Physiological Changes during Postharvest Life of Cut Sunflowers

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Abstract

The vase life of sunflowers (*Helianthus annuus*) is limited by early wilting of leaves and ray flowers. Vase life was positively correlated with stem length (5 days in 50 cm stems, 9 days in 70 cm stems). We also studied the vase life after a 24 h pulse treatment with a number of chemicals. It was significantly increased by treatment with 150 mg L^{-1} citric acid. Treatment with 10 µl L^{-1} ethylene reduced vase life and induced both flower bending and abscission of ray flowers. In contrast, 2 mM amino-oxyacetic acid (AOA), an ethylene inhibitor, reduced ethylene production but did not increase vase life. 8-Hydroxyquinoline (8-HQS) at 150 mg L^{-1} did not lengthen vase life. Vase life was reduced by treatment with 2% sucrose combined with either 150 mg L^{-1} citric or with 150 mg L^{-1} 8-HQS.

INTRODUCTION

The sunflower is native to North America. In the early days, European invaders used this species for various purposes, including decoration. In recent years the consumer demand of cut sunflowers has been increasing, but little information is available on their senescence. Sunflower vase life is very variable, depending on the variety. It reportedly ranged from 4 to 13 days (Gast, 1995). Sunflowers of some cultivars may therefore need to be treated with preservative solutions for improve their vase life. A non-ionic detergent used as a pulse treatment (for 1 h) increased water uptake and the length of vase life in cut sunflowers stored for three days at 8°C prior to vase life (Jones et al., 1993). A lower storage temperature (0-1°C) both increased the length of vase life and reduced stem bending (Çelikel and Reid, 2002). Sunflowers have long stems when harvested, but the stems are cut several times during the distribution chain. This is done to avoid xylem occlusion in the basal stem end, and to adapt stem length to the use of the flowers in bouquets.

The aim of the present work was to investigate the effects of stem length, of an ethylene inhibitor, ethylene, and biocides (alone or in combination with sucrose). Although sunflower is in *Asteraceae*, a family in which petal senescence is generally insensitive to ethylene, our preliminary trials indicated that ethylene had an effect on vase life. We therefore used ethylene-related treatments and measured ethylene production.

MATERIALS AND METHODS

Plant Material

Cut sunflowers (*Helianthus annuus* L.) cv. Sunrich Orange were bought from the cooperative Geoflor (in Lucca, Italy) and transported to the laboratory in Pisa. In the laboratory flowers were selected for uniformity and stems were recut under water. The flowers were placed in deionised water. Experiments were performed in a controlled environment maintained at 20°C, 60% relative humidity and 15 µmol m^{-2} s^{-1} photosynthetically active quantum flux for 12 h day^{-1}, from cool-white fluorescent lamps.

Flowers were cut to stem lengths of 50, 60 and 70 cm. Bottles, with and without flowers, were weighed daily. Data were used to calculate water uptake and fresh weight.

Postharvest Treatments

Control flowers were placed in vase solution containing distilled water. Treatments lasted 24 h and were 2 mM amino-oxyacetic acid (AOA; Sigma), 150 mg L^{-1}

8-hydroxyquinoline, hemisulfate hemihydrate, 98% (8-HQS, Sigma), 150 mg L^{-1} 8-HQS plus 2% sucrose (Sigma), 150 mg L^{-1} citric acid (Sigma) and 150 mg L^{-1} citric acid plus 2% sucrose. 10 g L^{-1} sodium hypochlorite (Carlo Erba) was applied for 1 h. A treatment with exogenous ethylene was performed placing cut sunflowers in a plastic bin of 50 L capacity and ethylene, with a final concentration of 10 µl L^{-1}, was injected using a syringe. Flowers were pulse-treated with ethylene for 24 h in the laboratory under the conditions described above. After the various pulse treatments all flowers were individually placed in distilled water.

The vase life of the flowering stems was considered to be ended when they showed one of the following symptoms: petal wilting, petal curling, petal drop, leaf yellowing and stem bending.

Ethylene Production

Ethylene production was measured by enclosing ray and disc florets in airtight containers. Two ml gas samples were taken from the headspace of the containers with a hypodermic syringe, after 1 h incubation at room temperature. The ethylene concentration was measured using a gas chromatograph (HP5890, Hewlett-Packard, Menlo Park, CA) with a flame ionization detector (FID), and a stainless steel column (150 x 0,4 cm ø packed with Hysep T). Column and detector temperatures were 70° and 350°C, respectively. Nitrogen carrier gas was used at a flow rate of 30 ml min^{-1}.

