DECLINE IN STOMATAL CONDUCTANCE AND PHOTOSYNTHESIS OF VETERAN *QUERCUS ROBUR* TREES

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INTRODUCTION

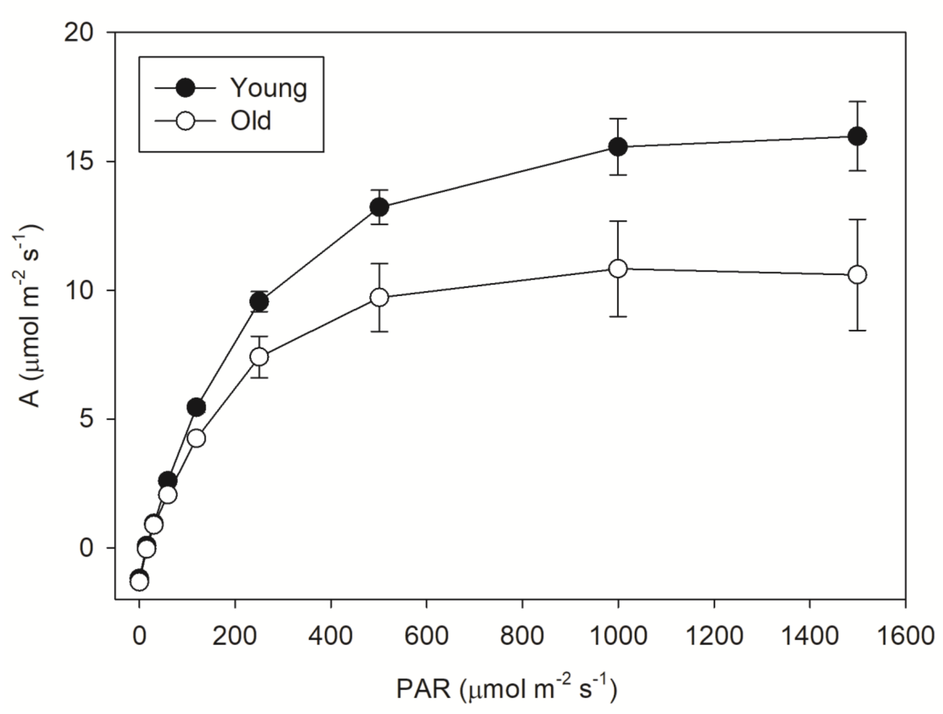
Age-related changes in the physiological processes of trees have been a fundamental problem for forest biologists and plant physiologists for many years. Tree aging results in pronounced changes in leaf-level gas exchange and foliar structure, hormonal regulation, allocation to reproduction, and wood anatomy, all of which may contribute to the decline in vitality of old trees. Understanding the underlying mechanisms of tree decline is crucial for predicting the response of old trees to anthropogenic environmental changes, such as drought stress, repeated wildfires, and severe insect attacks. Ecophysiological parameters were used to assess the effect of age on the photosynthesis of pedunculate oak (*Quercus robur*).

MATERIAL AND METHODS

Two groups of trees were compared: the first group consisted of trees over 600 years old (veteran trees, Fig. 1), whereas the second group comprised trees approximately 25 years old (young trees). The study was conducted in the protected area of Kulháň nature reserve in the Trenčín region of west Slovakia (48.70 N°, 18.09 E°). We measured photosynthesis and stomatal conductance (g_s) using a LiCor 6400, and water potential using a Scholander pressure chamber (PMS 1000). The measurements were carried out in July and September.

Fig.1: Veterans' oaks with age over 600 year old at Kulháň nature reserve.

RESULTS



Light-saturated photosynthesis was lower in the old than in the young oak trees (Fig. 2).

Fig. 2: Light-saturated photosynthesis in the old and in the young oak trees.

The reason for the differential photosynthesis rate was higher stomatal limitations in old trees than in young trees (Fig. 3).

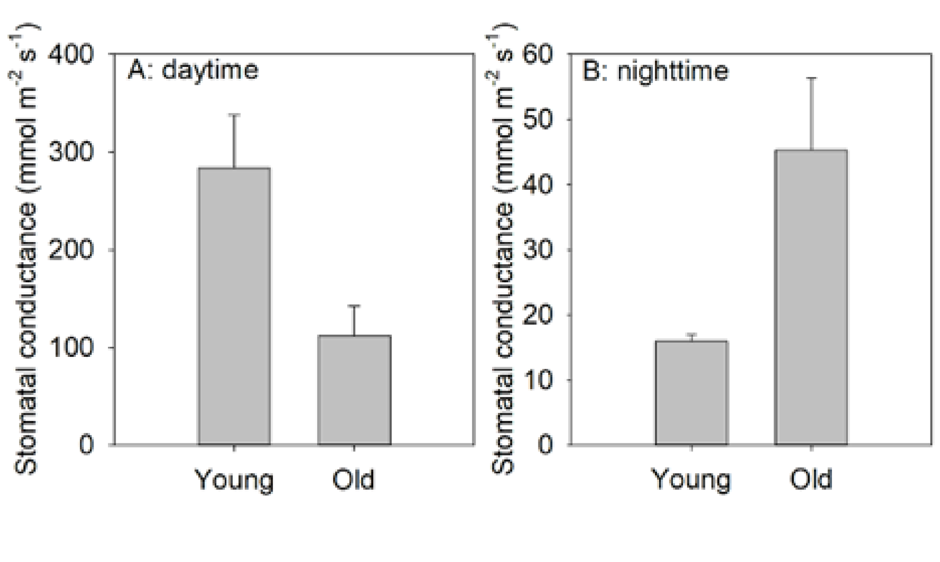


Fig. 3: Stomatal conductance of young and old trees in daytime (left) and nighttime (right)

