a hidden threat to food security

Ozone pollution

When you are eating your sandwich or surreptitiously tucking into chips from the local chippie, do you ever stop to think about which crops these products came from or what threats they may be under as our climate changes? We take for granted that these foods will always be plentiful, but in fact our food supply faces severe threats. Gina Mills explains the serious problems that ozone in the air causes, and how scientists are responding.

Our crops are under attack from pests and diseases, weeds, fluctuations in rainfall and temperature, and other climate extremes; all of this results in troughs and peaks in the availability and value of food. But few people realise that many of our most important crops are also sensitive to air pollution, with ozone being the most damaging kind. We all know about the important role that ozone plays in the upper atmosphere protecting us from harmful ultraviolet radiation from the sun, but when the same chemical is present in the lowest few kilometres it becomes a damaging pollutant that harms human health and the environment.

At ground level, ozone is a secondary pollutant – it forms in the air when gases emitted by burning fossil fuels and some industrial processes react in the presence of sunlight. Ozone concentrations are strongly influenced by the weather. They are highest on warm, sunny days in spring and summer, especially in rural areas downwind of major cities. There is always some ozone in ground-level air (the so-called 'background' concentration, partly influenced by pollution from other continents). Yet ozone concentrations can rise to a higher level for several days when conditions are right for it to form – during so-called 'ozone episodes'.

Although international agreements in Europe have succeeded in reducing the highest peak ozone concentrations, current background and episodic ozone levels remain high enough to damage human health, natural vegetation and crops. Ozone enters plants through the small pores on the leaf surface, known as stomata. Once inside the plant, ozone reacts to form oxidising chemicals that can damage cell membranes and key processes such as photosynthesis.

In crops, this leads to reduced growth and smaller, lower-quality seeds and tubers with less oil or protein. If ozone episodes last a few days, visible damage to the leaves of sensitive species can appear. This can be seen as pin-head-sized pale yellow or brown blotches, below which the cells have died. It can reduce the value of leafy crops like lettuce, spinach and herbs.

Some of the world's most important staple food crops are sensitive to ozone,

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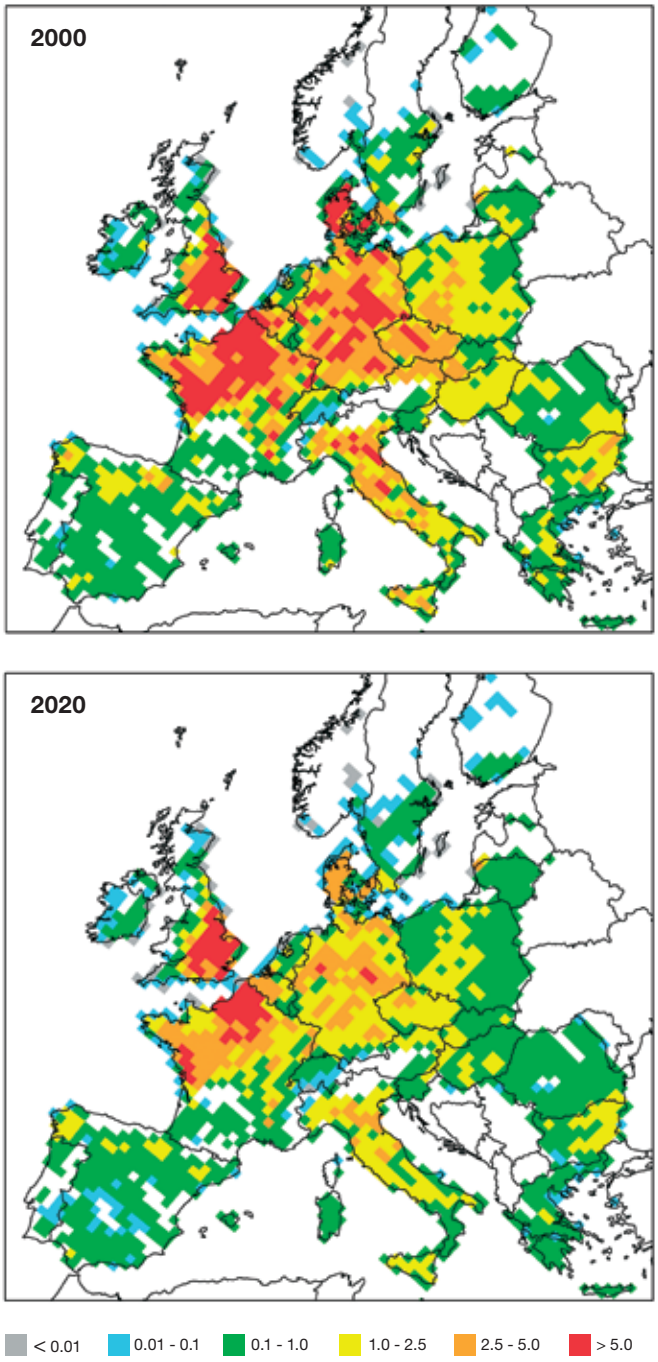

