Effects of Reduced Nutrient and Water Availability on Plant Growth and Post-Production Quality of *Hibiscus rosa-sinensis*

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Abstract

The intensive use of chemical growth retardants in ornamental plant production is of environmental concern. There is a need for developing efficient alternatives. We used drought stress as a single factor or combined it with reduced phosphorus (P) availability, reduced nitrogen (N) availability, or reduced application of chemical growth regulators. In *Hibiscus rosa-sinensis* we showed that reduced P and N availability during production improved post-production quality. It significantly reduced the number of senescent flower buds compared with the controls (using growth regulators). This may be important, since most cultivated flowering plants have inadequate keeping quality if their growth is regulated by chemicals.

INTRODUCTION

Currently there is clearly a need for developing new and more environmental suitable production methods to reduce the use of water, fertiliser, and chemicals. Drought stress (water deficit), for example, can reduce plant height, and therefore replace chemicals that have the same effect (Röber and Hafez, 1981; Williams et al., 1999; Egilla et al., 2001). Reduced plant height and more compact potted miniature roses (Williams et al., 1999) and *Campanula carpatica* (Petersen and Hansen, 2003) were reported as an effect of reduced water availability during production. Low P availability may also affect growth. It stimulates root growth at the expense of shoot growth (Gutschick and Kay, 1995). Reducing P availability has been reported to be a new and promising method for non-chemical growth regulation of a number of ornamental plant species (Hansen and Nielsen, 2001; Hansen, 2002). Reduced N has also been reported to be a potential method for non-chemical growth regulation (Starkey and Anderson, 2000).

Our objectives was to study if several cycles of drought stress (either as a single factor or combined with reduced P availability, reduced N availability, or reduced application of a chemical growth regulator) can reduce the use a growth regulator in *Hibiscus rosa-sinensis*.

MATERIALS AND METHODS

Plant Material

Cuttings of *Hibiscus rosa-sinensis* 'Cairo Red' were planted with three cuttings per 12 cm pot. The substrate was peat-perlite. After six weeks of propagation the plants were pinched to enhance branching. Production conditions (light, temperature, fertigation) and the lay out of the experiment have been described previously (Hansen and Petersen, 2003).

Nutrient Availability

We used a P buffer technique (Compalox®-P, Martinswerk GmbH, Germany) to maintain a predetermined and stable P concentration in the substrate (Hansen & Nielsen, 2001). Two vol.-% of Compalox®-P buffer was mixed into the substrate and P availability was reduced by 20 fold (approx. 1.5 ppm in the soil solution throughout production) compared with the control (32 ppm P just after fertigation). Low N levels were obtained using a dynamic supply. N availability varied according to plant demand: 54 ppm N until four weeks after pinching (WAP) when the plants showed signs of N deficiency, then 80 ppm N for one week followed by two weeks 161 ppm N (similar N availability as in control plants) to overcome the N deficiency symptoms. During the last two weeks of production (from 7 WAP), N availability was again 80 ppm.

Drought Stress

Drought stress was applied as a cycle. The water content of the substrate alternated between container capacity and levels where the plants visibly wilted (this occurred at -650 to -800 hPa as measured with tensiometers in the substrate). Container capacity after drying out to visible wilting was obtained by three consecutive fertigations compared with one for the irrigated control. The time of irrigation was judged visually. The first drought cycle started two WAP. At this time the first treatments with Chlormequat-chloride (CCC), for chemical growth regulation, was given. Combinations of drought stress with reduced P or reduced application of CCC were employed in order to study if there were additive effects on plant growth and post-production quality.

Post-Production Evaluation

At the end of production (at the marketing stage), ten plants per treatment were transferred to a post-production evaluation room with low photosynthetic photon flux density (12 µM m^{-2} s^{-1} PPFD) for 12 h per day and 20°C day/night temperature. The number of open flowers, the number of fresh flower buds, and the number of senescent flowers and flower buds were recorded at intervals, during a 28-day period.

RESULTS AND DISCUSSION

Chemical growth regulation (100% CCC) reduced plant height to 43% compared with control plants (Table 1). Same efficient growth regulation was achieved by combining drought with reduced application of CCC, hereby saving 83% CCC and reducing the number of applications from 7 to 3, but the number of flower buds, leaf size, and dry weight of the above-ground plant parts were reduced compared with chemically growth regulated plants (Hansen and Petersen, 2003). Drought stress as a single factor reduced plant height to 68% and reduced P to 85% relative to the control plants (Table 1). Combining reduced P availability with drought stress did not reduce plant height, leaf area, dry matter accumulation, and the number of flower buds much further than drought stress as a single factor (Table 1). Chemically growth regulated plants were the most compact plants with the highest specific fresh weight (mg fresh weight per cm stem). Control plants and plants grown with a combination of reduced P and reduced application of CCC had a slightly lower specific fresh weight than chemically growth regulated plants, and were less compact. (Hansen and Petersen, 2003).

Chemically growth regulated plants formed more flower buds than plants from all other treatments except for non-growth regulated control plants (Table 1), but from day 14 and onwards very few flowers opened and many flower buds senesced, especially compared with reduced P and N plants and also to some extent compared with control plants (Fig. 1). Despite a much lower number of flower buds at the end of production (day 0, start of post-production evaluation) on plants produced at reduced P they developed the same number of open flowers as control plants (Fig. 1). After 28 days at simulated interior room conditions the poorest post-production performance was seen in chemically growth-regulated plants (Hansen and Petersen, 2003). Also drought stressed plants had a high percentage of senescent flower buds compared with control plants (data not shown). However, combining drought with reduced P availability to some extent reduced the number of senescent flower buds (Hansen and Petersen, 2003). Reduced P and N availability during production improved the post-production stress tolerance by significantly reducing the number of senescent buds and increasing the percentage of open flowers compared with chemically growth regulated plants and with non-growth regulated control plants (Hansen and Petersen, 2003).

