Water dynamics and use in coffee shaded with *Tabebuia rosea* Bertol. and *Simarouba glauca* D.C. compared to full sun coffee in sub optimal environmental condition for coffee cultivation

Maria da Penha Padovan

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Thesis presented by Maria da Penha Padovan to opt for the

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Tropical Agricultural Research and Higher Education Centre (CATIE), Turrialba, Costa Rica

School of Environment, Natural Resources and Geography, Bangor University (BU), Bangor, Gwynedd, United Kingdom

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Doctoral Advisory Committee

Dr. Bruno Rapidel (Major Advisor)

CIRAD (Centre de coopération Internationale en Recherche Agronomique pour le Développement)

Montepellier, France.

CATIE (Centro Agronómico Tropical de Investigación y Enseñanza)

Turrialba, Costa Rica.

Dr. Robert Brook (Co-Advisor)

BU (Bangor University - College of Natural Resources)

Bangor, Gwynedd, United Kingdom.

Dr. Aureliano Nogueira da Costa (Committee member)

INCAPER (Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural) Espirito Santo State, Brazil.

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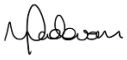
Signed  (candidate)

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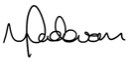
Signed  (candidate)

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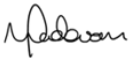
Signed  (candidate)

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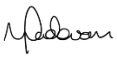
Signature:  Date: 18.12.2015

Dedication

To Cloves, Pedro and Daniel

To the coffee producer Olindo Padovan *in memorian*

my inspiration

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SUMMARY

Water availability is predicted to be reduced and temperature to rise in the global climate change context. Future climate conditions may thus represent a serious risk for coffee cultivation especially in less favorable environment. Agroforestry has been postulated as a promising strategy to adapting to climate changes. Shade tree may minimize radiation and temperature near the soil surface and reduce soil evaporation. Shade tree may enhance infiltration, reduce runoff and increase rainfall water use efficiency by taking up water from deep soil layers. However, shade tree may reduce the water that reaches the soil by rainfall interception. Trees may consume additional water and can establish a competitive relationship depending on tree species characteristics, soil water availability, site conditions and management.

In this experiment water dynamics and use was monitored in a mature agroforestry experiment where coffee shaded by a mixture of *Tabebuia rosea* and *Simarouba glauca* is compared to full sun coffee over 2012 and 2013. The water balance was obtained by two independent approaches: 1) measuring directly all components of water balance (trees and coffee transpiration; soil evaporation; rainfall interception); and 2) measuring changes in the soil water stock through Time Domain Reflectometers (TDR) probes.

Agroforestry (AFS) showed greater transpiration and lower soil surface evaporation compared to full sun (FS). Shade tree did not represent a serious constraint for coffee water use during most of the period of the experiment. Coffee water consumption represented 75% of the total transpiration in agroforestry while *Tabebuia rosea* transpired 17% and *Simarouba glauca* 8%. Complementarity was demonstrated by root niche differentiation between coffee and *Simarouba glauca* that seemed to be more suitable as coffee shade tree compared to *Tabebuia rosea*. We also demonstrated high competition between coffee and shade tree when an atypical very dry season occurred. Transpiration was stabilized although the high evaporative demand and coffee leaf water potential reached its lowest value in AFS which suggested high level of coffee water stress. Adaptation strategies for coping with climate change using shade trees need to be devised taking into account this quantified information into account.

RESUMEN

En el contexto del cambio climático global disminución de la disponibilidad de agua y el aumento de la temperatura han sido esperados en el futuro próximo. Variaciones en las condiciones climáticas futuras pueden por lo tanto representar un grave riesgo para el cultivo del café, especialmente en condiciones menos favorables. Los sistemas agroforestales han sido postulados como una estrategia promisora para la adaptación a los cambios climáticos. Árboles de sombra pueden minimizar la radiación y la temperatura cerca de la superficie del suelo y reducir la evaporación. Además pueden mejorar la infiltración, reducir la escorrentía y aumentar la eficiencia del uso del agua de lluvia, tomando el agua de las capas profundas del suelo. Sin embargo, árboles de sombra puede reducir el agua que llega al suelo mediante la interceptación de la lluvia. Los árboles pueden consumir mucha agua y pueden establecer una relación de competencia en función de las características de las especies de árboles y la disponibilidad de agua del suelo. En este experimento, la dinámica y el uso del agua fueron monitoreados en café bajo la sombra de *Tabebuia rosea* y *Simarouba glauca* comparados con el café a pleno sol durante 2012 y 2013. El balance hídrico se obtuvo mediante dos métodos independientes: 1) se midió directamente los componentes del balance hídrico (transpiración de café y árboles, la evaporación del suelo y la intercepción de lluvia); y 2) se midió el cambio en el contenido de agua del suelo por medio de sensores TDR – Time Domain Reflectometers. Es sistema agroforestal presentó mayor transpiración y menor evaporación de la superficie del suelo en comparación con café pleno sol. Árboles de sombra no representaron una limitación para el uso del agua de café durante la mayor parte del período del experimento. El consumo de agua del café representó el 75% del total de la transpiración en AFS mientras que *Tabebuia rosea* transpiró 17% y *Simarouba glauca* 8%. La complementariedad fue demonstrada por la diferenciación de nicho de raíces de café y *Simarouba glauca* la cual pareció ser más adecuada como árbol de sombra para el café en comparación con *Tabebuia rosea*. Se demostró además una competencia potencial entre café y árbol de sombra cuando se produjo una estación atípica muy seca. La transpiración se estabilizó aunque la gran demanda evaporativa y el potencial de agua en la hoja del café alcanzó su valor más bajo en AFS lo que sugirió alto nivel de estrés hídrico en el café. Las estrategias de adaptación para hacer frente al cambio climático utilizando árboles de sombra deben ser concebidas teniendo en cuenta esta información.

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