**PE&RC PhD PROJECT PROPOSAL**

*Please submit the signed PDF of the PE&RC PhD Project Proposal by email to the PE&RC office (*[*office.pe@wur.nl*](mailto:office.pe@wur.nl)*) no later than* ***6 months*** *after the start of the PhD project. In case a peer-reviewed full project proposal is available (e.g., NWO or EU), please send that proposal along together with the reviewers’ comments, rebuttal(s) and the final letter of acceptance.*

**Part 1: General information**

**1.1 ABOUT THE PROJECT PROPOSAL AND EVALUATION CRITERIA:**

The PE&RC PhD proposal is written by the PhD candidate in consultation with and feedback from the supervisory team. After submission, the proposal is sent out for review. The candidate and the supervisory team are encouraged to suggest possible independent reviewers that can provide constructive feedback to the candidate.

The reviewers are asked to evaluate the proposal on:

* Scientific quality

Clarity of writing, depth of literature review, definition of research question(s) and objective(s), and originality of subject and/or methodology.

* Feasibility  
  Feasibility given the 4-year time frame, (financial) resources, effectiveness of the proposed approach/strategy, logistical/practical aspects and evaluation of the expertise within the supervising team and/or collaborations for adequate support in the proposed project.
* *Scientific and/or societal impact*

The importance of the potential research results in the short and long term in the field of research, potential use and relevance in other scientific disciplines, and potential use and relevance for society (economic, technical, social, cultural), including technological application.

**1.2 GENERAL PROJECT INFORMATION:**

|  |  |
| --- | --- |
| Main PE&RC affiliated Institute/University | Wageningen University & Research |
| Main PE&RC research group | Crop Systems Analysis |
| Other PE&RC research groups involved |  |
| Where will the research be conducted (country) |  |
| Full name of the PhD candidate | Leonel Eduardo Alvarado Huaman |
| Project duration | FROM dd/mm/yy TO dd/mm/yy |
| Time spent on PhD project | * Fulltime * Part-time: for ... hours per week |
| Principal supervisor/Promotor | Niels Anten |
| Additional supervisor(s) | Danae Rozendaal |

**1.3 ETHICS:**

*Ethical issues such as experiments with animals (vertebrates), work with genetically modified organisms, work with material under the Nagoya protocol, or personal data privacy considerations (AVG) may have legal implications. Also, ethical guidelines of the respective research institution may apply.*

|  |  |
| --- | --- |
| Do any of the above mentioned, or other ethical issues apply to this project? | YES / NO |
| If YES, please elaborate: | |

**1.4 PE&RC RESEARCH THEME(S)**

*In which of the PE&RC research theme(s) does the project fit (multiple options possible). Please elaborate.*

|  |  |
| --- | --- |
| **Themes** | **Elaboration** |
| * Biodiversity and Systems Dynamics * One Health * Redesign of (argo-) ecological systems * Data and Engineering Science for Life and Environment |  |

**Part 2: Proposal structure**

*Please note: Proposal length: Max. 8 pages excl. list of literature references, using Verdana font at font size 8.5 (or similar) and 2 cm page margins in either direction*

* 1. **TITLE**

*Crop ecological aspects of cocoa production (Theobroma cacao L.)*

* 1. **ABSTRACT** (max. 250 words)

*In the abstract proposed research is summarised for scientific peers.*

* 1. **RESEARCH TOPIC AND BACKGROUND**

*This section should include objectives, background, scientific originality and/or innovative approach of the proposed research. It should concisely describe* ***what*** *will be investigated and* ***why****.*

The impacts on agricultural systems provoked by climate change will be significant, considering the predictions of the Intergovernmental Panel on Climate Changes (IPCC, 2007). Previous studies in different regions and crops concluded that there will be more negative impacts than positive due to climate change, particularly in rainfed agriculture with limited economic and institutional resources (Sultan & Gaetani, 2018).

The climate is the result of the interaction of different variables that compose it. However, it is common to find references to optimal values for plant growth and development of some variables, such as temperature. For example, authors such as Hardy (1961) point out that cacao grows well in areas with an average of 25.5 °C, a minimum of 21 °C and a maximum of 30 °C and it has been observed that flowering decreases when the temperature is below 22 °C. Other authors, such as Sáenz and Gutierrez (2007) sustain that the recommended temperature for this crop is between 22 to 27 °C and that flowering decreases below 20 °C. However, when we analyse the climate of important producing countries, we found that temperatures often extend beyond the recommended ranges.

