

# Effects of Zeolite-Peat Mixtures on Yield and Some Quality Parameters of Carnation Grown in Soilless Culture

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## Abstract

Soil-borne pathogens have become more and more problematic due to continuous production of carnation in recent years in Isparta Province of Turkey. Methyl bromide (MB) was the most effective soil fumigant to control soil-borne diseases, pests and weeds. However, the use of MB had been phased out at the end of 2007 in Turkey. Other methods such as steam, solarization and some chemicals currently used to control these problems are hazardous, ineffective and costly. Therefore, soilless culture may be an effective tool to control soil-borne pathogen in Turkey. Initial investment cost of soilless culture is also expensive; however, locally available substrates may reduce production cost in the long term. Substrates (clinoptilolite and peat) used in this study are locally and large quantitatively available in Turkey. Effects of clinoptilolite and peat mixtures on carnation yields and some quality parameters were investigated in this study. An open soilless culture system was used to grow carnations under plastic-house. Two standard carnation cultivars ('Silkroad' and 'Falcon') grown on two different sizes of clinoptilolite and peat mixtures (Ø 0-0.5 mm and Ø 0.8-2.8 mm) at ratios of clinoptilolite:peat of 1:1; 2:1 and 3:1, v/v:1c:1p, 2c:1p and 3c:1p, v/v were produced. Results of this study indicated that effects of growing media and cultivars on yields and quality parameters were statistically significant. The highest yields per plant in both cultivars ('Falcon'; 4.87 stems, 'Silkroad'; 4.68 stems) were obtained from 0-0.5 mm sizes of clinoptilolite + peat mixture at the ratio of 3c:1p, v/v. The lowest yield was in 0-0.5 mm sizes of pure clinoptilolite medium for both cultivars. Cultivar 'Silkroad' provided better yield and quality than that of 'Falcon'. In conclusion; mixtures of clinoptilolite and peat can be successfully used to grow carnations. However, 0-0.5 mm size of clinoptilolite alone may not be suggested for carnation production in Isparta Province.

## INTRODUCTION

Carnation is one of the most important cut flower species in the world. Carnation is also the most commonly grown cut flower which comprises 43% of the total cut flower production areas in Turkey. This is followed by rose, gerbera, gladiolus, chrysanthemum and others. More than 90% of carnation production is exported (Anonymous, 2007).

In protected horticulture, the most important problems encountered are soil-borne diseases, pests and weeds. To control these problems, previously MB was regularly used. However, after MB was phased out at the beginning of 2008 in Turkey, the use of soilless culture has become more and more popular. There are some other alternatives to MB, but they have some disadvantages. Steam is very effective to disinfest soil; however, it is very costly. Even though solarization is cheap and effective, it requires at least 4 weeks application period which is not available in Isparta Province due to summer production.

In protected vegetable and cut flower cultivation, substrate culture is the most

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commonly used growing technique among soilless culture types. Substrate culture is preferred by growers because of some advantages. These include; requiring cheap materials initially, creating a buffer zone around the roots and easy use by growers (Samartzidis et al., 2005; Yetişir et al., 2006). Properties of different materials used in growing media can directly and indirectly affect plant physiology and yield (Verdonck et al., 1981). Therefore, choosing right media for soilless culture is of vital importance to have optimum growing conditions. The selection of a particular substrate depends on its cost, availability, and local experience on its use (Klougart, 1983; Verdonck et al., 1983; Samartzidis et al., 2005). Growing media should have certain characteristics which may include; having high water and air capacity, high drainage ability, low level of degradation speed, containing very limited pathogen and pests, not having toxic materials and keeping up its characteristics for long time (Klougart, 1983; Grass, 1985).

In recent years, growing media containing zeolite has getting more popularity as an alternative to traditional soilless production (Samartzidis et al., 2005) both in the world and in Turkey which has very rich zeolite reserves ( $45.8 \times 10^9$  tons) (Koksaldi, 1999). It was reported zeolite increased yields in vegetables such as eggplant, tomato and pepper (Mumpton, 1999) and gerbera (Issa et al., 2001). Among natural zeolite types, the most abundant and commonly used in agriculture is clinoptilolite (Ming and Dixon, 1987). This substrate is a good growing media due to having high cation exchange capacity, being a good soil amendment and other characteristics (Harland et al., 1999; Mumpton, 1999).

