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RESEARCH PAPER

Assessment of Different Growing Media on Cut Flower Performance of Two Gladiolus (*Gladiolus grandiflorus*) Cultivars

Ümmü Özgül KARAGÜZEL[1]

[1]Recep Tayyip Erdoğan Unvirsity, Faculty of Agriculture, Department of Horticulture, 53300, Rize, Türkiye

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Corresponding Author
E-mail: tezkara@yahoo.com

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Abstract

One of the most important problems encountered in the cultivation of cut flower gladiolus is soil-borne diseases and pests. This problem substantially reduces flower yield and quality. Soilless culture is very limited for gladiolus and it has not been studied extensively. The characteristics of the growing media used in soilless culture either directly or indirectly affect yield and quality. Therefore, it is quite essential to determine the appropriate growing media in cut flower cultivation. At the same time good flower production usually depends upon various factors including the type of growing media used. The present study was conducted to determine the effects of two different gladiolus varieties (*Gladiolus grandiflorus* L. cv. "Purple Flora" and "Ibadan") and six different growing media (peat+pumice: 1:1, v/v; peat+perlite: 1:1, v/v; rice hull+pumice: 1:2, v/v; coarse sand+peat: 2:1, v/v; soil; and cocopeat) on the some quality parameters of gladiolus in in Batı Akdeniz Agricultural Research Institute (BATEM), Antalya, Türkiye. Quality parameters (stem length, flower stem diameter, stem weight, flowering time, number of florest) were significantly ($p < 0.01$) affected by the different growing media and cultivars. Among the growing media, the earliest flowering time (77.8 days) and the longest stem length (128.0 cm) were determined in peat+perlite, whereas the largest number of florets (15.0 florets spike^{-1}) were recorded in peat+pumice. Regarding the varieties, Purple Flora (84.7 days) flowered earlier than Ibadan (102.7 days), while Ibadan displayed more superior characteristics in terms of the other parameters.

1. Introduction

Gladiolus (*Gladiolus grandiflorus* L.) is an important ornamental plant with a bulbous corm which is among the international cut flower industry. The Netherlands, world leader in the flower bulb trade, exports annually more than 200 different gladiolus varieties to more than 88 countries (Anonymous, 2021). The Netherlands exported gladiolus to the world having worth of € 21.3 million following by the other EU countries (€0.2 million) in 2021 (Anoymous, 2022). Gladiolus is called the "queen of bulbous flowers" as it is a popular bulbous cut flower (Meena et al., 2018). It has a magnificent flowering feature with long and color variety in the flower vase (Mahadik and Neha, 2015). It is an indispensable flower especially in flower baskets, wreaths and car ornaments (Yalçıntaş, 2011). But gladiolus plants and bulbs are susceptible to fungal, bacterial and viral diseases. *Fusarium oxysporium* f. sp gladioli, a soil-borne disease, is one of the most important diseases of gladiolus (Lakshman et al., 2012). In the production of gladiolus and other bulbous cut flowers, especially in field production, soil-borne diseases can hinder production to a great extent. One of the most effective methods used to

eliminate soil-borne diseases is soilless culture (El Sharkawi et al., 2014). In addition, soilless culture is used to produce quality flowers for one year in ornamental plants (Ahmad et al., 2012 b). There are different types of soilless culture. For years, hydroponic culture has been used around the world to grow ornamental plants. Nowadays it has been replaced by solid media culture (aggregate systems). The properties of different materials used as growing media both directly and indirectly affect plant yield and physiology. Organic substrates includes sawdust, coco peat, peat moss, woodchips, fleece, marc, bark etc. whereas, inorganic substrate are perlite, vermiculite, zeolite, gravel, rockwool, sand, glass wool, pumice, sepiolite, expanded clay, volcanic tuff and synthetically produced substrates are hydrogel, foam mates (polyurethane), oasis (plastic foam) etc. (Hussain et al., 2014; Asaduzzaman et al., 2015). Thus, choosing the right material as the growing medium is crucial. Most growers use a peat based substrate for growing their crops; however there is a tendency using alternative growing media such as rice hulls and cocopeat in recent years (Ahmad et al., 2012a; El Hanafy et al., 2018).