Cacao is considered a shade tolerant perennial tree, but it is not a shade plant and it has been found that photosynthesis is saturated at photon flux densities; between 400 and 600 µmol m-2 s-1, intensities that constitute between 25 and 30% of the maximum, radiation on a sunny day and that maximum rates of CO2  assimilation do not usually exceed 6 to 7 µmol m-2 s-1 (Jaimez et al., 2008). Daymond and Hadley (2007) found an increase in fruit losses (cherelle wilt) at higher temperatures and showed variations in the response of different genotypes to their photothermal environment. In contrast, previous studies have shown that elevated CO2  concentration increased significantly leaf and canopy level photosynthesis, vegetative growth and alleviates the effect of water deficit (Lahive et al., 2021). According to Hasanuzzaman et al. (2013), at high temperatures plants can lose flowers, fruits and, in extreme conditions, even die. This phenomenon can occur with slight increases in temperature and also with extreme heat shocks. In cacao, drought can cause the loss of flowers and as a consequence an 45% decrease in yield was reported by Shwendenmann et al. (2010). Given the relatively limited detailed research on how climate change will impact this economically important crop, it is crucial to continue to develop our understanding of the impacts of climate change on cacao ecology (ecophysiology), considering the interactive effects of environmental variable (temperature, water availability and CO2).

Among the factors limiting cocoa production, the low capacity of tropical soils to meet the nutritional requirements of cocoa plants, along with inadequate fertilization practices stands out as one of the most important. Mineral nutrition not only influences crop yields but also impacts the quality of harvested products. It is important to distinguish between the concepts of nutrient absorption and nutrient removal. The first one refers to the total amount of nutrients absorbed by the plant during its growth and development cycle, while the second represents the total nutrients found in harvested organs (pods for cocoa). Using the absorption criterion for nutrient replacement would entail applying all the nutrients taken up by the plant, distributed throughout its tissues and organs, whether harvestable or non-harvestable. On the other hand, which is more commonly employed, the aim is to replace the nutrients taken up by the plant and deposited in harvested tissues. For cocoa, there is a wide range of information regarding crop nutrition, due to the variability of production systems concerning nutrient cycles and nutrient balance (Fontes et al., 2014). This variation can be attributed to climatic conditions, soil types, tree age, plant density, genotype, shading, and also in research approaches and methods employed (Hartemink and Donald, 2005; van Vliet et al., 2015).

Different methods for fertiliser recommendation in agriculture can be divided into four groups: nutrient balance analysis, soil analysis, leaf analysis and fertilizer response trials (van Vliet et al., 2015). For example, in Colombia it has been reported that cacao beans production increased by 51% when applying 150 kg/ha of nitrogen (N), 90 kg/ha of phosphorus (P), and 200 kg/ha of potassium (K) (Puentes-Páramo et al., 2014). Mejía (2000), cited by Puentes-Páramo et al., 2014, observed an increased production of cocoa beans in hybrid genotypes with the application of 80 kg/ha of N, 100 kg/ha of P, and 160 kg/ha de K. Additionally, Mora et al. (2011) cited by Puentes-Páramo et al. (2014), found positive responses to the application of 500 g per tree of a composite fertilizer (19-4-19-3). In a clay soil in Colombia, with pH of 4.7, organic matter content of 9.3%, 66% aluminum saturation, 9.0 pp of phosphorus (P), and 0.11 meq/100 g of potassium (K), the best yield was obtained with 150 kg/ha of nitrogen (N), 90 kg/ha of phosphorus (P2O5), and 200 kg/ha of potassium (K2O), resulting in 11602 kg of dried cocoa beans per hectare (Uribe et al., 2000). And a negative nutrient balance in cocoa production is found when is considered a yield of 1000 kg/ha/yr (van Vliet, 2017).

Previous and current research at the Wageningen University Research has focused on understanding the ecophysiology of cocoa production (Zuidema et al., 2005; Asante et., 2021; Asante et al., 2022; Tosto et al., 2023; Tosto et al., 2023). A knowledge gap remains concerning the impact of climate events and the exploration of the impact of agronomic practices (irrigation, fertilization, shade?) on the growth, physiology, phenology? of cocoa, that forms the basis of this proposed research.