Statistical Analysis

The data are means with standard errors. Each treatment composed of 8 replicate stems. Data were subjected to one-way analysis of variance and the differences among treatments were analyzed by Tukey's multiple comparison test ($P<0.05$). Experiments were repeated at least two times.

RESULTS

Stem Length, Weight Variation and Water Uptake

Sunflowers were cut to three different lengths, 50, 60 and 70 cm. The vase life was proportional to stem length (Fig. 1). Fig. 2 shows the increase or decrease in FW. During the first 2 days of vase life, FW increased more in flowers with a 60 or 70 cm stem length (Fig. 2). In all treatments there was a net decrease in FW, from day four of vase life. The rate of water uptake decreased from day 0. The rate of water uptake in flowers with a stem length of 70 cm was higher than that of the other two treatments, form day 4 of vase life (Fig. 3).

Postharvest Treatments

Stems of 60 cm length were used in these experiments. Flowers treated with citric acid had the longest vase life. Adding 2% sucrose to the vase solution containing citric acid reduced vase life, but longevity was still higher than in the control. Treatment with 8-HQS reduced vase life, both when given alone or in combination with sucrose (Table 1). The sodium hypochlorite treatment (1 h) did not improve vase life, while longer treatment induced damage in the lowermost part of the stem (data not shown). AOA did not significantly delay the time to visible senescence. However, exogenous ethylene significantly reduced vase life (Table 1).

Ethylene production by both ray florets (Fig. 4) and disc florets (Fig. 5) was inhibited by the AOA treatment. 8-HQS reduced ethylene production in ray florets but had no effect in disc florets. Reduced vase life (HQS and sucrose) was correlated with higher ethylene production in ray florets.

DISCUSSION

When grown in the filed sunflowers usually reach a stem length of more than one meter. Cv. Sunrich Orange are usually 1.20-1.80 m tall (Gast, 1995). After harvest the

sunflowers are cut to uniform stem length (for example 70 or 90 cm). However, the end users may need sunflowers with a shorter stem length especially if they are used in bouquets. Our experiment showed that the vase life is longer when the stems are longer.

Cut sunflowers are short-lived but their vase life may be increased by pulse treatments that reduce the bacterial growth and keep the xylem vessels free from occlusion. 8-HQS is a common biocide used for prolonging the vase life of cut flowers, but we found that it did not improve vase life in cut sunflowers.

Sugars generally improve the vase life of cut flowers, but they cannot be used alone as they induce bacterial proliferation. Therefore, a sugar treatment must be accompanied by the use of an antibacterial compound (van Doorn, 1997). In sunflowers, however, sucrose decreased longevity (and promoted ethylene production). Ethylene production was nonetheless not completely correlated with vase life. Its was inhibited by AOA treatment, even if this treatment did not lengthen vase life. These results seem in agreement with the opinion that petal senescence in members of the *Asteraceae* is not sensitive to low exogenous ethylene (Reid, 1989).

We found a positive effect of citric acid on sunflower vase life. Cut *Acacia amoena* flowers treated with citric acid had better water uptake as citric acid reducing xylem cavitation (Williamson and Milburn, 1995).

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Tables

Table 1. Vase life of cut sunflowers pulse-treated for 24 h with water (control), 2 mM AOA, 150 mg L^{-1} 8-HQS, 150 mg L^{-1} 8-HQS + 2% sucrose, 150 mg L^{-1} citric acid, 150 mg L^{-1} citric acid + 2% sucrose or 10 µl L^{-1} ethylene. The sodium hypochlorite was used as short treatment (1 h) with 10 g L^{-1}. Values are means of 8 stems, with standard error. Data were analysed by one-way ANOVA. Different letters mean that values are statistically different at $P<0.05$.

