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SHORT COMMUNICATION

SHOOT GROWTH IN 2-3 YEAR OLD *NOTHOFAGUS* SEEDLINGS

Summary: Shoot growth was studied in 2 to 3 year old seedlings of 56 provenances of black, mountain, red, and silver beech. Differences between provenances within species groups were smaller than differences between species. Latitudinal variations occurred in the growth of silver beech provenances, but the altitudinal variation in mountain beech provenances reported earlier for younger seedlings was found not to be significant here. Genetic differences detectable between provenances in younger plants may become obscured by the later influence of local environmental factors as plants mature. Temperature but not rainfall was positively correlated with the rate of shoot growth.

Red and silver beech provenances were the most susceptible to frost and mountain beech to grass grub beetle attacks.

Keywords: provenance trial, phenology, Nothofagus, New Zealand.

Introduction

Seasonal growth of New Zealand *Nothofagus** species has been monitored in several studies (see Wardle, 1984). Although growth of trees from different sites has been compared, for example along altitudinal gradients (Norton, 1984), site variations usually prohibit detailed comparisons of growth between species or different populations (provenances) of the same species. Such comparisons can, however, be made by growing similar aged plants together under uniform edaphic and climatic conditions (e.g.Yin *et al.,* 1984).

This paper is the third in a series on genetic variation in New Zealand *Nothofagus* species (Ledgard and Cath, 1983; Wilcox and Ledgard, 1983) and presents weekly measurements of shoot growth of 56 provenances made during the third (1981/82) and fourth (1982/83) growing seasons. The aim of the study was to compare the duration and pattern of shoot growth between provenances and species, and to investigate the influence of climate on the rate of shoot extension in these seedlings.

Methods

Trial layout is described by Wilcox and Ledgard (1983); only provenances at Rangiora were analysed. Ten seedlings were chosen from each provenance with at least one and up to a maximum of three seedlings from each of five replicates. One healthy terminal shoot (or one showing terminal potential) was measured to the nearest millimetre for each seedling. The number of seedlings damaged by frost or night-time attacks by the grass grub beetle *Costelytra zealandica* were recorded at each measurement.

The 1981/82 measurements (40) extended from early August to the following May and the 1982/83 measurements (31) from the end of August to early May. To overcome difficulties associated with separating bud swelling and initial shoot extension, the commencement of growth was defined as the date by which 30/0 of the total annual growth had been achieved. For similar reasons, the cessation of growth was defined as the date by which 97% of the total annual growth had been achieved.

Rainfall and screen temperature data from the Forest Research Institute's meteorological station (H32352) about 150 m from the trial site was used to assess the relationships between the rate of shoot growth and climate. Because seasonal differences in growth and climate are much greater than the differences between individual measurements, the seasonal cycle was removed using Gaussian filters and the resultant standardized growth and climate series compared. .

Results

Only the silver beech provenances showed significant correlations between provenance origin and growth, latitude of origin being significantly correlated with the date growth ceased and the length of the growth

*Black beech, *Nothofagus solandri var. solandri*. Hard beech; *N. truncata*. Mountain beech, *N. solandri var. cliffortioides*. Red beech, *N. fusca*. Silver beech, *N. menziesii*.

Table 1: *Timing, duration and amount of shoot growth for main beech provenance groupings. Standard deviation in brackets. *Cessation date underestimated, as measurements ceased on April 28. **Undifferentiated provenances of black/mountain beech complex.*

	n	Date growth commenced	Date growth ceased	Duration of growth (days)	Total amount of growth (mm)
1981/82					
Black	1	Oct 26 (-)	Mar 28 (-)	153 (-)	549 (-)
Mountain	18	Nov 5 (5.0)	Apr 2 (6.0)	149 (9.3)	425 (80)
Red	9	Oct 23 (3.8)	Apr 2 (10.8)	161 (13.1)	402 (29)
Silver	to	Nov 5 (6.1)	Apr 27 (10.9)	173 (15.1)	471 (72)
Undifferentiated**	4	Oct 29 (3.0)	Apr 15 (3.5)	168 (0.6)	533 (53)
1982/83					
Black	2	Nov 17 (0.0)	Apr 28*	162 (0.0)*	630 (53)
Mountain	21	Nov 11 (2.8)	Apr 18 (9.8)	157 (10.5)	604 (59)
Red	11	Nov 11 (5.8)	Apr 28*	168 (6.1)*	678 (103)
Silver	to	Nov 18 (2.4)	Apr 28*	161 (2.5)*	598 (43)
Undifferentiated**	3	Nov 7 (6.6)	Apr 28*	171 (8.1)*	643 (76)

period ($r = -0.66$ & -0.68 respectively, both $p < 0.05$). Variations between provenances within provenance groupings were small (Table 1), although the date when growth ceased was more variable than the date when growth commenced (see standard deviations in Table 1). The five provenance groupings showed little consistency in their rankings between the two seasons. For example, silver beech provenances grew the most in 1981/82 and red beech the least, but the pattern was reversed in 1982/83, when all provenances grew more.

The growth patterns of the provenances within each species group were similar, and in 1981/82 there was only a small difference between the three main species (Fig. 1). By early January red beech had completed 62% of its seasonal growth, mountain beech 46% and silver beech 42%. Black and undifferentiated beech followed the mountain beech pattern. The three main species groups showed different growth patterns in the 1982/83 season and their rankings changed (Fig. 1). By late January, the mountain beech provenances had completed 62% of growth, red beech 42% and silver beech 35%. The two black beech provenances and two of the three undifferentiated provenances closely followed the red beech pattern. The third undifferentiated beech provenance followed the mountain beech pattern.

