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The effects of transplanting stress on photosynthesis, stomatal conductance and leaf water potential in *Cedrus atlantica* Manetti seedlings: role of root regeneration

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Introduction

Artificial forest stand establishment may be achieved either with container-grown seedlings or with bareroot planting stock. Since growing seedlings in containers may lead to abnormal root development after transplanting (Aussenac *et al.*, 1988), renewed attention should be given to bareroot planting.

Bareroot transplanting is accompanied by a specific transplanting stress, that may lead to substantial plant mortality or reduced growth, due to the disturbance of the functional continuity at the soil-root interface (Sands, 1984), or to mechanical damage to roots caused by lifting the plants from the nursery beds (Chung and Kramer, 1975).

Physiological processes, such as CO₂ assimilation and translocation (Stupendick and Shepherd, 1980), stomatal conductance and plant water status (Sands, 1984; Kaushal *et al.*, 1987; Aussenac and

El Nour, 1986), considered separately, have been shown to be affected significantly by transplanting. However, a satisfactory rationale for studying effects of transplanting should also include valuable information on the possible linkages between these processes and the interrelationships with root regeneration after transplanting.

Materials and Methods

One yr old seedlings were transplanted from a nursery to a glasshouse in polyethylene bags (16 x 60 cm) containing sphagnum peat and were maintained well-watered. One yr later, in October 1985, half of the plants were lifted from the bags, stored for 20 h at 20°C, 100% relative humidity and in darkness, and then planted again in similar bags. The other half (control plants) were maintained in the initial bags. The carbon dioxide assimilation rate (*A*), stomatal conductance (*g_s*) and predawn needle water potential (ψ_p) of these seedlings were measured just prior to transplanting (day 0), and

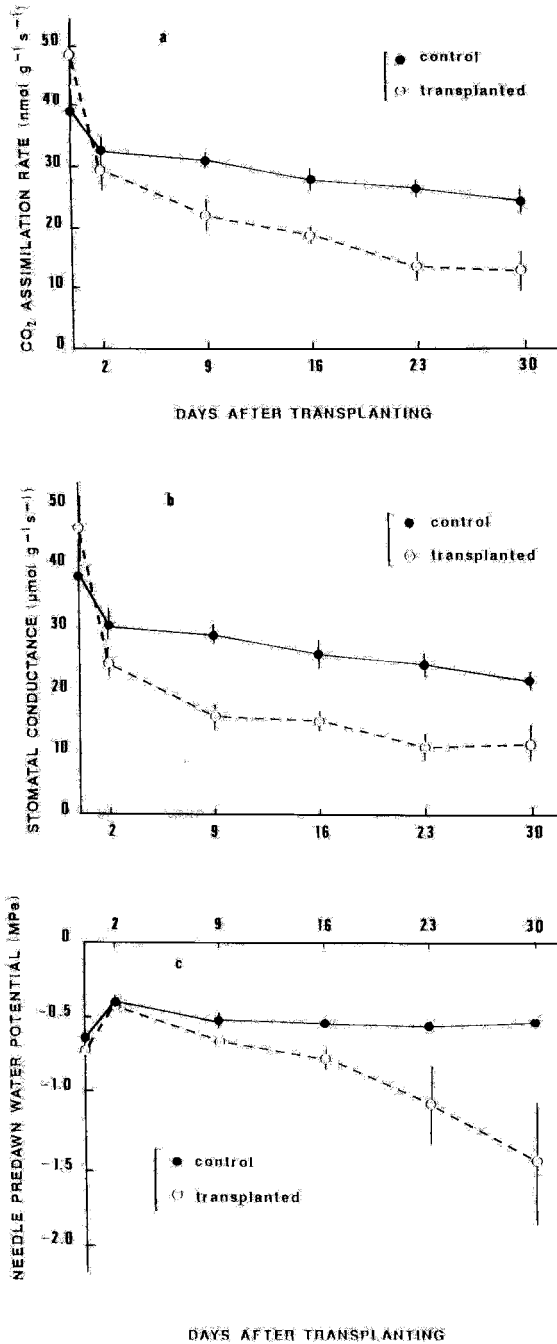


Fig. 1. Concurrent time course of: a, CO₂ assimilation rate (A); b, stomatal conductance for CO₂ (g_s) and c, pre-dawn needle water potential (ψ_p) in control and transplanted *Cedrus atlantica* seedlings. Transplanting was carried out on day 0, after the gas exchange measurements. $n = 6$; bars denote ± 1 SEM.

then on days 2, 9, 16, 23 and 30 after transplanting.

