Crop Production

Farmers lose soybean yields to ozone

PEOPLE tend to think of ozone as something in the upper atmosphere that protects the Earth's surface from ultraviolet radiation. At the ground level, however, ozone is a pollutant that damages crops, particularly soybeans.

Lisa Ainsworth, a University of Illinois associate professor of crop sciences and USDA Agricultural Research Service plant molecular biologist, says establishing the exposure threshold for damage is critical to understanding the current and future impact of this pollutant.

Key Points

- Ozone can significantly limit soybean yields, according to research.
- University of Illinois conducted first ozone dose-response experiment in soybeans.
- Breeding hasn't increased ozone tolerance in soybean varieties.

"Most of my research is on measuring the effects of ozone on soybean, determining the mechanisms of response, and then trying to improve soybean tolerance to ozone so that we can improve soybean yields," she explains.

Ozone is highly reactive with membranes and proteins, and is known to damage the human lung. It also harms plants, slowing photosynthesis and accelerating senescence. As a result, plants take in and fix less carbon, reducing yield. Ainsworth says ground-level concentrations of ozone are already high enough to damage crop production.

"Ozone reacts very quickly once it enters the leaf through the stomata," she explains. "It can form other oxygen radicals and also hydrogen peroxide. Then, a series of cascading reactions causes a decrease in photosynthesis, reducing stomata conductance."

The plant's response to ozone mimics a hypersensitive response to a pathogen attack. "At quite high concentrations of ozone, you can get leaf bronzing, stippling of the leaves and necrotic spots," Ainsworth notes. "At really high concentrations, you get cell death." The metabolic changes then feed forward to affect plant productivity.

First ozone-dose experiment

Ainsworth's group conducted a two-year study in 2009 and 2010 at the Soybean Free Air Concentration Enrichment, or SoyFACE, facility at the U of I South Farms. It was the first dose-response experiment to look at ozone and soybeans under entirely open-air conditions.

The researchers investigated the responses of seven different soybean genotypes to eight ozone concentrations. The plants were exposed to ozone concentrations ranging from ambient levels of 38 parts per billion up to 200 ppb. "This is quite high, but unfortunately, those kinds of concentrations are what very polluted areas of China and India are looking at today," Ainsworth adds.

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"This is significant," Ainsworth says. "Especially considering that background concentrations of ozone today vary year to year, anywhere from about 38 to 39 parts per billion to about 62. That can be 15 bushels per acre from one year to the next that farmers are losing to ozone."

Older lines just as tolerant

The researchers compared the results of this study, which used modern genotypes, with results from experiments conducted in controlled environments in the 1980s. They found that the responses of the modern genotypes were similar to those of the older genotypes.

"Breeders haven't inadvertently bred for ozone tolerance in more modern lines," Ainsworth says.

Potential increases in background ozone are predicted to increase soybean yield losses by 9% to 19% by 2030. Levels were particularly high during this year's growing season because most days were sunny and warm, and thus favorable for ozone formation. Peaks on many days exceeded 80 ppb, twice the known sensitivity threshold.

Source: University of Illinois