Coffee productivity, ecosystem services provision and adaptation to climate change: how useful can be a model that simulates coffee growth and development?

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⇨ Introduction

Models have been developed to synthesize knowledge of many dynamic systems. They seem to be particularly useful for systems consisting of many processes, whose interactions are difficult to predict. Coffee growth and development in the context of climate change is such a system. The impacts of climate change (CC) on coffee production have been estimated by taking into account variation in temperature and rainfall only. It is hypothesized that increasing CO_2 concentration could interact with these two factors, and that a simulation model would be well suited to predict these effects.

The objective of this study was to test the suitability of the model CAF2007, a coffee simulation model developed during the EU-funded CASCA project by Van Oijen *et al.* (2008), to evaluate the likely impacts of CC on coffee productivity in Chiapas, Mexico, and to test adaptation strategies.

Coffee grown under the shade of* Erythrina poeppigiana *in Orosi, Costa Rica

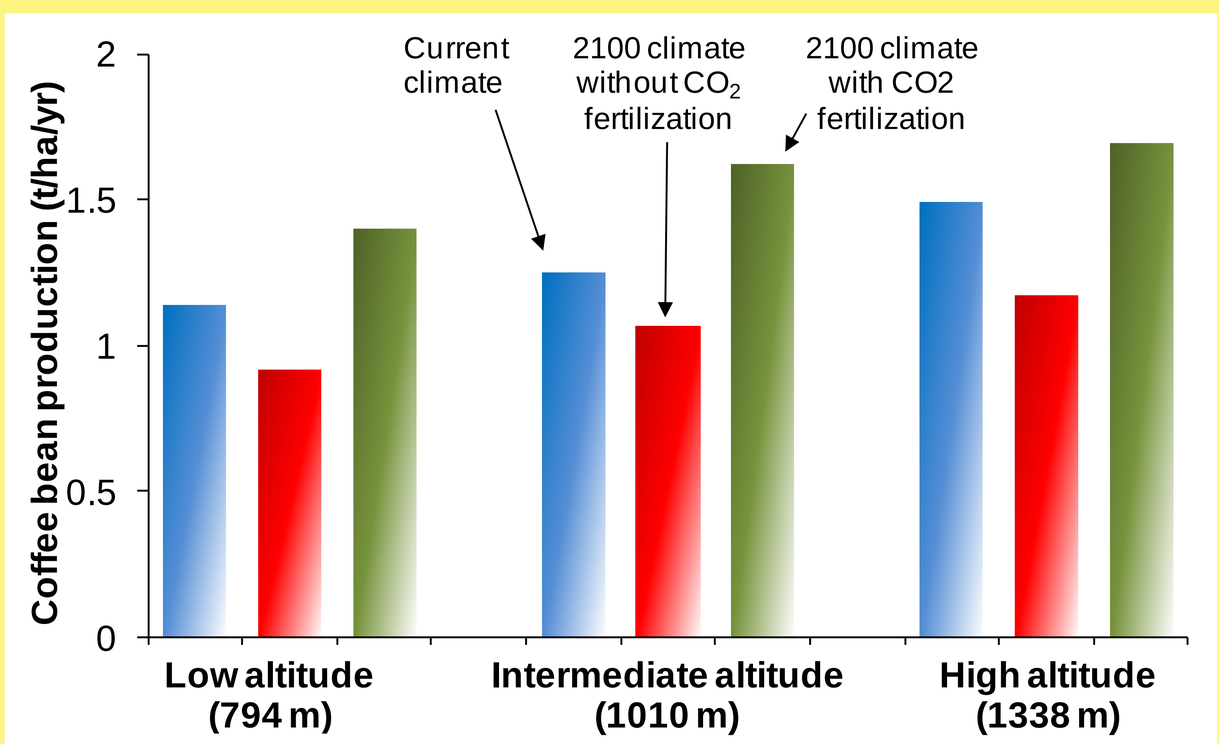


Fig. 1: Effect of climate change on bean production at three altitudes in Chiapas. Results from the CAF2007 model. Blue bars: current climate. Red bars: 2100 climate without CO_2 fertilization. Green bars: 2100 climate taking into account CO_2 fertilization.

⇨ Material and methods

Model CAF2007

The model considers, for shaded and sunlit coffee plants separately, how carbon and nitrogen content, leaf area and phenology change over time, on a daily time step. Inputs are daily values of weather conditions - radiation, temperature, precipitation, humidity and wind speed - and the plot management, both of the coffee trees and the shade tree species, density, pruning. Competitions for light, water and N modify coffee and tree growth. The major outputs of the model are coffee and tree productivities and the impacts of the crop on the environment.