Peat, an organic substrate abundantly and cheaply available in different regions of Turkey (Sevgican, 2003), has also been commonly used in soilless culture. Peat improves physical and chemical characteristics of growing media. However, combining different organic and inorganic substrates at different ratios allows the plants the best nutrient uptake and sufficient growth and development due to optimized water and oxygen holding capacity (Abo-Rezg et al., 2009). Therefore, in this study we aimed to determine the effects of different substrates on yield and some quality parameters of two cultivars of carnation under an open soilless production system.

## MATERIALS AND METHODS

This study was conducted in PE covered greenhouse belonging Çelik Tarım Inc. in Isparta (Turkey) having  $37^{\circ}47'N$  latitude,  $30^{\circ}30'E$  longitude and 1019 m altitude. Two standard carnation cultivars (*Dianthus caryophyllus* L. 'Silkroad' and 'Falcon') were used as plant materials. Plants were cultivated on 8 different substrates containing particle sizes of 0-0.5 mm and 0.8-2.8 mm for clinoptilolite (c) and peat (p), respectively. The mixtures of these substrates (S) were; [S1: c ( $\emptyset$  0-0.5 mm), S2: 1+1 c ( $\emptyset$  0-0.5 mm)+p, S3: 2+1 c ( $\emptyset$  0-0.5 mm)+p, S4: 3+1 c ( $\emptyset$  0-0.5 mm)+p, S5: c ( $\emptyset$  0.8-2.8 mm), S6: 1+1 c ( $\emptyset$  0.8-2.8 mm)+p, S7: 2+1 c ( $\emptyset$  0.8-2.8 mm)+p, S8: 3+1 c ( $\emptyset$  0.8-2.8 mm)+p]. In this study, clinoptilolite was provided by Enli Madencilik Inc., from Gördes, Manisa and peat from Afyon Province of Turkey. Physicochemical characteristics of the clinoptilolite and peat used were: bulk density 650-850 kg m<sup>-3</sup>, porosity 45-50%, SiO<sub>2</sub> 65-72%, Al<sub>2</sub>O<sub>3</sub> 10-12%, Fe<sub>2</sub>O<sub>3</sub> 0.8-1.9%, CaO 2.5-3.7%, MgO 0.9-1.2%, Na<sub>2</sub>O 0.3-0.65%, K<sub>2</sub>O 2.3-3.5%, TiO<sub>2</sub> 0-0.1%, cation exchange capacity (CEC) 1.5-1.9 meq g<sup>-1</sup>, pH 7.0-8.0. Peat: pH 7.9, EC  $\mu\Omega/cm$  260, organic matter 36.6%, % nem 62.6, ash 63,4, dry matter 37.4%, N 1.1%, K 0.56%, Mg 1.31%, S (ppm) 1967, Fe (ppm) 4806, Mn (ppm) 450, Zn (ppm) 72.

Rooted cuttings of carnation were planted into beds (2 m length, 80 cm width, 20 cm depth and 3 mm thickness) with 4 rows (32.5 plant/m<sup>2</sup>) on 11 May 2007. The beds manufactured from PP corrugated sheets (white) were placed 20 cm above the ground. Water and nutrient requirements of the plants were supplied through a complete nutrient solution, applied with a drip irrigation system. Plants were fertilized with the following complete nutrient solution (mg/L): NO<sub>3</sub>-N (161), NH<sub>4</sub>-N (3.5), P (45.4), K (246.5), Ca (122), Mg (20), Fe (1.29), Mn (0.43), Cu (0.03), Zn (0.26), B (0.31), Mo (0.04). The electrical conductivity (EC) was kept 1.7 mS cm<sup>-1</sup>, while the pH of solution was maintained between 5.5-5.7 by adding HNO<sub>3</sub> (65%). The timing varied from 5 to 10

