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Effect of DIF and Drop on Growth of some Ornamental Shrubs under Two Nutrition Regimes

Wirkung von DIF und Drop in Kombination mit zwei Düngerstufen auf das Wachstum einiger Ziersträucher

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Summary

Cotinus coggygria, *Photinia* × *fraserii*, *Pieris japonica* and *Viburnum tinus* were grown on ebb-and-flow benches under positive DIF, negative DIF or Drop temperature regimes and fertigated with nutrient solution of two concentrations (EC 0.8 or 1.6 mS cm^{-1}). Negative DIF reduced growth of all species except *Viburnum* but internode length was decreased only in *Photinia*. Drop was generally ineffective in controlling of plant growth. Concentration of nutrient solution had no effect on growth of tested species except *Pieris* where higher concentration of nutrient solution resulted in lower dry matter content of shoots.

Zusammenfassung

Cotinus coggygria, *Photinia x fraseri*, *Pieris japonica* und *Viburnum tinus* wurden im Gewächshaus auf Ebbe-Flut bewässerten Tischen unter Klimaregel-Strategien (DIF und Drop) von Ende Januar bis Ende Mai kultiviert. Das Düngen der Pflanzen erfolgte mit niedrig- oder hochkonzentrierter Nährlösung (EC 0,8 oder 1,6 ms cm^{-1}).

Negative DIF reduzierte bei den geprüften Gattungen mit Ausnahme von *Viburnum* das Längenwachstum, allerdings war die Länge der Internodien nur bei *Photinia* verkürzt.

Drop hatte im allgemeinen keine Einfluss auf das Pflanzenwachstum. Die Konzentration der Nährlösung beeinflusste das Wachstum der untersuchten Arten mit Ausnahme von *Pieris* nicht. Bei dieser Art führte die hochkonzentrierte Nährlösung zu geringerem Trockengewicht der Triebe.

Der Einfluss der Klimaregel-Strategien (DIF und Drop) und der Nährlösungskonzentration auf Wachstum und Habitus der geprüften Gattungen war zu gering, um für kommerzielle Zwecke in der Praxis (Erwerbsgärtnerei) Verwendung zu finden.

Introduction

Cotinus, *Photinia*, *Pieris* and *Viburnum* when grown in a greenhouse can obtain saleable size much faster than in outside beds. Detailed procedures for greenhouse production of these species, like many other nursery crops, are not developed. Unfortunately, loss in plant quality during protected cultivation can exceed benefits of faster growth. Main problems encountered during greenhouse cultivation of the above species are poor branching and excessive elongational growth of *Cotinus* as well as excessive elongational growth and consequently loose growth habit of *Photinia*, *Pieris* and *Viburnum* (JOUSTRA 1994). As less and less chemical growth regulators may be used due to environmental reasons, cultural techniques that would ensure high quality of plants are required.

Lower day than night temperature called negative DIF (ERWIN et al. 1989a) can reduce stem elongation and result in more compact plants. This phenomenon was reported among others on *Dendranthema grandiflora* (COCKSHULL et al. 1994), *Euphorbia pulcherrima* (BERGHAGE and HEINS 1991), *Fuchsia* × *hybrida* (ERWIN et al. 1991), *Campanula isophylla* (MOE 1990) and *Lilium longiflorum* (ERWIN et al. 1989b). ZIESLIN and TSUJITA (1988) showed that negative DIF resulted in significantly shorter stems of Easter lilies 'Nellie White', while VAN DEN BERG (1984) observed the same reaction on roses. Also rapid lowering of temperature in the morning (Drop) can decrease shoot elongation in some pot plants (ERWIN et al. 1989a; MOE 1993). It was suggested that variation in day and night temperature bring about changes in endogenous gibberellin level, with GA_1 being mostly involved (MYSTER et al. 1995). Also photoperiod and far-red light may influence DIF effect, presumably due to modification of gibberellin biosynthesis (MOE et al. 1995). Moreover, the water vapour pressure deficit gradient of the air is affected by day and night temperature thus altering the transpiration and nutrient uptake of the plants (SCHÜSSLER 1995).