Cyclic drought during production was reported by Williams et al. (2000) to reduce the number of damaged and senescent flowers in one variety of potted miniature roses in the post-production phase. In our study post-production performance of *Hibiscus rosa-sinensis* was not improved by several cycles of drought. Starkey and Anderson (2000) reported that post-production quality was improved in *Euphorbia pulcherrima* when grown at reduced N during production. Also reduced P availability has been reported to improve the post-production quality of ornamental plants (Borch et al., 1998; Hansen and Nielsen, 2001). This is consistent with our findings showing that reduced P and N availability during production improved the post-production quality substantially in *Hibiscus rosa-sinensis* compared with chemically growth regulated plants, but also compared with non-growth regulated control plants. This indicates that reduced nutrient availability during production is a potential method for preconditioning plants to cope better with post-production stresses like low light in the interior room. Improving plant tolerance to post-production stress may have considerable importance to the horticultural industry and to the consumer, since most cultivated flowering plants have inadequate keeping quality when grown with traditionally high nutrient availability.

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Table

Table 1. Height, leaf area, number of flower buds, and dry weight of leaves+stems (Top DW) relative to control plants.

	Plant height	Leaf area	Flower buds	Top DW
Control	100	100	100	100
Reduced N	94	87	71	70
Reduced P	85	70	62	74
Drought	68	59	59	48
Drought + Lov P	64	46	55	42
Drought + 17% CCC	44	60	69	35
100% CCC	43	59	86	53

Figures

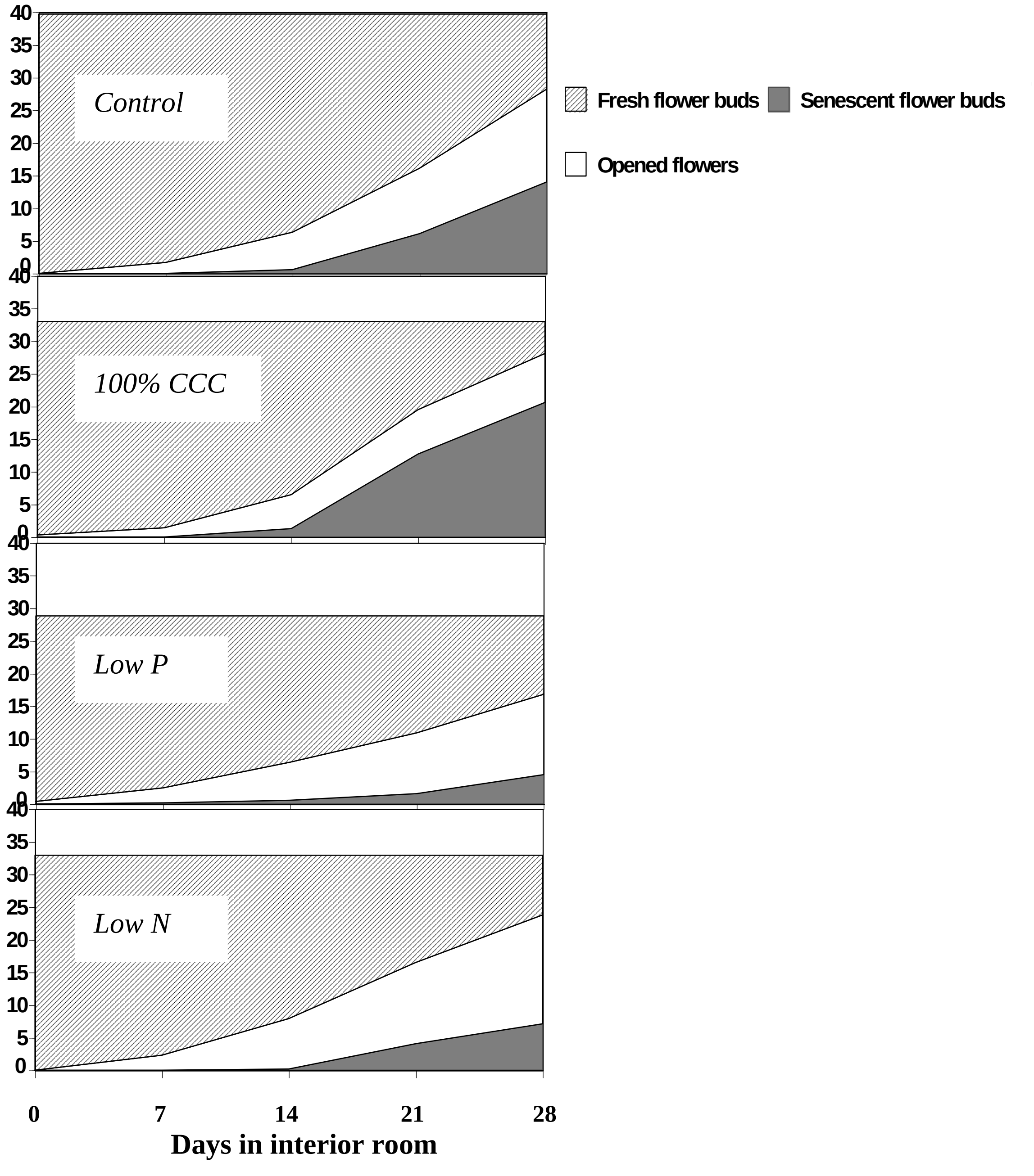

Fig. 1. Accumulated number of opened flowers, fresh flower buds, and senescent flower buds per plant during the post-production evaluation of *Hibiscus rosa-sinensis*.