Geophysical Research Abstracts
Vol. 13, EGU2011-4083, 2011
EGU General Assembly 2011

Soil water, temperature regime and root growth of young oak stands grown in lysimeters subjected to drought stress and air warming

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In a 3-year lysimeter experiment with open top chambers (OTC) we investigated how the growth, mineral nutrition and water consumption of young trees of the three oak species Quercus robur, Q. petraea and Q. pubescens may respond to predicted climate changes with higher summer temperatures and more extended drought periods on different types of soil. Four different climate treatments (control, air-warming (+2°C), drought (-40% precipitation), combination of air-warming & drought) were applied during the vegetation periods to mixed stands of the three species on an acidic loamy sand and a calcareous sandy loam in four replicates each.

While the water potential in soils during drought periods was clearly lower than in the control treatment, as intended, the air-warming treatment had only little effect on soil water availability. Decreased evapotranspiration from the drought-stressed stands led to significantly higher air and soil temperatures due to the reduced transpirational chilling effect. The air-warming treatment had no significant effect on evapotranspiration. The effects on water consumption by the trees were paralleled by the effects on tree growth: Drought significantly reduced shoot, leaf and root biomasses on both soils, whereas growth did not respond to air-warming. Drought-treated oaks invested relatively more growth into roots and less into shoots than trees not subjected to the drought treatments. There was no mortality in any of the treatments, demonstrating that by reducing their growth rates young oaks can resist drought stress quite well.

With no water limitation, more water was consumed and more shoot, leaf and root biomass produced on the acidic than on the calcareous soil, accompanied by lower water potentials in the acidic soils. Under drought conditions, there were no differences in growth between the two soil types, suggesting that growth was limited by another factor than water availability on the calcareous soils. Preliminary leaf mineral analyses indicate a potential manganese deficiency on these soils.

The results suggest that extended drought periods, expected to become more frequent with global climate change, will be a major challenge for trees in temperate forests. In comparison to many other forest tree species in temperate humid regions, oaks, known to be more drought resistant, may still be well prepared to deal with such conditions in the future.