MDPI

Article

A modelling strategy to improve cacao quality and productivity

Angela RV [1,†,‡], Adriana [1,‡] and Anyela VCR[1,*]

[1] The John Bingham Laboratory, NIAB, 93 Lawrence Weaver Road, Cambridge CB3 0LE, UK 1; e-mail@e-mail.com
[2] BIOS 2; e-mail@e-mail.com
* Correspondence:anyela.camargorodriguez@niab.com; Tel.: (optional; include country code; if there are multiple corresponding authors, add author initials) +xx-xxxx-xxx-xxxx (F.L.)
† Current address: Affiliation 3
‡ These authors contributed equally to this work.

Abstract: As.

Keywords: ICS95; CCN51; thermal time (List three to ten pertinent keywords specific to the article; yet reasonably common within the subject discipline.)

Citation: Lastname, F.; Lastname, F.; Lastname, F. Title. *Journal Not Specified* **2021**, *1*, 0. https://doi.org/

Received:
Accepted:
Published:

1. Introduction

Cocoa (*Theobroma cacao* L.) is a perennial tropical crop endemic to the South American rainforests [**? ? ? ?**]. Only the 5% of the world cocoa yield is desalinated for Fine-cocoa production due to the low productivity of the traditional crop management [**?**]. Cacao plant member of the Malvaceae (formerly Sterculiaceae) botanical family, is grown for its fruits, known as cacao pods. [**? ?**].

Cocoa has a long tradition in Colombia where cocoa is widely consumed as a beverage. It is one of the crops promoted by the Colombian government in the social and agricultural development programs aimed at favouring peace in post-conflict regions [**?**] (Abbott et al. 2018).

In this work we used the SIMPLE crop model [**?**] for three reasons: 1: That it is very comprehensively described in the original paper. 2: That the code was available in R for initial trials and 3: That it had already been successfully fitted to perennial crops in south America. Overall, the model simulates crop development, growth and yield, and predict the maturation day when the friut is ready to harvest. It includes 13 parameters to specify a crop type, with four of these for cultivar characteristics. Commonly available inputs that are required for the model include daily weather data, crop management, and soil water holding parameters and key dates. Malvaceae such as cotton *Gossypium hirstium* [**?**] wich is modeled in SIMPLE model [**?**]. The aim of this study is predict the best time for harvest cocoa fruits.

2. Materials and Methods

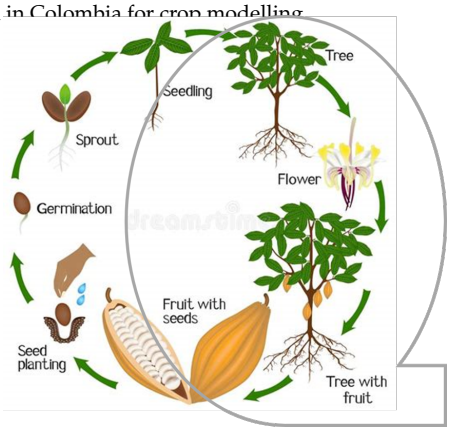
2.1. Phenology of Cocoa in Colombia

.

2.2. Crop model acquisition

A zip file of the R codes and input files for the SIMPLE model was kindly provided by Dr Chuang Zhao of the Agricultural and Biological Engineering Department, University of Florida. The main directory contains R codes, the "Parameter definition" Excel ® file, where the units required in each input file for the model are described, instructions and directories containing other input files. Examples of all input files are provided in the Zip files together with a range of data sets that can be used to check model operation after installation. Before running the SimpleB.R program initially line 72 was edited,

Figure 1. Phenology of cocoa in Colombia for crop modelling



Credits: Taken from Download from Dreamstime.com, 2021

with RStudio, to provide the full path for the installation. Also, the single year/single experiment mode was selected by setting the GridsimulationSwitch in line 58 to "off" by entering [1] at the end of line 58. After checking the first column in the Input/Simulation Management.csv file is all zeros apart from 1 on line alongside cocoa experiment, then "Source" at the top of the RStudio editing window was clicked.

In the SIMPLE model dummy files are provided for adding new crop data and weather data, and files 2 to 6 in the list below can be edited to define new cultivars or experiments etc. Then modifying the simulation management file will cause the new files to be read when the program is run.

