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INFLUENCE OF COLD STORAGE OF UNROOTED CUTTINGS ON SOME VEGETATIVE, ROOTING AND FLOWERING CHARACTERS OF *Dianthus caryophyllus* L. cvs.

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ABSTRACT

This experiment was carried out during two seasons of 1995/1996 and 1996/1997 at the Experimental Station and Laboratory of the Veget. and Floric. Dept., Faculty of Agriculture, Mansoura University, Egypt, to study the effect of cold storage of unrooted cuttings on the characters of cuttings and the obtained plants until flowering stage of *Dianthus caryophyllus* L. of cultivars Bianca, Festival and Salmony.

The obtained results indicated that Festival cv. cuttings stored at 2-4°C for various periods showed a positive effect and significant increase in all vegetative, rooting and flowering measurements followed by Bianca cv., while Salmony cv. was the lowest in that respect in both seasons. Also the vegetative and rooting growth parameters of cuttings were linearly decreased with increasing the storage periods. However, the highest fresh weight of cuttings and vegetative growth, plant height, number of branches per plant as well as rooting percentage and fresh weight of root per plant resulted from cuttings stored for 3 months, while the lowest vegetative and rooting growth values resulted from cuttings stored for 6 months before rooting in both seasons.

At harvest time, number of days until colour showing, number and diameter of flowers and the length of flowering stems were affected by the cold storage periods. Flowering characters at harvest were decreased with increasing the storage periods especially when the cuttings were stored for 6 months comparing with relatively shortest periods for 3 months in both seasons. Mortality percentage of rooted cuttings growing in culture medium has been also affected by cold storage periods. Longer storage periods of unrooted cuttings for 4, 5 or 6 months resulted in higher mortality percentages comparing with other periods, in both seasons.

The obtained results revealed that the cold storage of unrooted cuttings up to 3 months at 2-4°C and 85% relative humidity in polyethylene bags was without any effect on subsequent quality and is recommended.

INTRODUCTION

Carnation (*Dianthus caryophyllus* L.) is an important crop having potential for cut flower export, in most countries of the temperate zone. The flowers of modern cultivars can be available all the year around with a great range of colors, which comprises white, pink, salmon, red, violate and yellow.

Planting schedules for carnations are the basic means of production planning for market demand. All plantings are not made at one time, because market demand dose not always coincide with the peak flowering cycles. Therefore, the production availability of rooted or unrooted cuttings at different demanded times is a matter of importance.

A successful storage system must minimize growth and development during storage, sustain photosynthetic with regrowth potential at the same time maintaining visual quality. Numerous bedding plant species have been evaluated for their low-temperature storage potential in the dark, and storage

for 3 to 6 weeks at 0 to 12°C is feasible depending on the species (Lange *et al.*, 1991).

Reduced plant quality and poor establishment are often problems following cold storage of transplants in dark conditions (Koranski *et al.*, 1989). Unfavorable dark storage environment induces loss of chlorophyll (Conover, 1976). Leaf abscission (Curtis and Rodney, 1952), use of carbohydrates reserves (Behrens, 1988) and pathogen susceptibility (Smith, 1982) were reported during storage and propagation. All factors during storage may reduce appearance and field establishment of transplants. In addition, Paton and Schwabe (1987) reported that low temperature storage reduced rooting ability of Pelargonium cuttings, while pretreatment of cuttings with sucrose or light in storage improved rooting ability. Storage of carnation cuttings at 0.5°C for 1 to 4 months without any loss in their rooting potential has been reported by Hellmer (1962). Moreover, Burg (1973) was able to hold unrooted carnation cuttings up to 240 days under 60 mm Hg pressure in cold storage.

The objective of this study was to evaluate the effect of cold storage of unrooted cuttings on the characteristics and tolerance ability of cuttings and the behavior of the obtained plants until flowering stage of some carnation cultivars.

MATERIALS AND METHODS

The experiment was carried out in the Experimental Station and Laboratory of the Veget. and Florc. Dept., Faculty of Agriculture, Mansoura University, Egypt during two successive seasons of 1995/96 and 1996/97.