Climatic data

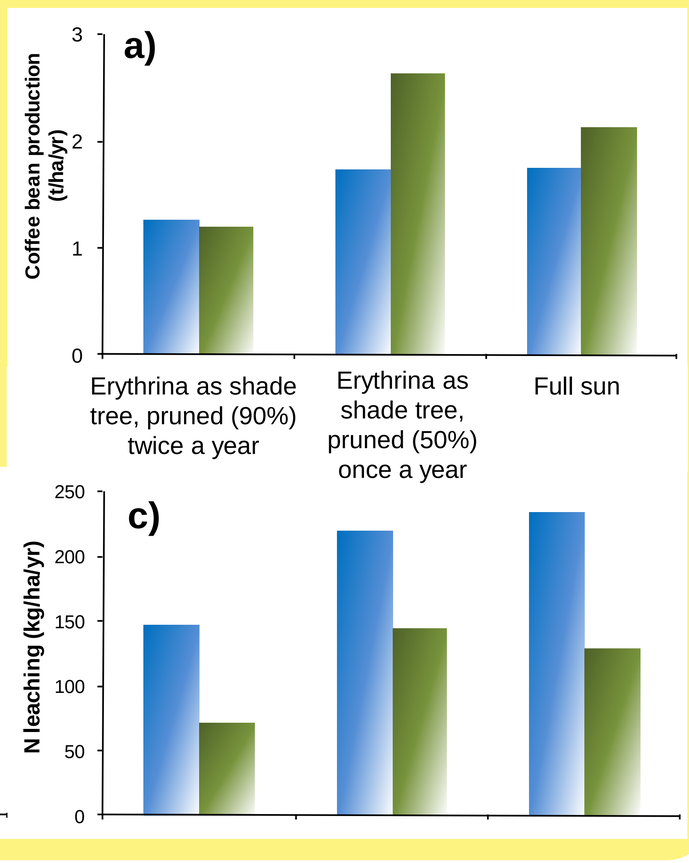
We constituted a complete 7-year climatic data set based on the 1950-2000 monthly data at three locations in the coffee producing area in Chiapas (Mexico), simulating day to day variation. The three locations differed by altitude: 794, 1010 and 1338 m, corresponding respectively to the lower, intermediate and optimal altitudes for coffee production. The CC for 2100 was considered, taking the A1B emission scenario and regional climate projection calculated by Christensen *et al.* (2007): +3.2 °C on mean temperature, -25% in rainfall from June to August, -7% from December to February, and intermediate for the remaining months. These modifications were applied to our climatic 7-year set. CO_2 partial pressure was considered to reach 730 ppm in 2100.

⇨Results

Production, as calculated by the model, increased with altitude, irrespective of the global climate considered. When CO_2 fertilization was not considered (pCO_2 of 380 ppm in 2100), then temperature increase and modification of rainfall pattern reduced bean production (Fig 1). This reduction was worse at higher than at lower altitudes. When CO_2 fertilization was included (pCO_2 of 730 ppm in 2100), then the model calculated a positive effect of CC on bean production, and this positive effect was higher at intermediate altitude.

Simulations were also made to show the possible use of the model to test shade management effects on coffee production and on environmental services provision (Fig 2). Management modified all performances. These effects were modified by CC: for example, bean production is higher under full sun than under *Erythrina* pruned once a year under current climate, but lower under 2100 climate.

Fig 2. Calculated effect of shade management (annual pruning, biannual pruning and full sun coffee) for high altitude coffee in Chiapas on bean production (a), C sequestration in the system (b), and N leaching (c), at present climate (blue bars) and future climate (2100 with CO_2 fertilization, green bars).



⇨ Conclusion

The CAF2007 model has yet not been validated, and we must be very cautious in the interpretation of these results. Nevertheless, CO_2 fertilization is a well known effect (Ainsworth and Long, 2005), and these results showed that we must take it into account to determine possible impacts of CC on coffee production.

⇨ References

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agroforestry systems with perennial crops

The Mesoamerican Scientific Partnership Platform (PCP) "*Agroforestry Systems with Perennial Crops*" is a long term commitment between six non-profit organizations with complementary skills to work together in order to increase the competitiveness and sustainability of the agricultural sector of Mesoamerica through the quantification, valuing and development of products and services provided by AFS with perennial crops.

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