Europ.J.Hort.Sci., **70** (3). S. 105–108, 2005, ISSN 1611-4426. © Verlag Eugen Ulmer GmbH & Co. Stuttgart

The Influence of Stock Plant Light Exposure on Optimum Storage Conditions and Rooting Behaviour of *Plectranthus coleoides* Cuttings

R. Kadner
(Institut für Gemüse-und Zierpflanzenbau Großbeeren/Erfurt)

Summary

Mother plants were cultivated under two separate sets of conditions to establish the impact of exposure to different levels of light intensity on the storage and rooting of *Plectranthus coleoides* cuttings. One set of mother plants was cultivated in a climate chamber with a photosynthetic photon flux density (PPFD) of 1000 µmol m^{-2} s^{-1} (Halogen HQI) for 12 h a day at a temperature of 20 °C simulating southern latitudes. The other set was exposed to climatic conditions in a greenhouse with an average PPFD of 84 µmol m^{-2} s^{-1} per average daylength of 10.3 h and an average temperature of 16.6 °C simulating Central European conditions. Then, all cuttings were wrapped in polyethylene foil, stored for periods of 3, 4, 5, 6, 7 or 14 d at temperatures of 1, 5 or 12 °C. For rhizogenese, they were inserted into a propagation substrate (white peat, perlite) and cultivated in the greenhouse at an average temperature of 20 °C and an average PPFD of 88 µmol m^{-2} s^{-1}.

Damage to shoots was influenced by preharvest light conditions. Cuttings from the climate chamber (1000 µmol m^{-2} s^{-1}) were particularly susceptible to a storage temperature of 5 °C, where they developed damaged shoots in fairly, large numbers, whereas cuttings produced in the greenhouse (84 µmol m^{-2} s^{-1}) were more susceptible to such damage at a storage temperature of 12 °C. Cuttings from both treatments did not differ in regards to rooting percentage when they were stored at 5 or 12 °C. Storage at 1 °C generally resulted in a large number of decayed cuttings during the rooting period, regardless of the preharvest conditions.

The experiments demonstrated that exposure to high PPFD during the cultivation of stock plants and the cutting production stage resulted in a pronounced preference of the cuttings for certain storage temperatures. *Plectranthus* cuttings can be easily stored for 7 d without any adverse effect on quality, but the storage and transport temperatures will have to be adapted to the conditions under which the cuttings were produced. Storage and transport temperatures for cuttings produced in southern latitudes under high PPFD should not fall below 10 °C, whereas for cuttings produced under central European conditions in the winter and early spring, a storage and transport temperature of 5 °C is most suitable.

Key words. cuttings – light intensity – *Plectranthus coleoides* – rooting – stock plants – storage – vegetative propagation

Zusammenfassung

Einfluss unterschiedlicher Lichtangebote in der Mutterpflanzenhaltung auf Lagerung und Bewurzelung von *Plectranthus coleoides*-Stecklingen. Um den Einfluss unterschiedlicher Lichtangebote auf Lagerung und Bewurzelung von Stecklingen von *Plectranthus coleoides* zu prüfen, wurden Mutterpflanzen unter zwei unterschiedlichen Klimabedingungen kultiviert. Um die Bedingungen in südlichen Breiten zu simulieren, erfolgte eine Mutterpflanzenkultur in einer Klimakammer mit einer Photonenflussdichte (PPFD) von 1000 µmol m^{-2} s^{-1} (Halogen HQI) bei einer Tageslänge von 12 h und einer Temperatur von 20 °C. Die zweite Mutterpflanzenkultur wurde unter Gewächshausbedingungen (durchschnittliche PPFD 84 µmol m^{-2} s^{-1}, Tageslänge 10,3 h, Temperatur 16,6 °C) entsprechend den Bedingungen in Mitteleuropa, kultiviert. Alle Stecklinge wurden in PE-Folie verpackt, bei einer Temperatur von 1, 5 bzw. 12 °C über einen Zeitraum von 3, 4, 5, 6, 7 bzw. 14 Tagen gelagert. Nach der Lagerung wurden sie in Vermehrungssubstrat (Weißtorf, Perlite) gesteckt und zur Wurzelbildung im Gewächshaus bei 20 °C und einer durchschnittlichen PPFD von 88 µmol m^{-2} s^{-1} kultiviert. Triebspitzenschäden traten in Abhängigkeit von den Lichtbedingungen auf. Stecklinge aus der Klimakammer (1000 µmol m^{-2} s^{-1}) reagierten bei einer Lagertemperatur von 5 °C mit einem hohen Anteil geschädigter Triebspitzen, während bei Stecklingen aus dem Gewächshaus (84 µmol m^{-2} s^{-1}) gleiche Triebspitzenschäden nach der Lagerung bei 12 °C auftraten. Bei Lagertemperaturen von 5 und 12 °C traten keine Unterschiede in der Bewurzelungsrate der Stecklinge beider Standorte auf. Die Lagertemperatur von 1 °C führte unabhängig von den Kulturbedingungen der Mutterpflanzen zu hohen Ausfällen während der Bewurzelung.

