Climanosco Research Articles

Collection 2, Climate change and its impacts

Rising carbon dioxide is decreasing nutrition in crops and endangering health among the less wealthy

By Matthew Smith and Samuel S Myers, 15 October 2019

RESEARCH ARTICLE

Carbon dioxide levels are rising globally. The increasing CO_2 levels reduce the concentration of nutrients in many of the crops that are consumed worldwide (wheat, rice, barley, maize, legumes, and potatoes). The larger effects for human health are concentrated in regions that heavily rely on these crops for their nutrition such as South and Southeast Asia, North Africa, and the Middle East. Because these effects are likely to be hidden, we should better monitor the nutritional status of populations as well as crop nutrient content over the coming decades.

Global nutrient deficiency has been declining, but not for everyone

Over the past several decades, global nutritional status has been improving for most countries — worldwide rates of stunting (low height-for-age), wasting (low weight-for-age), and deficiencies of many key micronutrients (including iron and zinc) have seen significant declines. However, this improvement has not been felt everywhere, with major parts of South Asia (particularly India) and sub-Saharan Africa seeing uneven or stalled improvement of their nutritional status.

Nutritional deficiencies — particularly for iron, zinc, and protein — can lead to a range of health complications, ranging from lowered immune functioning, anemia, reduced cognitive development, low birthweight for newborns, and many more. Furthermore, despite global declines, iron and zinc deficiencies together are still estimated to have accounted for 5.7% of all life-years lost to death or disability in 2015 (a measure of the impact of illness due to either premature death or through reduced quality of life during sickness). Protein deficiency is not usually estimated on its own, but it contributes an additional 1.7% of total life-years lost. The continuing and equitable improvement of nutritional status is therefore crucial to promoting and fostering global health in the future.

Nutrients come mainly from plants, especially for those who are less wealthy

The main way that people consume these vital macro- and micronutrients in their diet is from plants: 63% of protein, 68% of zinc and 81% of iron globally are eaten in plant-based foods. This is even more pronounced among developing countries that have less income to spend and where animal source foods are more difficult to access. Because of our global reliance on plants for nutrition, it is clear that our ability to provide adequate nutrition to the world depends in large part on sustaining our plant-based forms of nutrition.

Rising CO_2 can lower the nutrient content of major crops

Meanwhile, each year our global carbon dioxide (CO_2) emissions — from the burning of fossil fuels, industrial output, and land use change — continue to outpace the last. One of the oldest continuous direct measurements of atmospheric CO_2 concentration found a level of 317 parts per million (ppm) in 1960. As of 2015, we have now surpassed 400 ppm CO_2 globally, and we are on an aggressively accelerating trajectory to reach 550 ppm by roughly 2050.

Rising CO_2 has been thought to increase the growth rate of many plants through its beneficial role in photosynthesis, though it has also been predicted to cause dramatic disruptions to many of our global food systems. Our work has focused on a subtler, but no less dangerous effect of higher CO_2. In a set of experiments spread across the globe, a range of important food crops — wheat, rice, maize (corn), potato, sorghum, and barley — were tested for their nutritional response to being grown under higher CO_2.

To do this, two identical plants were grown in an open field under nearly the same environmental conditions: soil, weather, fertilizer, and water. However, one of the plants was surrounded by a ring of carbon-dioxide-emitting jets to maintain a locally elevated CO_2 concentration of roughly 550 ppm. An experiment designed this way isolates the specific impact of CO_2 by keeping all other variables constant.

When these plants were harvested and their edible portions analyzed, it was found that many of the foods grown under the higher CO_2 had 3 to 17% less iron, zinc, and protein [S.S. Myers et al., 2014] — nutrients important for global health — compared to the nearby plants grown at normal CO_2 levels. This collection of 143 side-by-side comparisons was the largest-ever collection of data to have found this effect in high-quality open-field experiments. Though it is still debated why these plants tend to have less nutrients compared to those grown under current CO_2 levels, the effect was found under all experimental trials in this study.

Some plants respond more strongly to CO_2 than others

The effect was not the same across all nutrients and foods. The crops that behaved most consistently were a group of major grain crops — wheat, rice, and barley — which each saw significant declines across all important nutrients: iron, zinc and protein.

For other crops, the results were more mixed. Legumes (peas and soybeans), like major grains, also saw drops in their zinc and iron, but interestingly had relatively little or no loss of protein. We believe this occurs because legumes, unlike most plants, can harvest nitrogen direct from the air, which they then turn into protein, regardless of CO_2 levels. Other crops must pull in nitrogen from the soil via their roots as they do with iron and zinc, and the speed of that process is controlled to some degree by the amount of CO_2.

Other major crops, maize and sorghum, showed less or no response across all nutrients when grown under higher CO_2. This is likely caused by the way these and other biologically similar crops (e.g. sugar cane, millet) perform photosynthesis, which is different than the ways most other crops do. This group of crops keep an artificially high internal CO_2 concentration in their plant tissues even under current conditions, so the addition of more CO_2 does little to affect their uptake of nutrients. As a result, these crops are more immune to the nutritional decreases caused by higher carbon dioxide.

This has the potential to worsen existing deficiencies

Because the CO_2-related loss of nutrients from plants is mostly imperceptible, unlike a loss of calories which could be felt as hunger, it is more likely that this effect could result in a rise of nutrient deficiency.