1. Input/Simulation Management.csv
2. Input/Species parameter.csv
3. Input/Cultivar.csv
4. Input/Treatment.csv
5. Input/Irrigation.csv
6. Input/Soil.csv
7. Observation/Obsdummy crop Exp name.csv
8. Weather/dummy weather.WTH

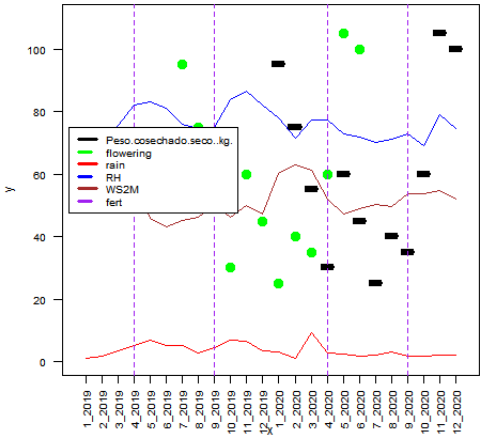
2.3. Applying the SIMPLE model for the Colombia cocoa crop

In outline the procedure used was a sequential process of modifying or adding the appropriate files, changing the parameters in the simulation management file, running the program and inspecting the results. This cycle was then repeated until the dry matter yields for Colombia were reasonably reproduced in the results. The first step was add the new experiment for cocoa in the dummy crop and experiment names were replaced with our crop and treatment names in the input files and flowering and harvest dates were changed to harvest at 6 months after flowering to check that our modifications could be read. Initially, the new experiment name "KOKOlatl" for the cultivar ICS 95 was used in the species parameter file with other parameters and data founded in papers debo completar eso con la bibliografia de donde saque datos de fisio, including irrigation, soil features and radiation use efficiency. An appropriate treatment label was added (Figure 7), but all other options pointed to the test data from Brazil.

2.4. Input data acquisition

Input Weather data were sourced from the POWER Data Access Viewer [**?**], which allows automatic download. These were used in as inputs for SIMPLE model. Weather data had to be transformed to .WHT file.

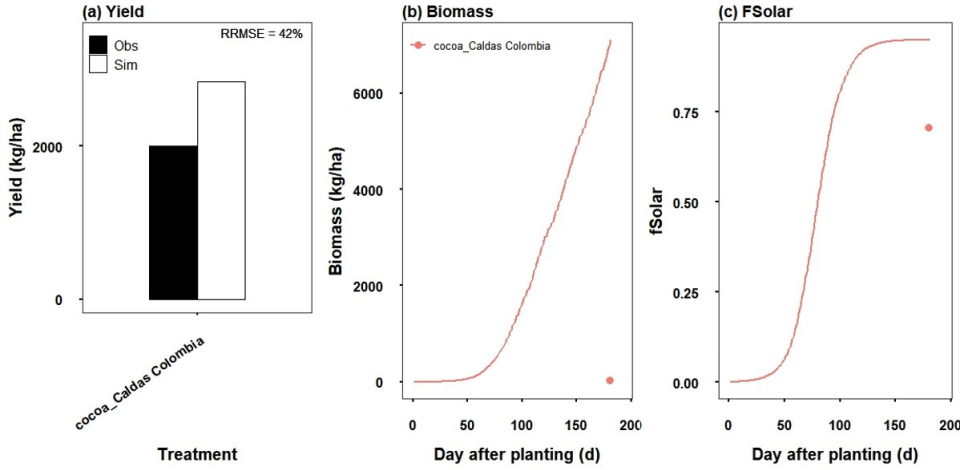
Figure 2. SIMPLE model output for cocoa in Colombia



3. Results

.

Figure 3. SIMPLE model output for cocoa in Colombia



.

4. Discussion

Authors should discuss the results and how they can be interpreted from the perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

5. Conclusions

This section is not mandatory, but can be added to the manuscript if the discussion is unusually long or complex.

6. Patents

This section is not mandatory, but may be added if there are patents resulting from the work reported in this manuscript.

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, X.X. and Y.Y.; methodology, X.X.; software, X.X.; validation, X.X., Y.Y. and Z.Z.; formal analysis, X.X.; investigation, X.X.; resources, X.X.; data curation, X.X.; writing—original draft preparation, X.X.; writing—review and editing, X.X.; visualization, X.X.; supervision, X.X.; project administration, X.X.; funding acquisition, Y.Y. All authors have read and agreed to the published version of the manuscript.", please turn to the CRediT taxonomy for the term explanation. Authorship must be limited to those who have contributed substantially to the work reported.

Funding: Please add: "This research received no external funding" or "This research was funded by NAME OF FUNDER grant number XXX." and and "The APC was funded by XXX". Check carefully that the details given are accurate and use the standard spelling of funding agency names at https://search.crossref.org/funding, any errors may affect your future funding.

Data Availability Statement: In this section, please provide details regarding where data supporting reported results can be found, including links to publicly archived datasets analyzed or generated during the study. Please refer to suggested Data Availability Statements in section "MDPI Research Data Policies" at https://www.mdpi.com/ethics. You might choose to exclude this statement if the study did not report any data.

Acknowledgments: In this section you can acknowledge any support given which is not covered by the author contribution or funding sections. This may include administrative and technical support, or donations in kind (e.g., materials used for experiments).

Conflicts of Interest: Declare conflicts of interest or state "The authors declare no conflict of interest." Authors must identify and declare any personal circumstances or interest that may be perceived as inappropriately influencing the representation or interpretation of reported research results. Any role of the funders in the design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript, or in the decision to publish the results must be declared in this section. If there is no role, please state "The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results".