Identical indices of chlorophyll fluorescence (Fig. 4) and biochemical parameters of photosynthesis in the two age groups of trees suggested that oaks were capable of maintaining optimal levels of light and carbon reactions of photosynthesis until advanced age. Furthermore, the maximum quantum efficiency of photosystem II in the oaks was 0.8, indicating that the foliage of these trees was healthy, undamaged, and not subjected to any significant stress.

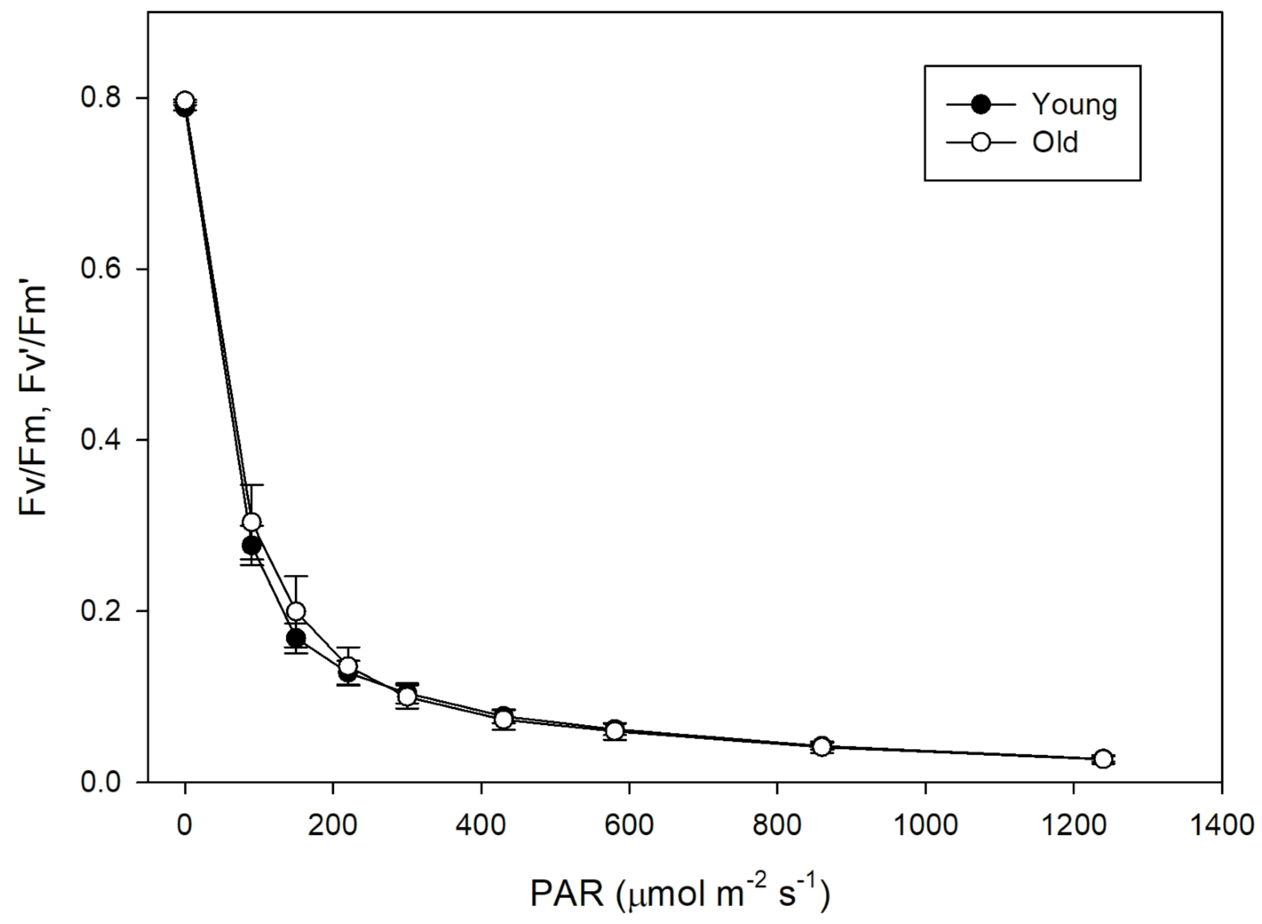


Fig 4. Dependence of chlorophyll fluorescence *Fv/Fm* on photosynthetically active radiation (PAR; *Fv´/Fm´*) for old and young oaks. Points represent average *Fv/Fm* values measured in darkness and *Fv´/Fm´* at non-zero illumination, bars represent standard error.