In the literature, there are a lot of studies about the gladiolus: corm size (Laskar and Jana, 1994; Kazaz and Özzambak, 2002; Memon et al., 2009), plant growth regulators (Karagüzel et al., 1995), planting time (Kalasareddi et al., 1997; Özzambak and Kazaz, 2002; Ahmad et al., 2011), adaptation (Gürcan and Türkoğlu, 2000), irrigation (Baştuğ et al., 2006), plant nutrition (Halder et al., 2007), low temperature applications (Zalewska and Antkowiak, 2009), planting time and phenology (Schwab et al., 2015), heritability (Patra and Mohanty, 2015), planting spacing and depth (Tomiozzo et al., 2018), and hybridization (Hossain et al., 2012; Azimi, 2019) on yield, quality and earliness in gladiolus have been investigated by many researchers. However, the studies conducted on gladiolus in soilless culture are limited (Bazaraa et al., 2014; Saeed, 2018). For the above-mentioned reasons, the study aimed to determine the effects of different growing media and their mixtures on yield and some quality parameters of two gladiolus cultivars under soilless culture.

2. Material and Methods

2.1. Experimental site

The research was conducted in a naturally ventilated plastic greenhouse at the Batı Akdeniz Agricultural Research Institute (BATEM), Antalya, Türkiye between December 24, 2011 and March 13, 2012. The greenhouse is located at coordinates of 36°56'35˝ N and 30°53'39˝ E and is 12 m above sea level. The average temperature and relative humidity inside the greenhouse for the study period are presented in Figure 1. The temperature and relative humidity ranged from 7.6 to 23.3°C and 28.1 to 85.4%, respectively.

2.2. Plant material and planting

Corms with a circumference of 6-8 cm belonging to two different gladiolus varieties (Purple Flora and Ibadan) were used as plant material. Ibadan is an orange-colored variety with a flowering time of 95 to 105 days, whereas Purple Flora is a blue and purple- colored variety with a flowering time of 75 to 85 days (Anonoymous, 2009; Yalçıntaş, 2011). The corms were stored at 5ºC for 2.5 months and left in a solution containing 50% Benomyl as a protectant against fungal diseases for 30 minutes prior to planting. The corms were planted into the boxes (37.0 cm in length, 37.0 cm in width, and 22.5 cm in depth) in a depth of 5 cm with 15.0×15.0 cm spacing and in 2 rows on October 24, 2011.

2.3. Treatments

Five different growing media, i.e. peat+pumice (1:1, v/v), burnt rice hull+pumice (1:2, v/v), coarse

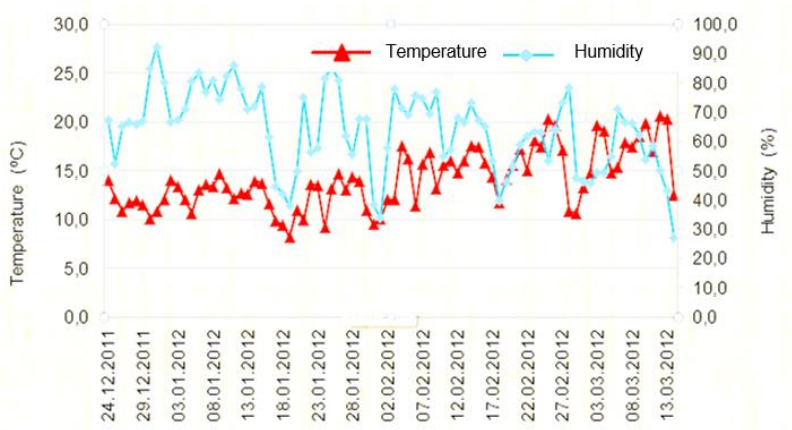

Figure 1. Average temperature and relative humidity measured inside greenhouse.

sand (>1 mm)+ peat (2:1, v/v), cocopeat, and peat+perlite (1:2, v/v), and soil alone as the control were used in the study. After preparation of the mixture, the pre-planting media was wetted until saturated. No fertilizer has been added to the media. The physical and chemical analyses of soil and different growing media were made and then they were placed into the boxes. The results of the analyses are presented in Tables 1 and 2.

