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Effects of Site Related Environmental Stresses on Radial Growth of Scots Pine Stands *Pinus sylvestris* (L.)

By

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Key words: Dendroecology, dolomite, nutrient deficiency, principal component analysis, *Pinus sylvestris*, tree ring, water stress.

Summary

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Dendrochronological and multivariate techniques were used to assess the influence of climate and site-specific factors on radial growth (tree ring-width) of stunted Scots pine trees *Pinus sylvestris* (L.). Tree growth within the study area (750 m a.s.l.) is strikingly restricted due to the inherent low nutrient content and retarded soil development of dolomite parent material and low water holding capacity of the predominantly shallow, stony soils. The climate-tree-growth relationship of eight scattered populations belonging to the same phytosociological community, a Spring Heath-Pine wood (*Erico-Pinetum typicum*), was investigated. Arrangement of sites was in relation to a "moisture gradient" defined in terms of a physiographic series from hollows to open south-facing slopes, i.e. from slightly moist to the most xeric sites.

Though the overall climate response at the various habitats is similar, principal component analysis resulted in clustering of habitats according to topographic features (slope magnitude, slope aspect, soil depth, vegetation cover). This study shows that at the limit of tree growth, small scale variation of edaphic conditions exert a major influence on susceptibility of trees to environmental stresses.

Introduction

Although tree growth can be influenced by a wide variety of abiotic and biotic factors, it is well established that geomorphic factors, such as slope aspect and slope magnitude, can substantially modify the local environment of plants by

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altering microclimate conditions and soil development at a small scale. Several dendroecological studies confirm the importance of microsite influences on tree ring formation and the individual response of trees to environmental stress (for a review see SCHWEINGRUBER 1996).

However, most studies have focused on sites at the timberline and/or at large spatial scales. Therefore, we examined whether small scale topographic variations play a major role in modifying cambial activity (tree ring-width) of *Pinus sylvestris* stands exposed to water stress. To accomplish this we used principal component analysis (JOLLIFFE 1986), which has been shown to provide an efficient way of analyzing differences in tree growth caused by site-specific factors (PETERS & al. 1981, GRAUMLICH 1993).

Materials and Methods

Study area

The study site is part of a postglacial rock-slide area situated in the montane belt (750 m a.s.l.) within the inner alpine dry valley of the Inn River (Tyrol, Austria). Mean annual rainfall during 1921-1990 is 714 mm a year. The predominantly stunted growth form of *Pinus sylvestris*, which dominates the tree-layer at all sites, indicates stressful environmental conditions. Stands were selected in relation to distinct topographic features (Table 1) and are located very close to each other within an area of about 1 km^2, except site K135, which is approximately 2.5 km distant.

Table 1. Site description and characteristics of selected stands (Topography: F = foot of the slope, H = hollow, P = plateau, R = ridgetop, S = slope; TRW = tree ring-width). Soils are predominantly of protorendzina type and consist of unconsolidated, coarse-textured materials.

Site code	Topo-graphy	Aspect	Slope (°)	Soil depth (cm)	n trees	Tree height (m)	Age[a] (years)	TRW (mm) Mean±SD
K130	S	SW	50	5-10	13	4-6	138±39/205	0.54±0.23
K134	S	SSE	40	5-10	20	4-6	118±14/139	0.54±0.29
K132	P	-	-	15-20	18	8	126±6/136	0.80±0.55
K137	F	SSW	<15	15-20	16	13	144±12/161	0.67±0.28
K138	P	-	-	10-15	15	5	123±12/158	0.55±0.25
K131	H	N	<20	30	11	10	153±15/176	0.77±0.29
K135	H	-	-	15-20	15	10	92±9/104	0.89±0.24
K136	R	WNW	20	5-10	15	5	105±23/145	0.62±0.32

[a] Cambial age at breast height, mean values ± Standard deviation/Maximum

Field collection and chronology development

At each stand at least 15 trees were sampled (two radii) that where dominant in the canopy. Total ring-width was measured to the nearest 0.01 mm using a linear table connected to a PC and the tree-ring program CATRAS (ANIOL 1983). Cross-dating of series was checked by COFECHA and two-stage detrending was accomplished using ARSTAN (HOLMES 1994).

Principal component analysis (PCA)

PCA (JOLLIFFE 1986, MANLY 1994) was used as a clustering technique to identify stands with similar growth patterns. Scatter plots of the orthogonally rotated component loadings (Varimax-criterion) were used to display the clustering of chronologies (common interval 1892 – 1994). Time series of component scores were compared with monthly temperature and precipitation data from a nearby meteorological station (Ötz, 5 km from the study area). Pearson correlation coefficients were calculated for a uniform 70-year period extending from 1921 to 1990. The software package used for the analysis was STATISTICA for Windows, Release 5.0 (StatSoft Inc., Tulsa, USA).

