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EFFECT OF VARIOUS FERTILIZER APPLICATIONS ON NUTRITIONAL CONTENT AND LENGTH OF STEM AND NODE OF A CARNATION (*DIANTHUS CARYOPHYLLUS* L) SEEDLINGS

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Abstract

In the present study, sprayed carnation cuttings either stored in a cold storage at 4^{o}C for 55 days or non-stored were used as plant material. During rooting process, 3 different fertilizer solutions were applied through leaves of carnation cuttings at two separate application intervals and its respective effect on some of the morphological characteristics and nutritional contents of the seedlings were investigated. As a result of the study, it was found that the fertilizer solutions increased the K, Ca, Mg, Zn and Cu contents in seedlings obtained from stored cuttings and that the solutions increased the K, Ca and Cu contents in seedlings formed by rooting of non-stored cuttings while they attenuated the Mn amount. The fertilizer solutions increased the length between the stem and the first node and decreased the length between the stem and the fifth node in seedlings obtained from the stored cuttings. On the other hand, they increased the number of nodes in the seedlings from non-stored cuttings. Frequency of the application was found to affect the N, P, K and Mg amounts in seedlings obtained from stored cuttings and the Mg and Cu contents in seedlings obtained from non-stored cuttings. When their morphological characteristics were investigated, it was identified that the fertilizer solutions proved to affect the fifth node length of seedlings obtained from stored cuttings and the stem diameter of the seedlings obtained from non-stored cuttings.

Introduction

Carnation (*Dianthus caryophyllus* L.), a member of Caryophllaceae family is native to the Mediterranean region (Salehi, 2006). As a result of the culture studies having been carried out since the Ancient Greek times on various characteristics of this plant such as the shape, quality, scent and color, hundreds of species of that plant have been developed (Çokuysal, 1994).Carnation are divided into two groups, standard and miniature (spray), they produce in each stem, one large terminal flower and several smaller lateral flowers, respectively (Dole & Wilkins, 1999). In Turkey, carnation is in the lead among species of cut flowers with a production amount of 259 million and $ 21.386.821 production value. Carnation production is carried out mostly in provinces of Antalya and İzmir (Babadoğan, 2009).

Carnation production is carried out in three different ways; that is by means of seeds, cuttings and meristem culture. Most of the carnation producers in Turkey use cuttings as production method. In production with cuttings, the cuttings taken from the primary seedlings are used as seedlings again. This goes on for years, as a result of which quality and efficiency of carnation production decrease as it is contrary to principles of modern carnation production (Gürsan, 1988). Primary reason for low efficiency rates both in greenhouse and outdoor production areas across the country is the production using low quality seedlings. Carrying out production using proper and high quality seedlings is one of the most important factors affecting the efficiency positively (Kabay, 1999).

Producers take cuttings from a primary carnation plant for 5 or 6 times every two weeks. There are two reasons for the producers to take cuttings from the carnation on a frequent basis. The first one is abundance of carnation production areas despite limited areas reserved for seedlings and primary plants. The other reason is producers' interest in gaining the market share where prices of cut plant are high. Thus, producers store cuttings taken from the seedlings in the cold storage for a long time, and then they implant them in a rooting media while they implant cuttings which are obtained lastly in a rooting media directly without storing them in the cold storage. However, significant challenges regarding the product quality are met in seedlings obtained from stored and non-stored carnation cuttings. The problem met in stored cuttings is that the young sprouts overgrow following rooting of stored cuttings, which eventually leads weakening of the sprout. As for the seedlings obtained from non-stored cuttings, the problem is that weak and short seedlings come into being. In this study, the effects of different fertilizers applied through leaves on the seedling morphology and nutritional contents during the rooting process have been examined. Several studies have been carried out on the seedlings multiplied from cuttings (Krisantini *et al*., 2002; Garrido *et al*., 2002; Haver *et al*., 2003; Salehi, 2006). However, no studies have been found on the effects of the fertilizer applied through leaf during the rooting process. In this study, it is aimed at producing data concerning solution and elimination of some challenges by means of fertilizer applications through leaf during the rooting process of the problematic seedlings.