Treatments	Vase life (days)
Control	6.8 ± 0.2 b
AOA	7.0 ± 0.0 b
8-HQS	6.8 ± 0.2 b
Sucrose + 8-HQS	5.8 ± 0.2 c
Sodium hypochlorite	7.5 ± 0.4 b
Citric acid	9.1 ± 0.3 a
Citric acid + sucrose	7.3 ± 0.3 b
Ethylene	5.8 ± 0.2 c

Figures

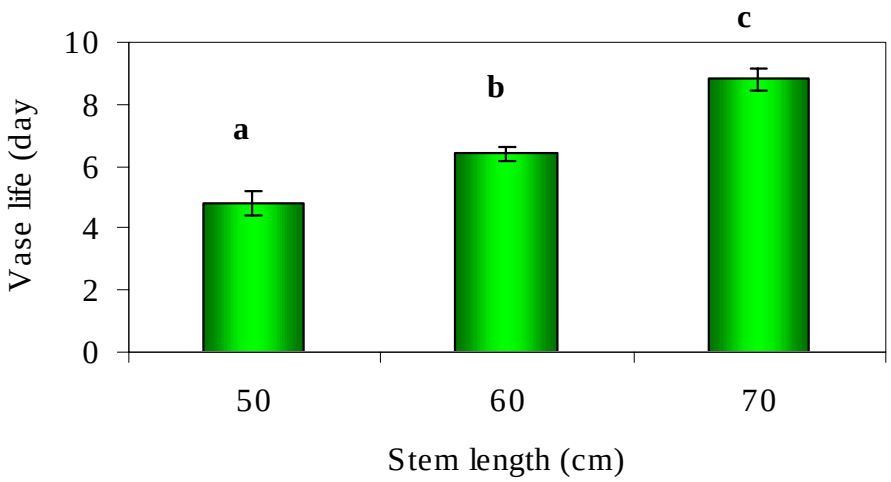

Fig. 1. Vase life of sunflowers cut to 50, 60 and 70 cm. The data shown are means of 8 stem, with standard error. Data were analysed by one-way ANOVA. Different letters mean that values are statistically different at $P<0.05$.

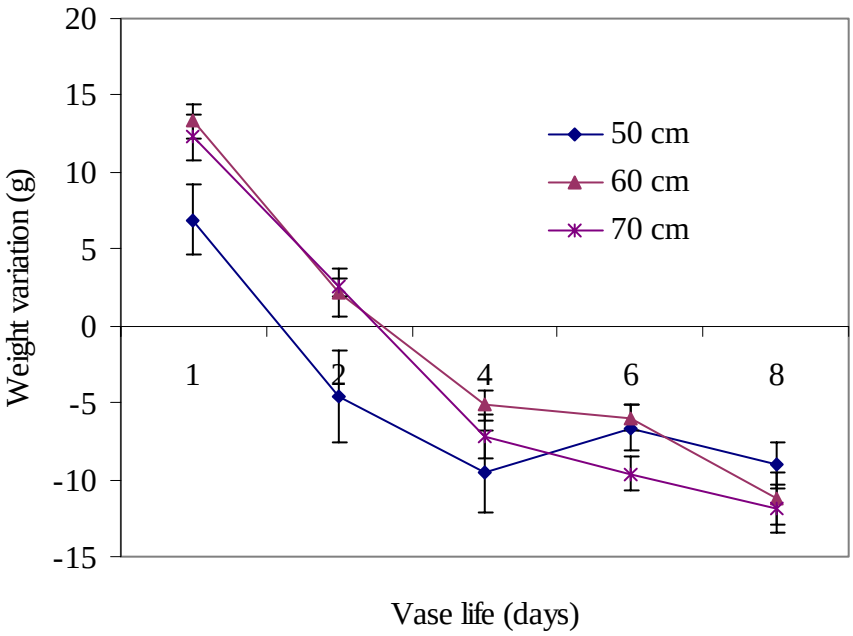

Fig. 2. FW during vase life of sunflowers cut to 50, 60 and 70 cm. Values are means with standard errors. Data were analysed by one-way ANOVA. No differences were found among treatments (P<0.05).

