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Physical stem-end treatment effects on cut rose and acacia vase life and water relations

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ABSTRACT

Cut *Rosa hybrida* cv. High & Mighty flowers and *Acacia holosericea* (Velvet Leaf Wattle) foliage were subjected to various physical stem-end treatments as practised by florists. Their effects on longevity (vase life) and water relations [relative fresh weight (RFW) and vase solution uptake (VSU)] were quantified. All vase water contained sodium dichloroisocyanurate (DICA) biocide. Bark removal had either positive or neutral effects on the vase life of fresh-cut rose and had either neutral or negative effects on fresh-cut acacia. Stem-end splitting had either no or negative effects on the vase life of fresh-cut rose and acacia. However, both bark removal and stem-end splitting increased the vase life of both species when applied after short term storage for 24 h at 4 °C. Crushing stems had no effect on the vase life of fresh-cut rose, but tends to increase the vase life of fresh-cut acacia. Hot water scalding either increased or had no effect on the vase lives of rose and acacia. The tendency for bark removal to increase vase life of fresh-cut rose was associated with better maintenance of RFW and sustained VSU. However, for the most part, stem-end treatments had typically negative or neutral effects on RFW of fresh-cut rose and acacia. Likewise, the treatments had mostly negative or neutral effects on VSU. Overall for both species, there is little or no benefit and potentially negative effects on vase life, RFW and VSU of applying stem-end treatments as sometimes advocated by florists.

1. Introduction

Cut flowers and foliage can have limited commercial value because they dehydrate during vase life as a result of decreased water uptake. This is true for cut rose flowers (van Doorn, 1997) and cut acacia foliage (Horlock et al., 2000; Williamson et al., 2002; Damunupola, 2009). In cut roses, water stress caused by xylem vessel blockage is a major cause of vase life termination due to premature petal wilting, lack of proper flower opening, wilting of foliage and/or bending of the pedicel ('bent neck') (van Doorn and Perik, 1990; Knee, 2000). In the case of *Acacia holosericea* (Velvet Leaf Wattle) foliage, a very short vase life of 4–7 d limits its commercial potential. Insufficient water uptake due to possible stem-end occlusion leads to early phyllode (leaf) wilting and desiccation in this otherwise promising Australian native cut foliage crop (Damunupola et al., 2010).

Cut flowers and foliage develop water deficit even when placed in water (Halevy and Mayak, 1981; van Doorn, 1997). A negative water balance develops when transpiration is greater than uptake (Halevy et al., 1978). Impaired water uptake is typically caused by cut stem occlusions due to microbial, physiological and physical plugging of xylem vessels (e.g. Nijsse et al., 2000; van Doorn and Cruz, 2000). Resistance to water flow in cut rose stems rises markedly soon after they are harvested (Evans et al., 1996).

Numerous studies have demonstrated positive effects of various chemical additives (e.g. biocides, surfactants, ethylene inhibitors, wound healing enzyme inhibitors) on the postharvest water relations and longevity of cut flowers (e.g. de Stigter, 1980; Jones et al., 1993; van Doorn et al., 1993). However, despite anecdotal evidence of positive effects (Milner, 2009), improving postharvest water relations of cut flowers and foliage by various physical stem-end treatments is little researched.

There has been research into bark removal at the base of cut rose stems to increase water uptake (de Stigter and Broekhuysen, 1986). This physical treatment effected increased water uptake and a 25% increase in FW compared with the control. Florists sometimes advocate splitting or crushing stems and also removing bark at the base of the stem to increase water uptake and extend vase life (Jones, 2001; Milner, 2009). These practices are thought to increase exposure of the vasculature to vase solution. Dipping of stem-ends into scalding (almost boiling) water is also recommended in some cases. This is particularly so for stems which contain latex with

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a view to preventing it from exuding and blocking xylem vessels (Jones, 2001). However, scalding might also sterilize stem-ends and/or destroy enzymes that otherwise lead to blockages in water uptake. Dipping of the base of *Thryptomene calycina* stems into 100 °C water for 1 min markedly increased vase life (Jones et al., 1993).

On the other hand, physical treatments are likely to damage xylem vessels, allow ingress of microbes and increase nutrient supply for microbes, which occlude stems (Jones, 2001). Other possible side effects of wounding tissues include stimulated defence-related enzyme activity and gene expression; e.g. peroxidase (Kawaoka et al., 1994) and ACC oxidase (Peck-Scott and Kende, 1999). These responses lead to biosynthesis of suberin, lignin and other wound healing compounds (Negrel et al., 1993; Moehs et al., 1996), including deposition of mucilage and tylose formation (Weiner and Liese, 1995) along with deposition of gums in the lumen of xylem conduits (Davies et al., 1981). Production of such compounds in nature serves, by xylem occlusion, to reduce entrance of microbes into damaged tissues (Bucciarelli et al., 1998). Wounding may also stimulate ethylene production (Ciardi and Klee, 2001) and promote senescence (Abeles et al., 1992) and abscission (Rapaka et al., 2007).

In addition to improving water uptake, other approaches to maintaining a positive postharvest water balance for cut flowers and foliage include minimising water loss though reduction in leaf area, keeping them in an environment conducive to less water loss (viz. low temperature and high RH) and providing compatible osmotica (e.g. sucrose) in vase and/or pulsing solutions (Halevy and Mayak, 1981; Jones et al., 1993; van Doorn, 1997).