Durch die Untersuchungen wurde deutlich, dass eine hohe PPFD während der Mutterpflanzenhaltung bzw. Stecklingsproduktion zur Modifikation der Optimaltemperatur bei der Stecklingslagerung führt. *Plectranthus-S*tecklinge lassen sich ohne Qualitätsverluste 7 Tage lagern, jedoch ist die Lager- und Transporttemperatur in Abhängigkeit vom Produktionsort der Stecklinge zu wählen. Wenn Stecklinge unter hoher PFD an südlichen Standorten produziert wurden, sollte die Lager- und Transporttemperatur nicht unter 10 °C liegen, während für unter mitteleuropäischen Bedingungen im Winterhalbjahr produzierte Stecklinge eine Lager- und Transporttemperatur von 5 °C optimal ist.

Introduction

The *Plectranthus* genus belongs to the family of mint plants (*Labiatae)* and has its habitat in south-east India and South Africa. Its 20 different species have attracted a certain amount of interest, mainly due to their therapeutic properties (BUCHBAUER et al. 1993; RABE and VAN STADEN 1998). Over the past few years, *Plectranthus coleoides* has become popular as a structural plant in flowerbeds and window boxes. It exclusively is propagated through cuttings from mother plants that are cultivated in regions with a suitably warm climate, i.e. mainly in southern Europe and Africa. Then, the cuttings are transported to central and northern Europe, where they are rooted in nurseries. In the past, some nurseries have encountered problems during this rooting process that have resulted in a large number of failures. It was shown that cuttings from mother plants cultivated under high PPFD (1000 µmol m^{-2} s^{-1}) and low storage temperatures developed damaged shoots and generally exhibited poor rooting behaviour (KADNER 2002). The symptoms did not become immediately apparent, but a few days after planting the cuttings, the tips of the shoots turned brown. Later, this was accompanied by a secondary *Botrytis* infection. Cuttings from stock plants cultivated in Germany generally did not exhibit such symptoms. Based on these experiments, we studied, whether the high PPFD in the cultivation of stock plants was one of the reasons for damaged shoots and poor rooting at low temperature.

Materials and Methods

In order to simulate the light conditions of southern latitudes, we cultivated the mother plants in a climate chamber with a PPFD of 1000 µmol m^{-2} s^{-1} (Halogen HQI) for 12 h a day at a temperature of 20 °C. Simultaneously, we exposed a second set of stock plants in a greenhouse to the type of climatic conditions that would be natural for the relevant period of young plant production from February to April. In line with the reduced exposure to natural light, the night and day temperatures were 15 and 18 °C, respectively, with an average temperature of 16.6 °C. The PPFD for the plants reached an average of 84 µmol m^{-2} s^{-1} at a mean daytime period of 10.3 h.

Storage

Ten cuttings with three leaves were wrapped in polyethylene foil and stored for periods of 3, 4, 5, 6, 7 or 14 d at temperatures of 1, 5 or 12 °C.

