Journal of Fruit and Ornamental Plant Research Vol. 11, 2003: 99-105

ROOTING AND GAS EXCHANGE OF CONIFER CUTTINGS TREATED WITH INDOLEBUTYRIC ACID

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(Received November 5, 2002/Accepted August 11, 2003)

A B S T R A C T

Cuttings of *Juniperus scopulorum* 'Skyrocket' and *Thuja occidentalis* 'Smaragd' were collected at the end of February, processed, and the stem bases were treated with 0, 0.1, 0.3, 0.6 or 0.9% potassium salt of indolebutyric acid in talc after which cuttings were inserted into rooting medium. After 72 h and 6 weeks photosynthesis and respiration of cuttings were measured, while rooting was evaluated after 10 weeks.

Auxin significantly improved rooting of cuttings of both species. For *Juniperus scopulorum* 'Skyrocket' rooting percentage as well as the number of roots and quality of root system enhanced with an increasing auxin concentration within its tested range, while cuttings' fresh weight gain was not affected by the treatment. The best rooting of *Thuja occidentalis* 'Smaragd' was obtained for auxin concentration ranging from 0.3 to 0.6%.

Basal treatment of cuttings with potassium salt of indolebutyric acid influenced neither photosynthesis nor respiration of cuttings on any measurement date.

Key words: adventitious rooting, auxins, conifers, hardy nursery stock

INTRODUCTION

Ornamental conifers are propagated mainly by cuttings. However, they generally require a relatively long time to produce roots and rooting may often be non-uniform. This significantly increases production costs as well as make proper production planning more difficult.

Adventitious root formation is an extremely complex process controlled by many internal (genetic, physiological etc.) and external (cutting collection, rooting conditions etc.) factors. Since the research of Thimann and Went (1934), exogenous applica-

tion of auxins has become an important method of rooting promotion. Although the fundamental modes of auxin action during rhizogenesis are not completely known yet, it was proved that cells are not sensitive to auxins during dedifferentation phase but a high level of auxins is crucial for induction of root meristems and root initials (De Klerk et al., 1999).

In commercial nurseries auxins are usually applied to cuttings by a powder basal treatment with talc as an inert carrier. The indolebutyric acid (IBA) is the most commonly used auxin and Hrynkiewicz-Sudnik et al. (1995) recommend it at the concentration of 0.4-0.8% for optimal rooting promotion of *Thuja occidentalis* cultivars and at 0.8% for *Juniperus scopulorum* cuttings. However, the research of Chong et al. (1992) showed that requirements of specific cultivars may substantially vary within species and for instance the recommended concentrations of IBA for rooting junipers range from 0.3 to 4.5% (Hartmann et al., 1990).

Generally, the intensity of photosynthesis in cuttings is lower than in shoots of intact plants (Eliasson and Brunes, 1980; Okoro and Grace, 1976), and its rapid decrease was observed during the first 24-48 h after cuttings collection (Davis and Potter, 1981). Usually, photosynthesis intensity starts to increase as new roots appear on a cutting (Davies, 1988).

The objective of the experiment was to evaluate the effect of treatment with potassium salt of indolebutyric acid on rooting, photosynthesis and respiration of *Juniperus scopulorum* 'Skyrocket' and *Thuja occidentalis* 'Smaragd' cuttings.

MATERIAL AND METHODS

Rooting of cuttings was tested during two consecutive seasons. Cuttings from outside-grown mother plants were collected at the end of February. Scales from the 2 cm basal part of stem were removed and the cuttings were individually weighted. Next, 1 cm base of the cutting was dipped in a talc powder containing 0, 0.1, 0.3, 0.6 or 0.9% of potassium salt of indolebutyric acid (K-IBA). Treated cuttings were inserted into peat:perlite (2:1) medium under low polytunnels without mist in a greenhouse. During the second year of the experiments gas exchange of cuttings was analysed. After 72 hours and 6 weeks photosynthesis and respiration of cuttings treated with 0 and 0.9% IBA were measured with a portable solid state gas analyser LCA-3 (ADAC, England) on five cuttings from each treatment. Photosynthesis was evaluated over a range of light intensities and all gas measurements were conducted at 20°C under the natural concentration of CO_2. Rooting of cuttings was assessed after 10 weeks from the beginning of propagation by counting the number of rooted cuttings, number of roots per rooted cutting, evaluation of quality of root system on a scale from 1 (poor root system) to 4 (very good) and the calculation of fresh weight gain of rooted cutting.

Experiment was set as a randomised block design in 4 replicates, each with 24 cuttings, according to EPPO standards (EPPO PP 1/186(2)).

