Could global warming's top culprit help crops?

April 18 2016

Researchers have introduced artificially heightened levels of carbon dioxide to farm fields, and measured the results on crop production. Here, experimental plots at the University of Arizona's Maricopa Agricultural Center. Credit: Bruce Kimball/USDA

Many scientists fear that global warming will hit staple food crops hard, with heat stress, extreme weather events and water shortages. On the other hand, higher levels of carbon dioxide—the main cause of ongoing warming—is known to boost many plants' productivity, and reduce their

use of water. So, if we keep pouring more CO2 into the air, will crops fail, or benefit? A new study tries to disentangle this complex question. It suggests that while greater warmth will reduce yields of some crops, higher CO2 could help mitigate the effects in some regions, unless other complications of global warming interfere.

The study, by 16 researchers from a half-dozen countries, uses newly available crop models and data from ongoing large-scale field experiments. It appears this week in the journal *Nature Climate Change*.

"Most of the discussion around climate impacts focuses only on changes in temperature and precipitation," said lead author Delphine Deryng, an environmental scientist at Columbia University's Center for Climate Systems Research, the NASA Goddard Institute for Space Studies and the University of Chicago's Computation Institute. "To adapt adequately, we need to understand all the factors involved." Deryng cautions that the study should not be interpreted to mean that increasing carbon dioxide is a friend to humanity—only that its direct effects must be included in any calculation of what the future holds.

Many studies say that as temperatures rise, crops across the world will suffer as average temperatures become unsuitable for traditionally grown crops, and droughts, heat waves or extreme bouts of precipitation become more common. Agricultural scientists say that losses could be mitigated to some extent by switching crops, developing varieties adapted to the new conditions, or moving some crop-growing regions poleward. But such adaptations pose daunting challenges.

A new study says more carbon dioxide in the air could help mitigate projected damage to crops caused by climate change -- at least for some crops, in some regions. Here, farmers harvest okra in the village of Loulouni, Mali. Credit: Francesco Fiondella/International Research Institute for Climate and Society

Due to human activities, average global levels of atmospheric carbon dioxide have risen by more than a quarter since 1960; they now stand at around 400 parts per million, and are expected to keep increasing, along with temperature. At the same time, experiments since the 1980s have shown that higher levels of carbon dioxide in the air helps plants build biomass. The concept is relatively simple; plants take in carbon to build their tissues, and if there is more carbon around, they have an easier

time. Leaves take in air through tiny openings called stomata, but in the process the stomata lose water; with more carbon available, they don't have to open up as much, and conserve moisture.

However, much of the initial evidence for so-called CO2 fertilization has come from lab experiments on isolated plants. These do not account for environmental factors that might affect plants even more powerfully in a warming world, including possibly increased insect and fungus attacks. Thus, suggestions that the greenhouse gas itself might prove a boon to crops have aroused deep skepticism.

In 2014, Deryng and her colleagues published the first global calculation of how heat waves might affect crops, and found that maize, spring wheat and soybeans would all suffer. When they added the effects of carbon-dioxide fertilization, they found that maize yields would still go down—but that spring wheat and soybeans might actually go up. Some media misinterpreted the study to say that climate change might help agriculture overall. The picture is much more complicated, say the authors.

The new study looks at how rising temperatures and carbon dioxide along with changes in rainfall and cloud cover might combine to affect how efficiently maize, soybeans, wheat, and rice can use water and grow. It confirms that heat and water stress alone will damage yields; but when carbon dioxide is accounted for, all four crops will use water more efficiently by 2080.

Based on the current biomass of these crops, water-use efficiency would rise an average of 27 percent in wheat; 18 percent in soybeans; 13 percent in maize; and 10 percent in rice. All things considered, the study projects that average yields of current rain-fed wheat areas (mostly located in higher latitudes including the United States, Canada and Europe), might go up by almost 10 percent, while consumption of water

would go down a corresponding amount. On the other hand, average yields of irrigated wheat, which account for much of India and China's production, could decline by 4 percent. Maize, according to the new projections, would still be a loser most everywhere, even with higher water efficiency; yields would go down about 8.5 percent. The study is less conclusive on the overall effects on rice and soybean yields; half of the projections show an increase in yield and half a net decline.

Deryng says the study is sturdier than past research, because it uses new data from experiments done in actual farm fields, and a half-dozen global crop models, several of which only recently became available. Nevertheless, she says, the uncertainties remain large. Field experiments, which involve blowing CO2 over sizable farm fields for entire growing seasons, have been done only at a handful of sites in the United States, Germany, Australia, Japan and China—not in Africa, India or Latin America, where subsistence farming are mainstays of daily life. She noted that greater yield also might not translate to more nutrition. For example, greater carbon uptake might not be balanced by other nutrients such as nitrogen, and trace elements like zinc and iron that are needed to make crops nutritious.

Bruce Kimball, a retired researcher with the U.S. Department of Agriculture who has studied crop-CO2 interactions, said the paper does "a good job on a huge scale," though, he said, "more data from more crops from more locations" is needed." Kimball cautioned also that previous research has shown that the benefits of higher CO2 levels tend to bottom out after a certain point—but that the damage done by heat only gets worse as temperatures mount. "Thus, for greater warming and higher CO2 the results would likely be more pessimistic than shown in this paper," he said.

More information: Regional disparities in the beneficial effects of rising CO2 concentrations on crop water productivity, *Nature Climate*

Change, DOI: 10.1038/nclimate2995

Provided by Columbia University