Ground-level ozone reduces maize and soybean yields

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A 10 percent decline in corn yield over three decades surprised researchers studying the effects of ground-level ozone on crops. Credit: Don Hamerman

Despite government regulations, ground-level ozone—an odorless gas that forms as polluting nitrogen oxides drift in sunlight across the

countryside—continues to threaten crop quality and yield. In a new study, researchers quantify this loss from historical yield data for the first time. They show that over the last 30 years, ozone emissions have reduced soybean and corn yields by 5 percent and 10 percent, respectively.

The findings are reported in the *Proceedings of the National Academy of Sciences*.

Justin McGrath led the study as a postdoctoral fellow with the Carl R. Woese Institute for Genomic Biology at the University of Illinois with plant biology and crop sciences professor Stephen Long and USDA Agricultural Research Service scientist Elizabeth Ainsworth.

Emissions regulations have had a positive effect on reducing ozone-related damage to crop plants, the researchers found, but may need to be upgraded to reduce crop damage and ease the resulting financial burden on growers, Long said.

"We had suspected for some time that surface ozone pollution, which can be surprisingly high in rural areas, was affecting crop yields, but until now there had not been a means to quantify this from actual yield data," Long said.

Ozone damage occurs when the gas enters a plant's leaves and dissolves in water within the leaves, producing toxic byproducts. Water availability increases a plant's vulnerability to ozone damage. The higher the concentration of ground-level ozone, the greater the likelihood of damage.

The researchers analyzed historical crop yields and climate and ozone data from 1980 to 2011 across the continental United States, focusing on corn and soybean. They found that past and current levels of ground-

level ozone were reducing yields of both crops.

"Laboratory studies had suggested that soybean was vulnerable to ozone, but the 10 percent yield loss in corn is a surprise and very significant," Ainsworth said. Even when water was not readily available during a period of drought, ozone damage was still extensive, she said.

The researchers calculated an annual loss of just over $9 billion nationwide between the two crops due to ozone damage. One way to ease this financial burden is to increase air-quality control regulations, McGrath said. Such regulations already appear to have reduced the amount of ozone-related crop damage, he said.

There is, however, some better news. Ainsworth is LINK: leading projects to identify genes in corn and soybean that decrease the crops' vulnerability to ozone. These may provide another means to decrease these losses, the researchers said.

More information: An analysis of ozone damage to historical maize and soybean yields in the United States, *Proceedings of the National Academy of Sciences*, www.pnas.org/cgi/doi/10.1073/pnas.1509777112

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