On the other hand a decreased difference between the water potential of roots and the soil reduces water uptake of the plants which can consequently lead to growth retardation (HENDRIKS and UEBER 1995). ROEBER and HORN (1993) reported a positive effect of drought stress on quality of poinsettia, while LEEUWEN (1994) showed that high concentration of nutrient solution results in more compact plants of *Pelargonium zonale*.

The objective of this study was to evaluate the effects of three temperature regimes and two concentrations of nutrient solution on growth of greenhouse grown *Coti-*

nus coggygria 'Royal Purple', *Photinia* × *fraseri* 'Red Robin', *Pieris japonica* 'Debutante' and *Viburnum tinus* 'Eve Price'.

Material and Methods

Rooted cuttings obtained from a commercial nursery were overwintered in a cool greenhouse. On 20 January they were planted into 2 dm^3 containers and placed on tables with an ebb-and-flow system under three different temperature treatments i.e. positive DIF, negative DIF or 5 °C temperature Drop at sunrise (Tab. 1). Potting mixture consisted of Finnish peat (30 % v/v), coarse white peat (46 %), pumice stone (4 %) and perlite (20 %). Additionally, mixture was supplemented with 2.0 kg m^{-3} lime, 0.8 kg m^{-3} PG-Mix ($N:P_2O_5:K_2O$ – 14.5 : 16.2 : 18.2 + micro) and 0.02 kg m^{-3} FeEDDHA. For the first two weeks all plants were watered with nutrient solution of EC = 0.4 mS cm^{-1}. Starting from the week 3 in each compartment two concentrations of nutrient solution were tested i.e. 'low' with EC value of 0.8 mS cm^{-1} ($N\text{-}NO_3^-$ 6.5; $N\text{-}NH_4^+$ 0.75; $H_2PO_4^-$ 0.5; K^+ 2.25; Mg^{2+} 0.75; Ca^{2+} 2.0; SO_4^{2-} 0.75 – mmol dm^{-3}) and 'high' with EC = 1.6 mS cm^{-1} ($N\text{-}NO_3^-$ 13.0; $N\text{-}NH_4^+$ 1.5; $H_2PO_4^-$ 1.0; K^+ 4.5; Mg^{2+} 1.5; Ca^{2+} 4.0; SO_4^{2-} 1.5 – mmol dm^{-3}). For every species there were 36 plants in each treatment organised in two replicates. Plants were grown under the natural photoperiod and except for *Cotinus* all species were pinched according to standard production procedures to obtain saleable plants. The plants of all species were harvested after 17 weeks of growth.

For all plants mean length of shoot and mean length of internode were assessed (except for *Pieris* where internode length was not measured). Additionally, number of shoots per plant as well as fresh and dry weight of shoots were recorded for *Photinia*, *Pieris* and *Viburnum*. From these the dry matter content of shoots was calculated. For *Photinia* dry weight of roots was also measured.

Two-factorial analysis of variance and Duncan's Multiple Range test were performed to establish significant differences between treatments at the 5 % level of significance.

Results

Temperature

The effect of temperature treatment depended strongly on a plant species. Negative DIF treatment reduced length of shoots in *Cotinus*, *Photinia*, and *Pieris* (compared to both positive DIF and Drop treatments) but it had generally no effect on growth of *Viburnum*. Negative DIF reduced also number of shoots of *Pieris* but did not affect branching of the other species. Mean length of internode did not differ between treatments except for *Photinia* where negative DIF resulted in shorter internodes compared to other treatments. Fresh and dry weight of shoots of *Photinia* was increased by Drop treatment but root dry weight was unaffected. For *Pieris* interaction between temperature treatments and nutrition was noted. Plants watered with less concentrated nutrient solution had the highest shoot fresh weight under positive DIF while for those given nutrient solution of higher EC shoot fresh weight was greatest under Drop treatment. Nevertheless, the lowest fresh and dry weight of shoots was found under negative DIF. For other species no interaction between temperature and nutrition was significant.

