Abstract

Scots pine (*Pinus sylvestris* L.) is one of the dominant tree species in temperate and boreal forests in Europe. Due to climate change, pine forests may be exposed to severe water deficits. In Poland, this applies especially to the north-western and central parts of the country, which currently have one of the lowest fresh water resources per capita among all European Union countries.

The aim of this study was to determine trends in drought occurrence for selected Central European countries during the period 1951–2015, determine the impact of drought on water and carbon cycle at pine stands - in particular on their transpiration, stand biomass increase, photosynthesis, as well as the relationships between these processes, both at an individual tree and ecosystem scale.

Trends in the intensification of meteorological droughts in Europe were detected by analyzing the course of SPEI index (Standardized Precipitation and Evapotransspiration Index), which consider not only precipitation, but also thermal conditions determining the intensity of evapotranspiration. The study used eddy covariance (EC) measurements to assess the exchange of water vapor and carbon dioxide (CO_2) on an ecosystem scale, and the sap flow method to assess transpiration on a tree and stand scale. The research was carried out at two Scots pine monoculture sites of different ages.

As a result of performed analyses it was found that the occurrence of severe droughts in the area of Central Europe has an upward trend in the last few decades. The analyzes also showed that the directly measured net primary productivity (NPP) at the young Scots pine monoculture was about 0.6 t C ha^{-1} lower in the dry year of 2019 than in the moderately wet year 2020, as was the estimated carbon use efficiency (CUE). In addition, high water use efficiency (WUE) was associated with low water content in the soil, which indicates a strong reduction of water loss (transpiration) while maintaining intensive CO_2 uptake (photosynthesis).

There is an indication that during periods of drought and water deficits, forest monitoring in terms of water and carbon cycle, carried out in a direct and real-time manner, will become increasingly important not only for forest management, but also for the local and global carbon, water and energy balance.

Key words: Scots pine, transpiration, photosynthesis, drought, eddy covariance, sap flow

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