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Original Article

Effects of Different Planting Systems and Densities on Yield and Quality in Standard Carnations*

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Abstract

This study was conducted to determine the effects of different planting systems and densities on yield and quality of standard carnations. There were eight different treatments consisting of different planting densities and planting systems [(S_1: 40 plants m^{-2} with 4 rows), (S_2: 45 plants m^{-2} with 5 rows), (S_3: 50 plants m^{-2} with 5 rows), (S_4: 48 plants m^{-2} with 6 rows), (S_5: 54 plants m^{-2} with 6 rows), (S_6: 54 plants m^{-2} with 6 rows), (S_7: 44 plants m^{-2} with a triangular shape) and (S_8: 59 plants m^{-2} with a triangular shape)], and 8 standard carnation cultivars belonging to *Dianthus caryophyllus* L. species were used as the plant materials. The results showed that the highest yields per plant among the planting densities and systems were found in S_1 and S_2 (4.33 and 4.20 stems plant^{-1}, respectively), whereas the lowest yields were obtained from S_8 and S_6 (3.34 and 3.57 stems plant^{-1} respectively). It was also found that Vittorio had the longest stem length (88.67 cm), the highest stem weight (49.09 g) and the greatest flower diameter (80.14 mm), while Judith and Lia had the highest yields per plant and yields per m^{-2} (4.34 stems plant^{-1} and 211.89 stems m^{-2} for Judith and 4.29 stems plant^{-1} and 209.54 stems m^{-2} for Lia, respectively). It was concluded that stem length and total yield per m^{-2} increased with increasing planting densities, whereas stem diameter, stem weight, flower diameter, dry matter content, vase life and yield per plant decreased.

Key words: *Flower yield, flower diameter, plant spacing, stem length*

This study is summarized from a thesis titled "Farklı Dikim Sistemleri ve Sıklıklarının Yaz Karanfili Üretiminde Verim ve Kalite Üzerine Etkileri",

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INTRODUCTION

Carnation is of great economic importance in the cut flower sector in Turkey due to both its production area and export potentiality. In Turkey, carnation accounts for 43% of the total cut flower production area of 1199 ha and more than 90% of cut flower export (Anonim 2009).

Yalova in the Marmara Region, Izmir in the Aegean Region and Antalya and its vicinity in the Mediterranean Region in Turkey are important cut flower and especially carnation production centers. In the recent years, Isparta has become an essential center particularly with its carnation production in summer months. In those regions of Turkey where carnation cultivation is considerably performed, the planting system with 4 rows is generally used and some 18000 to 22000 plants per decare are planted on average. In these regions, carnation is planted in June and July and flowering generally takes place between October and May. In Isparta, however, carnation is planted in April and flowering takes place between July and November. Therefore, there are significant differences in planting time, flowering period and vegetation period between Isparta and the other production regions. Thus, productivity is of importance to perform profitable cultivation in Isparta.

It has been reported that cultural treatments, such as planting density, planting date, pinching method, cultivar, irrigation, and fertilization, and ecological factors, such as temperature, light, and CO_2, play a significant role in flowering time, yield and quality in carnation (Besemer 1980; Whealy 1992; Sawwan 1998). Planting density varies depending on planting date, cultivar, light, and pinching date and method. In this study, it was aimed to determine the effects of different planting systems and densities on yield and quality parameters in standard carnations.

MATERIALS AND METHODS

The study was conducted in a plastic-covered greenhouse located at Yakaören (latitude: 37° 47' N, longitude: 30°30' E, altitude: 1019 m) in Isparta, Turkey between 2003 and 2004. Totally 8 treatments [(S_1: 40 plant m^{-2} with 4 rows), (S_2: 45 plant m^{-2} with 5 rows), (S_3: 50 plant m^{-2} with 5 rows), (S_4: 48 plant m^{-2} with 6 rows), (S_5: 54 plant $m^{-2}$with 6 rows), (S_6: 54 plant m^{-2} with 6 rows), (S_7: 44 plant m^{-2} with a triangular shape) and (S_8: 59 plant $m^{-2}$with a triangular shape)] consisting of different planting densities and systems were investigated in the study. Eight standard carnation cultivars (Lia, Malaga, Vittorio, Polka, Judith, Negev, Omaggio, and Silk Road) belonging to *Dianthus caryophyllus* L. species used as the plant materials.

