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ORIGINAL ARTICLE

The JIP test: a tool to screen the capacity of plant adaptation to climate change

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Abstract
Adaptation and acclimation are strategies that forests enact to cope with climate change. They consist of genotypic and phenotypic adjustments that allow plants to grow and reproduce successfully in a stressful environment. Both these aspects can be actively promoted by reforestation programmes. The key phases are: (1) selection of the most suitable provenances and genotypes; (2) adoption of adequate cultural techniques in nursery; and (3) monitoring of the plantations. Physiological techniques may be useful to assist all the phases of this process. Among these, chlorophyll fluorescence-based techniques, such as the JIP test, are relevant to monitor the stress conditions and the effectiveness of the cultural practices. JIP test is a non-destructive, non-invasive, informative, very fast and inexpensive technique, and can be used to support the cultural decision.

Keywords: *acclimation, adaptation, chlorophyll a fluorescence, climate change, JIP test, hardening, water use efficiency.*

Introduction

Different scenarios have been proposed to interpret the fate of the European forests, in view of the alleged climate change. In particular, researchers speak about migration and adaptation. The first term indicates the change in plant species composition (e.g. in certain conditions mesophilous forests can be replaced by a more xerophytic vegetation), whereas the latter (adaptation) refers to changes occurring in the genetic structure of the population favouring the most suitable individual genotypes.

The primary duty for foresters is to identify and select tree propagation material suitable for the installation of new forest stands capable of coping with the worsening climatic conditions. The identification of suitable species and genotypes, however, is a crucial issue, because each population represents a unique equilibrium between climate, recurring extreme weather events and photoperiod. Forests persist for a long time on a site and the use of unsuitable plant material may create problems at a distance of decades. To minimize these risks, it is good practice to select plant species and genotypes among the local flora and vegetation (e.g. basal vs mountain populations). This is a concept that also meets the needs of biodiversity conservation. Once a genotype has been identified, the problem is its cultivation in a nursery before it is planted in the field. A sustainable approach requires the application of field techniques aimed at maximizing water use efficiency (WUE); this objective can be achieved with hardening techniques, i.e. by applying a controlled dose of drought stress as an element of cultural practices. Stress may be either beneficial (eu-stress) or detrimental (dis-stress). A moderate exposure to drought reduces the net photosynthesis but triggers active responses favouring the acclimation in stressful environments. In these conditions, the plant's resources are directed to defences and root increment, rather than to epigean growth. Both selection of suitable genotypes (*adaptation*) and their cultivation for stressful environments (*acclimation*) require that plant responses be assessed carefully. Several physiological parameters can be tested to determine the potential performance of a plant or a

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