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Full Length Research Paper

Cold storage of rooted and non-rooted carnation cuttings

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The specific objectives of this study were to evaluate the effect of storage duration on the survival rate of rooted cuttings and to determine the rooting and survival rates of non-rooted cuttings for two standard carnation cultivars (that is., Dianora and Vittorio). The survival rates of rooted cuttings showed differences depending on the cultivar tested. Specifically, the Vittorio cultivar had a better reaction to long-term storage. The survival and rooting rates of non-rooted cuttings after cold storage also showed differences depending on the cultivar tested. Vittorio cultivar reacted better to storage than the Dianora cultivar.

Key words: Carnation, cuttings, cold storage, postharvest physiology.

INTRODUCTION

Low temperatures are commonly used for post-harvest storage of *in vitro* propagules, transplants, and rooted cuttings. Short-term post-harvest storage of cuttings allows cutting producers to regulate the market supply during surplus production or peak demand to help accommodate propagation and production schedules (Hentig and Kn¨osel, 1986; Heins et al., 1992; Bessembinder et al., 1993; Kubota and Kozai, 1995; Rajapakse et al., 1996; Joyce et al., 2000; Lopez and Runkle, 2008). However, cuttings can deteriorate with extended storage due to excess respiration, light exclusion, exposure to extreme temperatures, moisture loss, pathogen invasion, and ethylene accumulation (Wang, 1987; Purer and Mayak, 1988; Rapaka et al., 2007). These abiotic and biotic factors can influence the aesthetic qualities (example. necrotic lesions, senescence, desiccation, and chlorophyll degradation) of the cuttings and their subsequent performance during production. In addition, the survival and rooting rates of herbaceous and woody ornamental species can be influenced by environmental conditions during shipping and storage (Conover, 1976; Hentig and Kn¨osel, 1986; Wang, 1987, 1994; Garrido et al., 1996; Arteca et al., 1996; Rajapakse et al., 1996; Druege et al., 2000).

The genetic properties of cold storage materials and conditions had its effect on suitable cold storage duration. The duration and the temperature of cold storage vary according to the plant species and variety being stored (Hardenburg et al., 1986; Laurie et al., 1969; Nowak and Rudnicki, 1990). Non-rooted carnation cuttings can be stored for 2 months or more at 0 - 2°C according to Laurie et al. (1969), 6 months at 0°C according to Gürsan (1988) and Wright et al. (1954), 5 - 6 months at - 0.5 - 0°C according to Hardenburg et al. (1986), or 6 months at - 0.6°C according to Langhans (1954) prior to usage. For non-rooted chrysanthemums, cuttings can be stored for 5 - 6 weeks at - 0.5 - 0°C according to Hardenburg et al. (1986) or 6 months at - 0.6°C according to Langhans (1954) prior to usage. Non-rooted geranium cuttings can be stored for 4 - 6 weeks at - 0.5°C according to Eisenberg et al. (1978) prior to usage. The storage of rooted cuttings is similar to that of the non-rooted cuttings in which they can be store for a long time. According to Hardenburg et al. (1986), rooted carnation cuttings stored for 5 - 6 months at - 0.5 - 0°C, rooted chrysanthemum cuttings stored for 3 - 6 weeks at - 0.5 - 1.6°C, and rooted poinsettia cuttings stored for 1 week at 5°C can all be successfully used after storage. Laurie et al. (1969) do not recommend storage of rooted cuttings for more than 8 weeks because of a decreased survival rate after planting. On the other hand, for the storage of non-rooted cuttings, more cuttings must be taken from a limited number of rootstock plants (Laurie et al. 1969).

In the commercial production of rooted carnation plants and other species, cuttings usually must be stored for several weeks to match production with demand. Although

the exact influence of storage on rooting has not been widely investigated, storage in a cold chamber has long been known to be a good procedure for preserving carnation cuttings intended for rooting (Holley and Baker 1990; Garrido et al., 2003). In a pioneering study, Van de Pol et al. (1982) concluded that cold storage can accelerate the rooting process. An earlier study showed that the initiation of roots in 'Red Baron' carnation cuttings was promoted during storage; the effect was dependent on the temperature (0 - 25°C) and the storage period (3 -15 days) (Van de Pol and Vogelezang, 1983). Langhans (1954) obtained 100% rooting success for cuttings from four carnation varieties after 6 months of storage at -0.6°C, whereas Holey and Farmer (1951) obtained 72 - 92% rooting after 73 - 113 days of storage.

The specific objectives of this study were to evaluate how the duration of storage influences the survival rates of rooted cuttings and to determine the rooting and survival rates of non-rooted cuttings of two standard carnation cultivars, Dianora and Vittorio.