The current experiments compared various physical stem-end treatments as used by florists (i.e. bark removal, stem-end splitting, stem-end crushing and hot water scalding) with the aim to improve the postharvest water relations of cut rose and acacia. It was hypothesised that the various physical stem-end treatments would improve water uptake by presenting a larger surface area of stem xylem conduits to increase direct and indirect access of water.

2. Materials and methods

2.1. Plant materials

Cut stems of rose (*Rosa hybrida* L. 'High & Mighty') harvested when petals were about to reflex (Ichimura and Ueyama, 1998) and Velvet Leaf Wattle (*A. holosericea* A. Cunn. ex G. Don; Elliot and Jones, 1982) foliage were obtained from greenhouse and field plantings, respectively, at Karalee (152°50′E, 27°32′S), Queensland, Australia. They were transported to the University of Queensland, Gatton postharvest laboratory within 2 h of harvest. Harvests were conducted between 0600 and 0800 h serially from April to July (late autumn to early spring). Stems were harvested with clean sharp secateurs and placed into buckets of deionised water (DI), covered with polyethylene film and transported. Stems of rose and acacia were *ca.* 50 cm in length. Stem-ends were dipped into 80% (v/v) ethanol solution for 2–3 s for surface disinfection, rinsed with DI and re-trimmed under DI to remove stem-end air emboli. Resultant stem lengths were *ca.* 40 cm bearing the three upper leaves for roses and four phyllodes for acacia.

2.2. Experiment design and treatments

Six experiments were conducted in a vase life evaluation room maintained at *ca.* 20 ± 2 °C and 80 ± 20% relative humidity under a PAR flux of 8–12 μmol m^{-2} s^{-1} from white fluorescent tubes at flower level on a daily 12 h photoperiod and under 0.2–0.4 m s^{-1} air speed. In each experiment, stems were placed individually into 350 mL plastic vases containing DI with 10 mg L^{-1} available chlorine as sodium dichloroisocyanurate (DICA; Joyce et al., 2000). Low-density polyethylene film was used to cover the mouth of each vase to limit entrance of dust and foreign objects (e.g. dropping leaves) as well as to minimise vase solution evaporation. Vases with cut stems were arranged on benches in a completely randomised design with 10 replicates. Physical treatments were applied under water in all experiments.

2.2.1. Experiment 1: stem-end bark removal

With sharp scalpel blades, cut stems were subjected to five treatments: control (no bark removal), 2.5 cm bark removal, 5 cm bark removal, 7.5 cm bark removal and 10 cm bark removal from the lower end of stems.

2.2.2. Experiment 2: stem-end splitting

With sharp scalpel blades, cut stems were subjected to five treatments: control (no splitting), a 2.5 cm longitudinal split from cut end of the stem, two 2.5 cm splits at right angles, a 5 cm longitudinal split from cut end of the stem and 5 cm with 2 splits at right angles.

2.2.3. Experiment 3: stem-end crushing

With pliers, cut stems were subjected to five treatments: control (no crushing), 2.5 cm with one crush, 2.5 cm with two crushes, 5 cm with one crush and 5 cm with two crushes on the cut end of stems. One crush compressed the diameter of rose stems by *ca.* 7–10 mm and of acacia stems by *ca.* 4–8 mm. Second crushes were applied at right angles to the first, and compressed rose stems by *ca.* 10–15 mm and acacia stems by *ca.* 6–10 mm.

2.2.4. Experiment 4: hot water scalding

Cut stem-ends were subjected to three treatments: control (no hot water scalding), 5 cm of stem base immersed in boiling (100 °C) water for 30 s and 5 cm of stem base immersed in boiling water for 60 s.

2.2.5. Experiment 5: comparison of stem-end physical treatments

Cut stems were subjected to five treatments selected from the above experiments: control (no stem-end treatment), 5 cm bark removal, 5 cm with 2 splits at right angles, 5 cm with 2 crushes and 5 cm of stem base immersed in hot water for 30 s.

2.2.6. Experiment 6: fresh vs. simulated-handling

Cut stems were subjected to five treatments applied immediately after transportation to the laboratory (fresh-cut) and the same treatments were applied to the other half of the stems after dry storage at 4 ± 1 °C for 24 h (simulated commercial handling). The treatments were control (no stem-end treatment), 5 cm bark removal, 5 cm with 2 splits at right angles, 5 cm with 2 crushes and 5 cm of stem base immersed in hot water for 30 s.

2.3. Measurements

2.3.1. Relative fresh weight (RFW)

Fresh weights of cut stems were measured daily during vase life. RFW was calculated using the formula: RFW (% initial fresh weight) = $(FW_t/FW_{t=0}) \times 100$; where FW_t is the fresh weight of stem (g) at t = day 0, 1, 2, 3, etc., and $FW_{t=0}$ is the fresh weight of the same stem (g) at t = day 0 (He et al., 2006).

2.3.2. Vase solution uptake rate (VSU)

Weights of vases containing vase solution without the cut stems were recorded daily during the vase life evaluation period. Average daily VSU rate was calculated by the formula: VSU [g g^{-1} initial fresh weight (IFW)] = $(S_{t-1} - S_t)$/IFW of the stem; where S_t is weight