Non-chemical growth control of potted Callistemon laevis

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NON-CHEMICAL GROWTH CONTROL OF POTTED *CALLISTEMON LAEVIS* ANON

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SUMMARY - Potted *Callistemon laevis* Anon plants were grown into a greenhouse, under mild stress conditions to evaluate the possibility of controlling plant size without plant growth regulators. Treatments were: reduced irrigation (50% with respect to control); high salinity, adding irrigation water with NaCl (200 mM, 23.1 mS/cm); root restriction, achieved by using reduced size pots (Ø = 15 cm, volume = 1.5 L). Control plants were grown in 3 L pots (Ø = 18 cm), with normal irrigation and salinity (100% field capacity; 6 mM NaCl, 1.7 mS/cm). After three months some growth parameters (plant height and diameter, leaf area, dry matter accumulation) were determined. In addition, net photosynthesis, leaf water potential and stomatal conductance were measured. All the stress treatments reduced plant height and leaf area; high salinity and water stress also decreased stomatal conductivity, photosynthesis and total dry weight. Root restricted plants showed similar net photosynthesis and dry matter accumulation compared to the controls. Salt stress excessively reduced plant growth and negatively affected blooming, while water shortage induced lower growth and reduced flower production, but the overall plant quality was satisfactory. Root restriction resulted in a reduced height, but the plants were well-shaped and the number of inflorescences per plant was higher than in the controls. Our results suggest that using reduced-size pots could represent a valid alternative to plant growth regulators for plant height control, lowering at the same time the environmental impact of cultivation.

Key words: *plant quality, plant size, root restriction, salinity, water stress.*

INTRODUCTION

In the recent years, Australian plants are gaining an increasing interest among nurserymen and landscape architects, mainly due to the aesthetics characteristics (abundant flowering with unusual shapes and brilliant colours) and to their adaptability to Mediterranean environmental conditions (Serra and Pardossi, 2001; Paradiso *et al.*, 2005). The most important Australian species used as ornamentals belong to two families: *Myrtaceae* and *Proteaceae*; among the *Myrtaceae*, *Callistemon*, at the moment, is getting a great success as flowering shrub for the use in gardens and urban landscape (Rampinini, 1998).

The *Callistemon* genus includes several species showing interesting ornamental features (Mitchem, 1993) and most of them are characterized by some degree of tolerance to environmental stresses (Lippi *et al.*, 2003; 2005). In Europe, the most widely employed *Callistemon* species are *C. citrinus* Skeels and *C. laevis* Anon (the latter known also as *C. citrinus splendens* Stapf).

One of the most interesting novelties is represented by the cultivation of *Callistemon* as flowering potted plant, provided that plant growth is adequately controlled without loosing its ornamental characteristics, especially the abundant bloom (Cervelli, 2001). Growth control plays a very important role, since the plants should show many lateral

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branches, reduced internode length, thick dark-green leaves, and abundant, homogeneous and persistent blooming. Floriculturists should therefore be able to manage plant growth, leaning to reach marketing standards, by employing reliable and affordable techniques.

Currently plant growth regulators (PGRs) represent the most widely used tool for reducing plant size in ornamentals, due to their effectiveness, use simplicity and low cost, and satisfactory results have been obtained also with *Callistemon* (Ronco *et al.*, 1997). However the use of chemicals involves a significant environmental impact and many studies in this field have been devoted to individuate alternative techniques for controlling plant growth with reduced pollutant risk, also considering the increasing attention paid by the consumers to the sustainability of crop production.

Plant growth is strongly affected by environmental factors such as light (Ballarè, 1999), temperature (Moe and Mortensen, 1992), water availability (Mugnai *et al.*, 2005) and mechanical stimuli (Vernieri *et al.*, 2003; Braam, 2005), therefore one strategy to reduce the application of PGRs is the exploitation of moderate stress that may modulate plant growth. The present study was aimed to verify the possibility to control the growth of potted *Callistemon laevis* cultivated by means of controlled level of water, salinity or mechanical stress.