The cuttings were then inserted into the propagation substrate (white peat, perlite) and rooted in the greenhouse at a temperature of 20 °C, an average PPFD of 88 µmol m^{-2} s^{-1} and an average daylength of 10.4 h. After 12 d of rooting, an evaluation was conducted on the basis of the following criteria, which mainly focussed on shoot damage: the number of damaged shoots and leaves was determined and related to the total number of shoots (10) and leaves (30) per replication. In addition, the percentage of rooted cuttings was determined because this is the primary criterion for successful propagation of *Plectranthus*. The experiments were conducted between February and April 2003 (three series of experiments with three replications).

The data were calculated and processed with a variance analysis. The significance of results was confirmed with the Tukey test (p=5 %) (STATSOFT 1995).

Results

Damaged shoots and leaves

The effect of storage temperature on shoot damage clearly depended on the pre-harvest location (Fig. 1). For example, the 7 d percentage values are presented. For cuttings from the climate chambers the percentage of cuttings that developed damaged shoots increased from 7.8 % at 12 °C, 44.4 % at 5 °C and 74.4 % at 1 °C. The cuttings produced in the greenhouse reacted differently to the storage temperatures. After exposure to 1 °C or 12 °C, 43.4 % or 38.9 % of the cuttings developed damaged shoots. But after storage at 5 °C, the percentage was only 5.6 %.

The occurrence of damaged leaves (necrotic brown spots) ranged independently of any variation in light conditions from 1 % to 9 % after storage periods up to 7 d at temperatures of 5 °C and 12 °C (Fig. 2). However, after storage at 1 °C, this figure increased to 23 %

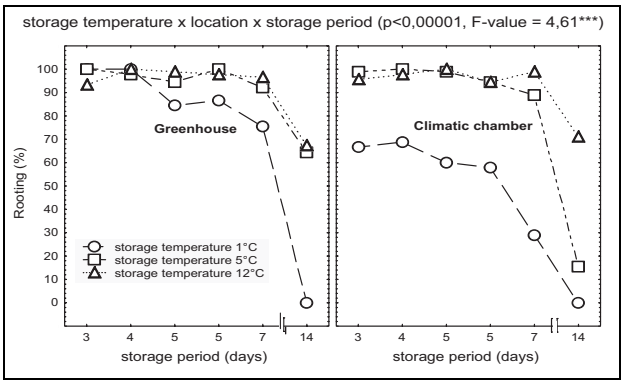


Fig. 1. Rooting of *Plectranthus* cuttings depending on preharvest location, storage temperature and storage period (mean values n = 9).

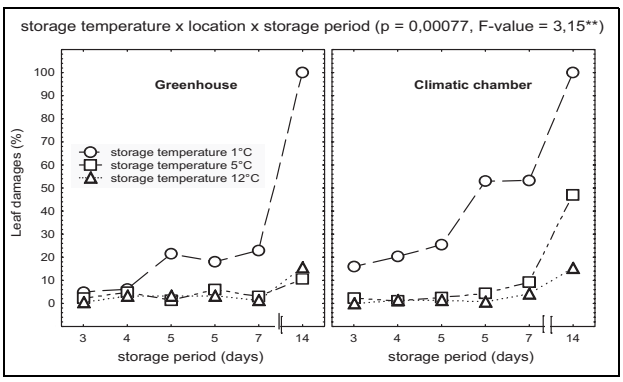


Fig. 2. Leaf damage of *Plectranthus* cuttings depending on preharvest location, storage temperature and storage period (mean values n = 9).