2.4. Nutrient solution and irrigation

Irrigation water and nutrients were applied to the plants with drip irrigation method. The plants were provided with 100 cc of water per plant in each irrigation application. When the plants reached the three-leaf period, fertigation was started, and a nutrient solution was applied to the plants twice a week. The composition of nutrient solution (ppm) was as follows: N:250, P:35, K:350, Ca:180, Mg:50, Fe:3, Mn:1, Zn:0.06, Cu:0.1, B:0.1 and Mo:0.01. The pH was measured in every fertigation and was adjusted to values between 5.7-6.0, and the EC kept between 2.0-2.5 mS cm^{-1}.

2.5. Harvest and measurements

The harvest was carried out to leave two mutual leaves on the plant as of the soil level when the 2 to 3 florets at the very bottom of the spike colored. Five sample plants were counted randomly taken from each treatment and average was calculated. Stem length (cm $plant^{-1}$), stem diameter (mm $plant^{-1}$), stem weight (g $plant^{-1}$), flowering time (day) and the number of florets (number $spike^{-1}$) were determined according to Yalçıntaş (2011) in the study. Stem length (cm) is the distance from ground level to the last candle; the number of florets (number $spike^{-1}$) is the total number of flower candles on a spike; flowering time (days to 50% flowering) is the number of days for 50 per cent plants to flowering; stem diameter is calculated by digital caliper from 5 cm below of lower candle; stem weight is calculated using digital weighing with 0.01 g accuracy.

2.6. Experimental design and statistical analysis

The experiment was set up according to the split-plot experimental design in randomized blocks with 3 replications, and a total of 720 corms were used, with each replication containing 20 corms for each growing medium. The obtained data were subjected to an analysis of variance in Tarist statistical program, and the mean values were compared using Duncan's multiple range tests at the 0.05 level.

3. Results and Discussion

3.1. Stem length

The effects of growing media and cultivars on stem length were found statistically significant ($p < 0.01$), whereas the effect of the variety × growing media interaction on stem length was statistically insignificant (Table 3). Among the growing media, the longest stem length was recorded in peat+perlite (128.0 cm), followed by peat+pumice (126.0 cm); however, both media were in the same statistical group in terms of stem length. The stem

Table 1. Some physical and chemical characteristics of the growing media.

Characteristics	Peat	Cocopeat	Rice Hull	Pumice	Sand
pH	6.6	7.2	6.5	8.6	8.7
EC (µmhos cm^{-1})	159.0	193.0	890.0	44.0	68.0
Moist (%)	68.0	81.7	9.3	-	-
Dry matter (%)	32.0	18.3	90.7	-	-
Organic matter (%)	91.9	89.9	81.0	-	-
Ash (%)	8.1	10.1	19.0	-	-
Total N (%)	1.2	0.2	0.54	-	-
C (%)	53.3	52.1	47.0	-	-
C/N	43.3	358.5	87.5	-	-

Table 2. Physical and chemical characteristics of the studied soil.

Characteristics	Value
pH*	8.3
Lime (%-w w^{-1})	25.7
EC (µmhos cm^{-1})	183.0
Sand (%)	13.0
Clay (%)	31.0
Silt (%)	56.0
Organic matter (%)	1.6
P (ppm)	17.0
K (ppm)	259.0
Ca (ppm)	5502.0
Mg (ppm)	518.0

* measured on watery extract 1:2.5 (v/v).

Table 3. The effects of different growing media on stem length of gladiolus cultivars (cm).