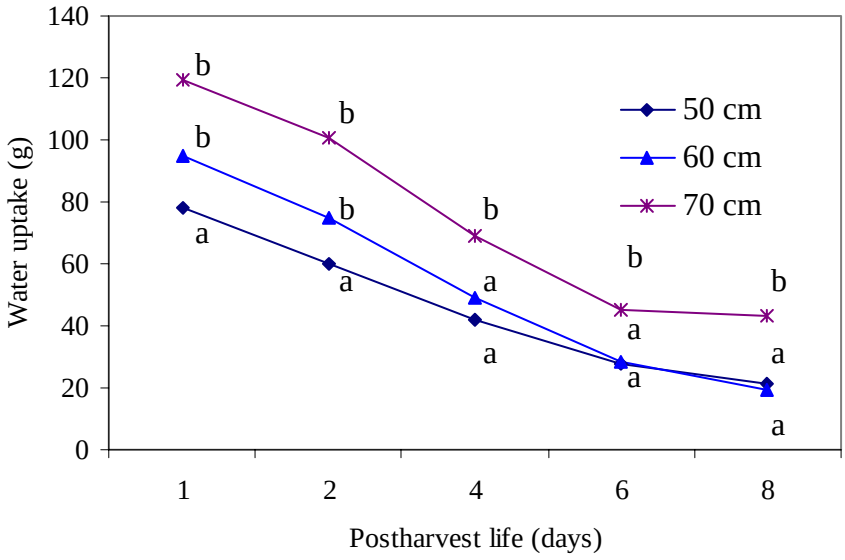

Fig. 3. Rate of water uptake during vase life of sunflowers cut to 50, 60and 70 cm. Values are means. Data were analysed by one-way ANOVA and different letters mean that values are statistically different with P<0.05.

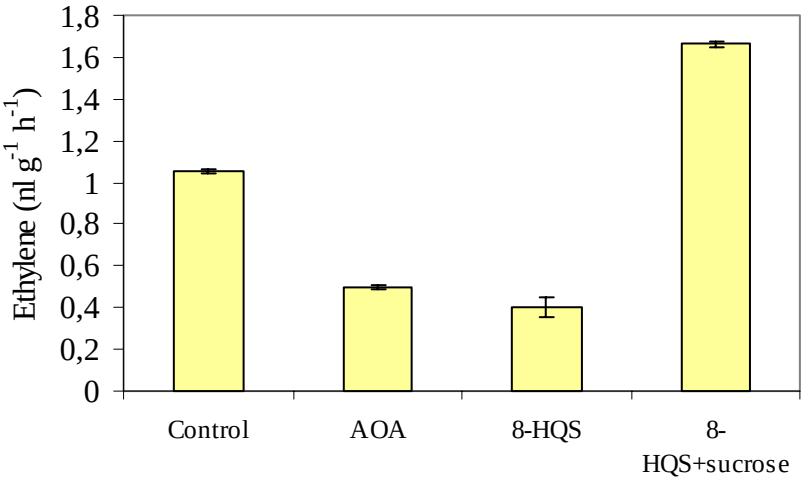

Fig. 4. Ethylene production (expressed as nl g^{-1} FW h^{-1}) during vase life from ray florets of cut sunflowers pulse treated with water (control), 2 mM AOA, 150 mg L^{-1} 8-HQS, 150 mg L^{-1} 8-HQS + 2% sucrose. Values are means with standard errors.

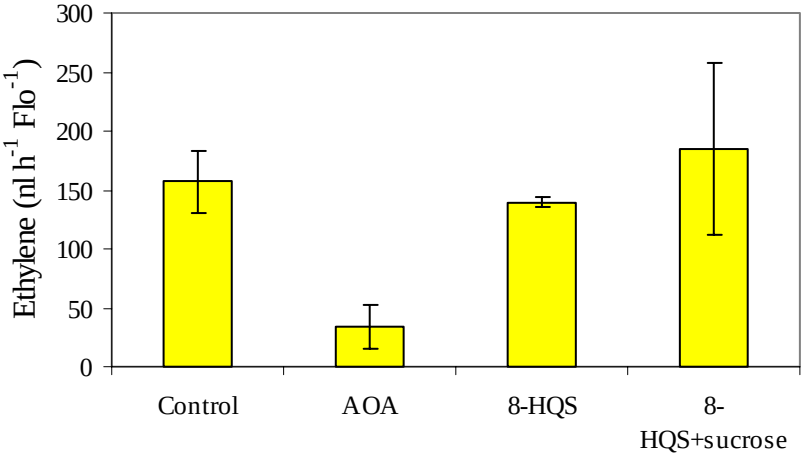

Fig. 5. Ethylene production (expressed as nl h^{-1} $Flower^{-1}$) during vase life from disc florets of cut sunflowers pulse treated with water (control), 2 mM AOA, 150 mg L^{-1} 8-HQS, 150 mg L^{-1} 8-HQS + 2% sucrose. Values are means with standard errors.