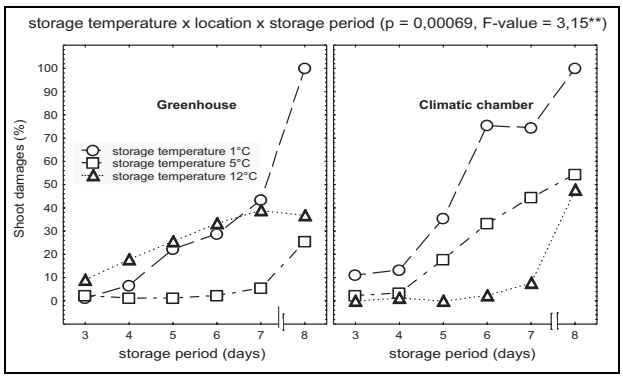


Fig. 3. Shoot damage of *Plectranthus* cuttings depending on preharvest location, storage temperature and storage period (mean values n = 9).

for cuttings in the greenhouse and 53 % for the climate chamber cuttings.

Rooting

After 7 d of storage at 5 °C and 12 °C, more than 90 % of the cuttings rooted successfully, independent of the light conditions during stock plant cultivation (Fig. 3). However, the rooting rate decreased sharply when the storage temperature was reduced to 1 °C, with the climate chamber cuttings showing a far greater susceptibility than cuttings produced in the greenhouse. For example, already after 3 d of cold storage, only 67 % of the climate chamber cuttings developed roots, a figure, which decreased to 29 % when the storage period was extended to 7 d. Cuttings produced in the greenhouse were significantly more resilient: more than 60 % developed roots. Even after exposure to 5 °C or 12 °C for 14 d, a result that the climate chamber cuttings matched only after storage at 12 °C.

Discussion

The relationship between storage temperature and damaged shoots agrees with previous research (KADNER 2002). Thus, it can be concluded that young tissue of shoots cultivated under a high PPFD are extremely sensitive to cold temperatures. The high PPFD seems to affect the inner structure of the plants, apparently prompting ontogenetic and physiological adjustments, which turn them into "sun plants" (LIBBERT 1987). The leaves of such *Plectranthus* cuttings was smaller and thicker and the colour of the leaves changed from a light green to white, probably due to an inhibited generation of chlorophyll. A similar strong variability in the external appearance of plants at different light intensities also has been found with other genera such as *Pelargonium* (FORSCHNER and REUTHER 1984) and *Actinidia* (GREER and HALLIGAN 2001). The alterations of cuttings by high PPFD and high temperature, also affects the optimum storage temperature. The high damage rate after storage at 1 °C is due to a stalling of the shoots through cold storage. Extending the storage period at low temperature results in increased damage to shoots and leaves. In plants from tropical regions, which are more sensitive, storage below 10 °C to 12 °C results in chilling damage (LYONS 1973; LEVITT 1980). The low shoot damage to cuttings produced in the greenhouse after storage at 5 °C indicates a potential adaptation to lower temperature. This has to be confirmed if stock plants were cultivated under lower PPFD and lower temperature.

Damaged shoots occurred at both the low (1 °C) and high end (12 °C) of the temperature range. The low temperature damage is clearly a consequence of chilling, whereas the storage temperature of 12 °C might have caused high respiration losses (BEHRENS 1988).

Damaged shoots in the form that we encountered as a consequence of storage temperatures of 1 to 3 °C were also observed in *Chrysanthemum* cuttings by VAN DER HOEVEN (1990). Physiological and morphological damaged leaves in the form of necrosis as a consequence of excessively cold storage of cuttings or young plants are known to occur in other genera of plants such as certain varieties of *Chrysanthemums* (RAJAPAKSE et al. 1996). It has been shown, that high temperature storage causes senescence, depletion of carbohydrates, and the degradation of leaf chlorophyll and proteins in *Pelargonium* cuttings (ARTECA et al. 1996; RAPAKA 2004).

Despite having developed into "sun plants", the rooting percentage of *Plectranthus* cuttings was not affected by storage at 5 °C and 12 °C. In other cultures (FORSCHNER and REUTHER 1984; WOLF and JAENICKE 2000; MESEN et al. 2001), many cuttings, that had been grown under high light intensity decayed during the rooting period. This observation was not confirmed in our experiment.

Acknowledgements

I would like to thank Ms Gabriele Eckart for the great care she took in conducting the experiments.

