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Photosynthesis and growth of present New Zealand forest trees relate to ancient climates

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Seedlings of temperate, northern hemisphere forest tree species have demonstrated optimum growing temperatures which equate closely with climates in which they presently grow (Table I). The species are regarded as recent, many having evolved during the cold Pleistocene climates of the last two million years, replacing species of a much older tropical and subtropical flora (Cox *et al.*, 1976).

Table I. Temperate, northern hemisphere, forest tree seedlings: a comparison, from the literature, of the differential between optimum growing temperatures and actual summer temperatures, for different species.

Species	*Optimum growing temp (°C)*	*Actual mid-summer temp (°C)* [a]	*Differential*
Pinus radiata [b]	23.0	21.0	2.0
Sequoia sempervirens [c]	19.0	17.0	2.0
Pseudotsuga menziesii [d]	21.0	20.2	0.8
Tsuga heterophylla [d]	18.0	20.2	−2.2
Pinus rigida [e]	26.0	27.2	−1.2
Pinus taeda [f]	26.5	28.3	−1.8
Pinus sylvestris [g]	17.0	19.0	−2.0
Larix decidua [g]	17.0	19.0	−2.0
Picea engelmannii [h]	19.0	24.1	−5.1
Mean	20.7	21.8	−1.1

[a] (Mean temperature of warmest month + mean maximum temperature of warmest month)/2.
Climatic data (from meteorological tables) relate specifically to the provenance used in the study.
[b] Hellmers and Rook (1973), [c] Hellmers (1966), [d] Brix (1971), [e] Good and Good (1976), [f] Kramer (1957) [g] Gowin *et al.* (1980), [h] Hellmers *et al.* (1970).

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A series of controlled temperature experiments were carried out with seedlings of 5 species of important New Zealand forest tree genera. Conditions were a 16 h photoperiod with 10 h of 'full' light at intensities ranging from 270 to 560 $\mu mol \cdot m^{-2} \cdot s^{-1}$ and a maximum *VPD* of 12 mbar. The results indicated that all species had an optimum growing temperature of 27°C (Table II). In 4 of the 5 species, the net photosynthetic optimum was also at 27°C, but species differed in whether the main determinant of their increased growth rate at 27°C was increased net photosynthetic rate or rate of leaf production (Table III). The New Zealand species in Table II differed significantly (P = 0.0001) from the northern hemisphere species in Table I, in the differential between optimal growing temperature and actual growing season temperature.

New Zealand's forest tree species are ancient and they, or their closest ancestors, have been a dominant element of the country's forest vegetation for the past 50 million years (Fleming, 1975).

The high temperature optimum for the New Zealand species is interpreted as being a physiological 'relic' from the Miocene period, 10–26 million years ago. During that time, temperatures were subtropical, with seas 5–7°C, warmer than today. That warmth was maintained

Table II. Growth response to temperature for seedlings of New Zealand forest tree species: differential between optimum growing temperatures and actual growing season temperatures.

Species	*Optimum growing temp (°C)*	*Actual mid-summer temp (°C)*	*Differential*
Dacrydium cupressinum	27.0	16.8	10.2
Nothofagus solandri var *cliffortioides*	27.0	17.0	10.0
Dacrycarpus dacrydioides	27.0	17.9	9.1
Podocarpus totara	27.0	21.5	5.5
Agathis australis	27.0	22.2	4.8
Mean	27.0	19.1	7.9

Table III. Growth response to temperature for seedlings of New Zealand forest tree species: percentage increase in growth parameters from 21/16 to 27/22°C day/night temperatures.

Species	*Total wt*	*Leaf wt/ total wt*	*Net photosynthesis*
Dacrydium cupressinum	41.7	30.4	2.4
Nothofagus solandri var *cliffortioides*	22.8	38.9	–29.0
Dacrycarpus dacrydioides	27.0	–6.4	5.2
Podocarpus totara	40.0	6.0	43.6
Agathis australis	8.3	4.7	25.9

through the early Pliocene and, 3 million years ago, sea temperatures were still warmer than today (Stevens, 1985).

The fact that 'relic' optimum temperatures for growth have persisted to the present in all species examined, would indicate that there has been little genetic selection for growth rate during the last 3 million years. The authors have data (unpublished) to support the expectation that a major selection pressure exerted by the Pleistocene environment on these subtropical species was for the development of cold resistance.

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