Results

Principal component loadings resulted in a grouping of chronologies according to topographic position (Fig. 1). Eigenvalues and common variance explained are given in Table 2. Three clusters were distinguished (cf. Table 1): stands growing on (i) steep, south-facing slopes (sites K130 and K134), (ii) on plateaus and on the foot of a slope (sites K132, K137 and K138) and (iii) in hollows and on a ridgetop (sites K131, K135 and K136).

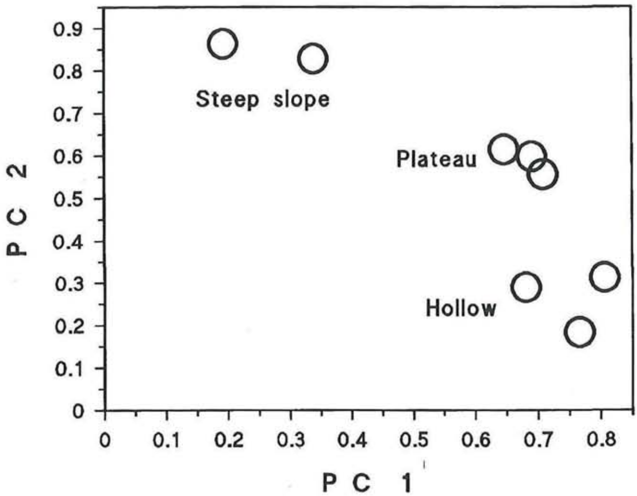

Fig. 1. Tree-ring chronologies plotted according to their loadings in space defined by PC 1 and PC 2. Varimax-rotated principal component axes are shown. The non-linear relationship between principal components is known as 'arch problem' or 'horseshoe-effect', which is an artifact of the method (MANLY 1994).

Table 2. Principal component analysis derived from ring-width chronologies (8 sites).

Principal component	Eigenvalue	% total variance	Cumulative % variance explained
PC 1	5.23	65.4	65.4
PC 2	0.71	8.9	74.3

Correlations between component-score time series and climatic data indicate that growth patterns are significantly correlated with growing-season precipitation variables (data not shown). Due to high loadings for PC 2 of stands growing at steep south-facing slopes (sites K130 and K134; see Fig. 1), correlation statistics ($p<0.05$) indicate that growth of these trees is best when May precipitation is higher and temperature is lower than average, whereas radial growth at slightly moist habitats (sites K131, K135 and K136) is favoured when precipitation in April and June of the current year and August of the previous year is higher than average (high loadings for PC 1; see Fig. 1).

Discussion

It could be shown in this study that stands growing within a small heterogenous rock-slide area exposed to soil dryness and nutrient deficiency respond quite differently to year-to-year climate variation depending on the interaction of soil condition and topographic features on water availability (cf. MEINERS & al. 1984).

Water stress is caused by a synergistic effect of low precipitation during April-June, low water holding capacity of coarse-textured, shallow soils and high temperatures in May (OBERHUBER & al. 1998). Because individual chronologies are more highly correlated with other chronologies displaying similar topography (Fig. 1 and Table 1), the major differences in growth variation among the sample chronologies are considered to be caused by site-specific environmental stresses (e.g. soil erosion, grazing) and differences in susceptibility to extreme climatic events at distinct topographic sites. KIENAST & SCHWEINGRUBER 1986 also found that trees often respond quite differently to climate variation depending on site-specific factors, especially soil depth.

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The Effect of the Mineral Nutrition and pH of the Rooting Substrate on Rooting and Mineral Content of Cherry Rootstock Greencuttings

By

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Key words: Cuttings, cherry rootstocks, mineral nutrition, pH.

Summary

OSTERC G. & SPETHMANN W. 2000. The effect of the mineral nutrition and pH of the rooting substrate on rooting and mineral content of cherry rootstock greencuttings. - Phyton (Horn, Austria) 40 (4): (153) - (155).

The conventional propagation methods (mound layering) and the in-vitro methods (with new weakly growing cultivars) are the common propagation methods for cherry rootstocks. The aim of this research was to optimize the cutting-propagation method with cherry rootstocks.

Two pH levels (4.5 and 7.3) and four slow release fertilizer levels (0, 0.2, 0.4 and 0.6 g N/l substrate) were tested under fog conditions to find the optimum combination of these parameters with the weakly growing 'Gisela' rootstock. pH did not have any significant influence on the rooting and over-wintering of the cuttings. The 0.4 g variant had the best rooting and over-wintering results, in the autumn these cuttings contained the lowest percentage of nitrogen. The highest percentage of nitrogen and potassium in the cuttings was found with the 0.6 g variant. These cuttings rooted and overwintered less successfully than the cuttings with the 0.4 g variant.