fertilizations per day of 1-3 min for the drip-irrigation. Irrigation frequency and duration was adjusted according to the effluent volume of 20 to 30% (Shröder and Lieth, 2002) and the effluent was allowed to run to waste. Single pinch method was applied to the plants and the shoot apexes were removed by hand above the fifth leaf pair from the bottom (Whealy, 1992). Flowers were harvested above the second node from the base when flowers were fully open (Kazaz et al., 2006). Flower yield and some quality parameters (stem length, stem diameter, stem weight, flower diameter, flower yield per plant) were measured. The experiment was terminated on 20 November 2007 due to cold damages on carnation plants.

The experiment was set up according to randomized plots in factorial design with three replications. Each replication contained 52 plants from each cultivar. The data were analyzed with MINITAB ver. 15 (2006) and MSTAT C package programs. The LSD test ( $P=0.05$ ) was employed to determine the differences among the group averages.

## RESULTS AND DISCUSSION

### Stem Length and Stem Diameter

Effects of growing media and cultivars were statistically significant ( $p<0.01$ ) on stem length (Table 1). The longest stem length with 83.05 cm was obtained from 2+1 c ( $\text{Ø}$  0.8-2.8 mm)+p substrate and the shortest stem length with 75.40 cm from clinoptilolite ( $\text{Ø}$  0-0.5 mm) alone. The cultivar 'Silkroad' (84.17 cm) had longer stem length than that of 'Falcon' (77.52 cm). Substrate x cultivar interaction on stem length was also significant. Samartzidis et al. (2005) reported that zeolite and perlite mixtures at different ratios increased the stem length in rose; in contrast, Özçelik et al. (1999) determined that different mixtures of growing media (peat, perlite, pumice and rockwool) did not have significant effect on stem length of gerbera. In this study, having shortest stem length on clinoptilolite ( $\text{Ø}$  0-0.5 mm) the medium alone may result from oxygen deficiency around root environment due to the small particle sizes of clinoptilolite.

Effects of cultivars and substrates on stem diameter were statistically significant ( $p<0.01$ ). The thicker stem diameter was in clinoptilolite ( $\text{Ø}$  0-0.5 mm) medium alone. There was no difference among other media. At the same time, stem diameter did not differ between cultivars.

### Stem Weight and Flower Diameter

Stem weight was influenced by neither cultivars nor substrates (Table 2). However, flowers diameter was affected by cultivars ( $p<0.01$ ). The flower diameter of 'Silkroad' (81.78 mm) was larger than that of 'Falcon' (75.33 mm). On the other hand, effects of substrates on flower diameter were not statistically significant. The interaction between cultivar and substrate on flower diameter was important ( $p<0.01$ ). Özçelik et al. (1999) reported that substrates did influence the stem weight. In most cases, growing carnation on different mixtures of peat and sawdust provided bigger flowers than that of plants grown in each substrate alone (Starck et al., 1991).

### Dry Matter and Yield per Plant

The content of dry matter in carnation plants was not influenced by different substrates (Table 3). However, the dry matter (18.86%) was higher in 'Silkroad' than that of 'Falcon' (18.32%).

Even though the yield between cultivars did not differ, effects of substrates on yield was statistically significant ( $p<0.01$ ). The highest yield per plant (4.78 stems) was in S4: 3+1 c ( $\text{Ø}$  0-0.5 mm)+p medium and the lowest (3.88 stems) was in clinoptilolite ( $\text{Ø}$  0-0.5 mm) medium alone (Table 3). It has been reported that mixtures of zeolite with other substrates increased plant yield in many species such as in gerbera (Issa et al., 2001), cucumber (Gül et al., 2007), tomato (Al-Ajmi et al., 2009). Zeolite in substrates mixtures may promote anion and cation exchange capacity (Issa et al., 2001).