Materials and Methods

In this study, cuttings were taken from the species "Darling" (red), which is widely used in spray carnation production, for two times. The carnation cuttings taken during the first period were stored in cold storage at 4^oC for 55 days. The carnation cuttings taken during the second period was implanted in the rooting area composing of 2/5 torf + 3/5 pearlite, without being stored. An implantation plan of 3 cm x 3 cm with 96 carnation flowers in each parsel was applied in the rooting area. Chemical analysis results and morphological specialities of carnation samples prior to the rooting period are given in Table 1. Divided parsels in the experiment coincidence blocks were constructed with 4 recurrings according to the experimental plan.

After four days of the implantation in the rooting area, one control and 3 different fertilizer solutions (Table 2) were applied every day and every other day by spraying on the leaves. The carnation seedlings were harvested 27 days after by cutting them closing to the root.

Randomly selected carnation seedling plants were collected from each plot for element analysis, and transported to the laboratory in closed polyethylene bags. In order to eliminate surface contamination, the samples were carefully washed by distilled water. Samples were dried in a forced-air oven at 65^oC to constant weight. The dried samples were ground in a stainless steel mill to pass through a 20 mesh screen and kept in clean polyethylene bags for analysis. The oven-dried-ground samples of 0.5 g were wet digested with 10 mL HNO_3:$HClO_4$ (4:1) acid mixture on a hotplate. The samples were then heated until a clear solution was obtained. The same procedure was repeated several times. The samples were filtered and diluted to 100 mL using distilled water. Concentrations of K, Ca, Mg, Fe, Mn, Zn and Cu contents in the digest were determined by using atomic absorption spectrophotometer (Kacar, 1972). N content of the samples has been analyzed according to modified Kjeldahl method (Kacar, 1972); while P, nitric-percloric acid mixture and vanadomolibdo phosphoric in the solution obtained by wet-burning has been analyzed according to yellow color method (Kacar & Kovanci, 1982).

Table 1. Chemical analysis results and morphological specialities of carnation samples prior to the rooting period.

Chemical and morphological properties	Stored	Non-stored
N (%)	2.59	2.62
P(%)	0.35	0.33
K(%)	3.48	2.77
Ca(%)	2.00	1.81
Mg(%)	0.27	0.28
Na(%)	0.032	0.031
Fe (ppm)	101.10	102.3
Zn (ppm)	59.30	62.00
Cu (ppm)	10.95	11.10
Mn (ppm)	86.70	82.90
Seedling length (mm)	178.20	131.27
Stem diameter (mm)	3.97	3.16

Table 2. Chemical analysis results of fertilizer solution (mg/100 L).

Chemical properties	1st solution	2nd solution	3rd solution
NH_4-N	18.80	1.80	1.80
NO_3-N	56.60	51.90	33.60
P	3.99	3.99	3.99
K^+	23.00	34.50	50.00
Ca^{++}	22.40	33.60	33.60
Mg^{++}	6.00	9.00	7.84
S			31.52
Fe	6.25	6.25	6.25
Mn	2.50	2.50	2.50
Zn	2.50	2.50	2.50
Cu	1.25	1.25	1.25
B	1.40	1.40	1.40
Mo	0.14	0.140	0.14
E.C (ms)	2.00	1.50	1.70
pH	5.53	5.18	5.76

Statistical analyses were performed on all data by using MINITAB 13.32 (Minitab Inc., PA, USA). One-way analysis of variance (ANOVA) was used to evaluate the statistical difference of treatment means. The level of significance was set at $p<0.05$. Duncan's Multiple Range Test was conducted for pair wise comparisons.

Result and Discussion

Average values regarding the total N, P, K, Ca, Mg, Fe, Zn, Cu and Mn contents of the carnation seedling depending on different fertilizer solutions and fertilizer application frequency are given in Table 3. Although the effect of the fertilizer solutions on the total N, P, Fe contents in the carnation seedlings resulted in no significant difference statistically, a certain amount of increase was recorded in the nutritional contents according to the controls (Table 3).

