A Physiological Model to Quantify Impacts of Climate Change Variables on Cocoa Productivity

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Climate change has the potential to alter cocoa production
Crop modelling allows prediction of yield changes in relation to climate events
Interventions to ameliorate climate change may be quantified through modelling

**Aim**: to construct a physiological model for cocoa enabling simulation of different climatic scenarios and interventions
Model modules represent processes with the crop

Canopy photosynthesis

Based on:-
- Light
- Temperature
- Vapour pressure deficit
- Canopy characteristics
- Photosynthetic parameters

Respiration

Growth

Partitioning

Pod dynamics/wilting

Yield

Model is spreadsheet based, utilising a series of embedded macros
Canopy photosynthesis - parameterisation

Convexity

Light saturated photosynthesis

Quantum efficiency

A (µmol m⁻² s⁻¹)

PAR (µmol m⁻² s⁻¹)

Leaf area index (LAI) = leaf area per unit ground area

Extinction coefficient (k) = light attenuation

Leaf

Canopy

Extinction coefficient (k)

Light saturated photosynthesis

Convexity

Quantum efficiency

Leaf area index (LAI) = leaf area per unit ground area

Extinction coefficient (k) = light attenuation
POUND 7/B: Amb CO₂ well-watered

POUND 7/B Amb CO₂ water deficit

POUND 7/B 700ppm CO₂ well watered

POUND 7/B 700ppm CO₂ water deficit
Influence of temperature and VPD

Based on Yapp (1992)
Assimilation to biomass and yield

Gross assimilation → Respiration → Net assimilation

- Roots
- Wood
- Leaves
- Pods
- Beans

Each component has a different “physiological cost” according to its chemical constituents.

Currently little information on how environment impacts on biomass partitioning.
Simulation based on Var: Amelonado, CO₂: 700 ppm

• Simulation based on assimilation only
• Predicted yield may be lower when pod dynamics/ wilting is incorporated

Current mean temperatures regimes in Ghana

Blue line is absence of water stress
Orange is low afternoon humidity (Higher VPD=2.5 kPa)
Pod dynamics sub-model

- Based on previous model developed at UoR (Pearson et al.)
- Considers assimilate demand of growing pods (greater at higher temperatures – higher respiration)
- Cherelle wilt is simulated based on demand & competition for carbohydrates from pods

Simulation of wilting assuming 6 pods set. Staggered pod set = 5 day interval. Assimilate production assumed to be constant for all simulations.
Conclusions

• Simulation of physiological processes allows prediction of relative changes in yield in response to environmental variables

• The model serves as a complement to experimental studies in understanding adaptation strategies to climate change

• We can model the responses of different varieties and management strategies under climate change scenarios
Acknowledgements

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