Data on rooting were statistically analysed with ANOVA and Duncan's multiple range t-test separately for each experimental year, based on a common error for both years of the trial. For photosynthesis and respiration measurements a non-linear analysis of regression was performed to estimate the values of R_d, A_{max}, and k parameters for the modified equation of Coombs et al. (1987):

$$Pn = R_d + Q \cdot A_{max} \cdot (k + Q)^{-1}$$

Pn – intensity of net photosynthesis ($\mu mol\ CO_2 \cdot g_{dw}^{-1} s^{-1}$)
R_d – intensity of respiration in darkness ($\mu mol\ CO_2 \cdot g_{dw}^{-1} s^{-1}$)
Q – irradiance ($\mu mol \cdot m^{-2} s^{-1}$)
A_{max} – maximal intensity of photosynthesis ($\mu mol\ CO_2 \cdot g_{dw}^{-1} s^{-1}$)
k – value of Q when $P_n = \frac{1}{2} A_{max}$ ($\mu mol \cdot m^{-2} s^{-1}$).

RESULTS AND DISCUSSION

Exogenously applied K-IBA significantly increased the rooting of cuttings of both cultivars. Due to non-uniform rooting of *Juniperus scopulorum* 'Skyrocket' in the first season of the experiment, auxin application yielded with no significant difference in rooting (Tab. 1). However, in the second year both rooting percentage and quality of root system enhanced with an increasing auxin concentration within its tested range. Only fresh weight gain of cuttings was not affected by K-IBA treatment. This suggests that to achieve the best rooting of *Juniperus scopulorum* 'Skyrocket' cuttings, the use of preparations containing at least 0.9% K-IBA will be necessary. This is more than previously recommended (Hrynkiewicz-Sudnik et al., 1995) and over twice the highest IBA content in the currently registered rooting powder in Poland. In contrast, 0.3-0.6% K-IBA was enough to ensure an optimal root formation of relatively easy-to-root *Thuja occidentalis* 'Smaragd' cuttings, resulting in the highest number of rooted cuttings, best quality of root system and the greatest relative increase of the total fresh weight of cuttings (Tab. 2). This roughly complies with the range recommended by Hrynkiewicz-Sudnik et al. (1995) and Hartmann et al. (1990) as well as IBA concentration in commercial rooting powders available in Poland. In the research of Chong et al. (1992), cuttings of *Thuja occidentalis* 'Little Champion' rooted best at 0.5-0.8% IBA while those of *Thuja occidentalis* 'Nigra' were not affected by auxin treatment. In our experiment, high rooting percentage of *Thuja* cuttings not treated with auxins suggests a potential propagation of this cultivar without exogenous auxins.

Gas exchange measurements revealed that, opposite to the suggestion of Davis (1988), basal application of auxins had no effect on the intensity of photosynthesis and respiration of cuttings of either cultivar, irrespective of observation

Table 1. Rooting of *Juniperus scopulorum* 'Skyrocket' cuttings as influenced by K-IBA concentration

Parameter	Year I					Year II				
	K-IBA concentration [%]					K-IBA concentration [%]				
	0	0.1	0.3	0.6	0.9	0	0.1	0.3	0.6	0.9
Percentage of rooted cuttings [%]	12.8a*	26.0a	23.2a	35.4a	41.6a	43.3a	60.4ab	80.6bc	78.6bc	96.6c
Mean number of roots per rooted cutting	2.6a	1.8a	2.4a	2.3a	2.0a	2.1a	2.2a	2.9ab	3.2b	4.2c
Quality of root system of rooted cuttings	2.6b	1.9a	2.4ab	2.3ab	2.4ab	2.1a	2.3ab	2.6bc	2.6bc	2.9c
Relative increase in fresh weight of rooted cutting	0.464a	0.309a	0.413a	0.372a	0.412a	0.259a	0.226a	0.344a	0.369a	0.294a

*Means denoted with the same letter do not differ significantly according to Duncan's multiple range t-test at P=0.05

Table 2. Rooting of *Thuja occidentalis* 'Smaragd' cuttings as influenced by K-IBA concentration

Parameter	Year I					Year II				
	K-IBA concentration [%]					K-IBA concentration [%]				
	0	0.1	0.3	0.6	0.9	0	0.1	0.3	0.6	0.9
Percentage of rooted cuttings [%]	88.7a*	93.3ab	98.0ab	99.7b	96.1ab	82.4a	87.1a	92.6ab	100c	99.6bc
Mean number of roots per rooted cutting	3.3a	3.9ab	4.9bc	5.6c	5.2bc	2.3a	2.7a	3.6ab	4.8bc	5.2c
Quality of root system of rooted cuttings	1.9a	2.0ab	2.3bc	2.4c	2.6c	2.2a	2.3ab	2.6bc	2.9c	2.9c
Relative increase in fresh weight of rooted cutting	0.340a	0.379ab	0.441ab	0.468b	0.436ab	0.272a	0.299a	0.330a	0.371ab	0.437b