A decrease in g_s was observed in old trees compared to young trees under unlimited soil water availability (Fig. 3). Conversely, higher values of water potential in old trees during mild drought in summer indicated their enhanced access to soil water (Fig. 5). The nighttime g_s was higher in older trees than in younger trees (Fig. 4). These results suggest that one of the factors contributing to the reduced vitality of old trees is their inability to regulate stomatal conductance during both day and night, and to optimize the carbon assimilation-water loss balance.

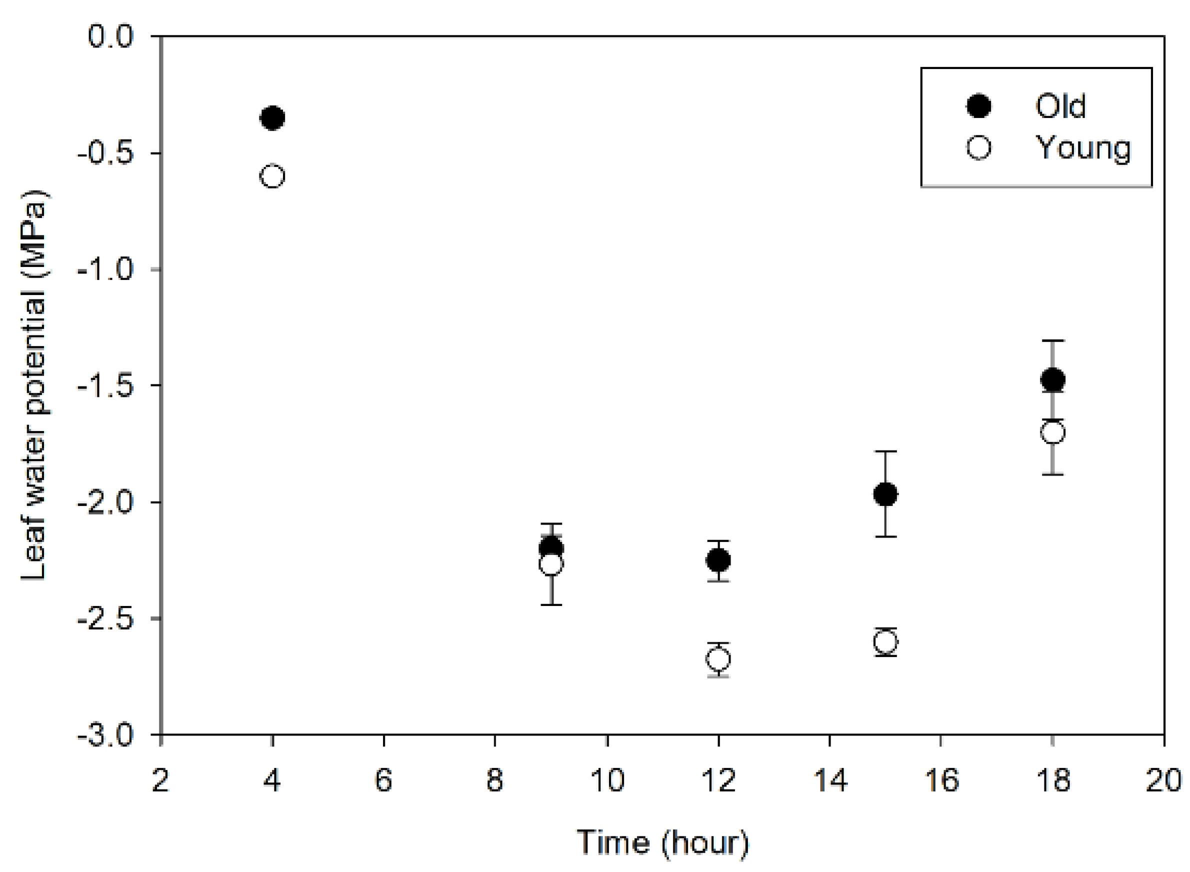


Fig. 5: Water potential of old and young pedunculate oaks. Points represent mean water potential and bars represent standard error

CONCLUSIONS

Our investigation demonstrated that while reduced stomatal flexibility in mature *Quercus* specimens increased water loss and limited the CO_2 fixation rate, thereby reducing tree vitality, it may also promote water use efficiency, which, in conjunction with deeper root systems, may contribute to drought resistance. Conversely, a higher minimum g_s than that of younger trees may compromise the survival of veteran trees during such drought periods. The response of large old trees to rising atmospheric CO_2 concentrations remains uncertain. For instance, while elevated CO_2 may have contributed to stomatal closure by decreasing stomatal density, it also enhances CO_2 fixation, potentially promoting tree growth. Consequently, veteran trees may represent unique organisms that have adapted during their lifespan to function effectively in the face of ongoing climate change, despite initiating their lives long before the onset of current climate warming.

ACKNOWLEDGEMENT

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