Table 3. Average values regarding the total N, P, K, Ca, Mg, Fe, Zn, Cu and Mn contents of the carnation seedling depending on different fertilizer solutions and fertilizer application frequency.

		N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)	Mn (ppm)
Fertilizer solution	**Stored**									
	Control	2.63	0.25	1.94 b[z]	2.10 b	0.19 b	105.45	228.80 b	18.80 c	254.7
	1st solution	3.08	0.27	2.12 ab	2.23 a	0.21 ab	112.70	253.55 ab	22.75 bc	257.18
	2 nd solution	3.00	0.27	2.14 a	2.26 a	0.20 ab	114.20	269.95 a	26.58 ab	263.4
	3 rd solution	3.00	0.27	2.17 a	2.23 a	0.22 a	119.70	285.30 a	33.70 a	278.23
	Significance	N.S.	N.S.	p<0.05	p<0.01	p<0.05	N.S.	p<0.05	p<0.01	N.S.
	Non-stored									
	Control	2.42	0.25	1.71 b	2.16 ab	0.23	118.15	235.6	12.33 b	333.75 a
	1st solution	2.84	0.27	1.90 ab	2.31 a	0.25	140.05	252.68	13.45 b	275.65 b
	2 nd solution	2.74	0.26	1.93 ab	2.17 ab	0.24	140.68	247.23	16.70 ab	260.70 b
	3 rd solution	2.64	0.25	2.04 a	2.09 b	0.23	131.2	238.83	19.78 a	288.88 ab
	Significance	N.S.	N.S.	p<0.01	p<0.05	N.S.	N.S.	N.S.	p<0.05	p<0.05
Application frequency	**Stored**									
	Every day	3.17 a	0.27 a	2.16 a	2.22	0.21 a	115.08	260.91	26.24	263.27
	Every other day	2.68 b	0.26 b	2.02 b	2.19	0.20 b	110.95	257.89	24.68	263.48
	Significance	p<0.01	p<0.05	p<0.05	N.S.	p<0.05	N.S.	N.S.	N.S.	N.S.
	Non-stored									
	Every day	2.76	0.26	1.92	2.2	0.24 a	134.19	243.28	17.51 a	281.14
	Every other day	2.56	0.25	1.87	2.17	0.23 b	130.85	243.89	13.61 b	298.35
	Significance	N.S.	N.S.	N.S.	N.S.	p<0.05	N.S.	N.S.	p<0.05	N.S.

[z]: Mean separation within columns by Duncan test at, 0.05 level, *N.S.*: Non-significant

The effect of the fertilizer solutions on the K, Ca and Cu contents of the carnation seedlings have been found to be significantly important. In both storing conditions, in seedlings on which fertilizer solution number 3 is applied, the highest increase rate was found to in at Cu and K content (Table 3). A similar result was found in another study carried out by Karanlık (1999). The same researcher has concluded that increasing K applications on carnations increased K and Cu contents of the plant.

It was found that the effect of the fertilizer solution on the Mg and Zn contents of seedlings from stored cuttings has been statistically significant ($p<0.05$), as compared to the effect of the fertilizer solution on seedlings from non-stored cuttings (Table 3). In plants obtained from stored cuttings, the highest Mg and Zn contents have been observed in seedlings on which the fertilizer solution number 3 whose K content was maxiumum was applied (Table 3).

The effect of the fertilizer solution on the Mn content of the seedlings derived from non-stored cuttings has been found significant (Table 3). The Mn content of the plants above the limit values can be explained with high Mn content of the pesticides sprayed against diseases during the seedling growth.

Ever day administration of fertilizer to carnation seedlings increased the N, P, K and Mg content of the stored plant samples and Mg and Cu contents of the non-stored plant samples significantly (Table 3). When the values obtained regarding the total N, P, Mg and Fe contents of the plant samples are compared with the limit values defined for carnation by Reuter & Robinson (1988); Jones *et al*., (1991) these values are found between the normal limit values whereas total Ca, Zn and Mn contents are above the normal limit values. The total Cu contents are at the upper limit of the normal values in the plant samples on which the fertilizer solution number three was applied among the seedlings from the stored cuttings, while it is within the normal limit values in the plant samples on which the other solutions were applied. The total K content is found at lower limit of the normal values when it is compared with the limit values.