## CONCLUSIONS

In conclusion, although clinoptilolite ( $\emptyset$  0-0.5 mm) substrate alone did show good performance on yield and some other characteristics of carnation, incorporation of this substrate into peat at different ratio specifically at 3+1 c ( $\emptyset$  0-0.5 mm)+p proportion significantly increased plant yield, stem length and diameter. Therefore, combination of clinoptilolite at different sizes with other substrates may be suggested to Turkish carnation growers. Moreover, availability and abundance of zeolite reserves in Turkey may promote the use of this material in soilless culture.

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## **Tables**

Table 1. Effects of different substrates and cultivars on stem length and stem diameter.

Substrates	Stem length (cm)			Stem diameter (mm)		
	Silkroad	Falcon	Mean*	Silkroad	Falcon	Mean*
T1	78.37 cde	72.43 f	75.40 D	6.16	5.84	6.00 A
T2	83.33 ab	76.27 de	79.80 C	5.43	5.56	5.50 B
T3	86.69 a	78.24 cde	82.47 AB	5.43	5.61	5.52 B
T4	81.80 bc	78.59 cde	80.20 BC	5.50	5.50	5.51 B
T5	86.37 a	75.29 ef	80.33 ABC	5.44	5.52	5.48 B
T6	85.80 a	79.49 cd	82.64 AB	5.33	5.58	5.46 B
T7	84.21 ab	81.88 bc	83.05 A	5.57	5.52	5.55 B
T8	86.82 a	77.94 de	82.38 ABC	5.58	5.59	5.59 B
Mean*	84.17 A	77.52 B		5.56	5.59	

Capital letters indicates among differences of means of cultivars and substrates, lower-case letters show cultivar x substrate interaction.

\*Numbers in the same column followed by the same letter are not significantly different ( $P < 0.01$ ), according to LSD test.

Table 2. Effects of different substrates and cultivars on stem weight and flower diameter.

Substrates	Stem weight (g)			Flower diameter (mm)		
	Silkroad	Falcon	Mean*	Silkroad	Falcon	Mean*
T1	47.41	46.11	46.76	83.82 a	70.45 g	77.14
T2	43.11	44.77	43.94	79.25 a-d	80.57 a-c	79.91
T3	45.21	46.96	46.09	82.65 ab	78.58 b-e	80.62
T4	42.56	45.64	44.10	81.95 ab	75.31 d-g	78.63
T5	44.67	45.16	44.92	82.00 ab	74.70 d-g	78.35
T6	43.37	47.41	45.39	80.61 a-c	72.44 fg	76.53
T7	46.63	47.25	46.94	81.49 a-c	73.90 e-g	77.70
T8	48.21	48.17	48.19	82.47 ab	76.72 c-f	79.59
Mean*	45.15	46.43		81.78 A	75.33 B	

Capital letters indicates among differences of means of cultivars and substrates, lower-case letters show cultivar x substrate interaction.

\*Numbers in the same column followed by the same letter are not significantly different ( $P < 0.01$ ), according to LSD test.

Table 3. Effects of different substrates and cultivars on dry matter and yield per plant.

Substrates	Dry matter (%)			Yield per plant (stem)		
	Silkroad	Falcon	Mean*	Silkroad	Falcon	Mean*
T1	18.14	18.03	18.08	3.75	4.02	3.88 C
T2	19.30	18.60	18.95	4.67	4.48	4.57 AB
T3	18.67	18.06	18.37	4.47	4.54	4.51 AB
T4	19.09	18.83	18.96	4.68	4.87	4.78 A
T5	19.79	18.09	18.94	4.54	4.54	4.54 AB
T6	18.50	19.22	18.86	4.64	4.53	4.59 AB
T7	18.90	17.58	18.24	4.29	4.63	4.46 B
T8	18.69	18.11	18.40	4.60	4.67	4.64 AB
Mean*	18.86 A	18.32 B		4.46	4.54	

Capital letters indicates among differences of means of cultivars and substrates, lower-case letters show cultivar x substrate interaction.

\*Numbers in the same column followed by the same letter are not significantly different ( $P < 0.01$ ), according to LSD test.