

WATER RELATIONS OF CUT FLOWERS. II. SOME SPECIES OF TROPICAL PROVENANCE

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Abstract

Several species of cut flowers that originate from the tropics are also grown in greenhouses in cooler climates, and some of these have become important commercial commodities, for example *Anthurium* and orchids. *Anthurium andraeanum* flowers are not sensitive to problems of water uptake, probably due to their low transpiration rate. The vase life of *Cymbidium* is also not limited by problems relating to water uptake. This is mainly due to the absence of stomata, which results in an extremely low rate of transpiration, compared to other cut flowers. The vase life of *Phalaenopsis* orchids, in contrast, is often short due to vascular occlusion. Other tropical flowers, in particular a number of monocots, for example *Canna* sp. and *Heliconia psittacorum*, have a vase life that is limited by inhibition of water uptake. In this group the blockage for water uptake is apparently mainly due to exudation of mucilage at the cut surface. Still other flowers originate in cool climates but can be grown in greenhouses in the tropics, for example roses. When grown in the tropics, roses tend to have thicker stems and often show earlier symptoms of water stress than flowers from the same cultivar grown in a climate with lower light intensity. A similar response is observed in chrysanthemums, where stems that are more woody show earlier symptoms of water stress. This is due to the earlier development of an occlusion, located in the stem base, that is large enough to inhibit the rate of water uptake to such an extent that it becomes lower than the rate of transpiration. In roses the occlusion is not due to plant mucilage, but to bacteria and xylem cavitation.

1. Introduction

Flowers can be called tropical when they originate in the tropics, but are grown not only in tropical climates but also when produced as a commercial commodity in temperate climates. Inversely, some flowers that originate in temperate climates are commercially grown in the tropical zone. When these flowers are sold in the world market, they can sometimes be distinguished from the produce grown in temperate zones. We will here define all commercial flowers grown in the tropics as flowers of tropical provenance.

The water relations of flowers grown in temperate climates has been studied much more extensively than those in flowers grown in temperate climates. I will here mainly discuss the water relations of some flower species that were grown in the tropics, and extend it to some tropical flowers grown in the temperate zone.

The species in the first group are *Anthurium*, *Heliconia*, *Canna*, and roses. Species in the latter group are *Cymbidium* and *Phalaenopsis* orchids. The work on *Anthurium* was done in the laboratory of Dr. Michael S. Reid, in Davis, California. The flowers were commercially grown in Hawaii, and shipped in boxes with wet shredded paper to California. *Heliconia* flowers were also commercially produced in Hawaii (by Floral Resources, Inc., on the big island of Hawaii). They were picked early in the morning, as growers know that picking later during the day aggravates problems with water relations. Some experiments on *Heliconia* were carried out in Michael Reid's lab, on material that was shipped to California (by air to San Francisco and by car to Davis) in boxes filled with wet paper. One experiment with material from Floral Resources (material shipped by

air to Honolulu, arrival on campus the same day) and one on freshly cut flowers was carried out in the laboratory of Dr. R. Paull at Honolulu, Oahu, Hawaii. The experiments on *Canna*, using locally grown produce, were performed in the laboratory of Dr. C.S. Whitehead in Johannesburg, South Africa. The roses were commercially grown in Kenya, shipped dry by air to Holland. *Cymbidium* flowers were commercially grown in Holland.

2. *Anthurium andraeanum*

Stalks of *Anthurium* contain no green leaves. Close to the distal end, the stalk contains one leathery, leaf-like, structure called spathe. The flowers are very small and borne on the end of the flowering stalk, in a structure termed spadix. Vase life of *Anthurium andraeanum* flowers is usually determined by blueing of the spathe, especially when it has been mechanically damaged, and by discolouration of the spadix. Ethylene may be involved in both spathe blueing and spadix discolouration. Vase life is often about 20 days, but may occasionally be shorter and then be extended by treatments that inhibit ethylene production. As water uptake rates drop with time, and waxing increases vase life, a vascular occlusion has been suggested to be a main reason for termination of vase life (Paull and Goo, 1985; Paull *et al.*, 1985). We confirmed that after a few days of vase life the water conductivity of the basal 5 cm stem segment was considerably lower than that of the other segments. The simplest assumption would be that the blockage is due to bacteria. An experiment in which antibacterial compounds in the vase water had no effect on vase life (Paull *et al.*, 1985) cannot be taken as evidence that the blockage is not due to bacteria as the controls in this experiment lasted 20 days, hence were not negatively affected by the blockage. In our experiments vase life was also invariably 20 days, and we were therefore unable to observe an effect of antibacterial compounds. The nature of the blockage, therefore, has not definitely been established, nor has it been investigated why vase life is often about three weeks, and only incidentally about 9-14 days. Even though there is a vascular blockage in this flower, it is not a serious problem as it has a vase life of more than a week. The long flower life, in the presence of an occlusion, may relate to the relatively low rate of transpiration of *Anthurium* flowers. We found no evidence for early symptoms of water stress. Only when sucrose or a suspension of bacteria was added to the vase water, the spathe was found to wilt. Such wilting was never observed in flowers placed in water.