Introduction

In nurseries the propagation of cherry rootstocks is carried out mostly through convetional propagation methods (mound layering) or by in-vitro methods (new weakly growing cultivars). Both propagation methods have many significant disadvantages. The mound-layering-propagation method is often ineffective and

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needs a lot of work. With the in-vitro-propagation method the most important disadvantage is the high price of the resulting plants. Because of this, the cutting-propagation method may play an important role in the production of cherry rootstocks in the future.

A simple and cheap system for greencutting propagation with cherry rootstocks was developed by OSTERC & SPETHMANN 1998. Many experiments with woody plants showed the importance of the mineral nutrition and pH of the rooting substrate for the rooting, growing and over-wintering of the cuttings (SPETHMANN 1997). We wanted to optimize these parameters with the cherry rootstocks, especially with respect to the rooting and over-wintering of the cuttings.

Materials and Methods

The experiment was carried out in an unheated plastic house under a fog system at the experimental station of the Section Tree Nursery Science at the University of Hannover in 1997. Four levels (0, 0.2, 0.4 and 0.6 g N/l substrate) of the slow release fertilizer "Osmocote-Plus 3-4M (15+11+13+2)" and two pH levels (4.5 and 7.3) were tested with the 'Gisela' rootstock in a two-factors experiment with 4 replications and 20 cuttings per replication. The cuttings were cut in the middle of June at the experimental station. Before being put in the rooting substrate (peat/sand in a 3:1 ratio) the cuttings were treated with 0.5 % IBA (with 10 % Euparen on talcum basis). Data was collected in the autumn of 1997 and the spring of 1998. On both occasions all the cuttings per replication (20 cuttings) were evaluated. The percentage of viable-rooted cuttings was counted each time. The data from spring 1998 represented the over-wintering results. The mineral analysis of all viable cuttings per replication was made in the autumn. All plant parts were analysed. Plants were washed out in water, ground and dried at 105 °C. The nitrogen content was determined by the Kjeldahl method, potassium levels using the flame-photometric method, calcium and magnesium contents by atomic absorption spectroscopy (AAS) and phosphorus was detected with the spectrophotometric method. The experiment was evaluated by Anova, the analyses of averages were tested with the Duncan-test at $\alpha = 5$ %. For evaluation the statistics program Ncss was used.

Results and Discussion

The best rooting, both in autumn 1997 and in spring 1998, was observed for the higher pH level (Table 1). These results do not support the findings of MLASOWSKY 1996, where the best rooting of oak cuttings was observed with the lowest pH levels (3.2 - 4.5). HARBAGE & al. 1998 also showed similar results: in the in-vitro cuttings by two apple cultivars the highest percentage of IBA taken up from the medium and the best rooting were measured at a low pH level (4.0). In our experiment the 0.4 g fertilizer level showed the best rooting of cuttings in the autumn and the best over-wintering results. In the autumn, the cuttings with this treatment contained the lowest level of nitrogen, phosphorus, magnesium and calcium. In the autumn, the worst rooting results were measured in the control variant, and in the spring with the 0.6 g and 0.2 g variants. In the autumn, the cuttings with these treatments contained the highest percentage of nitrogen and potassium. The interaction between pH and fertilization did not show any significant difference (Table 1). The results of MAC CARTHAIGH & EBLE 1989 did not show better rooting results with "Osmocote" fertilizer added to the rooting substrate. Differences between fertilized and unfertilized substrate were found with oak cuttings (HARMS 1992). MLASOWSKY 1996 showed that by adding "Osmocote" to the substrate of oak cuttings the rooting success was improved. According to JOHNSON & HAMILTON 1977 the rooting of *Juniperus conferta* and *Ligustrum japonicum* was quicker at lower "Osmocote" levels. The addition of "Osmocote" minimized the number of dead-rooted cuttings, thus the rooting percentages were higher by adding "Osmocote".

Table 1. Percentages of viable-rooted cuttings in autumn 1997 and in spring 1998 and mineral contents of the green parts of the cuttings in autumn 1997 by the 'Gisela' rootstock (Anova, $\alpha = 5\%$).

factor	treatment	rooting (%)		mineral content (% dry matter)				
		autumn 1997	spring 1998	N	P	K	Mg	Ca
pH value	4.5	71.3	41.9	1.54	0.21 b	0.61	0.17	0.60 a
	7.3	84.4	48.1	1.63	0.16 a	0.63	0.16	0.79 b
	SD	16.1	15.0	0.27	0.02	0.09	0.02	0.10
fertilization	0	49.4 a	62.4 b	1.51	0.20	0.53 a	0.18	0.87 b
	0.2	86.9 b	22.5 a	1.60	0.18	0.65 b	0.16	0.64 a
	0.4	95.0 b	70.6 b	1.45	0.17	0.59 ab	0.16	0.62 a
	0.6	80.0 b	24.4 a	1.80	0.19	0.72 c	0.16	0.65 a
	SD	24.7	23.0	0.42	0.05	0.06	0.04	0.15

Statistically significant differences between treatments are marked with a different letter.
Legend: SD: significant difference

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