MATERIALS AND METHODS

Plant material and growing conditions

Experiments have been carried out from March to September at the Department of Crop Biology of the University of Pisa. Rooted cuttings of *Callistemon laevis*, purchased from a specialised nursery in 7 x 7 cm pots, were transplanted into 3 L polyethylene pots (18 cm Ø), except for root restriction treatment (1.5 L pots, 15 cm Ø), filled with a peat-pumix-sand (60:30:10, v:v) substrate, added with 3 kg/m^3 horn-hoof mixture and 3 kg m^{-3} slow release fertiliser (18:12:30; 8 months). Plants were placed in rows on zinc-coated iron plate benches into a glass greenhouse; each bench was equipped with a separate drip irrigation system, to allow different water salinity and regimes. Plants were subjected to the following treatments:

1) *control*: 3 L pots (Ø = 18 cm), with optimal irrigation regime; the substrate moisture was maintained close to container water capacity by suppling a (100% container capacity; 6 mM NaCl, 1.7 mS/cm), by a daily volume of 900 ml pot^{-1}, with raw containing about 6 mM NaCl;
2) *salt stress*: 3 L pots (Ø = 18 cm) with optimal irrigation regime (100% container capacity) but using water added with NaCl (200 mM; 23.1 mS/cm);
3) *water stress*: 3 L pots (Ø = 18 cm), with reduced irrigation (daily volume was 450 ml pot^{-1}) with low salinity water;
4) *root restriction*: 1.5 L pots (Ø = 15 cm), with optimal irrigation regime (100% container capacity; daily water volume of 450 ml pot^{-1}).

Growth analysis

After three months of cultivation, five plants per treatment were sampled for the measurement of plant height and maximum diameter; leaf area and dry weight of leaves and stems. Leaf area was measured with a digital planimeter (ΔT Area Meter MK2, Delta T-Devices); dry weight was determined after drying the samples in a ventilated oven at 70 °C for 48 h. Relative growth rate (RGR) and net assimilation rate (NAR) were calculated as reported by Hunt (1978). After six months of cultivation, the aesthetic characteristics of the plants were assessed by measuring the number of inflorescences per plant and the mean length of inflorescence.

Physiological measurements

Leaf water potential (*Ψw*) was measured by a pressure chamber, according to Pardossi *et al.* (1991). Net photosynthesis (*A*) and stomatal conductance (*g*) were determined at ambient light and temperature on five mature leaves, during the central hours of the day, using an infrared gas analyzer (CIRAS 1, PPSystems, Herts, UK). Chlorophyll content was determined by an indirect colorimetric method (SPAD, Minolta SPAD 502 Chlorophyll Meter), on the same leaves used for gas exchange measurements.

Statistical analysis

A randomised block design was adopted. Data were analysed by ANOVA, and the mean values separated by LSD test ($P \leq 0.05$).

RESULTS AND DISCUSSION

Plant growth is influenced by environmental factors and several works have been reported on the use of controlled stresses to modulate plant height and shape (see for reviews: Heins *et al.*, 2000; Pardossi and Vernieri, 2002).

In our experiments, all the stress treatments led to a reduction of plant size with respect to the controls. The lowest values in terms of plant height were observed in salt treated plants (Fig. 1A), while plant diameter (Fig. 1B) was more reduced in the plants subjected to root restriction. For these two parameters, however, the differences among stress treatments were not statistically significant. Stress treatments also influenced leaf area, which showed significantly lower values than in controls (Fig. 1C) and these data are consistent with previous reports in other species (Latimer, 1991; Morales *et al.*, 1998; Mugnai *et al.*, 2000; 2005).

Biomass accumulation during the growing period was substantially reduced in all treatments, particularly in salt stressed plants, which showed the lowest values of dry weight either in stems or leaves, and in these plants subjected to reduced irrigation (Fig. 2). On the other hand, in root restricted plants, the decrease in dry matter accumulation was more evident in stems then in leaves, leading to a total biomass production only slightly lower than in control plants (Fig. 2).

