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Antitranspirant compounds alleviate the mild-desiccation-induced reduction of vase life in cut roses

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ABSTRACT

The vase life sensitivity to mild desiccation (12% weight loss) was addressed in rose, together with alleviation possibilities. The postharvest longevity upon arrival or following mild desiccation was determined on eight cultivars, combined with several morpho-physiological traits. Mild desiccation significantly decreased (10–39%) the vase life of six cultivars (termed sensitive), whereas it did not affect the vase life of two (thus tolerant). More severe desiccation (>12% weight loss) shortened the vase life of a tolerant cultivar. Stomatal control of water loss explained a large part of vase life variation following mild desiccation, whereas cut flower ability to rehydrate or pedicel rigidity (strength, wood density) did not significantly contribute to this variation. Four potentially-mitigating treatments were further tested on the three most sensitive to mild-desiccation cultivars. Antitranspirant treatments [SNP (elicitor of NO) or acetylsalicylic acid in vase water or darkening] decreased the cut flower water loss during the postharvest phase and alleviated the mild-desiccation-induced reduction in vase life. In contrast, Tween 20 (wetting agent) in the vase water shortened vase life. It is concluded that the vase life of previously desiccated cut roses can be extended by employing treatments that reduce the postharvest water loss.

1. Introduction

Postharvest handling of cut flowers is not always optimal. For instance, they are often held out of water at different points between producer and consumer (often referred to as dry storage; Reid and Jiang, 2012). Dry storage decreases vase life depending on the rose cultivar (Nell and Leonard, 2005; Moody et al., 2014), but the factors underlying this variation are poorly understood. It may be expected that rose cultivars with a better control of water loss or an improved ability to regain weight, following a dehydration event, are less prone to a vase life decrease owing to prior water stress (Fanourakis et al., 2013b). Less vase life problems are also expected from cultivars with more rigid pedicels, which often bend ending vase life (Fanourakis et al., 2015b).

Treatments that improve water balance are expected to mitigate the negative effect of prior water stress on vase life. Antitranspirant compounds, such as sodium nitroprusside (SNP) (a nitric oxide (NO) donor; Giday et al., 2013a) and acetylsalicylic acid (Miura and Tada, 2014), or darkening (Fanourakis et al., 2013a) that decrease water loss owing to stomatal closure, are expected to promote vase life of cut flowers that were previously partially desiccated. Conditions that promote water uptake, such as addition of surfactants in the vase water (van Doorn et al., 1993, 2002), may also be effective in alleviating the negative effect of partial desiccation on vase life.

Although the ability of cut flowers to recover from water deficit is an important trait, several other traits ought to be considered for evaluating and selecting a cultivar (Gitonga et al., 2014). Based on

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this background, our analysis was supplemented with additional morphological characters, including number of petals, distribution of prickles on the stem, leaf complexity, together with leaflet shape and serration.

The main objectives of the present work were: (i) to analyze the magnitude of variation in the effect of mild desiccation (12% weight loss) on vase life of eight cut rose cultivars, (ii) to relate the cultivar differences in vase life to water-status traits (control of water loss, ability to rehydrate) and to pedicel rigidity (strength, wood density), and (iii) to test alleviating possibilities of the mild-desiccation-induced reduction in vase life. This study also contains data on economically-important morphological traits.

2. Materials and methods

2.1. Plant material and growth conditions

Cut roses were obtained from a commercial grower (Polioudakis G., Rethymno, Greece). Plants were grown in a multispan plastic greenhouse. Two harvests were conducted (6 and 20 July, 2015), supplying material for the two respective experiments. In the first harvest, eight cultivars were tested (Testarossa, Avalanche, Bordeaux, Jumilia, Gladiator, Lenny, Sorbet avalanche, and Talea). Based on these data, four cultivars (Testarossa, Bordeaux, Lenny and Jumilia) were further selected for the second experiment.

Twenty days prior to each harvest (corresponding to the growth period), climate parameters were automatically recorded. Preceding the first harvest, mean air temperature was $22.3 \pm 0.4\,^{\circ}C$ and prior to the second harvest it was $23.7 \pm 0.7\,^{\circ}C$. Relative air humidity (RH) averaged $53 \pm 6\%$ in either period, resulting in vapour pressure deficits (VPDs) of 1.27 ± 0.16 kPa (experiment 1) and 1.38 ± 0.18 kPa (experiment 2). Based on the proximity of the two harvest dates and the comparable evaporative demand during the two growth periods, it is safe to attribute the noted phenotypic differences to the genotype (thus limiting its interaction with the growth environment).

In either experiment, harvested shoots had a length of approximately 70 cm and a flower bud with a cylindrical shape and pointed tip. Cut flowers were collected in the morning (08:00–10:00 h), and immediately placed in buckets with aqueous sodium hypochlorite solution (1%, v/v). The stems were transferred to the laboratory in these buckets at the day of harvest and by using refrigerated transport (2 °C). Upon arrival, the leaves on the lower 15 cm of the shoot were stripped. Cut flowers were stored overnight in buckets with water containing sodium hypochlorite (1%, v/v), at 2 °C and darkness.