The plant examined in this research was *Dianthus caryophyllus* L. a member of Fam. Caryophyllaceae. Rooted cuttings (20 – 22 cm long with 6 – 8 pairs of leaves) of three cultivars (Bianca, Festival and Salmony) were obtained from Tissue Culture Laboratory of Pico Company, Egypt on September 20th 1995 and 1996. At the beginning the rooted cuttings were planted on October 1st 1995 and 1996 in 25 cm polyethylene bags filled with a mixture of 2 clay : 1 sand : 1 peatmoss (by volume) treated with Benlate and Vetafax mixture at 2 g/l for 10 min. at the Experimental Station to be used as stock plants. All mother plants were pinched on November 1st in both seasons to encourage the production of side shoots and were fertilized with 4 cm^3/l from a complete Liquinure a commercial fertilizer at each watering weekly, starting four weeks after planting in both seasons. The other agriculture practices were normally done whenever needed.

The complete Liquinure fertilizer consisted of: 1- Macroelements: N(8%), P_2O_5 (40%) and K (40%), 2- Microelements: Zn (66 mg/kg), Fe (330 mg/l), B (3.3 mg/l), Mn (33 mg/kg), Mo (3.3 mg/l), Mg (200 mg/l) and Cu (10 mg/l).

The terminal cuttings (8 – 10 cm long with 5 – 6 pairs of leaves) were harvested from mother plants on January 1st in 1996 and 1997, the lowest leaves were discarded and dipped perior to storage in Benlate and Vetafax mixture at 2 g/l for 10 minutes. The cuttings were stored into unsealed and unperforated polyethylene bags of 200 gauge thickness at 2 – 4°C with average relative humidity during the experiment of 80% for 1, 2, 3, 4, 5 and 6

months in both seasons. Monthly cuttings were immersed in the Benlate and Vetafax mixture at 2 g/l for 10 min., allowed to dry using kitchen paper and were returned into storage bags.

Following removal from cold storage after 1, 2, 3, 4, 5 and 6 months storage, the freshly cut surfaces of cuttings were dipped to a depth of 2 cm in 500 ppm indole- 3- acetic acid (IAA) for 10 min. before being placed in rooting medium. The cuttings were planted singly in a mixture of 3 peatmoss: 1 sand (by volume) in plastic trays (64 plugs per tray). They were kept at 24°C under a constant fluorescent light of 3000 Lux for 16 h. daily, at this stage the shoot elongated a few centimeters. Thereafter were planted directly in the 25 cm polyethylene bags filled with a mixture of 2 clay: 1 sand : 1 peatmoss (by volume) and grown under plastic house conditions until flowering.

In both seasons, the collected data were: for the fresh weight per cutting (g) after 1, 2, 3, 4, 5 and 6 months storage were evaluated. Eight weeks after planting, root system of rooted cuttings was carefully washed with a tap-water and dried with kitchen paper and separated into vegetative parts and roots. The following data were evaluated: plant height per plant (cm) was obtained by measuring the length from the soil surface up to uppermost top, number of branches per plant, fresh weight of vegetative parts per plant (g), rooting percentage (%) as well as fresh weight of roots per plant (g). During flowering stage, the collected data were recorded after 3 and 6 months storage on: number of days until colour showing, number of flowers per plant, diameter of flowers (cm) (when flower had four to six layers of petal open) and length of the flowered stem (cm). Finally, the mortality percentages of plants were calculated, two weeks after planting.

The experiment was arranged in randomized complete block design with four replicates. All the obtained data were examined statistically using the computerized analysis of variance and Duncan's multiple range test procedures within the statistical analysis system, SAS (2000).

RESULTS

Vegetative growth measurements:

Since, the handling and marketing of carnation cutting is in the fresh form the data herein is concentrated on the fresh status.

Data in Table (1) showed that the variation due to cultivars may be detected in the indicated characteristics. The heaviest fresh weights of unrooted cuttings (1.20 and 1.17 g) were of Festival cv. cuttings. While the lowest fresh weights (1.02 and 1.00 g) were of Salmony cv. cuttings in both seasons, respectively. In the same Table, it was noticed that the increase of cold storage period for 3 months gradually increased the fresh weight of cutting. Consequently the highest fresh weights of unrooted cuttings (1.43 and 1.42 g) were of cuttings stored for 3 months comparing with the other storage periods, in both seasons, respectively. Regarding the interaction effect, it could be observed that Festival cv. cuttings stored for 3 months gave the heaviest fresh weight of unrooted cuttings (1.53 and 1.50 g) in both seasons, respectively, without significant differences between other interactions.