3. *Heliconia psittacorum*

The flowers in the genus *Heliconia* are usually colourful, but small. A number of flowers is enclosed by colourful bracts, which are the organs of interest in the flower trade because of their considerable ornamental value. These bracts apparently attract pollinators from greater distances. *Heliconia* inflorescences are sometimes held dry in practice and still last for several days, sometimes for more than a week. The inflorescences of several *Heliconia* species, therefore, seem not sensitive to water stress problems. Growers and exporters, nonetheless, expressed that they had difficulties in maintaining quality in *Heliconia psittacorum* cv. Parakeet (which has yellow bracts). In contrast to many other *Heliconia* species, the inflorescences of *H. psittacorum* are rather small, and are usually shipped with one or two attached leaves.

In one experiment, in which the flowers had been dry in boxes for five days, the leaves started to roll up within about a day (1.3 +/- 0.2 d). Recutting under water delayed inrolling only by one day. Chemicals that reduce bacterial growth also somewhat delayed inrolling: silver nitrate (1 min dip of the stem ends in 1000 mg/l) delayed it by one day (2.4 +/- 1.3 d) and a continuous treatment with hydroxyquinoline citrate (250 mg/l) by two days (3.4 +/- 2.1 d). When the flowers had been held dry for 2 days only, the time to leaf inrolling was 6-7 days. Recutting under water delayed time to inrolling by about two days, in this experiment. Treatment with a surfactant (Tween-20, 12 h in 100 mg/l), citric

acid (12 h in 2 mM), warm water (4 h in 40°C), ethanol (continuous treatment in 6%) had little effect on the time to leaf inrolling.

In the experiment involving five days of dry storage the inflorescences showed discolouration after 1-2 days. Recutting under water and treatments with silver nitrate or hydroxyquinoline citrate extended this by two days. In a second experiment (three days of dry storage), the inflorescences did not show discolouration until about 5 days after the beginning of vase life. Here, Recutting under water and treatments with silver nitrate and hydroxyquinoline citrate extended discolouration by about three days. In a third experiment (two days of dry storage) the time to bract discolouration was also about five days. The treatments with Tween, citric acid, warm water, and ethanol (as discussed above) had little effect.

In one preliminary experiment with *Heliconia brasiliensis* (red inflorescence bracts) also shipped from Hawaii to Davis, showed a time to inflorescence discolouration of 5 days. Recutting under water, and treatments with Tween, citric acid, and hydroxyquinoline citrate had no effect. These stems had no leaves.

The experiment in Honolulu with commercially produced and shipped *H. psittacorum* showed a time to leaf inrolling of about four days. Treatment included four concentrations of four chemicals. A surfactant (Triton at 0.01- 1.25 mg/l) or a cytokinin (kinetin at 0.001 -1 mM) had no effect on the time to leaf inrolling. Gibberellic acid at 0.01mM and abscisic acid at 0.0001 - 0.001 mM delayed inrolling by 2-3 days. The time to bract discolouration was little affected by the treatments. The life of the leaves and bracts on freshly cut stems was long and not affected by these treatments.

Rates of water uptake were low from the very first day of vase life, even in produce that had not been subjected to dry transport.

It is concluded that in *H. psittacorum* cv. Parakeet, premature leaf inrolling and bract discolouration occurs as a result of vascular occlusion. We observed low rates of water uptake, thereby corroborating results obtained by Donselman and Broschat (1986) and by Ka-Ipo *et al.* (1989). Symptoms of water stress are shown in particular following dry transport. However, traditional treatments against blockage by emboli or bacteria had only a small effect. Although the nature of the vascular occlusion in *H. psittacorum* is as yet unclear, we observed some slimy material in the xylem vessels; this material may be related to the blockage.

4. *Canna* sp.

Canna flowers, placed in water within a few minutes after cutting, showed rapid flower wilting, and virtually no water uptake. A layer of gelatinous material was observed at the cut surface of the stems, one day after the stems were placed in water. *Canna* stems, therefore, apparently exude mucilage to such a degree that it blocks water uptake. This seems to be the reason why these flowers are not used in the cut flower trade.

