

# Rising carbon dioxide may compromise human nutrition, study says

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Free Air Concentration Enrichment (FACE) systems, like this one at the University of Illinois, allow researchers to simulate future atmospheric conditions to determine their effects on plants. Credit: Don Hamerman

At the elevated levels of atmospheric CO<sub>2</sub> anticipated by around 2050, crops that provide a large share of the global population with most of their dietary zinc and iron will have significantly reduced concentrations of those nutrients, according to a new study led by Harvard School of Public Health (HSPH). Given that an estimated two billion people suffer

from zinc and iron deficiencies, resulting in a loss of 63 million life years annually from malnutrition, the reduction in these nutrients represents the most significant health threat ever shown to be associated with climate change.

"This study is the first to resolve the question of whether rising CO<sub>2</sub> concentrations—which have been increasing steadily since the Industrial Revolution—threaten human nutrition," said Samuel Myers, research scientist in the Department of Environmental Health at HSPH and the study's lead author.

The study appears online May 7, 2014 in *Nature*.

Some previous studies of crops grown in greenhouses and chambers at elevated CO<sub>2</sub> had found nutrient reductions, but those studies were criticized for using artificial growing conditions. Experiments using free air carbon dioxide enrichment (FACE) technology became the gold standard as FACE allowed plants to be grown in open fields at elevated levels of CO<sub>2</sub>, but those prior studies had small sample sizes and have been inconclusive.

The researchers analyzed data involving 41 cultivars (genotypes) of grains and legumes from the C3 and C4 functional groups (plants that use C3 and C4 carbon fixation) from seven different FACE locations in Japan, Australia, and the United States. The level of CO<sub>2</sub> across all seven sites was in the range of 546-586 parts per million (ppm). They tested the nutrient concentrations of the edible portions of wheat and rice (C3 grains), maize and sorghum (C4 grains) and soybeans and field peas (C3 legumes).

The results showed a significant decrease in the concentrations of [zinc](#), [iron](#), and protein in C3 grains. For example, zinc, iron, and protein concentrations in [wheat grains](#) grown at the FACE sites were reduced by

9.3%, 5.1%, and 6.3% respectively, compared with wheat grown at ambient CO<sub>2</sub>. Zinc and iron were also significantly reduced in legumes; protein was not.

The finding that C3 grains and legumes lost iron and zinc at elevated CO<sub>2</sub> is significant. Myers and his colleagues estimate that 2-3 billion people around the world receive 70% or more of their dietary zinc and/or iron from C3 crops, particularly in the developing world, where zinc and [iron deficiency](#) is already a major health concern.

C4 crops appeared to be less affected by higher CO<sub>2</sub>, which is consistent with underlying plant physiology, as C4 plants concentrate CO<sub>2</sub> inside the cell for photosynthesis so they might be expected to be less sensitive to extracellular changes in CO<sub>2</sub> concentration.

The researchers were surprised to find that zinc and iron varied substantially across cultivars of rice. That finding suggests that there could be an opportunity to breed reduced sensitivity to the effect of elevated CO<sub>2</sub> into crop cultivars in the future.

In addition to efforts to reduce CO<sub>2</sub> emissions, breeding cultivars with reduced sensitivity to CO<sub>2</sub>, biofortification of crops with iron and zinc, and nutritional supplementation for populations most impacted could all play a role in reducing the human health impacts of these changes, said Myers. "Humanity is conducting a global experiment by rapidly altering the environmental conditions on the only habitable planet we know. As this experiment unfolds, there will undoubtedly be many surprises. Finding out that rising CO<sub>2</sub> threatens human nutrition is one such surprise," he said.

**More information:** "Increasing CO<sub>2</sub> threatens human nutrition," Samuel S. Myers, Antonella Zanobetti, Itai Kloog, Peter Huybers, Andrew D. B. Leakey, Arnold Bloom, Eli Carlisle, Lee H. Dietterich,

Glenn Fitzgerald, Toshihiro Hasegawa, N. Michele Holbrook, Randall L. Nelson, Michael J. Ottman, Victor Raboy, Hidemitsu Sakai, Karla A. Sartor, Joel Schwartz, Saman Seneweera, Michael Tausz, Yasuhiro Usui, *Nature*, May 7, 2014, [DOI: 10.1038/nature13179](https://doi.org/10.1038/nature13179)

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