The experiments were carried out at the Institut für Gemüse- und Zierpflanzenbau Großbeeren/Erfurt e.V. (IGZ) and partly funded by the German Federal Ministry for Consumer Protection, Food and Agriculture, as well as the Ministry for Food, Agriculture and Forestry of the Brandenburg State and the Ministry for Agriculture, Conservation and the Environment of the Thuringia Free State.

References

ARTECA, R.N., J.M Arteca , T.-W. WANG and C.D. SCHLAGNHAUFER 1996: Physiological, biochemical, and molecular changes in *Pelargonium* cuttings subjected to short-term storage conditions. J. Amer. Soc. Hort. Sci. **121**, 1063–1068.

BEHRENS, V. 1988: Storage of unrooted cuttings. In: DAVIS T.D., B.E: HAISSIG and N. SANKHLA (eds): Adventitious root formation in cuttings. Chapter 17. Dioscorides Press, Portland, Oregon, pp. 235–247.

BUCHBAUER, G., L. JIROVETZ, M. WASICKY and A. NIKOFOROV 1993: Volatile constituents of the headspace and essential oil of *Plectranthus coleoides* Marginatus (*Labiatae*). J. Ess. Oil Res. **5**, 311–313.

FORSCHNER, W. and G. REUTHER 1984: Photosynthese und Wasserhaushalt von Pelargonium-Stecklingen während der Bewurzelung unter dem Einfluß verschiedener Licht- und CO_2-Bedingungen. Gartenbauwissenschaft **49**, 182–190.

GREER, D.H. and E.A. HALLIGAN 2001: Photosynthetic and fluorescence light for kiwifruit *(Actinidia deliciosa*) leaves at different stages of development on vines grown at two different photon flux densities. Aust. J. Plant Physiol. **28**, 373–382.

KADNER, R. 2002: Storage of cuttings from *Plectranthus coleoides*. Gartenbauwissenschaft **67**, 190–193.

LIBBERT, E. 1987: Lehrbuch der Pflanzenphysiologie 4. Aufl. Fischer, Jena.

LYONS, J.M. 1973: Chilling injury in plants. Ann. Rev. Plant Physiol. **24**, 445–466.

LEVITT, J. 1980: Chilling temperatures – Chilling injury and resistance. In: KOZLOWSKI, T.T. (ed.): Responses of plants to environmental stresses. Academic Press, London, New York, p. 23.

MESEN, F., R.B.R. LEAKEY and A.C. NEWTON 2001: The influence of stockplant environment on morphology, physiology and rooting of leafy stem cuttings of *Albizia guachapele*. New Forests **22**, 213–227.

VAN DER HOEVEN, B. 1990: Lage temperatuur bevordert stekverbranding. Vakblad voor de Bloemisterij **31**, 50–51.

RABE T. and J. VAN STADEN 1998: Screening of *Plectranthus* species for antibacterial activity. S. Afr. J. Bot. **64**, 62–65.

RAJAPAKSE, N.C., W.B. MILLER and J.W. KELLY 1996: Low-temperature storage of rooted *chrysanthemum* cuttings: Relationship to carbohydrate status of cultivars. J. Am. Soc. Hortic. Sci. **121**, 740–745.

RAPAKA, V.K. 2004: Rooting capacity of *Pelargonium* cuttings with special regard to carbohydrate availability and photosynthetic performance. Dissertation FB Gartenbau Universität Hannover 2004.

STATSOFT 1995: Statistica for Windows. StatSoft, Inc., Tulsa, OK.

WOLF, J. DE and H. JAENICKE 2000: Propagation of *Calliandra calothyrsus* through cuttings: effect of stockplant shading. Journal of Tropical Forest Science **12**, 571–580.

Received March 17, 2004 / Accepted March 11, 2005

Addresses of authors: Dr. R. Kadner, Institut für Gemüse-und Zierpflanzenbau Großbeeren/Erfurt, Abteilung Pflanzenvermehrung, Kühnhäuser Str. 101, 99189 Kühnhausen, e-mail: Kadner@Erfurt.igzev.de.