3.077 Potential co-benefits of intercropping as a sustainable agricultural practice for both air pollution mitigation and global food security.

Early Career Scientist

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Abstract:

The fast-growing world population will impose a severe pressure on our current global food production system. Meanwhile, boosting crop yield by increasing fertilization comes with a cascade of environmental problems including air pollution. Globally, agricultural activities contribute up to ~90% of total ammonia (NH_3) emissions. Such emissions are attributable to ~20% of the fine particulate matter ($PM_{2.5}$) formed in the downwind regions, which could be a severe health risk to densely populated cities. Field studies of intercropping of legumes and non-legume crops have demonstrated its potential to enhance crop yield, lower fertilizer use, and thus reduce NH3 emission by taking advantage of legume nitrogen fixation and enabling mutualistic crop-crop interactions. Our work employs a modeling approach to evaluate the effectiveness of large-scale adoption of intercropping in China on safeguarding food production and air quality. We revise the process-based biogeochemical model, DeNitrification-DeComposition (DNDC), to capture the belowground interactions of intercropped crops, and show that adopting intercropping nationwide can generate the same amount of maize plus an extra batch of soybean with only ~60% of fertilizer required by its monoculture counterpart, which can correspondingly reduce the NH_3 emission by more than 40% over China. Using the GEOS-Chem global 3-D chemical transport model, we estimate that such an NH_3 reduction can lessen downwind inorganic $PM_{2.5}$ concentrations by up to 2.1%, saving the country up to US$1.5 billion each year on air pollution-associated health damage costs. We further add to the Community Land Model (CLM) two new schemes for parametrizing intercropping and estimating soil NH_3 emission to further appraise the multifold benefits of a worldwide shift from the current practice to intercropping. This study can be used as a scientific basis to evaluate the costs and benefits of adopting intercropping as a means to maintain a sustainable global food supply while minimizing environmental impacts.