Nutrition

Contrary to the temperature treatments concentration of nutrient solution did not affect growth of tested species except *Pieris*. For this species use of more concentrated nutrient solution reduced dry matter content of shoots while interaction with temperature treatment was noted for fresh weight of shoots. However, length

Tab. 1. Average day and night temperature (°C) in greenhouse compartments and total sum of solar radiation during experiment
Mittlere Tag- und Nachttemperatur (°C) sowie Gesamtsonneneinstrahlung

Week of experiment	Positive DIF			Negative DIF			DROP (5 °C)		
	DT	NT	ADT	DT	NT	ADT	DT	NT	ADT
1	15.1	10.5	12.2	12.0	13.8	13.2	14.8	10.1	11.9
2	15.3	10.5	12.3	11.8	13.7	13.0	15.4	10.2	12.2
3	17.2	8.9	12.1	13.6	12,3	12.6	16.6	9.9	12.1
4	22.4	12.0	15.6	17.5	14,1	14.9	19.1	12.6	14.5
5	18.8	11.7	14.7	15.1	15.3	14.8	18.6	12.4	14.6
6	20.4	12.6	15.9	17.1	17.0	16.6	20.8	13.9	16.1
7	20.4	12.6	16.0	18.2	17.3	17.4	21.1	13.9	16.6
8	21.6	13.3	17.0	19.3	17.5	17.8	21.9	14.1	17.0
9	22.1	13.6	17.5	19.5	17.6	18.0	22.1	14.1	17.3
10	23.7	14.0	18.7	21.5	19.1	19.9	23.8	15.6	19.1
11	22.8	13.5	18.4	21.0	18.0	19.2	22.7	14.8	18.7
12	24.0	14.0	19.2	21.2	18.4	19.4	24.5	15.1	19.5
13	25.2	14.5	20.2	22.7	18.7	20.3	25.3	15.2	20.0
14	24.9	14.3	20.3	23.8	19.6	21.4	25.8	15.7	20.8
15	24.6	15.1	20.6	22.4	19.5	20.9	25.3	16.3	21.0
16	26.5	15.2	21.7	24.3	19.8	22.0	27.0	16.7	21.8
17	25.3	15.6	21.4	22.8	19.8	21.3	25.5	16.8	21.5
Total sum of solar radiation [MJ m^{-2}]									1134

Tab. 2. Growth of *Cotinus coggygria* 'Royal Purple', *Photinia* × *fraseri* 'Red Robin', *Pieris japonica* 'Debutante' and *Viburnum tinus* 'Eve Price' under different temperature regimes and two concentrations of nutrient solution.
Wachstum von Cotinus coggygria *'Royal Purple'*, Photinia × fraseri *'Red Robin'*, Pieris japonica *'Debutante' und* Viburnum tinus *'Eve Price' bei unterschiedlichen Temperaturstrategien und zwei Nährstofflösungskonzentrationen.*

