Exposure, Uptake and Effects of Ozone

Assessments based on stomatal conductance models for spring wheat, timothy and potato

Helena Danielsson

Abstract

In the late 1990s important steps were taken toward an uptake based approach for ozone effects on plants. This new type of ozone index is based not only on the concentration of ozone at plant level, but also on the abiotic and biotic factors important for the uptake of ozone through the stomata into the plant leaves. The aims of the work presented in this thesis were to develop dose-response relationship for ozone effects on potato, spring wheat and timothy, based on an exposure index describing the cumulated uptake of ozone (CUO) into the plants, to examine the importance of the potential growth rate for the effects of ozone on timothy growth and to examine if the maximum stomatal conductance is related to the ozone sensitivity. The new type of dose-response function is intended to be used as an instrument in the international negotiations on reductions of transboundary air pollution.

Measurements of stomatal conductance made in experiments performed in Sweden, Finland, Belgium, Germany and UK were used to calibrate multiplicative models for stomatal conductance for potato, spring wheat and timothy. The factors included in the models were identified using the boundary line technique and reflect the influence on stomatal conductance by solar radiation, leaf temperature, leaf-to-air water vapour pressure difference, soil water potential, phenology, ozone and carbon dioxide. Data from open-top chamber experiments performed in Sweden, Finland, Belgium, Germany and Italy were combined to derive relationships between ozone exposure and yield for potato, wheat and timothy. Two different exposure indices were compared: AOT40 (accumulated exposure over a threshold concentration for ozone of 40 nmol mol^{-1}) and CUO^t (cumulative uptake of ozone, using an ozone uptake rate threshold of t nmol m^{-2} s^{-1} based on hourly averages).

In terms of correlation between relative yield and ozone exposure, CUO^5 (the CUO index with an ozone uptake rate threshold of 5 nmol m^{-2} s^{-1}) performed best for spring wheat (r^2 = 0.77). For potato the uptake based index with an uptake rate threshold of 4 nmol m^{-2} s^{-1} (CUO^4) resulted in the highest r^2-value (0.49) and for timothy the CUO^3 index (CUO with an ozone uptake rate threshold of 3 nmol m^{-2} s^{-1}) performed best (r^2 = 0.83). For spring wheat the r^2-value of the dose-response relationship based on CUO performed considerably better than the AOT40 index (r^2 = 0.41). For potato and timothy the differences between the indices were not as large as for spring wheat and the r^2-values using the AOT40 index were almost as high as when using CUO (r^2 = 0.37 and 0.77, respectively for potato and timothy). For all three species the uptake based ozone exposure index performed better in terms of r^2-values than any concentration based index tested (AOT0 – AOT50).

Examination of the ozone effects on growth for different timothy genotypes showed that genotypes with higher potential growth rates were more ozone sensitive in terms of reduced growth rate. There were also indications that maximum stomatal conductance might be positively related to the development of visible ozone injury in timothy. No significant relationship was found between maximum stomatal conductance and growth rate.

Keywords: AOT40; dose-response; CUO; ozone; *Phleum*; potato; stomatal conductance; timothy; *Triticum*; wheat; *Solanum tuberosum*; uptake; yield

Göteborg, February 2003

ISBN 91 88376 19 2