2.2. Morphological traits (experiment 1)

Since previous studies on roses are mostly limited to either morphological characteristics or postharvest longevity (Gitonga et al., 2014; Carvalho et al., 2015), combined examination (or selection) of these traits is currently not favored. To stimulate the overlap between these two trait groups and provide a more comprehensive data set, we here recorded three important ornamental traits of the eight cultivars under study. No relation of these morphological traits with vase life is to be expected.

Since the number of flower organs, especially petals, mainly determines flower size (Bendahmane et al., 2013), we counted the number of petals and sepals on the flower ($n = 30$). Counts were obtained from maximally opened flowers (i.e., visible anthers).

A morphometric analysis of the compound leaf is also provided, by analyzing leaf complexity ($n = 30$) and leaflet shape ($n = 20$). For the former, the number of leaflets was counted in all leaves. The latter was derived from photographs. Leaves were photographed (Sony DSC-W830, Sony Corporation, Tokyo, Japan) under non-reflective glass from a distance of 50 cm, employing a copy stand. Images included two rulers for scale. For each of the twenty replicate shoots, we measured 14, 15, 16, 16, 19, 20, 22 and 28 leaflets for the cultivars Jumilia, Gladiator, Testarossa, Lenny, Sorbet avalanche, Bordeaux, Avalanche, and Talea, respectively (representing more than 3,000 measured leaflets). Using ImageJ, leaflet lamina outlines were processed to calculate two metrics of leaf form, the circularity $[(4\pi \times \text{area})/(\text{perimeter})^2]$ and the aspect ratio [(major axis)/(minor axis); axes of the best-fitted ellipse]. Circularity ranges from 0 (infinitely narrow) to 1 (perfectly circular), and is sensitive to serration (low circularity means increased serration) (Chitwood et al., 2015). The aspect ratio of a circle is 1, and increases as shape becomes more elongated.

Absence of prickles on the stem is an increasingly important trait due to the ease of harvest, handling and transport of the flowering shoots (Gitonga et al., 2014). The number of prickles was counted on every 10-cm segment taken along the length of the shoot, starting from the cut point ($n = 30$).

2.3. Traits potentially related to vase life (experiment 1)

It may be expected that cut flowers that lose less water upon water deprivation have a better longevity when water availability is restored (Giday et al., 2014; Fanourakis et al., 2015a,b). Cultivar differences in the control of water loss in response to desiccation (as an indication of stomatal responsiveness to water stress) were investigated. The cut flowers were taken from the refrigerated storage (2 °C and darkness) and placed into the test room, where they were kept for 2 h prior to measurements. This period served the dual aim of inducing stomatal opening and bringing cut flowers to test room temperature. The cut flowers were then placed in empty vases in the test room, and cut flower weight was recorded for 6 h. Test room conditions were air temperature of $25.0 \pm 0.2\,^{\circ}C$, RH equal to $50 \pm 3\%$, and light intensity of $50\,\mu mol\,m^{-2}\,s^{-1}$ provided by fluorescent lamps (T5 fluorescent lamp; GE lighting, Cleveland, OH, USA). The eight cultivars under study were assessed ($n = 14$).

In the way of expectations, cut flowers with improved ability to regain weight, lost as a result of desiccation, have a longer vase life upon re-watering. Under this background, the rehydration ability following a dehydration event (as an indication of water transport restoration) was determined on the eight cultivars under study. Cut flowers were taken from the refrigerated storage, and the same procedure as applied for desiccation was followed, as described above. Cut flowers were allowed to dehydrate to 82% of the initial weight. Then the cut ends were immediately placed in buckets filled with water. Afterwards, the cut flowers were incubated for 12 h in the refrigerated storage (2 °C and darkness). Subsequently, cut flower weight was measured. Measurements were conducted on fourteen cut flowers per cultivar.

The vase life of cut roses often ends owing to bending of the pedicel (Fanourakis et al., 2015b). The strength (mass per unit length) and wood density (mass per unit volume) (Larjavaara and Muller-Landau, 2010) were calculated for both stem and pedicel, as potential indicators of the sensitivity to bending of the latter. Stem and pedicel volume was calculated considering the respective diameter assessed midway along its length $[\pi \times (\text{radius})^2 \times (\text{length})]$. Fresh mass was employed in the calculations. Eleven (strength) and twenty (wood density) cut flowers per cultivar were evaluated.

2.4. Effect of mild desiccation on vase life (experiment 1)

The effect of mild desiccation on vase life was investigated on the eight cultivars under study. The night before the experiment, the cut flowers were kept in the dark refrigerated storage (2 °C) for