Data in Table (2) showed that Festival cv. plants were significantly the tallest since the former reached (30.54 and 34.25 cm) than of Bianca and Salmony cvs. In both seasons, respectively. It was evident from the same Table that the tallest plant, (37.27 and 41.58 cm) were produced from cuttings stored for 3 months compared to 1, 2, 4, 5 and 6 months storage in both seasons, respectively. Regarding the interaction, it was found that, the significantly tallest plants (38.95 and 42.77 cm) were of Festival cv. plants, produced from cuttings stored for 3 months comparing to the other interactions in both seasons, respectively.

Data of number of branches presented in Table (3) showed that Festival cv. produced the highest number of branches (4.90 and 5.92 branch) over Salmony cv. (4.39 and 4.93 branch) in both seasons, respectively. In addition it was shown that cuttings stored for 3 months produced the significantly greatest number of branches (6.00 and 7.25 branch) when compared with 1, 2, 4, 5 and 6 months storage in both seasons, respectively. Concerning the interaction effect, the significantly greatest number of branches (6.1 and 7.7 branch) was produced from Festival cv. cuttings stored for 3 months in both seasons, respectively.

Data in Table (4) showed that the highest fresh weights of vegetative parts (16.31 and 18.34 g) were of Festival cv. plants in both seasons, respectively. Moreover, it was obvious that the fresh weights of vegetative parts were severely decreased with increasing the storage period more than 3 months. The significantly highest fresh weights of vegetative parts (19.07 and 22.08 g) were of plants resulted from cuttings stored for 3 months in both seasons, respectively. As regard to the interaction, it was noticed that the significantly highest fresh weights of vegetative parts (19.97 and 22.50 g) were of Festival cv. plants produced from cuttings stored for 3 months. While the lowest fresh weight of vegetative parts (7.42 and 10.30 g) were of Salmony cv. plants produced from cuttings stored for 6 months in both seasons, respectively.

Rooting characteristics:

Concerning rooting percentages data in Table (5) showed that the significantly highest rooting percentage (76.14 and 79.18%) were of Festival cv. Cuttings compared to Bianca cv. (71.07 and 76.37%) and Salmony cv. (62.96 and 65.82%) in both seasons, respectively. In addition, the significantly highest rooting percentages (81.76 and 84.46%) were of cuttings stored for 3 months. Cuttings stored for 6 months showed significantly reduction in the rooting percentage, which did not exceed (53.55 and 58.55%) in both seasons, respectively. As regard to the interaction, it was noticed that the significantly highest rooting percentages (87.02 and 88.38%) were of Festival cv. cuttings stored for 3 months. The least percentages in this respect (46.63 and 50.55%) were of Salmony cv. cuttings stored for 6 months, in both seasons, respectively.

Table (1): Fresh weight of unrooted cuttings, which received different periods of cold storage at 2–4°C as unrooted cuttings during 1995/1996 and 1996/1997 seasons.

Character	Fresh weight of unrooted cuttings (g)							
	First season 1995/1996				Second season 1996/1997			
Treatment	Bianca cv.	Festival cv.	Salmony cv.	Mean	Bianca cv.	Festival cv.	Salmony cv.	Mean
Storage periods (month):								
1	1.18	1.34	1.13	1.22	1.21	1.29	1.16	1.22
2	1.34	1.50	1.26	1.37	1.35	1.32	1.23	1.30
3	1.45	1.53	1.31	1.43	1.45	1.50	1.31	1.42
4	1.03	1.12	0.93	1.02	1.13	1.11	0.94	1.06
5	0.88	0.91	0.81	0.87	0.98	0.97	0.75	0.90
6	0.81	0.80	0.70	0.77	0.79	0.83	0.60	0.74
Mean	1.11	1.20	1.02		1.15	1.17	1.00	
L.S.D. at 5%								
Cultivars		0.52				0.52		
Storage periods		0.74				0.74		
Cultivars x storage periods		1.29				1.29		

Table (2): Plant height of rooted plants, which received different periods of cold storage at 2–4°C as unrooted cuttings two months after planting during 1995/1996 and 1996/1997 seasons.