In experiment 2, seedlings were transplanted in minirhizotrons. The plants were given optimal fertilization and the root systems were maintained at 20°C in order to promote root regeneration. Assimilation rate measurements and root observations (number of growing roots and root elongation) were made just before transplanting (day 0) and then weekly from day 7 to day 49 after transplanting.

Gas exchange measurements were made with a classical open system under standard environmental conditions. In experiment 1, intercellular CO₂ concentration (c_i) values were calculated from the A and g_s data, which permits assessment of the extent to which changes of A following transplanting are due to reduced diffusional supply of CO₂ to the mesophyll or to decreasing mesophyll photosynthetic capacity

(Jones, 1985). In an A vs c_i plot, these 2 limitations are represented by the supply (S_u) and demand (D) functions, respectively (see Fig. 2).

Results

Experiment 1

In the transplanted seedlings, a marked and parallel decline in both CO₂ assimilation and stomatal conductance occurred from day 0 to day 9 after transplanting (Fig. 1a and b); afterwards the decline continued, but was less pronounced. The control plants presented a decreasing trend of gas exchange, but the decline

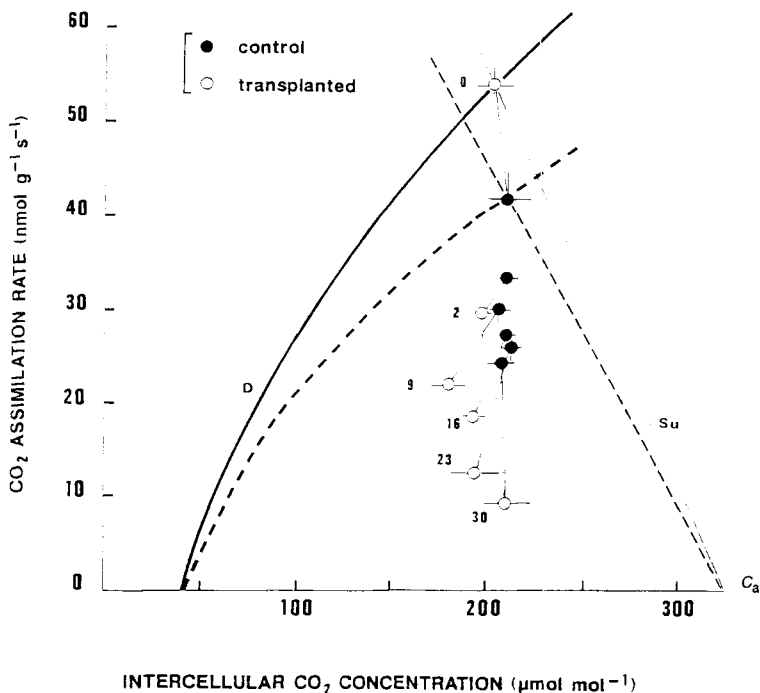


Fig. 2. Carbon dioxide assimilation rate (A) versus intercellular CO₂ concentration (c_i) in the control and transplanted plants from day 0 (before transplanting) to day 30 after transplanting. The photosynthetic CO₂ demand (D) and supply (S_u) functions have been reported only for day 0. C_a is the ambient CO₂ concentration. $n = 6$; bars denote ± 1 SEM.

was significantly less pronounced than in the transplanted plants. Predawn needle water potential (Fig. 1c) was affected by transplanting, but significantly lower values than in the control plants occurred only after day 9. The severe decline in A

for the transplanted plants was accompanied by an almost constant c_i (Fig. 2), thus indicating that, despite the parallel evolution of A and g_s , the changes in A were mainly due to an alteration of mesophyll photosynthetic capacity.