The rooted cuttings of carnation were planted in plots (25 m in length and 1 m in width) on April 20 in the first year (2003) and on April 16 in the second year (2004). Some characteristics of the greenhouse soil (in 0 to 20 cm depth) in the study area were as follows: texture: sandy-loam, lime: 1.6 %, pH: 7.5, and organic matter: 1.7 %. The plants were single-pinched above the fifth leaf pair from the bottom (Whealy 1992; Kazaz et al. 2009). To maintain straight stems, carnation plants were supported by four layers of mesh. Water and nutrients were supplied through a drip irrigation system. Harvesting was performed above the second node from the base when flowers were fully open (Kazaz et al. 2009). The following data were recorded: stem length, stem diameter, stem fresh weight, flower diameter, dry matter content, vase life, days to flower, yield per plant, and yield per m^{-2}.

The experiment was set up according to randomized plots in factorial design with three replications. 1 m^{-2} plots were formed for each replication. Data were subjected to analysis of variance using MINITAB software (Minitab Inc., State College, PA), and means values were compared using Duncan's multiple range test at $p = 0.05$ level (Düzgüneş et al. 1983). The results obtained in the research were provided as the averages of both years (2003-2004) of the study.

RESULTS AND DISCUSSION

Stem Length

The longest stem among the planting densities and systems was determined in S_8 (80.81 cm). However, there was no statistical difference in stem length between S_8 and S_5 (79.02 cm) and S_6 (78.91 cm) treatments. The shortest stems were determined in S_1 (72.95 cm) and S_2 (75.27 cm) (Table 1). When the stem lengths were examined in terms of cultivars, the cultivars were also found to statistically significantly vary depending on different planting densities and systems. The cultivar with the longest stem was Vittorio (88.67 cm), whereas the cultivar with the shortest stem was Malaga (68.16 cm).

One of the most important quality criteria in carnation cultivation is the stem length. The stem lengths above 40 cm are generally considered marketable; however, although varying by country, the stem lengths above 60 cm are generally preferred in the market (Kazaz et al. 2010). In the study, the stem lengths were above 60 cm both in all planting densities and systems and all cultivars. The results obtained in the study were in agreement with the findings by Kitamura et al. (1990) and Altan and Altan (1982), who reported that stem length increased with increasing planting density in carnations.

Stem Diameter

Among the planting densities and systems, the thickest stems were obtained in S_1 (5.02 mm) and S_2 (4.89 mm), while the thinnest stem was obtained in S_8 (4.27 mm) (Table 1). The thickest stem among the cultivars was determined in Negev cultivar (5.03 mm), followed by Polka cultivar (4.82 mm). On the other hand, the thinnest stems were found in Omaggio (4.34 mm) and Judith cultivars (4.52 mm) (Table 1). In our study, stem diameter decreased with increasing planting density.

Holley and Baker (1991) reported that a high planting density reduced flower quality, whereas Mastalerz (1983) reported that high light increased stem diameter. The cultivars quite varied in terms of stem diameter. It is considered that this might be due to the characteristic of cultivars and because cultivars display different development performances.

Stem Fresh Weight

The effects of cultivars and planting densities and systems on stem fresh weight were statistically significant. The stem fresh weights were found to range from 32.67 to 46.03 g among the planting densities and systems and from 35.02 to 49.09 g among the cultivars (Table 1). In the study, the stem fresh weight decreased with increasing planting density. Similar results were reported by Mastalerz (1983), Sakai and Kojima (1988), and Sakai and Asano (1990).

Flower Diameter

The planting densities and systems and the cultivars significantly affected the flower diameter. The flower diameter ranged from 70.82 to 74.51 mm among the planting densities and systems and from 69.16 to 80.14 mm among the cultivars (Table 2). The flower diameters obtained from the planting densities and systems between 40 and 48 plants m^{-2} (73.12-74.51 mm) were found bigger than the flower diameters obtained from the planting densities and systems between 54 and 59 plants m^{-2} (72.10-70.82 mm). Our results were in agreement with Bunt (1978), who reported that flower diameter got smaller with increasing planting density in carnations. Singh and Sangama (2002) reported that flower diameters varied among the cultivars of carnation, while Laurie et al. (1969) stated that the flower diameter was around 7.60 cm in standard carnations.

