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Radiation and thermal microclimate in tree shelter

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ABSTRACT

Single-tree shelters are used to protect trees, but they greatly affect tree growth, largely because of their internal microclimate. The shelter walls have a PAR transmissivity from 35% to 60%, depending on the beam angle. Far infrared radiation is trapped in the shelter creating various temperature gradients. During the night, the internal air temperature is colder than outside air. During the day the internal temperature is much warmer than the outside air. Leaf temperature is warmer than the air temperature only when the sun's beam is directed to the leaf. The wall temperature is usually lower than inside air temperature. Therefore, leaves are not able to transpire and condensation appears on the inner wall of the shelter. This increases the energy surplus within the shelter.

1. Introduction

Single-tree shelters have been used intensively for almost two decades now in Europe (Evans and Potter, 1985). They are aimed at protecting broad-leaved tree seedlings from foliage browsing and stem rubbing by wild or domestic animals. Their utility is now well established. Furthermore, in forestry plantations, the shelter allows an easy identification of the position of the tree for different treatments: weeding, pruning, etc.

The first study on sheltered tree growth (Tuley, 1983) showed that tree shelters enhanced both height and stem diameter growth. But later studies (Rendle, 1988; Dupraz et al., 1989; Dupraz and Cavet, 1991; Bergez, 1993; Burger et al., 1996; Kjelgren and Rupp, 1997; Mayhead and Boothman, 1997) showed that stem diameter growth was often reduced in tree shelters. Furthermore, in some long-term trial studies (Dupraz, 1997) it was shown that, although *Juglans* trees emerged from the top of the shelter during the first growing season, the adverse effect of tree shelters on tree diameter growth was still significant 10 years after planting, while the height advantage had vanished.

To understand the effect of the shelter on the tree's physiology, general studies to characterise the microclimate within the shelter have been carried out. Main studies are based on brown, round, 10 cm diameter shelters, height ranging from 1.10 m to 2.00 m. As shown by different authors, the microclimate surrounding the tree within a tree shelter is strongly modified (Rendle, 1985; Bergez, 1993; Kjelgren, 1994; Kjelgren et al., 1997; Sharew and Hairston-Strang, 2005): photosynthetically active radiation (PAR) is reduced by almost 60% (ranging from 20% to 70%), daytime temperature may exceed ambient temperature by up to 10 °C and the air is often saturated with water vapour. CO_2 concentration patterns are also considerably modified in the tree shelter (Dupraz and Bergez, 1999). The effects of such a microclimate on the tree's metabolism in the standard unventilated tree shelter leads to interesting results: transpiration rate is somewhat decreased (Bergez and Dupraz, 1997) and assimilation is slower due to an inadequate ventilation rate (insufficient CO_2 concentration in the shelter) and too high a temperature (Dupraz and Bergez, 1999). Furthermore, due to this microclimate, the energy budget of sheltered leaves is altered. However, knowledge of

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