Character	Plant height per plant (cm)							
	First season 1995/1996				Second season 1996/1997			
Treatment	Bianca cv.	Festival cv.	Salmony cv.	Mean	Bianca cv.	Festival cv.	Salmony cv.	Mean
Storage periods (month):								
1	34.02	34.67	31.91	33.53	37.43	38.29	34.86	36.86
2	35.39	36.26	33.75	35.13	40.94	42.21	39.12	40.76
3	37.32	38.95	35.54	37.27	42.18	42.77	39.80	41.58
4	28.09	29.33	26.05	27.82	30.31	34.10	27.90	30.77
5	22.78	24.46	19.86	22.36	25.35	26.70	22.39	24.81
6	18.52	19.60	15.80	17.97	19.47	21.43	18.20	19.70
Mean	29.35	30.54	27.14		32.61	34.25	30.37	
L.S.D. at 5%								
Cultivars		0.63				0.66		
Storage periods		0.89				0.94		
Cultivars x storage periods		1.55				1.63		

Table (3): Number of branches of rooted plants, which received different periods of cold storage at 2 – 4°C as unrooted cuttings two months after planting during 1995/1996 and 1996/1997 seasons.

Character	Number of branches per plant							
	First season 1995/1996				Second season 1996/1997			
Treatment	Bianca cv.	Festival cv.	Salmony cv.	Mean	Bianca cv.	Festival cv.	Salmony cv.	Mean
Storage periods (month):								
1	5.3	5.5	4.9	5.23	6.6	6.9	5.2	6.22
2	5.7	5.8	5.4	5.63	7.2	7.1	6.2	6.84
3	6.0	6.1	5.9	6.00	7.6	7.7	6.4	7.25
4	4.5	4.6	3.8	4.30	5.0	5.2	4.4	4.93
5	4.1	4.1	3.4	3.80	4.8	4.6	3.8	4.41
6	3.3	3.4	2.9	3.22	4.0	4.2	3.6	3.93
Mean	4.80	4.90	4.39		5.90	5.92	4.93	
L.S.D. at 5%								
Cultivars		0.46				0.42		
Storage periods		0.65				0.59		
Cultivars x storage periods		1.13				1.03		

Table (4): Fresh weight of vegetative parts of rooted plants, which received different periods of cold storage at 2–4°C as unrooted cuttings two months after planting during 1995/1996 and 1996/1997 seasons.

Character	Fresh weight of vegetative parts per plant (g)							
	First season 1995/1996				Second season 1996/1997			
Treatment	Bianca cv.	Festival cv.	Salmony cv.	Mean	Bianca cv.	Festival cv.	Salmony cv.	Mean
Storage periods (month):								
1	17.17	18.30	15.36	16.94	19.00	19.71	18.03	18.91
2	19.11	19.86	16.97	18.65	20.35	21.40	18.96	20.23
3	19.83	19.97	17.40	19.07	21.93	22.50	21.81	22.08
4	14.72	15.12	12.62	14.15	16.15	15.63	12.97	14.91
5	11.15	13.40	9.26	11.27	14.88	16.19	11.69	14.25
6	9.59	11.22	7.42	9.41	12.78	14.62	10.30	12.56
Mean	15.26	16.31	13.17		17.51	18.34	15.62	
L.S.D. at 5%								
Cultivars		0.67				0.65		
Storage periods		0.95				0.95		
Cultivars x storage periods		1.65				1.65		

Regarding fresh weight of roots the values in Table (6) showed that the significantly highest fresh weights of roots (4.71 g) were of Festival cv. cuttings compared to Salmony cv. (3.95 g) in the first season. Moreover, it was observed that the significantly heaviest fresh weight of roots (5.29 g) was of cuttings stored for 3 months compared to the other storage periods, in the first season. Dealing with the interaction, it was obvious that the significantly highest fresh weights of roots (5.98 and 5.76 g) were of Festival cv. cuttings, stored for 3 months over the other interactions in both seasons, respectively.

Flowering characteristics:

Cold storage duration for 3 or 6 months significantly influenced flowering characteristics. Data of flowering characteristics produced from cuttings stored for 3 months, were presented in Table (7) which clarified that, Festival cv. started flowering significantly earlier (after 101.80 days) than those of Salmony cv. plants which started flowering later (after 106.80 days) in the first season. The same Table demonstrated that, Festival cv. plants had the highest number of flowers (8.43 and 8.68 flower/plant) than those of Salmony cv. (7.56 and 7.98 flower) in both seasons respectively, with significant differences in between. Concerning diameter of flower the results in the same Table showed that, the significantly highest increase in the diameter of flower (6.32 and 6.11 cm) were observed with Festival cv. than those of Salmony cv. (4.82 and 5.31 cm) in both seasons, respectively. The length of flowering stems presented in the same Table showed that the significantly longest flowering stems (23.89 cm) were observed with Festival cv. than those of Bianca and Salmony cvs. (22.72 cm) and (22.23 cm) in the first season, respectively.