Dry Matter Content

The effects of different planting densities and systems on dry matter content were statistically significant, and the dry matter contents ranged from 15.72 to 18.27 %. High planting densities reduced the dry matter content. The dry matter contents ranged from 16.01 to 18.84 % among the cultivars, and the difference in dry matter content among the cultivars was statistically significant (Table 2).

Table 1 Effects of treatments on stem length, stem diameter, and stem fresh weight

Variation sources Planting density and system (PD)	Stem length (cm)	Stem diameter (mm)	Stem fresh weight (g)
S_1	72.95 d	5.02 a	46.03 a
S_2	75.27 cd	4.89 ab	44.62 ab
S_3	77.37 bc	4.64 de	42.43 bc
S_4	76.82 bc	4.73 cd	43.05 b
S_5	79.02 ab	4.54 e	40.75 cd
S_6	78.91 ab	4.52 e	40.17 d
S_7	75.76 c	4.80 bc	44.50 ab
S_8	80.81 a	4.27 f	32.67 e
Cultivar (C)			
Lia	71.07 e	4.62 cd	39.98 c
Malaga	68.16 f	4.61 cd	38.03 cd
Vittorio	88.67 a	4.72 bc	49.09 a
Polka	78.49 c	4.82 b	45.77 b
Negev	82.83 b	5.03 a	45.22 b
Judith	71.52 e	4.52 d	37.36 d
Omaggio	74.85 d	4.34 d	35.02 e
Silk Road	81.35 b	4.75 bc	43.74 b
PD x C	ns	ns	ns

Means within a column followed by different letter are significantly different at P<0.05, Duncan's multiple range test. ns: not significant.

Vase Life

Among the planting densities, the longest vase life was recorded in S_1 (12.65 days), S_2 (12.46 days) and S_7 (12.40 days), while the shortest vase life was determined in S_8 (10.60 days) (Table 2). When the vase life was examined among the cultivars, the longest vase life was found in Polka cultivar (13.60 days), followed by Judith cultivar (13.03 days). The cultivar with the shortest vase life was Vittorio (9.07 days) (Table 2). In the study, vase life decreased with high planting densities. This might result from the inadequate carbohydrate formation due to lack of light in high planting densities.

Table 2 Effects of treatments on flower diameter, dry matter content, and vase life

Variation sources Planting density and system (PD)	Flower diameter (mm)	Dry matter content (%)	Vase life (day)
S_1	74.51 a	18.27 a	12.65 a
S_2	73.87 ab	17.77 ab	12.46 a
S_3	72.91 bc	17.05 bc	11.68 bc
S_4	73.12 abc	17.34 bc	11.79 b
S_5	72.10 cd	16.58 c	11.23 cd
S_6	71.78 cd	16.56 c	11.08 d
S_7	73.87 ab	17.38 b	12.40 a
S_8	70.82 d	15.72 d	10.60 e
Cultivar (C)			
Lia	74.73 b	16.01 c	11.41 d
Malaga	73.34 bc	16.35 bc	11.73 d
Vittorio	80.14 a	16.71 bc	9.07 f
Polka	72.34 cd	16.01 c	13.60 a
Negev	71.29 de	18.64 a	12.41 c
Judith	70.15 ef	17.01 b	13.03 b
Omaggio	69.16 f	17.10 b	9.89 e
Silk Road	71.81 d	18.84 a	12.76 bc
PD x C	ns	ns	ns

Means within a column followed by different letter are significantly different at P<0.05, Duncan's multiple range test. ns: not significant.

Gast (1997) and Anonim (2002) reported that inadequacy of carbohydrate and inappropriate conditions and cultural treatments in the cultivation period also played a significant role among the reasons why cut flowers had a short postharvest life.

Days to Flower

Planting densities and cultivars significantly affected the days to flower. Although the earliest days to flower among the planting densities and systems were determined in S_1 (135.14 days), the difference between it and S_2 (136.22 days) was found statistically insignificant. On the other hand, the latest days to flower was recorded in S_8 (142.47 days) (Table 3).