The effect of the fertilizer solutions on the seedling length obtained from the stored cuttings has been found statistically significant ($p<0.01$), and the highest increase was observed in the seedlings on which the fertilizer solution 3 was applied (Table 4). This is unwanted for the seedlings obtained from the stored cuttings. However, when the seedlings on which the fertilizer solution number three is applied were compared with the control seedlings, the fertilizer solutions increased the distance between the first node and decreased the distance between the fifth node (Table 4, Fig. 1) and this effect is statistically significant ($p<0.01$). It is thought that the high K content and low N content of the fertilizer solution 3 result in an important effect on the growth of the plant (Table 2). However, only the physiological studies can help explaining whether this effect results from the azote and potassium rates or from the chemical interactions with other nutritions. Aplication of potasium is known to improve such physiological characteristics as stomatal resistance, relative water content, chlorophyll and proline contents, enzyme activation which might improve the overall plant water status and metabolism (Havlin *et al*., 2005, Umar *et al*., 2006).

The fertilizer solutions created a difference at 5 % significance level on the number of nodes in the seedlings from the non-stored cuttings only. The highest number of nodes, which is 5.48 on average, was found in the seedlings on which the fertilizer solution 2 was applied. Though statistically insignificant, the fertilizer solution 2 increased the seedling length and stem diameter of the non-stored carnation cuttings (Table 4). The effect of the application frequency of the fertilizer solutions on the fifth node of the seedlings obtained from the stored carnation cuttings as well as on the stem diameter of the non-stored carnation cuttings is statistically ($p<0.05$) significant (Table 4).

Table 4. Average values regarding effects of fertilizer solutions and frequency of fertilizer application on the seedling length, stem diameter, number of nodes and the distance between the nodes.

		Seedling length (mm)	Stem diameter (mm)	Node quantity	1. Node length (mm)	2. Node length (mm)	3. Node length (mm)	4. Node length (mm)	5. Node length (mm)	6. Node length (mm)
		Stored								
Fertilizer solution	Control	173.32 b[z]	4.62	7.11	8.48 b	8.35	7.57	9.57	16.35 a	23.06
	1st solution	185.21 a	4.43	6.83	8.53 b	8.52	6.88	10.21	15.32 ab	20.76
	2 nd solution	186.85 a	4.44	7.35	9.82 a	8.39	7.44	8.89	14.29 ab	20.99
	3 rd solution	189.35 a	4.31	7.15	10.12 a	8.55	7.14	8.67	12.99 b	20.49
	Significance	$p<0.01$	N.S.	N.S.	$p<0.05$	N.S.	N.S.	N.S.	$p<0.05$	N.S.
		Non-stored								
	Control	146.98	4.00	4.90 b	7.37	6.92	6.10	7.19	9.59	11.09
	1st solution	145.23	3.75	5.33 a	7.09	6.70	5.68	6.52	8.70	11.26
	2 nd solution	147.52	4.22	5.48 a	7.37	7.10	6.16	6.70	9.10	11.46
	3 rd solution	144.55	4.10	4.92 b	6.87	6.78	6.06	7.07	9.55	9.79
	Significance	N.S.	N.S.	$p<0.05$	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
		Stored								
Application frequency	Every day	184.31	4.45	7.14	9.66	7.64	7.28	8.83	13.71 b	20.55
	Every other day	183.06	4.45	7.07	8.80	7.61	7.24	9.83	15.77 a	22.11
	Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	$p<0.05$	N.S.
		Non-stored								
	Every day	145.17	4.17 a	5.22	7.14	7.74	5.98	6.64	9.17	10.96
	Every other day	146.97	3.86 b	5.10	7.21	7.67	6.03	7.10	9.93	10.83
	Significance	N.S.	$p<0.05$	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

[z]: Mean separation within columns by Duncan test at, 0.05 level, *N.S.:* Non-significant

