Keeping Coffee and Chocolate on the Table in a Warming World

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Despite being global staples and daily comforts for many, coffee and chocolate can only grow in specific regions, making these two crops particularly susceptible to global warming for many reasons. Arabica coffee, for example, the most popular variety, requires a small range of mild temperatures, specific diurnal cycles, and precise amounts of rain to develop the desired quality and flavor. As tree crops, they also accumulate damage over time rather than being replaced annually, making adaptations much more challenging as well. Under RCP8.5, it is predicted that global Arabica coffee yields could decrease by 45% by the end of the century. Under RCP6.0, suitable land for cocoa farming in the West African cocoa belt (which produces 70% of the world's cocoa) could decline by 50% by 2050. Declines in yields could lead to exorbitant prices for consumers, widespread unemployment along the supply chain, and potential impoverishment for millions of smallholder farmers.

Given the threats to coffee and chocolate production posed by climate change, this study investigates whether sunlight reflection methods could alleviate the number of stress days and maintain yields for these two crops. We use the ALMANAC crop model, a site-based model validated for these two crops, to estimate cocoa and coffee responses to stratospheric aerosol injections. To characterize some of the future uncertainties, six climate models are included for the SSP2-4.5 scenarios and five ensemble members for the global cooling scenario. The climate model, CESM2, simulated the global cooling scenario by following the path of SSP2-4.5 and injected SO_2 into the stratosphere annually from 2035 to 2069 to keep the global average temperature at 1.5°C above the pre-industrial level. We extract daily climate forcings, including maximum temperature, minimum temperature, precipitation, humidity, wind, and solar radiation at specific locations for cocoa and coffee. After bias correction, we run ALMANAC and find that while yields still decline compared to today, cooling improves yields by about 10% for both trees compared to SSP2-4.5 alone. The global cooling scenario was able to reduce the number of heat stress days without introducing additional water stress. Without global cooling, adaptations will be needed to maintain global coffee and cocoa yields.