Growing media (M)	Cultivars (C)		Mean for growing media
	Purple Flora	Ibadan	
Soil	102.0	116.3	109.1 b
Cocopeat	102.6	121.6	112.1 b
Pumice+Rice hull	103.3	121.3	112.3 b
Peat+Perlite	120.6	135.3	128.0 a
Sand+Peat	104.6	120.0	112.3 b
Peat+Pumice	116.0	136.0	126.0 a
Mean for cultivars	108.2 b	125.1 a	

Cultivars (C):** Growing media (M): ** C×M: ns
** Significant at the p < 0.01 level, ns: not significant.
Means followed by the same letter do not different significantly according to Duncan's test (p≤0.05).

Table 4. The effects of different growing media on stem diameter of gladiolus cultivars (mm).

Growing media (M)	Cultivars (C)		Mean for growing media
	Purple Flora	Ibadan	
Soil	9.3 b	8.7 c	9.0 c
Cocopeat	10.0 ab	10.8 a	10.4 ab
Pumice+Rice hull	10.0 ab	10.8 a	10.4 ab
Peat+Perlite	10.6 a	11.2 a	10.9 a
Sand+Peat	10.0 ab	9.7 b	9.8 b
Peat+Pumice	10.3 ab	10.4 a	10.3 ab
Mean for cultivars	10.1 b	10.3 a	

Cultivars (C):** Growing media (M): ** C×M: ns
** Significant at the p < 0.01 level, ns: not significant.
Means followed by the same letter do not different significantly according to Duncans test (p≤0.05).

length ranged from 109.1 to 112.3 cm among the other growing media and the differences among them were statistically insignificant. Regarding the varieties, Ibadan (125.1 cm) had a longer stem length than Purple Flora (108.2 cm). Tehranifar et al. (2011) investigated the effect of three soilless media on growth and development of two types of Lilium, and they were used 100% coco peat, 50% gravel + 50% sand and 40% peat + 60% perlite as growing media. They noted the lowest flower stem length with 31.7 cm was obtained from 50% gravel + 50% sand, while the highest were obtained from 40% peat + 60% perlite substrates. El Hanafy et al. (2018) tested the effect of using substrate soilless culture technique on the plant growth, flowering and corms production of Gladiolus *cv*. "Chinon". Three types of soilless culture substrates were put under investigation as follow; mixture of sand and rice husk (1:1 v/v), mixture of peat moss: rice husk (1:1 v/v) and perlite 100%. They reported the longest stem length recorded in peat moss and rice husk (1:1 v/v) (87.5 cm) followed by the sand and rice husk (1:1 v/v) (81.3 cm) in first year in gladiolus. In the second year, the highest stem length was obtained from peat: rice husk (91.3 cm) followed by perlite (82.0 cm). Bhandari et al. (2017) investigated four different growing media (soil, coconut peat, coconut peat+sand, coconut peat+soil) in *Lilium longiflorum* and they found that the maximum stem length was from coconut peat media with 99.8 cm.

3.2. Stem diameter

As a result of the evaluation of the data about stem diameter, the varieties and the growing media were found to have statistically significant (p < 0.01) effects individually (Table 4). Flowers with the thickest stem (10.9 mm) were obtained from the plants grown in peat+perlite. On the other hand, the flowers with the smallest stem diameter (9.0 mm) were in the plants grown in soil. Results of stem diameter confirmed the data given by Tehranifar et al. (2011) who observed the highest root diameter in the lily when grown in peat + perlite substrates. El Hanafy et al. (2018) reported that the highest value for the spike base diameter was recorded in peat: rice husk substrate with 11.2 mm and 12.1 mm while the smallest value was obtained in sand: rice husk substrate 6.0 mm and 7.0 mm in 2016 and 2017 respectively. In our study, the thinnest stem diameter was obtained from the mixture of sand + pumice after soil.