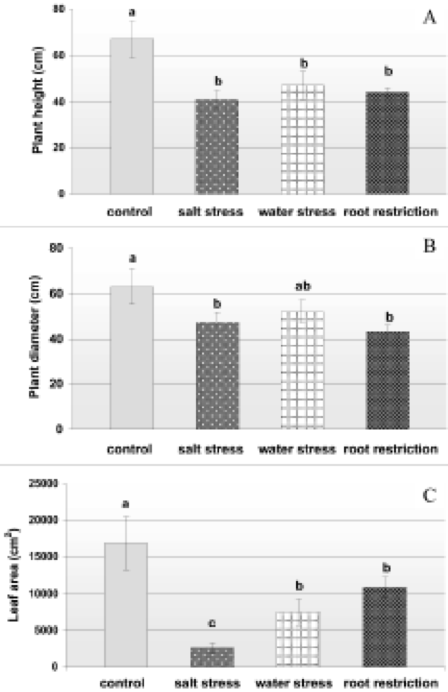

Fig. 1 - Plant height (A), maximum plant diameter (B) and leaf area (C) of potted *Callistemon laevis* plants after three month of cultivation under different stress conditions. Data are mean ± SD (n = 5). Different letters indicate significantly different values for $P \leq 0.05$.

The effect of salt stress, water shortage and root confinement on plant growth and dry matter accumulation has been described in several crop species (De Pascale *et al.*, 1997; Morel, 2001; Mugnai *et al.*, 2000; 2005) and, in most cases, a reduction in shoot dry weight was observed. However, in our experiments, the differences in dry matter partitioning among treatments indicates that, in root restricted plants, stress mainly conducted to

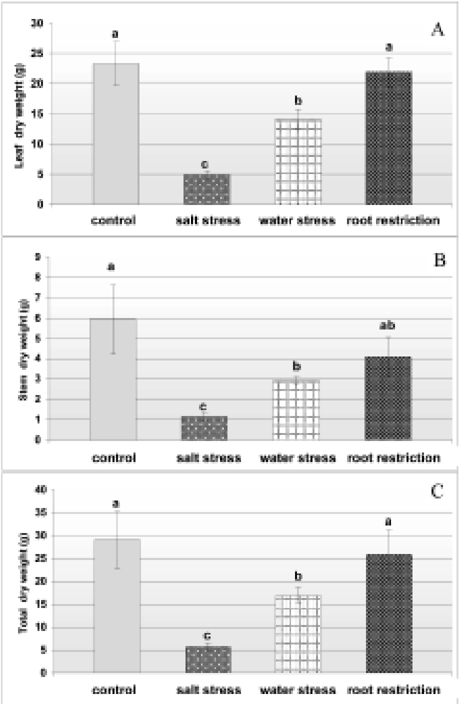

Fig. 2 - Leaf (A), stem (B) and total (C) shoot dry weight of potted *Callistemon laevis* plants after three month of cultivation under different stress conditions. Data are mean ± SD (n = 5). Different letters indicate significantly different values for P ≤ 0.05.

reduced stem dry weight (Fig. 2B), while the total biomass (Fig. 2C) was only slightly affected. More, while in salt and water stressed plants the reduction in leaf area values was related to a decline in leaf dry weight, root restricted plants showed reduced leaf area but similar leaf dry weight values compared to control plants (Fig. 2A). This indicates that root restricted plants modified their growing behaviour by reducing leaf area, but increasing leaf thickness.

Net assimilation rate values suggest that in root restricted plants photosynthetic efficiency was enhanced (Tab. 1). On the other hand, no significant differences in leaf chlorophyll content were found among treatments (Tab. 1).

Water deprivation and high salinity induced a marked decrease in net photosynthesis, while in plants subjected to root confinement *A* values were similar to those observed in control plants (Tab. 2). Analogous results were described in cucumber (Kharkina *et al.*, 1999) and in Ponkan mandarin (Mataa and Tominaga, 1998) root restricted plants.

The reduction in *A* in water- and salt-stressed plants was associated with lower *g* with respect to controls; on the contrary, in root restricted plants photosynthetic activity remained high in spite of a reduction in stomatal conductance (Tab. 2). This apparently confirms an increase in photosynthetic efficiency in plants subjected to root confinement.

As plant water status is concerned, total leaf water potential measurements indicate that salt stress caused a strong water imbalance, while the reduction of irrigation volumes led to a less evident drop in Ψw; on the other hand, leaf water potential was only slightly affected by root restriction (Tab. 2). These results appear to be consistent with those reported by Hurley and Rowarth (1999) in root restricted tomato plants.