During both growing seasons maximum temperatures were close to average, although minimum temperature was 1.2ºC lower in 1982/83 than in 1981/82. Rainfall was below average in both seasons. The rate of shoot growth was not significantly correlated with rainfall (Table 2) despite

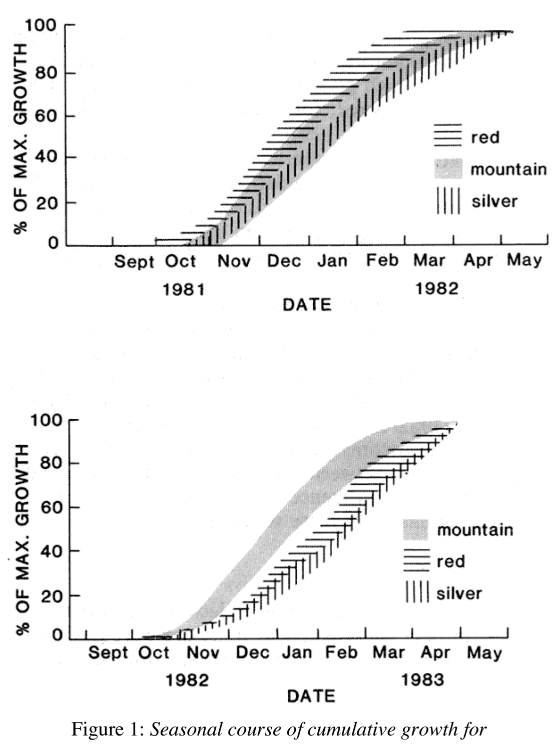

Figure 1: *Seasonal course of cumulative growth for mountain, red and silver beech. a. 1981/82 season; b. 1982/83 season.*

Table 2: *Correlation coefficients for standardised shoot growth time-series. Values are for the period of active growth only (n* = 22 in both seasons). *#Undifferentiated provenances of black/mountain beech complex. Significance levels:* *p<0.05; **p<0.01.

	Black	Mountain	Red	Silver	Undiff#
RAINFALL					
1981/82	-0.09	-0.01	-0.06	0.10	0.06
1982/83	0.07	-0.01	0.22	0.06	-0.03
MAX. TEMP					
1981/82	0.46*	0.48*	0.50*	0.35	0.48*
1982/83	-0.07	0.40	-0.08	-0.16	0.17
MIN. TEMP					
1981/82	0.46*	0.34	0.50*	0.46*	0.55**
1982/83	0.30	0.45*	0.39	0.19	0.50*

the below-average rainfall. However, adjacent watering may have affected the trial. The rate of shoot growth showed some significant positive correlations for all five provenance groupings with temperature in 1981/82, but only for mountain and undifferentiated beech in 1982/83 (Table 2). Four periods of frost between August and November (up to -7.2 ∞C) damaged terminal shoots in red and silver beech (Fig. 2) and in the few remaining hard beech seedlings. No significant differences were detected between provenances within species.

Insects, predominantly grass grub beetles, attacked 5% of the seedlings in 1981/82 and 1% in 1982/83 from December to March. Mountain beech was most attacked followed by black and silver beech, then undifferentiated and red beech.

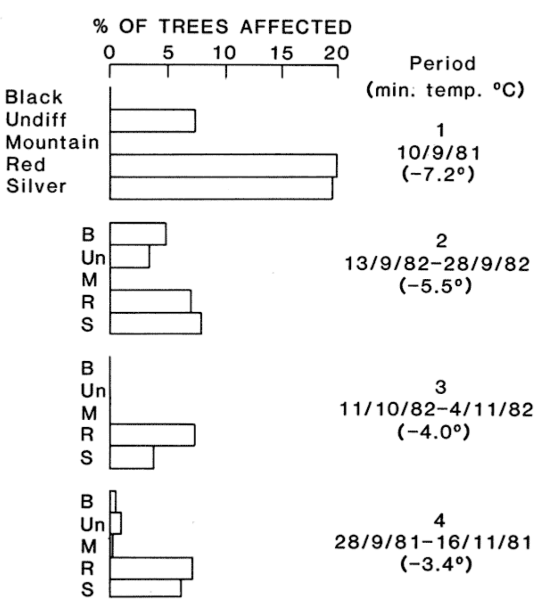

Figure 2: *Percentage of trees affected by frost for selected periods during the two growing seasons studied.*

Discussion

Growth patterns in silver beech provenances were significantly correlated with latitude, in agreement with Wilcox and Ledgard (1983); southern provenances had shorter growth periods than northern provenances, and ceased growth earlier. However, no altitudinal variations in silver beech provenances were detected. The significant correlation observed in I-year old mountain beech seedling growth from an altitudinal series of provenances (Wilcox and Ledgard, 1983) was not maintained in the older plants examined here. This may indicate that genetic differences detectable in young plants are obscured by the influence of local environmental factors as the plants mature.

The better growth in 1982/83 (Table 1) presumably reflects the normal increase in growth rate as seedlings age (Wardle, 1984), but it is difficult to explain the change in the relative seasonal growth patterns of red and mountain beech (Fig. 1). Temperature was significantly correlated with growth in all five provenance groupings in one or both seasons, but differences between species were small (Table 2). The more consistent correlations with minimum temperature suggest that night-time temperatures have a greater influence on growth than day-time temperatures. Extreme minimum temperatures clearly have a marked effect on growth (Fig. 2), especially in red and silver beech, with up to 20% of trees affected in one event. The greater susceptibility of red and silver beech is consistent with their known frost hardiness (Baylis, 1958; Sakai and Wardle, 1978).

Silver beech appears to be the most genetically distinct of the five provenance groupings studied. Growth started later and continued longer, and showed weaker links with temperature. The separate nature of silver beech has also been noted in other studies (see Wardle, 1984).

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