MATERIALS AND METHODS

This study was carried out on two standard carnation varieties (*Diantus caryophillus* L., cultivars,'Dianora' and 'Vittorio'). The rooted and non-rooted cuttings used in this experiment were obtained from a custom grower. The cuttings were immersed in Rovral solution (1% iprodione) to prevent fungal contamination (Zencirkiran and Mengüç, 2003), dried for 10 min and then stored at 0 - 0.5°C in polyethylene bags, which were placed inside cardboard boxes. The first analysis was performed at the beginning of the experiment, and then rooted cutting samples taken from cold storage were planted in beds in the plastic house. The survival rate perlite, and cuttings were not treated with any hormones. The (%)was then determined at one - month intervals. The non-rooted cuttings were rooted in a mist propagation setting, which contained maximal and minimal ambient temperatures in the greenhouse (daily mean ± SD) were 24 ± 1°C and 13 ± 1°C, respectively, and the substrate temperatures were 20 ± 1°C and 15 ± 1°C, respectively. Irrigation by micro aspersion was programmed to maintain 80 - 85% relative humidity during the rooting period (for 30 days after planting). After the thirty -day period, the rooting rate was determined, and the rooted cuttings were planted in beds in the plastic house, after which the survival rate (%) was determined.

The trial was carried out using randomized plots in a factorial experimental design with five replicates, which comprised 30 cuttings each. Statistical analyses were performed using the PC-Excel software package. The data were analyzed using a two-factor analysis of variance (ANOVA). Separation of means was performed using Duncan's Multiple Range Test at the 0.01 level.

RESULTS

Rooted cuttings

Based on statistical evaluation, the variety of the carnation and the duration of cold storage had important effects on the survival rates of rooted carnation cuttings. The two varieties showed different survival rates after cold storage, with a higher survival rate (88.15%) being observed for the Vittorio cultivar. On the other hand, the survival rates decreased with increased durations of cold storage (Tables 1 and 2).

Non-rooted cuttings

The variety of the carnation and the duration of cold storage also significantly affected the rooting and survival rates for non-rooted carnation cuttings. The rooting and survival rates were decreased depending on the duration of cold storage (Tables 3 and 4).

DISCUSSION

The rooted cutting survival rate showed differences depending on the cultivar being tested. The Vittorio cultivar had a better reaction to long-term storage. In addition, the survival rate of the rooted cuttings decreased depending on the duration of cold storage. In particular, after two months of storage, the decrease in survival rate became significantly important, and after 4 months storage, the decrease was close to 50% (Table 1). Despite higher losses in emergence, rooted cuttings can remain in cold storage for longer periods of time (Langhans, 1954; Özbek, 1959; Laurie et al., 1969; Hardenburg et al., 1986; Gürsan, 1988; Nowak and Rudnicki, 1990; Garrido et al., 1996; Rajapakse et al., 1996; Holley and Baker, 1990).

After cold storage, the survival and rooting rates of non-rooted cuttings showed differences depending on the cultivar tested. The Vittorio cultivar had better results than the Dianora cultivar. However, the survival and rooting rates of the cuttings decreased by 50% after 4 months of storage (Table 4). These results for the non-rooted cuttings parallel those of Holey and Farmer (1951). However, the reduction in the rooting rate was not too high after 2 - 3 months of cold storage in the present study. This finding can be attributed to the known promotion of root formation by cold storage, which is dependent on the storage time and temperature (Van de Pol and Vogelezang, 1983). Based on the results of this study, rooted and non-rooted carnation cuttings can be stored at 0 ± 0.5°C for 3 - 4 months, especially when storage is necessary to meet the increased demands for production materials during special times. However, the tolerable duration of cold storage and the survival and rooting rates are influenced by carnation cultivar. The decreases in rooting and survival rates must always be kept in mind during long-term storage, and varieties that tolerate long-term storage should be used.

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Table 1. Survival rate of rooted cuttings of carnation cultivars.

Cultivars	Survival rate after cold storage (%)
Dianora	66.45 b*
Vittorio	88.15 a

*Mean separation in columns by Duncan's multiple range test (P = 0.01).

Table 2. Survival rate of rooted cuttings of carnation at different cold storage periods.

Storage period (month)	Survival rate after cold storage (%)
0 (Control)	100.0 a*
1	90.12 b
2	73.62 c
3	64.90 d
4	57.85 e

*Mean separation in columns by Duncan's multiple range test (P = 0.01).

Table 3. Survival and rooting rate of non-rooted cuttings of carnation cultivars.

Cultivars	Rooting rate after cold storage (%)	Survival rate after rooting (%)
Dianora	57.66 b*	67.57 b*
Vittorio	92.52 a	89.11 a

* Mean separation in columns by Duncan's multiple range test (P = 0.01).

Table 4. Survival and rooting rate of non-rooted cuttings of carnation at different cold storage periods.

Storage period (Month)	Rooting rate after cold storage (%)	Survival rate after rooting (%)
0 (Control)	100.0 a*	100.0 a*
1	94.0 b	89.10 b
2	63.50 c	75.15 c
3	60.15 d	68.17 d
4	57.80 e	59.28 e

* Mean separation in columns by Duncan's multiple range test (P = 0.01).

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