Data of flowering characteristics produced from unrooted cuttings cold stored for 6 months were presented in the same Table, which showed that, Festival cv. started flowering significantly earlier (after 134.50 and 133.7 days) than those of Bianca cv. (140.0 and 139.6 days) and Salmony cv. (142.5 and 140.4 days) in both seasons, respectively. The same Table demonstrated that, Festival cv. had the highest number of flowers (5.20 flower) than those of Bianca (4.88 flower) and Salmony cv. (4.67 flower) in the second seasons, respectively without significant differences in between. In addition, the significantly highest increase in the diameter of flowers (3.34 cm) was observed with Festival cv. than those of Bianca cv. (2.88 cm) and Salmony cv. (2.58 cm) in the first season. Studying the length of flowering stems, data confirmed that, the significantly longest flowering stems (10.57 cm) was observed with Festival cv. than those of Bianca and Salmony cv. (9.55 cm) and (9.20 cm) in the first season, respectively.

Mortality percentage:

Data of mortality percentage were presented in Table (8) and showed, in general that as storage duration increased the percentage of mortality was also increased. It should be noted that cold storage of unrooted cuttings has affected the mortality percentage of carnation plants after planting in the Plastic house. The results showed that Salmony cv. had the significantly highest mortality percentage (8.03 and 8.01%) than those of Bianca cv. (5.61 and 6.61%) and Festival cv. (4.68 and 6.06%) in both seasons, respectively.

Table (5): Rooting percentage of unrooted cuttings, which received different periods of cold storage at 2–4°C during 1995/1996 and 1996/1997 seasons.

Character	Rooting percentage (%)							
	First season 1995/1996				Second season 1996/1997			
Treatment	Bianca cv.	Festival cv.	Salmony cv.	Mean	Bianca cv.	Festival cv.	Salmony cv.	Mean
Storage periods (month):								
1	77.69	82.65	71.00	77.11	83.50	86.23	70.85	80.19
2	80.90	86.00	73.75	80.21	85.96	87.37	75.84	83.05
3	83.30	87.02	74.98	81.76	86.58	88.38	78.43	84.46
4	69.03	74.22	59.08	67.44	74.29	78.14	63.21	71.88
5	61.50	67.00	52.34	60.28	67.46	70.31	56.09	64.62
6	54.02	60.02	46.63	53.55	60.45	64.66	50.55	58.55
Mean	71.07	76.14	62.96		76.37	79.18	65.82	
L.S.D. at 5%								
Cultivars		0.67				0.67		
Storage periods		0.95				0.95		
Cultivars x storage periods		1.65				1.65		

Table (6): Fresh weight of roots of rooted cuttings, which received different periods of cold storage at 2–4°C as unrooted cuttings two months after planting during 1995/1996 and 1996/1997 seasons.

Character	Fresh weight of roots per plant (g)							
	First season 1995/1996				Second season 1996/1997			
Treatment	Bianca cv.	Festival cv.	Salmony cv.	Mean	Bianca cv.	Festival cv.	Salmony cv.	Mean
Storage periods (month):								
1	4.87	5.34	4.59	4.93	4.77	5.36	4.60	4.91
2	4.91	5.81	4.31	5.02	4.86	5.74	4.24	4.94
3	4.93	5.98	4.97	5.29	4.88	5.76	4.82	5.15
4	3.92	4.25	3.68	3.95	3.92	4.24	3.69	3.95
5	3.55	3.62	3.25	3.47	3.51	3.59	3.22	3.44
6	3.22	3.29	2.91	3.14	3.19	3.23	2.89	3.10
Mean	4.23	4.71	3.95		4.18	4.65	3.91	
L.S.D. at 5%								
Cultivars		0.67				0.67		
Storage periods		0.95				0.95		
Cultivars x storage periods		1.36				1.36		

Table (7): Flowering characteristics of unrooted cuttings after 3 and 6 months cold storage at 2–4°C of different cultivars during 1995/1996 and 1996/1997 seasons.