Predicted economic losses for ozone effects on wheat yield in million euros per 50km grid square.

including wheat, maize, rice and soybeans. Several studies have shown that crop varieties grown in south-east Asia may be at least as sensitive as those in Europe and North America. Ozone concentrations are rising here, partly due to rapid industrialisation, and alarm bells are beginning to ring about current and potential future ozone impacts in the region, where food security is precarious.

Focusing on wheat and tomatoes, we calculated the production of ozone, and the economic losses it causes, in the 27 EU countries plus Norway and Switzerland. We looked at whether current European policies to reduce emissions of the chemicals that lead to ozone pollution will reduce ozone damage by comparing data from

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2000 with predictions for 2020.

Using a recently-developed modelling method that calculates the amount of ozone plants take up through their stomata over a whole growing season, we predicted that around €3.2 billion was lost in 2000 due to ozone effects on wheat yield. Even with current legislation to reduce ozone pollution in Europe, we predict losses will still be €2 billion in 2020.

These numbers are based on wheat prices and production in 2000; given the rising price of wheat, economic losses could end up substantially higher. The biggest impacts were predicted in areas of France, Germany, the UK and Italy. Losses for tomatoes, an important crop in southern Europe and the Netherlands, are estimated at more than €1 billion in 2000, and predicted to fall to €0.63 billion in 2020.

In a more detailed study looking at smaller geographical areas, we investigated the effects of ozone on eight UK crops in 2006 – a hot, dry summer of the kind that's expected to happen more often in coming decades – and 2008, a more typical year for the UK. Ozone-sensitive wheat is grown on some 2 million hectares in the UK, especially in the south and east where some of our highest rural ozone concentrations occur. So it's not surprising that more than a third of the total losses in monetary terms for the UK could be attributed to effects on wheat yield.

What was surprising, though, was that estimated losses for wheat were the same (5.6 per cent of economic value) for both 2006 and 2008. Although ozone concentrations were higher in 2006, the drier conditions in that year meant that stomatal pores didn't open as much – a defence against water loss which also reduced the amount of ozone uptake. There were also differences in the UK regions most likely to have been affected.

Protecting our crops from ozone pollution in the future will require a multi-faceted approach. Firstly, we need international effort to reduce the emissions of the chemicals that lead to ozone pollution. The results presented here have fed into United Nations negotiations for the Convention on Long-range Transboundary Air Pollution via ICP Vegetation, an international programme coordinated by the Centre for Ecology & Hydrology at Bangor.

We also need more research to develop ozone-resistant varieties of staple crops, to investigate farming practices that might reduce ozone uptake during episodes, to gain further insight into how ozone damages crops and to investigate chemicals that could be used to protect against damage.

MORE INFORMATION

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http://icpvegetation.ceh.ac.uk/

www.ceh.ac.uk/sci_programmes/GroundLevelOzone.htm