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Title:

Poleward Expansion and Tropical Contraction of Global Soybean Footprint: Regional Losses in Iron and Zinc Delivery Threaten Millions

Authors & affiliations:

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Abstract: (Your abstract must use **Normal style** and must fit in this box. Your abstract should be no longer than 300 words. The box will 'expand' over 2 pages as you add text into it.)

Preparation of Your Abstract

1. The title should be as brief as possible but long enough to indicate clearly the nature of the study. Capitalise the first letter of the first word **ONLY** (place names excluded). No full stop at the end.

2. Abstracts should state briefly and clearly the purpose, methods, results and conclusions of the work.

Introduction: Clearly state the purpose of the abstract

Methods: Describe your selection of observations or experimental subjects clearly

Results: Present your results in a logical sequence

Discussion: Emphasize new and important aspects of the study and conclusions that are drawn from them

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Soybean is a globally important crop and a major plant-based source of dietary iron and zinc – two micronutrients whose deficiencies affect over a billion people, particularly women and children. Most climate-change studies on soybeans focus on aggregate yield or economic outcomes using multi-model ensembles, but often overlook how shifting agroecological suitability may alter the availability of these micronutrients they provide, especially for populations reliant on crop-derived nutrients and most at risk of deficiencies. Here, we coupled the first high-resolution Spatial Production Allocation Model (SPAM) derived harvested-area data with species-distribution modelling (MaxEnt) to forecast change in soybean suitability under the Shared Socioeconomic Pathway 2-4.5 climate scenario by 2050, with suitability outputs validated against ecophysiological thresholds for soybean growth. We then translated these shifts into changes in iron and zinc yield relative to population requirements. Our ensemble 2050 projections reveal poleward expansions of soybean in the Americas, Europe, and Russia, but large declines across key tropical belts in sub-Saharan Africa and Asia. In Southern Africa, projected declines (-10.67%), could result in annual losses of over 51 billion gram of soybean-derived iron and 15.7 billion gram of zinc – equivalent to the dietary requirements of more than 6 and 4 million people, respectively. Similarly, in Southeast Asia, micronutrient losses (-7%) of over 24 billion g of iron and 7.4 billion g of zinc could affect over 2 million people each year. While these shifts threaten to deepen existing nutritional inequities in low- and middle-income regions, they may also support increased iron and zinc yields in temperate zones, potentially sufficient to meet the annual requirements of over a billion people. Closing this gap will require not only climate-informed agricultural adaptation but a decisive pivot toward nutrition-sensitive planning in a warming world.