Measurement / Cultivar	Number of days until color showing		Number of flowers per plant		Diameter of flower (cm)		Length flowering stem (cm)	
	First season 1995/96	Second season 1996/97	First season 1995/96	Second season 1996/97	First season 1995/96	Second season 1996/97	First season 1995/96	Second season 1996/97
3 months cold storage at 2-4°C								
Bianca	103.4	101.6	7.83	8.49	5.82	6.02	22.72	23.12
Festival	101.8	100.4	8.43	8.68	6.32	6.11	23.89	23.21
Salmony	106.8	105.5	7.56	7.98	4.82	5.31	22.23	22.81
6 months cold storage at 2-4°C								
Bianca	140.0	139.6	4.33	4.88	2.88	2.63	9.55	10.04
Festival	134.5	133.7	4.61	5.20	3.34	3.14	10.57	10.05
Salmony	142.5	140.4	4.48	4.67	2.58	2.95	9.20	9.73
L.S.D. at 5%								
Cultivars	1.59	1.30	0.46	0.62	0.33	0.39	0.80	0.77
Storage periods	26.47	21.61	0.37	0.51	0.27	0.32	0.65	0.63

Table (8): Mortality percentage of rooted cuttings, which received different periods of cold storage at 2–4°C as unrooted cuttings two weeks after planting during 1995/1996 and 1996/1997 seasons.

Character / Treatment	Mortality percentage of rooted cuttings (%)							
	First season 1995/1996				Second season 1996/1997			
	Bianca cv.	Festival cv.	Salmony cv.	Mean	Bianca cv.	Festival cv.	Salmony cv.	Mean
Storage periods (month):								
1	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.60
2	1.6	1.6	3.3	2.2	3.3	1.6	3.3	2.73
3	3.3	1.6	5.0	3.3	3.3	3.3	5.0	3.86
4	6.6	5.0	10.0	7.2	6.6	6.6	8.3	7.16
5	10.0	8.3	13.3	10.5	11.6	10.0	13.3	11.63
6	10.6	10.0	15.0	11.9	13.3	13.3	16.6	14.40
Mean	5.61	4.68	8.03		6.61	6.06	8.01	
L.S.D. at 5%								
Cultivars		0.30				0.22		
Storage periods		0.43				0.32		
Cultivars x storage periods		0.74				0.55		

Concerning the effect of cold storage periods, data in the same Table showed that plants produced from cuttings stored for 6 months had the significantly highest mortality percentages of Bianca, Festival and Salmony cvs. (10.6, 10.0 and 15.0%) and (13.3, 13.3 and 16.6%) than those stored for 3 months (3.3, 1,6 and 5.0%) and (3.3, 3.3 and 5.0%) in both seasons, respectively.

DISCUSSION

Storage potentiality and optimum storage duration do drastically influenced by the cultivar type. Storage at 2–4°C may be used to retard growth and maintain visual quality without adversely affecting growth of carnation cultivars with greater storage life. One, two and three months storage at 2-4°C did not significantly affect visual quality or the greenhouse establishment of the three cultivars with greater storage life, but extending storage up to 4, 5 and 6 months could reduced significantly visual quality and growth up on removal from environment storage. Results suggested that storage potential and optimum storage duration should be evaluated for each cultivar before deciding low-temperature storage degree. Results indicate that Festival cv. stored at 2-4°C for different periods was more cold-tolerance and showed significantly influence on growth as measured by vegetative, rooting and flowering growth than Bianca and Salmony cvs.

The cold storage of unrooted materials from 1, 2 and 3 months was superior to the storage duration of similar material for 4, 5 and 6 months. The deterioration of stored unrooted cuttings as characterized by reduction of fresh weight following the cold storage was found to be a limiting factor in the this study as well as in other studies which were obtained by Wills *et al.* (1982) and Rajapakse *et al.* (1996) since they found that the largest quantitative change associated with cold storage of cuttings for specific periods was depending on cultivar, storage period and storage temperature, whereas the breakdown of carbohydrates polymers especially pectic substances and hemicelluloses, led to the reduction of fresh and dry weights. On the other side, leaves of Chrysanthemum cuttings possibly lost some of their water content after storage for four or five weeks. This loss of water directly reduces the fresh weight of cuttings causing wilting and desiccation if cuttings are stored just for longer periods (Eisenberg *et al.*, 1978 and Rudnicki *et al.*, 1991).