*Explanations see Table 1

Table 3. Curve parameters of cuttings' photosynthesis 72 h and 6 weeks after treatment with pure talc or 0.9% K-IBA. R_d – intensity of respiration in darkness [μmol $CO_2 \cdot g_{dw}^{-1} s^{-1}$]; A_{max} – maximal intensity of photosynthesis [μmol $CO_2 \cdot g_{dw}^{-1} s^{-1}$]; k – light intensity when photosynthesis reaches ½A_{max} [μmol $\cdot m^{-2} s^{-1}$]

Species and treatment	Parameter			Correlation coefficient R^2
	R_d	A_{max}	k	
***Juniperus scopulorum* 'Skyrocket'**				
72 h after treatment				
Talc (no auxin)	-3.2	21.2	150.4	0.955
K-IBA 0.9%	-3.7	20.7	124.9	0.914
6 weeks after treatment				
Talc (no auxin)	-2.0	20.2	141.1	0.960
K-IBA 0.9%	-1.8	20.3	156.5	0.825
***Thuja occidentalis* 'Smaragd'**				
72 h after treatment				
Talc (no auxin)	-1.7	16.4	100.7	0.971
K-IBA 0.9%	-1.6	16.4	103.8	0.951
6 weeks after treatment				
Talc (no auxin)	-1.4	16.1	97.0	0.909
K-IBA 0.9%	-1.4	14.3	86.8	0.875

date i.e. 72 hours or 6 weeks after auxin treatment. This can be seen in Table 3 listing the estimated values of the parameters R_d, A_{max}, and k that describe curves of cuttings' photosynthesis. It is possible that such an influence would have occurred if auxin were applied as an overhead spray of cuttings after they were inserted into rooting medium as it was proposed by Szydło and Marczyński (1998).

CONCLUSIONS

1. Potassium salt of indolebutyric acid applied in a talc powder significantly increased the rooting of *Juniperus scopulorum* 'Skyrocket' and *Thuja occidentalis* 'Smaragd' cuttings.
2. Rooting percentage and quality of roots system of *Juniperus scopulorum* 'Skyrocket' enhanced with an increasing concentration of auxin up to at least 0.9%. However, fresh gain of cuttings did not depend on K-IBA treatment.
3. Optimal K-IBA concentration for rooting cuttings of *Thuja occidentalis* 'Smaragd' ranged from 0.3-0.6%.
4. Auxin application to the base of the cuttings influenced their photosynthesis and respiration rates neither 72 h nor 6 weeks after auxin treatment.

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UKORZENIANIE I WYMIANA GAZOWA SADZONEK ROŚLIN IGLASTYCH TRAKTOWANYCH KWASEM INDOLILOMASŁOWYM

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STRESZCZENIE

Sadzonki pędowe *Juniperus scopulorum* 'Skyrocket' i *Thuja occidentalis* 'Smaragd' pobierano w końcu lutego i po przygotowaniu, podstawy sadzonek traktowano pudrem talkowym zawierającym sól potasową kwasu indolilomasłowego w stężeniu 0, 0,1, 0,3, 0,6 i 0,9%. Następnie sadzonki były umieszczane w podłożu do ukorzeniania. Po 72 h i 6 tygodniach mierzono fotosyntezę oraz oddychanie ciemniowe sadzonek, ukorzenienie zaś sadzonek oceniano po 10 tygodniach.

Auksyny istotnie poprawiły ukorzenianie się sadzonek obydwu gatunków. W przypadku *Juniperus scopulorum* 'Skyrocket' zarówno procent ukorzenionych sadzonek, jak i liczba korzeni oraz jakość systemu korzeniowego wzrastały wraz ze zwiększającym się stężeniem auksyny, podczas gdy przyrost świeżej masy sadzonek nie zależał od zastosowania auksyn. Z kolei najlepsze ukorzenienie sadzonek *Thuja occidentalis* 'Smaragd' uzyskano przy zastosowaniu auksyny w stężeniu od 0,3 do 0,6%.

Traktowanie podstaw sadzonek solą potasową kwasu indolilomasłowego nie wpłynęło na fotosyntezę i oddychanie sadzonek, niezależnie od terminu pomiaru.

Słowa kluczowe: auksyny, korzenie przybyszowe, rośliny iglaste