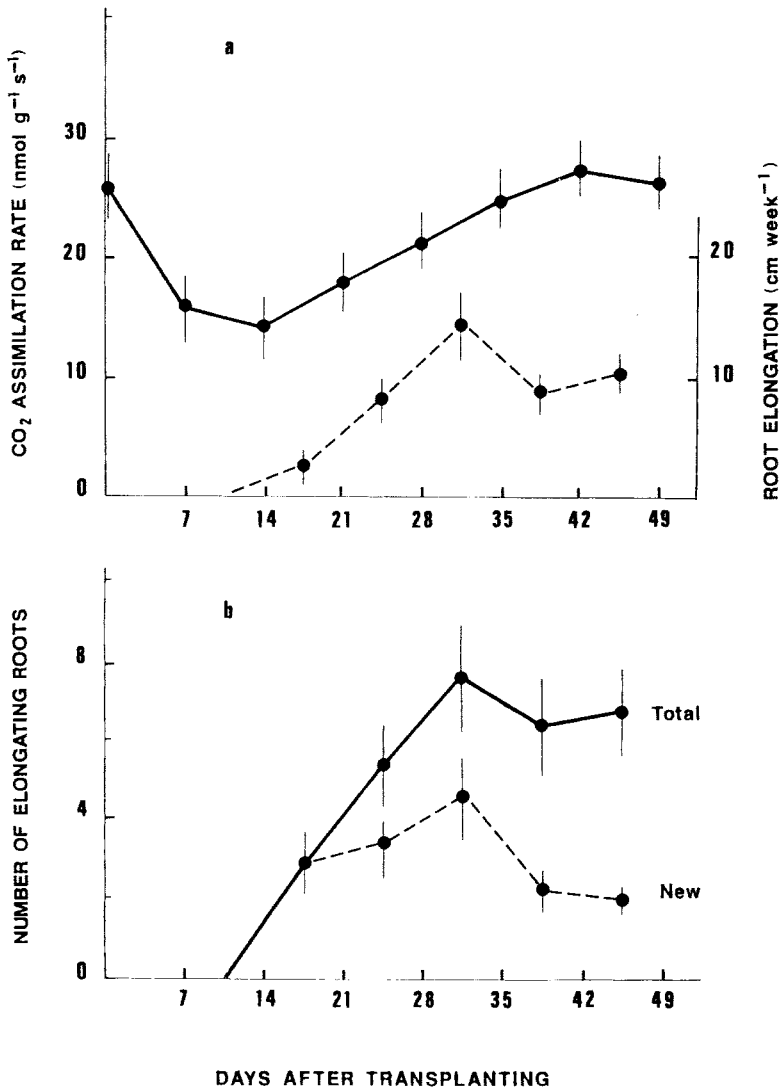


Fig. 3. Concurrent time course of: a, CO₂ assimilation rate (A , solid line) and root elongation (dashed line); and b, number of new and total elongating roots after transplanting. $n = 15$; bars denote ± 1 SEM.

Experiment 2

Carbon dioxide assimilation A markedly and gradually decreased after transplanting from day 0 to day 14 (Fig. 3a), and then, from day 14 to day 42, recovered its initial value. The start of recovery in A was concomitant to the beginning root regeneration (Fig. 3).

Discussion

The results of this study support the previous findings of several authors showing that A (Stupendick and Shepherd, 1980), g_s and ψ_p (Sands, 1984; Aussenac and El Nour, 1986) are affected by transplanting stress.

However, the decline of A due to transplanting was not a consequence of reduced g_s , but was primarily determined by alterations of mesophyll photosynthesis. This, plus the parallel time course of A and g_s , might even suggest that reduced g_s is the consequence of altered mesophyll photosynthesis.

Leaf water status is not the factor responsible for the initial decline of A and g_s , but it is likely to be a relevant physiological constraint. The (common?) signal that triggers the initial decline in A and g_s remains unknown (nutritional, hormonal?).

Recovery of A was strictly concomitant with root regeneration, but no evidence could be found to ascertain whether a functional linkage exists between these 2 parameters, or whether they respond to a third, still unknown, factor.

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