In addition, foliar chlorosis or yellowing was easily noticed in various degrees on unrooted cuttings from 4, 5 and 6 months, and found to be a limiting factor subsequently in this study. These results were in agreement with those obtained by Odom and Holley (1954) since they found that depletion of carbohydrates with high rates of respiration enhances foliar yellowing. Moreover, Eisenberg *et al.* (1978) explained that unrooted cuttings appeared more chlorotic after three weeks of cold storage since they tend to lose more water during storage than the rooted cuttings. It is mainly known that the green colour of leaves and stems is due to the presence of chlorophyll. The loss of green colour of cuttings following the cold storage for comparatively long periods or high temperature is due to degradation of the

chlorophyll structure as reported by Wills *et al.* (1982) and supported by the finding of Van de Pol (1988).

The present results showed that diseased tissue was not observed on the unrooted carnation cuttings, which were treated with Benlate and Vetafax mixture at 2 g/l for 10 min. monthly until the plant material had been in cold storage for 6 months. These results were in agreement with those obtained by Lutz and Hordenburg (1968) who reported the use of fungicides also reduce pathogen growth.

Also, the results indicated that the rooting percentage, and fresh weight of unrooted cuttings were declined gradually during storage starting from 4, 5 and 6 months storage. These results could be explained by the findings obtained by Van de Pol (1988) who reported that root production and rooting percentage were clearly found to be decreased with increasing the storage period of cuttings or the non suitable temperature of storage. In this concern, there are many reasons for maintaining leaves on stored cuttings and leaves which play an important role in the process of rootings. Leaves are known to produce auxins and rooting co-factors as well as being a site of carbohydrates synthesis (Hartmann and Kester, 1975). Without these root enhancing factors which are produced in the leaves, rooting would most probably be inhibited or reduced (Eisenberg *et al.*, 1978). Evidence supporting this inference is that the cuttings, kept in storage from 4, 5 and 6 months gave the lowest rooting percentages and lowest value of fresh weight, i.e. their content of carbohydrates and root enhancing factors are believed to be less than those cuttings stored for 1, 2 and 3 months only, which gave good rooting percentage in propagation medium. The foliar chlorosis of these cuttings stored from 4, 5 and 6 months storage is also responsible for the weak rooting ability obtained. Wills *et al.* (1982) and Van der Hoeven (1991) obtained similar results supporting this work, whereas green stems of chrysanthemum cuttings which might be low in carbohydrates but high in nitrogen usually were found to decay in the propagation bench without producing either roots or shoots (Yang, 1992). Cuttings in storage usually undergo several chemical catabolic changes including the partial breakdown of carbohydrates especially pectic substances and hemicelluloses which weakens cell walls and the cohesive forces binding cells together leading to the decay of cuttings before being able to root (Rajapakse *et al.*, 1996).

Finally, the number of days to flowering as well as number and diameter of flowers in all cultivars were significantly reduced by increasing the storage periods more than 3 months. These results could be explained by the finding obtained by Crater (1980) who stated that the delay or retardation of growth is a direct reaction for the week growth of rooted cuttings as affected by the long period of cold storage.

The length of flowering stems at harvest time were declined with increasing the storage period for more than 3 months storage. These results were in agreement with those results obtained by Langhans (1954) and Rajapakse *et al.* (1991) who found that unrooted cuttings stored longer usually recover more slowly, make less growth and produce shorter flowering stems. In this concern, the overall inhibition of growth, as well as the shorter

cut stems occurred following the refrigerated storage of unrooted cuttings of chrysanthemum are considered as an expected biological reaction. Delay or retardation of growth is a direct reaction for the week growth of rooted cuttings as affected by the long period of cold storage (Crater, 1980).

As storage time increased, the mortality percentage of young plants after planting in culture medium increased. Whereas, storage of unrooted cuttings for 4, 5 and 6 months gave the highest mortality percentage. There are many reasons of deterioration and mortality of young plants in culture medium often limited by the cuttings might not have healthy root system capable to continue growing in the soil after transplanting (Van der Hoeven, 1991). Foliar chlorosis is a direct reaction for the decomposition of carbohydrates and the subsequent deterioration which leads to continue yellowing in the greenhouse causing mortality (Rudnicki, 1991). The imbalance between root and shoot system may be related to which start growing in the greenhouse with poor root system, while all the environmental conditions in the greenhouse accelerates the growth of the shoot system. This kind of root/shoot imbalance leads to a severe stress resulting in the deterioration of cuttings in short time (Van der Hoeven, 1991).