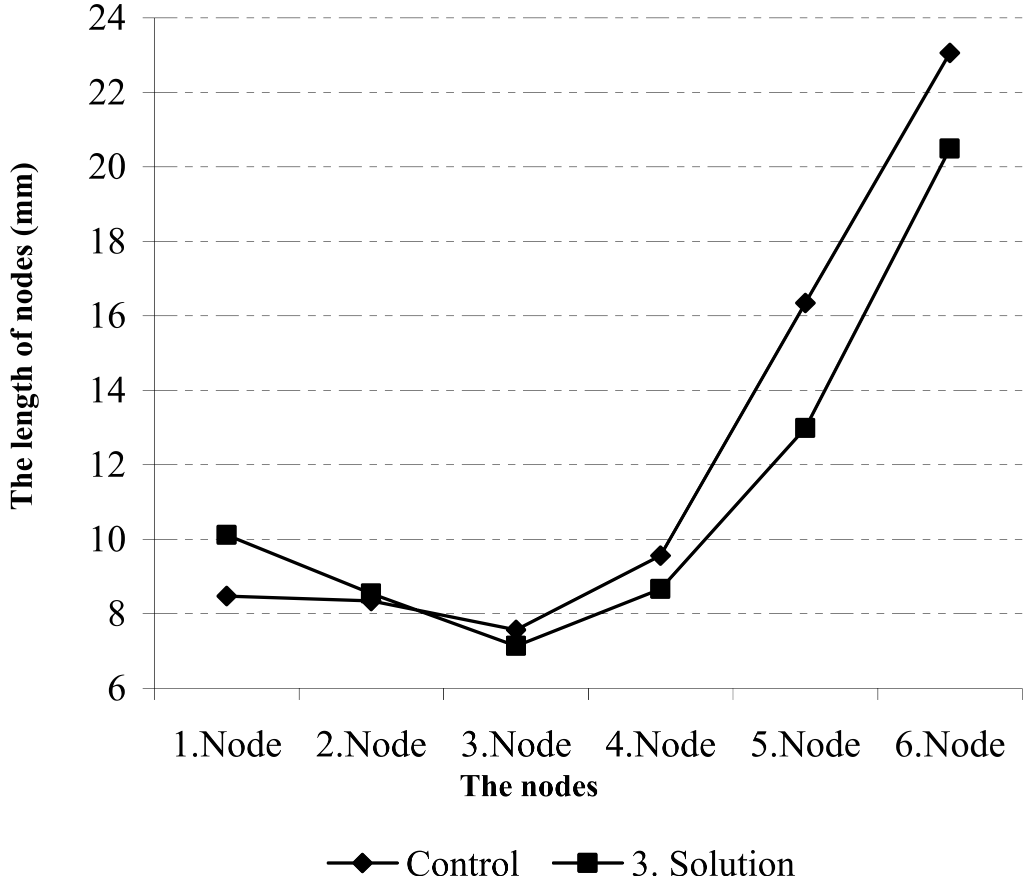

Fig. 1. The effects of control and no 3 solution on the length of nodes in seedlings obtained from stored cuttings.

In this study, frequency of the application has not led to a salient difference on morphological characteristics of the seedlings (Table 4). However, ever day application of the fertilizer increased the nutritional content under both storage conditions (Table 3). Quasim *et al.* (2008) indicated that application frequency of the fertilizer increase plant height, number of branches, number of leaves, number of flowers plant^{-1}, number of petals flower^{-1}, leaf nitrogen and phosphorus and potassium percentage. The fertilizer applications generally increased the nutritional content of the seedlings. It has been identified that the fertilizer solution 3 applied on the stored carnation seedlings balances the excessive node lengthening of the growing sprout (Fig. 1). For the seedlings obtained from the non-stored carnation cuttings on which the fertilizer solution 2 was applied, they showed the highest increase in the stem diameter and seedling length when compared with the other seedlings to which other solutions were applied. Based on these results, it has been identified that some differences can be recorded on the nutritional contents and the morphological characteristics of the seedlings *via* fertilizer applications.

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