Aesthetic value of blooming was evaluated by measuring both the number of inflores-

Tab. 1 - Relative Growth Rate (RGR), Net Assimilation Rate (NAR) and leaf chlorophyll content (SPAD values) of potted *Callistemon laevis* plants after three month of cultivation under different stress conditions. Mean values (n = 5). Different letters indicate significantly different values within each column for P ≤ 0.05.

Treatment	RGR ($g\ g^{-1}\ d^{-1}$)	NAR ($mg\ cm^{-2}\ d^{-1}$)	Chlorophyll (SPAD values)
Control	0.030 a	0.072 b	64.3 a
Salt stress	0.015 c	0.047 c	54.5 ab
Water stress	0.026 ab	0.080 b	60.1 a
Root restriction	0.029 a	0.095 a	63.2 a

Tab. 2 - Net photosynthesis (A), leaf conductance (g) and total leaf water potential (Ψw) of potted *Callistemon laevis* plants after three month of cultivation under different stress conditions. Mean values (n = 5). Different letters indicate significantly different values within each column for P ≤ 0.05.

Treatment	A (µmol $^{m-2\ s-1}$)	g $(m-2\ s-1)$	Ψw
Control	3.28 a	45.33 a	-0.77 a
Salt stress	0.83 c	5.82 c	-1.68 c
Water stress	2.10 ab	19.64 b	-1.34 b
Root restriction	3.52 a	26.62 b	-1.03 ab

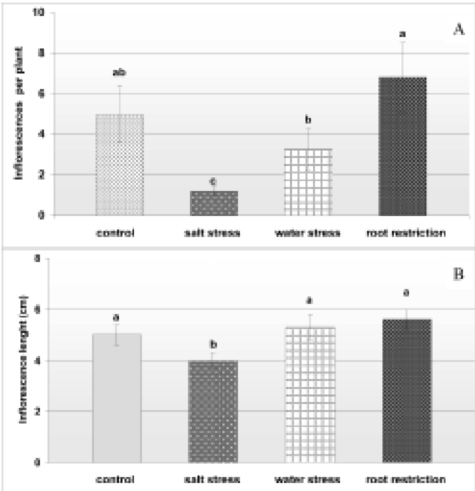

Fig. 3 - Number of inflorescences per plant (A) and inflorescence length (B) of potted *Callistemon laevis* plants after three month of cultivation under different stress conditions. Data are mean ± SD (n = 5). Different letters indicate significantly different values for P ≤ 0.05.

cences per plant (Fig. 3A) and the mean length of inflorescences (Fig. 3B). Results show that high salinity severely affected blooming, since plants produced very few inflorescences and of reduced size. Several *Callistemon* species are characterised by high degree of resistance to salinity, while others are salt-sensitive (Lippi *et al.*, 2003; 2005). The severe reduction of plant growth and the negative effect on blooming observed in this study suggest a poor tolerance to high salinity of *C. laevis*.

Water stressed plants produced somewhat less inflorescences than control plants (Fig. 3), but the overall plant quality resulted acceptable.

Root restriction did exert any significant influence the number and the length of inflorescences (Fig. 3), but it anticipated the blooming of some 10 days.

It has been reported that root restriction enhanced floral bud density in sweet peach (Webster *et al.*, 1997) and increased tree flowering in apple (Byers *et al.*, 2004), while in *Salvia splendens* a delay in blooming was observed by Van Iersel (1997).

CONCLUSIONS

These findings suggest that in *Callistemon laevis* cultivated as flowering pot plant, the plant size could be controlled by the reduction of irrigation, the use of saline water or root restriction

However, salt stress induced an excessive decrease in plant growth and negatively affect blooming, thus resulting in pot plants of poor quality. A limited water supply reduced markedly the plant growth, but did not influence significantly the blooming. The most effective treatment was root restriction achieved by using smaller pots; the height was decreased, but the plants showed a compact *habitus* and an earlier blooming with respect to the control.

To conclude, the use of reduced-size pots could represent a valid strategy to control plant size in commercial cultivation, which may reduced the environmental impact associated with the application of PGRs' use.

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