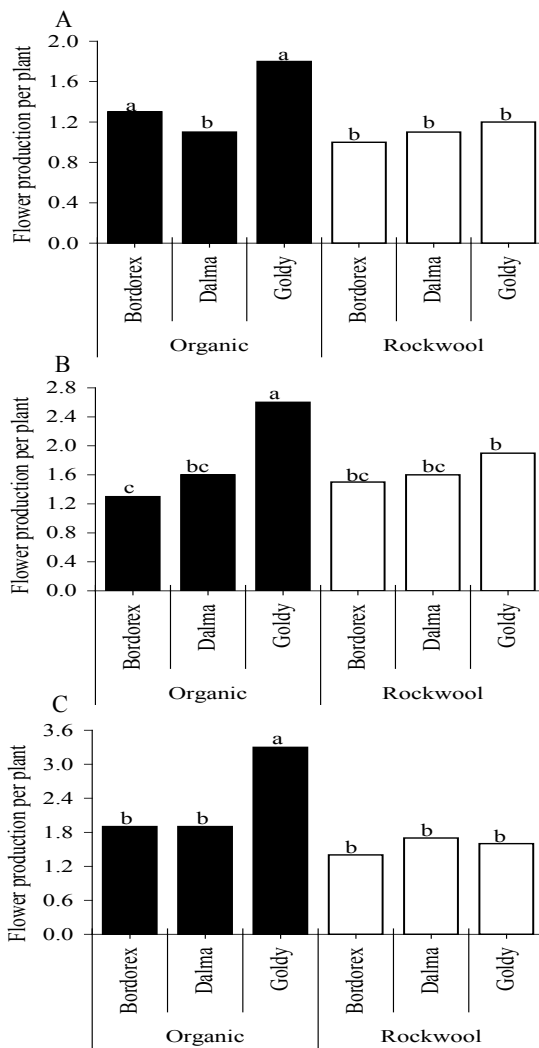


Fig.1 Effect of substrate and cultivar on flower production per plant in Jan. (A), Sept (B) and Nov. (C) in 2006.

Sl.1. Utjecaj supstrata i kultura na proizvodnju cvjeta po biljci u siječnju (A), rujnu (B), i studenom (C), 2006

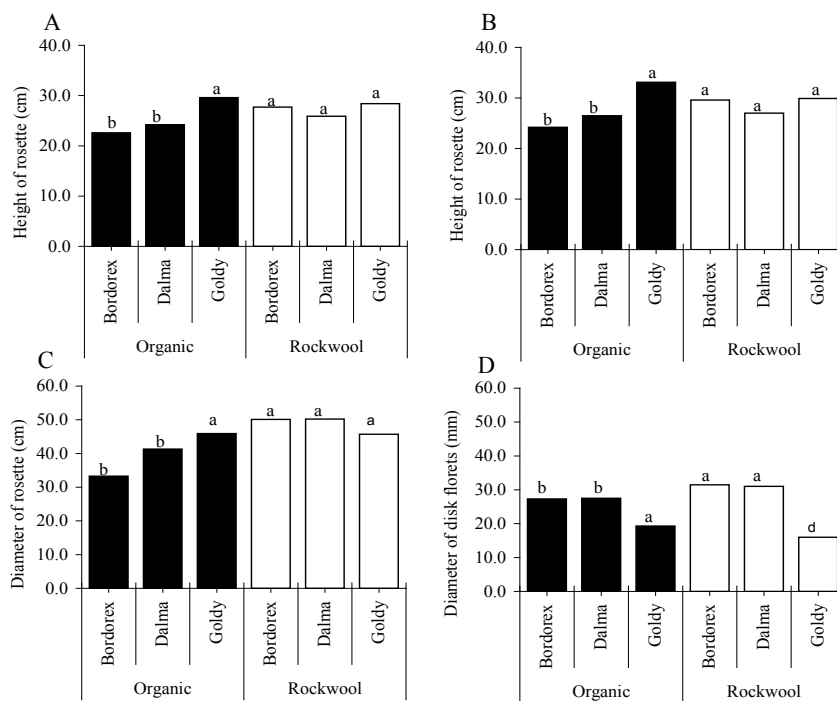


Fig.2. Effect of substrate and cultivars on rosette height on 28th Aug 2005 (A) and 5th Sep. 2005 (B), rosette diameter on at 20th Aug. 2005 (C) and disk florets diameter on 22. Feb 2006. (D).

Sl.2. Utjecaj supstrata i kultivara na visinu rozete 28.08.2005. (A) te 05.09.2005 (B), promjer rozete 20.08.2005. (C) i promjer centralnog diska cvjetne glavice 22.02.2006. (D).

substrate (Fig 2. A and B). The same effect was recorded for the diameter of rosette on 20th August ((Fig 2. C). Cultivar effect on the diameter was recorded only on 5th September.

On 22nd Feb. 2006 substrate showed no influence on either the diameter of inflorescence (capitulum), diameter of disk florets or the flower stalk diameter (Table 4). Diameter of flower stalk and diameter of inflorescence were wider in

'Dalma' compared to 'Bordorex' and 'Goldy' (Table 4). Cultivars on rockwool had wider diameter of disk florets than those on organic substrate, except "Goldy" (Fig.2 D).

As reported by Van Labeke and Dambre (2008), quality of flower stem parameters determined by stem length, stem weight, and flower diameter were affected by choice of the substrate (1998).

According to our results it seems that there is not much difference in flower productivity between organic substrate and rockwool slabs, although substrate affected EC and pH values in drainage solution during winter and spring. The EC of drainage solution from organic substrate was higher in both the periods compared to rockwool.

However, pH values were higher in rockwool (data not shown). This is consistent with the results of Abd El-Hady and Ebtisam El-Dardiry (2006) who determined higher EC values in organic (compost) than inorganic substrate (perlite).

CONCLUSION

This experiment showed that organic substrate compared to rockwool as a growing medium for gerbera cultivation in a non heated greenhouse in the Mediterranean do not considerably affect flower production or flower stem quality. Choice of cultivars, however, had a significant effect

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