5. *Rosa hybrida*

Roses that are grown in the tropics tend to have thicker stems than those grown in temperate climates. Roses grown in Africa and flown into the Netherlands often have problems with water uptake. Several samples of rose flowers from Africa were brought to our laboratory by representatives from the Aalsmeer flower auction. These roses invariably had thick stems. They showed little water uptake, wilting of the leaves and flowers, lack of flower opening and bending of the pedicel. When the stems were recut under water, or placed in a dilute solution of the surfactant Agral-LN, these water stress symptoms were not observed. Bacterial numbers in the stems were high but not high enough to account for the symptoms. It is concluded from these tests that the stems have become occluded, probably mainly by air emboli. It is unclear what the role is of the period of dry transport and of stem thickness. They may both be involved in the response. In chrysanthemum water uptake depends on the place where the stem is cut. When cut at

the lowermost, woody, end of the stem, water uptake is mostly low compared to cutting at a place higher up the stem (Marousky, 1973). This may also play a role in roses, but the precise role of stem thickness (woodiness) still remains to be established.

6. *Cymbidium* and *Phalaenopsis*

The vase life of many orchid flowers is shortened by exogenous ethylene, and by pollination, and in the case of *Cymbidium*, by removal of the pollinia. Except for the removal of pollinia, which occurs when the flowers are not handled with care, pollination is rare, and effects of exogenous ethylene also seem incidental only.

Compared with numerous other cut flower species, such as lily, rose, carnation, the rate of transpiration in *Cymbidium* is very low. The flowers were found to contain no stomata. This is in contrast to the other mentioned flowers, that contain numerous stomata on the green parts of the flowering stem.

Although during vase life the rate of water uptake in *Cymbidium* flowers eventually becomes low, apparently as a result of a blockage by bacteria, the flowers do not wilt. This is probably due to the low rate of transpiration. Flowers such as *Cymbidium* may, therefore, have an occlusion in their stems, but as long as transpiration is low from the onset of vase life it will take long before the water deficit leads to visual wilting.

The vase life of *Phalaenopsis* flowers, in contrast, is often limited by problems relating to water stress. The flowers wilt after a few days of vase life, due to low rate of water uptake. Results obtained by the Research Station of Floriculture in Aalsmeer, the Netherlands, showed that inclusion of sugar and a good antibacterial compound in the vase water considerably delays the time to wilting. The use of water at about 50°C, at the beginning of vase life, was also beneficial in order to avoid early problems with water uptake in *Phalaenopsis* flowers, in particular when this warm water treatment was combined with sugar and the antibacterial compound (Anonymous, 1989).

7. Conclusions

The expression of early wilting in tropical cut flowers, as in any other cut flowers, depends on the degree of vascular blockage on the one hand, and the rate of transpiration on the other.

Some flowers that originate from the tropics, such as *Cymbidium* have a vase life that is not seriously limited by problems relating to water uptake. Although their stems may become occluded, this does not lead to loss of turgor, as their rate of transpiration is low. *Anthurium* flowers also seem to fall in this category.

Other tropical flowers, in contrast, do have clear problems with water relations. *Phalaenopsis* flowers, for example, rapidly wilt, due to an occlusion in the stem, combined with a higher rate of transpiration than in *Cymbidium* orchids. Some tropical flower, such as *Canna*, can even not be used in the cut flower trade as their rate of water uptake rapidly becomes too low due to an occlusion. *Heliconia* leaves show rapid inrolling, also apparently due to a vascular blockage, but only in a few species and cultivars do the showy bracts show rapid discolouration. The nature of the blockage in *Canna* and *Heliconia* stems remains to be fully elucidated.

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References

- Anonymous. 1989. Phalaenopsis, postharvest treatment (in Dutch). Vakblad voor de Bloemisterij 1989 (3): 87.
- Donselman, H.M., and T.K. Broschat. 1986. Production of *Heliconia psittacorum* for cut flowers in South Florida. Bull. Heliconia Soc. Int. 1(4): 4-6.
- Ka-Ipo, R., W.S. Sakai, S.C. Furutani, and M. Collins. 1989. Effect of postharvest treatment with antitranspirants on the shelf life of *H. psittacorum* cv. Parakeet cut flowers. Bull. Heliconia Soc. Int. 4(3): 13-14.
- Marousky, F.J. 1973. Recent advances in opening bud-cut chrysanthemum flowers. HortScience 8: 13-16.
- Paull, R.E. and T.T.C. Goo. 1985. Ethylene and water stress in the senescence of cut Anthurium flowers. J. Amer. Soc. Hort. Sci. 110: 84-88.
- Paull, R.E. N.J. Chen and J. Deputy. 1985. Physiological changes associated with senescence of cut Anthurium flowers. J. Amer. Soc. Hort. Sci. 110: 156-162.