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A generic model for estimating biomass accumulation and greenhouse gas emissions from perennial crops

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Agriculture is essential to maintain humankind but is, at the same time, a substantial emitter of greenhouse gas (GHG) emissions. With a rising global population, the need for agriculture to provide secure food and energy supply is one of the main human challenges. At the same time, it is the only sector which has significant potential for negative emissions through the sequestration of carbon and offsetting via supply of feedstock for energy production.

Perennial crops accumulate carbon during their lifetime and enhance organic soil carbon increase via root senescence and decomposition. However, inconsistency in accounting for this stored biomass undermines efforts to assess the benefits of such cropping systems when applied at scale. A consequence of this exclusion is that efforts to manage this important carbon stock are neglected. Detailed information on carbon balance is crucial to identify the main processes responsible for greenhouse gas emissions in order to develop strategic mitigation programs. Perennial crops systems represent 30% in area of total global crop systems, a considerable amount to be ignored. Furthermore, they have a major standing both in the bioenergy and global food industries.

In this study, we first present a generic model to calculate the carbon balance and GHGs emissions from perennial crops, covering both food and bioenergy crops. The model is composed of two simple process-based sub-models, to cover perennial grasses and other perennial woody plants. The first is a generic individual based sub-model (IBM) covering crops in which the yield is the fruit and the plant biomass is an unharvested residue. Trees, shrubs and climbers fall into this category. The second model is a generic area based sub-model (ABM) covering perennial grasses, in which the harvested part includes some of the plant parts in which the carbon storage is accounted. Most second generation perennial bioenergy crops fall into this category. Both generic sub-models presented in this paper can be parametrized for different crops. Quantifying CO_2 capture by plants and biomass accumulation and changes in soil carbon, are key in evaluating the impacts of perennial crops in life cycle analysis.

We then use this model to illustrate the importance of biomass in the overall GHG estimation from four important perennial crops - sugarcane, Miscanthus, coffee, and apples – which were chosen to cover tropical and temperate regions, trees and grasses, and energy and food supply.