3.3. Stem weight

The effects of the growing media and varieties on stem weight were statistically significant (p < 0.01), while the effect of the growing media × variety interaction was statistically insignificant (Table 5). Among the growing media, the greatest stem weight was obtained from the mixture of peat and pumice (103.6 g plant^{-1}), whereas the lowest stem weight was recorded in pumice+rice hull (76.5 g plant^{-1}). When the stem weights of the varieties were examined, Ibadan was found to have a stem weight of 113.9 g plant^{-1} and Purple Flora was detected to have a stem weight of 65.8 g plant^{-1}. Stem weight results are in alliance with the observations of Yalçıntaş (2011) who claimed in gladiolus when grown in traditional media. Yalçıntaş (2011), determined the stem weight as 114.2 g plant^{-1} in Ibadan and as 56.0 g plant^{-1} in Purple flora.

Table 5. The effects of different growing media on stem weight of gladiolus cultivars (g plant^{-1}).

Growing media (M)	Cultivars (C)		Mean for growing media
	Purple Flora	Ibadan	
Soil	63.8 a	97.3 b	80.5 bc
Cocopeat	66.2 a	120.4 a	93.3 ab
Pumice+Rice hull	61.3 a	91.6 b	76.5 c
Peat+Perlite	61.8 a	122.8 a	92.3 ab
Sand+Peat	64.9 a	121.4 ab	88.1 abc
Peat+Pumice	76.7 a	130.3 a	103.6 a
Mean for cultivars	65.8	113.9	

Cultivars (C):** Growing media (M): ** C×M: ns
** Significant at the p < 0.01 level, ns: not significant.
Means followed by the same letter do not different significantly according to Duncan's test (p≤0.05).

Table 6. The effects of different growing media on flowering time of gladiolus cultivars (day).

Growing media (M)	Cultivars (C)		Mean for growing media
	Purple Flora	Ibadan	
Soil	92.6 a	113.3 a	103.0 a
Cocopeat	86.0 bc	102.0 b	94.0 b
Pumice+Rice hull	89.6 ab	117.3 a	103.5 a
Peat+Perlite	77.0 d	78.6 c	77.8 c
Sand+Peat	80.0 cd	101.3 b	90.6 b
Peat+Pumice	83.0 cd	104.0 b	93.5 b
Mean for cultivars	84.7 b	102.7 a	

Cultivars (C):** Growing media (M): ** C×M: **
** Significant at the p < 0.01 level.
Means followed by the same letter do not different significantly according to Duncans test (p≤0.05).

Table 7. The effects of different growing media on number of florets in gladiolus cultivars (number spike^{-1}).

Growing media (M)	Cultivars (C)		Mean for growing media
	Purple Flora	Ibadan	
Soil	10.3	12.3	11.3 c
Cocopeat	12.6	13.6	13.1 b
Pumice+Rice hull	11.6	15.0	13.3 b
Peat+Perlite	12.6	14.0	13.3 b
Sand+Peat	12.3	14.0	13.1 b
Peat+Pumice	13.6	16.3	15.0 a
Mean for cultivars	12.22 b	14.22 a	

Cultivars (C):** Growing Media (M): ** C×M: ns
** Significant at the p < 0.01 level, ns: not significant.
Means followed by the same letter do not different significantly according to Duncan's test (p≤0.05).

3.4. Flowering time

Cultivars, growing media and the cultivars × growing media interaction significantly (p < 0.01) affected flowering time (Table 6). In the cultivars × growing media interaction, the earliest flowering time was in peat+perlite in both varieties (Purple Flora: 77.0 days; Ibadan: 78.6 days), whereas the latest flowering time was in pumice+rice hull in Ibadan (117.3 days). Among the growing media, the earliest flowering time was determined in peat+perlite (77.8 days), later flowering time was found sand + peat (90.6 days). The latest flowering time was obtained in soil (103.0 days).

Regarding the varieties, Purple Flora (84.7 days) flowered earlier than Ibadan (102.7 days). Tehranifar et al. (2011), reported that the time of bud emergence (29.6 day) and flower harvest (53.5 day) were days earliest when used peat+perlite as media in lilium. El Hanafy et al. (2018) determined the earliest flowering time with sand: rice husk substrate 87.3 and 86.6 days after planting while the latest flowering time was obtained with perlite substrate 106.0 and 101.0 days after planting in 2016 and 2017, respectively.

