Photo: Shutterstock

# Global Challenge Network on Tropospheric Ozone

# Agricultural and crop-effects of ozone

## How does ground-level ozone affect agricultural crops and food production?

**Ground-level ozone is a threat to food production as it has a negative impact on the yield and quality of important staple crops. Soybean, wheat and rice are the most sensitive to ozone, with maize and barley being moderately sensitive.**

**Ground-level ozone is formed by a series of complex chemical reactions which take time to build up ozone concentrations. High concentrations are therefore found in rural and upland areas, some distance downwind of cities and other areas where the chemical precursors of ozone are emitted. Hot, sunny weather leads to the highest concentrations.**

*Example of ozone-induced leaf damage to an agricultural crop*

**Photo:** Dimitris Velissariou

## Key Facts

- Ground-level ozone has often been ignored as a threat to food production;
- Current ambient ozone concentrations are above the threshold where we can expect significant effects on yield and quality of sensitive crop species;
- In Europe, estimated loss of wheat grain yield from ozone was €3.2 billion in 2000;
- Evidence from seven European countries, India and the USA indicates wheat yield increased by an average of 9% when ground-level ozone concentrations were reduced by filtration to near natural levels;
- The value of salad crops (e.g. lettuce, spinach, chicory, salad onions) can be reduced by the development of ozone-induced visible damage to leaves;
- Current crop cultivars tend to be more sensitive to ozone than older varieties.

## Links

icpvegetation.ceh.ac.uk

http://www.ceh.ac.uk/our-science/research-facility/solardomes

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Science & Technology Facilities Council

ICP VEGETATION

## Recent developments

The uptake of ozone by crops through the leaf pores is affected by weather, soil water availability and plant development. Irrigation of crops during warm, sunny days can enhance the amount of ozone taken up by leaves.

Ozone concentrations are rising in developing areas of the world (e.g. India and China) due to rapid increases in population and industrialization, threatening global food production.

The background ozone concentration in Europe is rising due to increases in emissions elsewhere in the northern hemisphere. For example, emissions from North America may be contributing up to 60% of the current ozone effects on crop yield in Europe.

Even with current legislation to reduce ozone pollution in Europe, economic losses of wheat are still predicted to be €2 billion in 2020 (based on wheat prices in 2000).

The figure on the right shows predicted economic losses for ozone effects on wheat in million € per 50 km x 50 km square in 2000 (top) and 2020 (bottom).

It is assumed that soil moisture is not limiting, i.e. irrigation is used as needed.

## What is needed?

Ozone pollution is a global problem requiring global solutions. More stringent reductions of the emissions of precursors of ozone are required across the globe to reduce the threat from ozone pollution to food production. Air pollution abatement policies need to be integrated with climate change policies as both affect global food production. Improved quantification of impacts of ozone within the context of climate change is urgently required to facilitate improved future planning of the availability of food at a range of scales (national, regional, global).

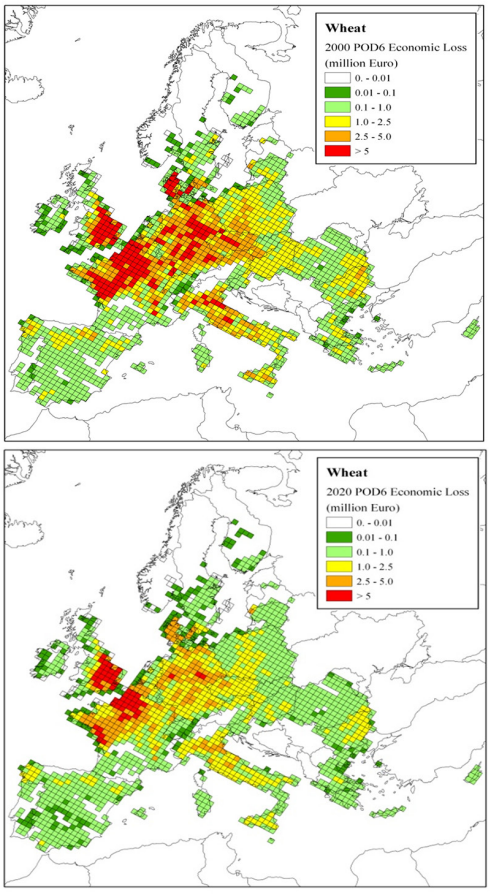
Crop breeding programmes should include a test for ozone sensitivity to develop more resistant varieties. Future crop management strategies should consider ways of reducing ozone uptake into crops, for example by withholding irrigation during ozone episodes.

Further research is needed to improve our ability to quantify and forecast effects of ozone on crop yield and quality. Field-based experiments are required especially to enhance our knowledge on the impacts of ozone on crop quality, such as protein yield and content, sugar and mineral content, to assess the impacts of ozone on nutritive value.

Little is known about the impacts of ozone on fodder production and quality. Further research on this is needed to assess the impacts of ozone on for example meat and milk production and quality.

*Ozone damage to wheat modelled for the years 2000 and 2020*

**Source:** Mills and Harmens (2011), icpvegetation.ceh.ac.uk




## The Ozone Challenge

Ozone is formed in the lower atmosphere by the action of sunlight on nitrogen dioxide ($NO_2$), which is naturally present from lightning, biomass burning and soil emissions; man-made contributions to $NO_2$ from burning fossil fuels dominate in developed regions. Ozone formation is accelerated by the presence of organic gases, both biogenic and man-made. Ozone is toxic to plants, animals and humans; toxic concentrations are found in polluted air, downwind of $NO_2$ sources and especially in strong sunlight. Ozone is removed from the atmosphere by deposition to plants, and also by reaction with nitric oxide (NO) to form $NO_2$.

**Further information and contact details:**

**www.ozone-net.org.uk**

**Other Fact sheets in the series:**

- Ozone monitoring
- Ozone modelling
- Health effects of ozone
- Ecosystem effects of ozone