* 1. **SCIENTIFIC AND/OR SOCIETAL IMPACT**

*Theobroma cacao* is considered a native species of South America but its cultivation, in the 19th century, expanded to other regions and is currently produced by 40 countries in the tropical regions of Africa, Asia, and America. Cacao is cultivated by 5.5 million farmers, mainly small producers with less than five hectares, who due to different factors, have limited access to technology, lack of technical assistance and financing to improve their crop. Despite these difficulties, cocoa has proven to be a powerful tool to generate employment and fixed income for farmers in rural areas (Ríos et al., 2017). This crop also has an environmental importance, since it is traditionally cultivated under Agroforestry systems, allowing carbon sequestration, soil, water, and biodiversity conservation (MINAGRI, 2018).

*Describe the scientific impact that the research will have on its research field, on related research fields and the broader scientific community.*

*Describe societal impact by indicating possible cultural, economic, industrial, environmental and/or societal impacts that the research may have.*

* 1. **DETAILED DESCRIPTION OF THE RESEARCH PLAN**
* *Describe the methods and techniques that will be used.*
* *Include a detailed work plan and indicate the duration of the proposed research.*
* *Discuss feasibility of the research proposal and indicate*
* *the possible risks involved with the proposed research, including possible methodological, logistical, financial and/or time constraints and how these can be mitigated or whether an alternative approach (plan B) exists.*

*Note that a PhD project should be finished within contract time, which means that the reading version of the PhD thesis has to be submitted within 4 years in the case of a fulltime appointment.*

Trials within … will be utilized within this research.

Proposed experiments

Building on previous work conducted by the CSA chair group, Wageningen University & Research, experiments will be performed to study the impacts of agronomy practices (fertilization, irrigation, ..?) on the growth and physiology of cocoa plantations. Here the focus will be on …..?

Measurements will include:

Growth analysis

Biomass

Photosynthetic performance (gas exchange and chlorophyll fluorescence)

…

* 1. **DATA MANAGEMENT**

*This section outlines the data management plan and must encompass:*

* *Data storage (short term and long-term storage),*
* *Data ownership (issues with respect to ownership of data produced in this project or external data used for this project)*
* *Data sharing (agreement on who will have access to and use your (un)published data)*

*This section should include references to a more comprehensive (i.e., 2 to 3 pages) data management plan in which elements are outlined in more detail and can also refer to a plan at the level of a research group. Note that the full data management plan does not need to be included in this proposal, and that data collection is also part of a data management plan but is specified in section 2.4 of this project proposal.*

*It is recommended that you seek advice from a data steward or research support office at your home institution to complete this section. They will be able to recommend suitable storage facilities and repositories for your data, and to advise on data management costs.*

*References*

Asante, P., Rahn, E., Zuidema, P., Rozendaal, D., van der Baan, M., Laderach, P., Asare, R., Cryer, N., Anten, N. 2022. The cocoa yield gap in Ghana: A quantification and an analysis of factors that could narrow the gap. Agricultural Systems, 201. <https://doi.org/10.1016/j.agsy.2022.103473>

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Sáenz, B., Cabezas, M. 2007. Un acercamiento a la ecofisiología del cacao. Innovación & Cambio Tecnológico 6(6): 44-50.

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Tosto, A., Evers, J., Anten, N., Zuidema, P. 2023. Branching responses to pruning in young cocoa trees. Scientia Horticulturae, 322. <https://doi.org/10.1016/j.scienta.2023.112439>

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**Part 3: Reviewers and signatures**

* 1. **POTENTIAL REVIEWERS**

*The proposal will be sent to 3 reviewers. Please provide the names and contact details of 4-5 potential reviewers who are in no way involved in the project. A balanced representation of gender and reviewers from inside and outside the main PE&RC affiliated institutes are preferred. To speed up the review process, it is allowed and even encouraged to verify the proposed reviewer’s willingness to provide an independent review of the proposal.*

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| --- | --- | --- | --- | --- |
| **#** | **Name + title** | **Organisation** | **Specialisation** | **Email address** |
| **1.** |  |  |  |  |
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**3.2 SIGNATURES**

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| --- | --- | --- |
| **PhD candidate** | **Principal supervisor / Promotor** | **Supervisor 2** |
| Name: | Name: | Name: |
| Date: | Date: | Date: |
|  |  |  |
| **Supervisor 3** | **Supervisor 4** | **Supervisor 5** |
| Name: | Name: | Name: |
| Date: | Date: | Date: |
|  |  |  |