To explore this, across three studies we and our colleagues attempted to estimate the potential size of the effect of CO_2 on future nutritional deficiencies. To do so, we looked at each country's diet compared with their nutritional needs and how each food in their diet responded to CO_2 to estimate the size of the population newly at risk of deficiency under 550 ppm CO_2. We found that the numbers of zinc deficient people globally could rise by 138 million

[S.S. Myers et al., 2015] and protein deficient people could rise by 148 million in 2050 [D.E. Medek et al., 2017].

The rise in iron deficiency could not be predicted due to a poorer link between diet and deficiency, so we instead looked solely at which populations around the world were at risk of health burden related to iron deficiency. To do this we summed up the total number of people that meet several criteria: they belong to the groups most sensitive to health effects from iron deficiency (children and women of childbearing age), they would lose the highest amounts of iron due to the CO_2 effect, and their current level of anemia was already high, indicating an existing vulnerability that could get worse. It was estimated that roughly 1.4 billion women and children live in countries that are in this highest-risk group [M.R. Smith et al., 2017]. Even worse, these numbers are in addition to the roughly two billion people already deficient in one or more of these nutrients whose deficiencies could become more severe if not helped.

Countries are more or less vulnerable to this effect depending on what they eat

But because crops respond differently to the rise in CO_2 (and animal-source foods do not respond directly at all because their nutritional content is controlled by their biological functions), it is also clear that populations around the world would suffer the burden unequally. Countries that have high intakes of animal foods — North America, Europe and wealthier East Asia — may be more insulated from any health impacts. Similarly, countries that rely on crops that are less affected by high CO_2 — maize, sorghum, millet — have lower vulnerability than those with wheat- or rice-dominant diets. This means that many maize-eating countries in Central and South America, as well as major swaths of Sub-Saharan Africa that eat a combination of these grains, would be less harmed.

Overall, the most susceptible regions would be those that already have large populations that are on the brink of deficiency and are high consumers of CO_2-affected wheat and rice: India and South Asia, Southeast Asia, China, the Middle East and North Africa. India alone constitutes some of the highest burden under higher CO_2: 53 million newly protein deficient and 48 million zinc deficient.

However, these countries are not necessarily destined to see a growth in nutritional deficiency as CO_2 rises. Changes in diets or nutritional status between now and 2050 could either act to protect or jeopardize countries from many of these health effects, depending on other factors that control what we eat: income, preference, or growing access to a wider range of foods. However, these studies that we have conducted reveal the regions that are most at risk to this CO_2-nutrition link and would be best served by heightened vigilance in monitoring public health and crop nutrition if these effects in fact materialize.

Rising CO_2 could have harmful consequences for many of Earth's systems, including those that humans rely upon for health. Here we show the implications for one of them — how higher CO_2 can lower the nutritional quality of crops, causing negative health impacts for those that need them most. This is an issue of global significance, affecting broad swaths of the world and potentially hundreds of millions of people. Because of its broad and significant effects, countries most in harm's way need to maintain a high level of awareness of their public nutrition and act swiftly as peril emerges.

Bibliography

- D.E. Medek, J. Schwartz and S.S. Myers: Estimated effects of future atmospheric CO2 concentrations on protein intake and the risk of protein deficiency by country and region, *Environmental Health Perspective*, vol. 125, https://doi.org/10.1289/EHP41, 2017.
- S.S. Myers, K.R. Wessells, I. Kloog, A. Zanobetti and J. Schwartz: Effect of increased concentrations of atmospheric carbon dioxide on the global threat of zinc deficiency: a modeling study, *Lancet Global Health*, vol. 3, e639–e645, 2015.
- S.S. Myers, A. Zanobetti, I. Kloog and and co-authors: Increasing CO2 threatens human nutrition, *Nature*, vol. 510, 139-143, https://doi.org/10.1038/nature13179, 2014.
- M.R. Smith, C.D. Golden and S.S. Myers: Anthropogenic carbon dioxide emissions may increase the risk of global iron deficiency, *GeoHealth*, vol. 1, https://doi.org/10.1002/2016GH000018, 2017.

Article information

Cite as Matthew Smith and Samuel S Myers, Rising carbon dioxide is decreasing nutrition in crops and endangering health among the less wealthy, *Climanosco Research Articles* **2**, 15 Oct 2019, https://doi.org/10.37207/CRA.2.5

ISSN 2673-1568
DOI https://doi.org/10.37207/CRA.2.5

Retrieved 5 Feb 2025
Version 1
In collection 2, Climate change and its impacts

Authors

Matthew Smith, Department of Environmental Health, Harvard T. H. Chan School of Public Health, Harvard University, Boston, MA, USA

Samuel S Myers, Harvard T. H. Chan School of Public Health, Boston, MA, USA

Categories

Climate of the future, Earth, Health, Impacts, Life, Risks, Soil, Vegetation, Vulnerability, Global

Metadata

Date of final publication 15 October 2019
Type of article: General article; Multiple source article

Permanent url address:
https://www.climanosco.org/published_article/rising-carbon-dioxide-is-decreasing-nutrition-in-crops-and-endangering-health-among-the-less-wealthy/