It is a matter of interest to state that all the characters concerning flowering of Festival rose cultivar fossessed the superior values over the other two cultivars. This concept was true with 3 and 6 months storage. When comparing in general all different flowering values it was found that 3 months storage were better than those of 6 months storage. Since flowering characters were the main objective it may be concluded that storage more than 3 months resulted in less values. However, storage until 6 months could be applied in compulsory cases.

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تأثير التخزين البارد على بعض صفات النمو الخضرى والجذرى والزهرى للعقل غير المجذرة لبعض أصناف نبات القرنفل الأمريكى *Dianthus caryophyllus* L. cvs.

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أجرى هذا البحث فى المزرعة البحثية ومعمل أبحاث قسم الخضر والزينة بكلية الزراعة – جامعة المنصورة خلال موسمى الزراعة المتتاليين ١٩٩٥/١٩٩٦، ١٩٩٦/١٩٩٧ وذلك بهدف دراسة أفاق استخدام التخزين المبرد لعقل القرنفل غير المجذرة لفترات تخزين مختلفة على صفات النمو للعقلة الخضرية والنباتات التى يتم التحصل عليها خلال مرحلة النمو الخضرى وحتى مرحلة الأزهار فى أصناف Bianca, Festival , Salmony حيث أشارت النتائج المتحصل عليها إلى اختلاف الأصناف المذكورة فى مدى الاستجابة لمعاملات البحث ولكن بوجه عام فإن التخزين البارد لفترات تخزين مختلفة على درجة الحرارة ٢-٤°م لعقل القرنفل غير المجذرة لصنف Festival أعطى أعلى قيم لقياسات النمو الخضرى وعملية التجذير والنمو الزهرى يليه الصنف Bianca، بينما كان الصنفSalmony أقلهم فى ذلك فى كلا الموسمين.

وقد أظهرت النتائج أن قياسات النمو الخضرى والجذرى لنبات القرنفل قد انخفضت بدرجة معنوية انخفاضاً متوازياً مع إطالة فترة التخزين للعقل، وأشارت النتائج أيضاً أن التخزين البارد للعقل لمدة تصل إلى ٣ أشهر قبل مرحلة التجذير قد أعطى أعلى قيم لصفات النمو الخضرى والوزن الطازج للعقل والنمو الخضرى للنبات وطول النبات، عدد الأفرع بالإضافة إلى إنتاج الجذور على العقل ونسبة نجاح التجذير والوزن الطازج للجذور بالإضافة إلى أن قيم قياسات النمو الخضرى والجذرى قد انخفضت بوضوح وبدرجة معنوية مع زيادة فترة التخزين البارد للعقل لمدة تصل الى ٦ أشهر قبل مرحلة التجذير فى كلا الموسمين.

وقد استجابت قياسات عدد الأيام اللازمة حتى الأزهار وعدد وقطر الأزهار وطول الساق المزهر لفترة التخزين البارد فى مرحلة التزهير والقطف. وقد بينت النتائج أن قياسات صفات النمو الزهرى وقت القطف قد أظهرت انخفاضاً ملحوظاً بزيادة فترة التخزين خصوصاً عندما تم تخزين العقل لفترة ٦ أشهر مقارنة بالتخزين لفترة ٣ أشهر فى كلا الموسمين.

تشير النتائج بوضوح أيضا إلى تأثر نسبة موت الشتلات النامية فى أكياس الزراعة بالتخزين البارد حيث أدى تخزين العقل غير المجذرة لفترات طويلة نسبيا تصل إلى ٤ أو ٥ أو ٦ أشهر إلى ارتفاع نسبة موت الشتلات فى كلا الموسمين.

وعموماً فإنه يمكن التوصية بإمكانية التخزين البارد لعقل القرنفل غير المجذرة فى أصناف Bianca, Festival , Salmony لمدة تصل إلى شهر وتمتد إلى ٣ أشهر على درجة حرارة ٢ –٤ °م ورطوبة نسبية بمتوسط ٨٥% فى أكياس بولى ايثيلين غير مثقبة دون حدوث تأثيرات على الجودة ويمكن اللجوء إلى التخزين البارد لفترة تتراوح من ٤ إلى ٦ أشهر عند الضرورة.