Morphological traits	Temperature regime			Solution concentration	
	Positive DIF	Negative DIF	Drop	Low	High
Cotinus coggygria 'Royal Purple'					
Mean length of shoot [cm]	50.6 b*	31.5 a	47.7 b	42.5 a	44.0 a
Mean length of internode [cm]	2.6 a	2.2 a	2.4 a	2.4 a	2.4 a
Photinia × *fraseri* 'Red Robin'					
Number of shoots	3.3 a	3.0 a	3.2 a	3.1 a	3.3 a
Mean length of shoot [cm]	6.9 b	5.3 a	6.6 b	6.3 a	6.2 a
Mean length of internode [cm]	1.6 b	1.2 a	1.6 b	1.5 a	1.5 a
Fresh weight of shoots [g]	15.5 ab	13.5 a	18.2 b	15.3 a	16.1 a
Dry matter content of shoots [%]	28.7 b	27.2 a	28.3 ab	28.4 a	27.8 a
Dry weight of roots [g]	0.45 a	0.40 a	0.45 a	0.43 a	0.44 a
Pieris japonica 'Debutante'					
Number of shoots	20.5 b	15.2 a	18.8 b	17.6 a	18.7 a
Mean length of shoot [cm]	6.2 b	5.7 a	6.4 b	6.3 a	6.0 a
Fresh weight of shoots [g]	29.6 b**	22.0 a	29.0 b	26.4 a	27.4 a
Dry matter content of shoots [%]	24.8 a	24.6 a	24.2 a	25.0 b	24.1 a
Viburnum tinus 'Eve Price'					
Number of shoots	7.6 a	7.7 a	8.23 a	7.8 a	7.9 a
Mean length of shoot [cm]	12.4 a	12.0 a	12.7 a	12.4 a	12.4 a
Mean length of internode [cm]	5.1 a	5.2 a	5.2 a	5.3 a	5.0 a
Fresh weight of shoots [g]	11.1 a	12.8 a	13.7 a	12.7 a	12.3 a
Dry matter content of shoots [%]	26.7 a	26.9 a	26.7 a	26.3 a	27.2 a

* Means followed by the same letter do not differ significantly according to Duncan's Multiple Range test at P=0.05.
** Significant interaction between temperature and nutrition

and number of shoots were similar in both nutrition treatments (Tab. 2).

Discussion

Reduced growth observed under negative DIF conditions on *Cotinus*, *Photinia*, and *Pieris* agrees with the observations on other species (BIELENIN and JOUSTRA 2000; GRIMSTAD and FRIMANSLUND 1993). However, it seems that in this experiment, reduced growth of *Cotinus* and *Pieris* came exclusively from slower plant development and resulted in smaller but not more compact plants. This can be attributed to lower rate of photosynthesis during the day and higher respiration intensity during night in negative DIF treatment. The findings are in opposition to observations on *Lilium longiflorum* (ERWIN et al. 1989b), cucumber (GRIMSTAD and FRIMANSLUND 1993), *Lavandula angustifolia* (BIELENIN and JOUSTRA 2000) and many other plants where growth retardation was primarily due to reduction of internode length. In the reported experiment this was only true for Photinia where internode length was reduced by negative DIF of about one-fourth. The experiment confirms strong variation among species in reaction to negative DIF and Drop from decrease in shoot growth through no reaction to stimulation of shoot growth (MORTENSEN 1994). Limited effects observed in the trial question the possibility of practical use of negative DIF or Drop regimes for growth regulation of greenhouse-grown *Cotinus*, *Photinia*, *Pieris* and *Viburnum*.

Lack of effect of nutrition treatments on plant growth indicates that the concentrations of nutrient solution used in the experiment fell within the tolerance range for tested species but it failed to alter plant growth pattern. In comparison, increased concentration of nutrient solution reduced growth of the main shoot of *Magnolia soulangiana* (BIELENIN and JOUSTRA 2000) even though the effect was not great. It is doubtful that the use of more concentrated solution can yield with significant dwarfing of tested plants i.e. increased branching and reduced elongational growth. Smaller plants potentially obtained under salinity stress are not necessarily more dwarf ones as it was shown on *Lavandula angustifolia* 'Munstaed' (BIELENIN and JOUSTRA 2000).

Conclusions

Negative DIF reduces growth of *Cotinus*, *Photinia* and *Pieris* (including decreased length of internodes of *Photinia*) but has no effect on growth of *Viburnum*.
DROP treatment has little effect on growth of tested species.
Increased concentration of nutrient solution (EC of 1.6 vs. 0.8) does not affect growth pattern of *Cotinus*, *Photinia* and *Viburnum* but reduces dry matter content of shoots of *Pieris*.
Changes in plant growth are insufficient for practical employment of DIF or Drop regimes in greenhouse production of tested species.

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