Comparative Ecophysiology of *Larix kaempferi* (Lamb.) Carr. and *Abies veitchii* Lindl.

II. Mechanisms of Higher Drought Resistance of Seedlings of *L. kaempferi* as compared with *A. veitchii*

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Abstract

The underlying mechanisms of drought resistance in seedlings of *Larix kaempferi* as compared with those in *Abies veitchii* were investigated. First, seedlings of the two species were desiccated in air of differing water potential, and their survival rates were compared to detect any difference in desiccation tolerance between them. Contrary to differences in their drought resistance, *A. veitchii* showed higher survival. Next, the shoot heights and root depths of the two species were compared to detect any difference in desiccation avoidance. Although the shoot height differed little between the two species, the roots of *L. kaempferi* seedlings were much deeper than those of *A. veitchii* seedlings, and the death rate under progressing drought was well correlated with the root extensibility of each species. It was thus concluded that *L. kaempferi* seedlings are able to avoid desiccation by extending their roots in deep soil faster than *A. veitchii* seedlings, thereby resisting to drought.

Key words: *Abies veitchii*; Desiccation avoidance; Desiccation tolerance; *Larix kaempferi*; Root depth.

Introduction

Although water is indispensable for plant life, the extent of water requirement varies among species. Some plants can survive and grow under extremely dry conditions such as those in deserts, whereas others require a constant water supply for survival. The capacity of a given plant to withstand low availability of water is defined as drought resistance. *Larix kaempferi* (Lamb.) Carr. and *Abies veitchii* Lindl. are dominant species of the forest extending over the north slope of Mt. Fuji at about 2300 m altitude. Although forests dominated by *L. kaempferi* are concomitantly observed in the vicinity of forests dominated by *A. veitchii*, the areas in which the two species are established are known to be quite different. *L. kaempferi* is a pioneer species which is able to establish itself on bare ground, whereas *A. veitchii* is a secondary seral species that becomes established on the floor of *Larix* forests (Ohga and Numata, 1971; Nakamura, 1985). It has been proved experimentally that *L. kaempferi* is more resistant to drought than *A. veitchii*, and that this difference in drought resistance is responsible for the habitat segregation of the two species; *A. veitchii* seedlings cannot survive rainless periods in summer and is eventually eliminated from bare ground.

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whereas most *L. kaempferi* seedlings are able to become established under such conditions (Yura, 1988). This indicates that *L. kaempferi* seedlings have specific characteristics which enable them to survive for much longer periods than *A. veitchii* seedlings under progressing drought. Elucidation of such characteristics would help to reveal the ecologically significant mechanism of drought resistance.

Drought resistance may be understood to involve a combination of desiccation avoidance and desiccation tolerance (Levitt, 1958). The ability of plants to maintain a favorable water status under drought is known as desiccation avoidance, and depends mostly on morphological traits. One of the most effective safeguards against drought is a deep, widely spread and well branched root system (Kramer, 1983). In fact, many studies have already shown that differences in drought resistance are principally related to differences in root development (Hurd, 1974; Maruta, 1976; Barnes and Harrison, 1982; Park, 1989). On the other hand, drought tolerance is the ability of a plant to endure severe water loss. Leaves of some vascular plants can survive dehydration to the point of air dryness (Gaff, 1980). This ability depends on plant physiological traits.

The purpose of this study was to reveal the mechanisms responsible for the difference in drought resistance between seedlings of *L. kaempferi* and *A. veitchii*. After I had precisely determined the differences in the death rate between the two species under progressing drought, I compared the survival rates of seedlings which had been desiccated in air of differing water potential in order to evaluate the desiccation tolerances of the two species. Next, I examined the capability of desiccation avoidance of seedlings of *A. veitchii* and *L. kaempferi* based on morphological differences which could account for the drought resistance. The results suggested that *L. kaempferi* seedlings avoid desiccation rather than tolerate it by extending deep roots at a faster rate than *A. veitchii*.

**Materials and Methods**

**Differences in drought resistance between *Larix kaempferi* and *Abies veitchii***

Seeds of *L. kaempferi* were collected from an artificial forest in Ohtakimura, Kiso, Nagano, in 1982. Seeds of *A. veitchii* were collected from the forest on Mt. Fuji, Yamanashi, in 1985. Collected seeds of both species had been stored dry at 1–4°C, then stratified at 4°C on moist filter paper in Petri dishes for ca. two months before sowing. Stratified seeds of *L. kaempferi* and *A. veitchii* were sown together in scoriaceous soil material in eight pots, each 18.5 cm deep and 11 cm in diameter. According to germination rates evaluated beforehand, adequate amounts of seeds of the two species were sown together so as to expect at least 20 seedlings of each species per pot. The scoriaceous soil material was collected from bare ground on the east slope of Mt. Fuji at ca. 1300 m altitude. This soil consists of pumice pebbles (max. 1.5 cm in diameter) and fine sand. The water content of this soil at field capacity is ca. 14% of dry weight. Maruta (1976) determined the soil-moisture characteristics curve of this soil material, and estimated the permanent wilting percentage, corresponding to a water potential of −1.5 MPa, to be ca. 0.5% of soil dry weight.

The pots were placed in a growth chamber (max. 25±1°C and 60±10% RH during the day, min. 17±1°C and 80±10% RH at night) under a 14-h light (250 μmol m⁻² s⁻¹)/10-h dark cycle. Seedlings were irrigated with deionized water every two or three days. Twenty-one days after sowing, the seedlings were thinned to 20 each of the two species per pot.

Forty days after sowing, watering was withheld in all but two pots. The numbers of sur-