Among the cultivars, the earliest days to flower were found in Judith (129.70 days), while the latest days to flower were determined in Silk Road cultivar (148.47 days) (Table 3). In the study, the days to flower were delayed with increasing planting densities in all planting densities and systems other than S_2. Our results were in agreement with Mastalerz (1983). It was reported that days to flower also varied in carnations depending on cultural treatments, such as planting time, pinching date and method, day length, and cultivar, and ecological factors, such as temperature, light, and CO_2 (Laurie et al.1969; Besemer 1980; Whealy 1992; Mengüç 1996).

Yield per Plant (stems plant^{-1})

Yield per plant statistically significantly varied among the planting densities and systems and the cultivars. Even though the average highest yield per plant was determined in S_1 (4.33 stems plant^{-1}), the difference between S_1 and S_2, the average yield per plant of which was 4.20 stems plant^{-1}, was statistically insignificant. The average lowest yield per plant was found in S_8 (3.34 stems plant^{-1}). Among the cultivars, the highest yield per plant was recorded in Judith (4.34 stems plant^{-1}) and Lia cultivars (4.29 stems plant^{-1}), whereas the lowest yield per plant was obtained from Silk Road cultivar (3.07 stems plant^{-1}) (Table 3). In the study, the values of yield per plant decreased with increasing planting densities. Similar results were reported by Hanan and Heins (1975), Heins (1975), Garibaldi and Volpi (1977), Spithost (1977), Yonemura and Higuchi (1977), Altan and Altan (1982), Bunt and Powell (1982), Mastalerz (1983), Powel and Bunt (1983), and Khanna et al. (1986).

Yield per m^{-2} (stems m^{-2})

The planting densities and systems were included in two different groups in terms of total yield per m^{-2}. The first group consisted of S_8 (197.43 stems), S_5 (195.68 stems), S_6 (192.97 stems), S_3 (191.83 stems), S_4 (190.16 stems) and S_2 (189.02 stems) planting densities, while the second group comprised S_7 (177.64 stems) and S_1 (173.25 stems) planting densities. The total yields per m^{-2} ranged from 150.00 to 211.89 stems among the cultivars. The cultivars with the highest total yield per m^{-2} were found to be Judith (211.89 stems) and Lia (209.54 stems), whereas the cultivar with the lowest total yield was found to be Silk Road (150.00 stems) (Table 3).

Table 3 Effects of treatments on days to flower, yield per plant, and yield per m^{-2}

Variation sources	Days to flower (day)	Yield per plant (stems plant^{-1})	Yield per m^{-2} (stems m^{-2})
Planting density and system (PD)			
S_1	135.14 e	4.33 a	173.25 b
S_2	136.22 de	4.20 ab	189.08 a
S_3	139.08 bc	3.83 cd	191.83 a
S_4	137.83 cd	3.96 bc	190.16 a
S_5	140.75 ab	3.62 de	195.68 a
S_6	140.91 ab	3.57 ef	192.97 a
S_7	137.41 cd	4.03 bc	177.64 b
S_8	142.47 a	3.34 f	197.43 a
Cultivar (C)			
Lia	137.00 d	4.29 a	209.54 a
Malaga	144.04 b	3.87 b	189.16 b
Vittorio	138.66 d	3.76 b	183.35 b
Polka	140.56 c	3.92 b	191.10 b
Negev	134.00 e	3.70 b	181.31 b
Judith	129.70 f	4.34 a	211.89 a
Omaggio	137.39 d	3.93 b	191.70 b
Silk Road	148.47 a	3.07 c	150.00 c
PD x C	ns	ns	ns

Means within a column followed by different letter are significantly different at P<0.05, Duncan's multiple range test. ns: not significant.

According to the obtained results, yield per plant decreased but total yield per m^{-2} increased with increasing planting density and system. These results are in agreement with Hanan and Heins (1975), Heins (1975), Spithost (1977), Garibaldi and Volpi (1977), Yonemura and Higuchi (1977), Bunt and Powell (1982), Mastalerz (1983), Powel and Bunt (1983), Khanna et al. (1986), Skashita et al. (1987), and Os and Weel (1988).

CONCLUSION

The effects of different planting densities and systems on yield and some quality parameters of standard carnation cultivars were investigated in the study. The study revealed that with increasing planting densities, stem length and total yield per m^{-2} increased but stem diameter, stem fresh weight, flower diameter, dry matter content, vase life and yield per plant decreased.

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