3.5. Number of florets

The effects of the cultivars and the growing media on the number of florets were statistically significant (p < 0.01), whereas the effect of the cultivars × growing media interaction on the number of florets was statistically insignificant (Table 7). The growing media were in 3 different groups in terms of the number of florets. The mixture of peat and pumice with the largest number of florets (15.0 florets plant^{-1}) was in the first group; the 2nd group was comprised of pumice+rice hull (13.3 florets plant^{-1}), peat+perlite (13.3 florets plant^{-1}); and soil with the smallest number of florets (11.3 florets plant^{-1}) was in the last group and it followed sand+ peat and cocopeat media (13.1 florets plant^{-1}).

Potassium has an important role in the production of proteins and hydrocarbons. Pumice is

alkaline and rich in potassium. In potassium deficiency, growing stops and this stress may limit flowering because the plant cells can not divide to allow the growth and because of potassium deficiency reduce the quality of flowers (Anonymous, 2019a; Khalaj et al., 2019). Therefore, the presence of pumice may have caused a high number of flowers and a short duration of flowering due to the potassium content.

When evaluated all of results among the growing media, the best results were obtained from peat+perlite in terms of plant height, stem diameter and flowering time, in peat+pumice in terms of the number of florets and plant weight. In terms of plant height, one of the most important criteria for quality in gladiolus, the plants in peat+perlite and peat+pumice were approximately 18.8 to 16.8 cm longer than the plants grown in soil. In terms of the number of florets, the plants grown in the growing media concerned had 2.0 to 3.6 more florets than the plants grown in soil. Lopez et al. (2008) reported that different growing media significantly affected growth and flowering in gladiolus (*Gladiolus tristis* subsp. Concolor) and that the stem length, the spike length and the number of florets in the plants grown singly in peat were greater than those of the plants grown singly in perlite. According to Issa et al. (1999), using peat moss based substrates gave more yield with high quality of flower comparing with single substrate.

To determine the rate of plants growth it would be important their physical-chemical properties, water holding capacity and aeration capacity of growing media. Soils are generally inadequate for the production of plants because soils do not provide the aeration, drainage and water holding capacity required. Soil compound can limit plant growth during greenhouse production. Even when the top soil is worked, plants may suffer when roots reach the compacted subsoil. (Anonymous, 2019b). To reduce this disadvantage in pure substrates, various materials with large particle are added (Sambo et al., 2008) the most commonly used being perlite. The addition of perlite to peat improves aeration (Londra et al., 2012).

When the varieties were evaluated in terms of the parameters under examination in the study, it was concluded that Purple Flora flowered 18 days earlier than Ibadan, while better results in terms of the other parameters were obtained in Ibadan in comparison with Purple Flora.

Although the results obtained between the varieties in the study are generally in agreement with the findings by Yalçıntaş (2011), their lower and upper limits vary. This might result from different ecological and growing conditions. The results obtained in the study in terms of plant height, stem diameter and the number of florets resemble the findings by a large number of researchers (Gürcan and Türkoğlu, 2000; Özzambak and Kazaz, 2002; Akpınar and Bulut, 2006; Anonymous, 2009; Saraç et al., 2010).

4. Conclusion

In the study conducted to determine the quality characteristics of two different gladiolus varieties grown in different covered growing media in Antalya, peat+perlite and peat+pumice showed quite good results in terms of the parameters under examination as compared with the other media. Moreover, regarding the varieties, Ibadan showed more superior characteristics than Purple Flora. The plants grown in pumice+rice hull and soil flowered rather later in comparison with the plants that were grown in the other media, and the lowest values in terms of the other parameters were obtained from soil, pumice+rice hull, and sand+peat. In the light of the data obtained in the study, peat+perlite and peat+pumice might be successfully used in the cultivation of gladiolus.

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