



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

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

Thesis presented by Maria da Penha Padovan to opt for the degree of Doctor of Philosophy at CATIE – BU joint PhD Program

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)

Montpellier, 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)
Espírito Santo State, Brazil.

Dra. Carolina Vega Jarquín (Committee member)

UNA (Universidad Nacional Agraria)

Managua, Nicaragua.

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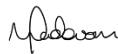
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Dedication

To Cloves, Pedro and Daniel

To the coffee producer Olindo Padovan *in memoriam*

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 promisor 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 interceptación 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 demostrada 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.

CONTENTS

Declaration and consent.....	ii
Dedication.....	vi
Acknowledgements.....	vii
Summary.....	ix
Resumen.....	x
CHAPTER I.....	1
1. GENERAL INTRODUCTION	1
1.1. INTRODUCTION.....	1
1.2. CONTEXT OF THE RESEARCH.....	4
1.3. OBJECTIVES	6
1.4. HYPOTHESES	7
1.4.1. Roots distribution and water use in the full sun coffee compared to coffee agroforestry.....	7
1.4.2. Rainfall interception, stemflow and throughfall in a coffee shaded by <i>Tabebuia rosea</i> Bertol. and <i>Simarouba glauca</i> DC.....	7
1.4.3. Evapotranspiration in a coffee shaded by <i>Tabebuia rosea</i> and <i>Simarouba glauca</i> timber tree species compared to unshaded coffee in sub optimal environmental conditions.....	7
1.5. GENERAL OUTLINE OF THE THESIS.....	8
CHAPTER II.....	9
LITERATURE REVIEW.....	9
2.1. COFFEE WATER RELATIONS.....	9
2.1.1. Coffee transpiration.....	10
2.1.2. Coffee leaf water potential.....	11

2.2. CLIMATE IMPACTS ON COFFEE GROWTH AND YIELD.....	12
2.3. WATER DYNAMICS IN COFFEE AGROFORESTRY.....	15
2.4. COFFEE AGROFORESTRY WATER BALANCE.....	16
2.5. COFFEE SHADE TREE CHARACTERISTICS AND PERFORMANCE.....	18
2.6. THE BELOW GROUND RELATIONSHIP IN COFFEE AGROFORESTRY.....	20
2.7. GAPS IN THE KNOWLEDGE OF COFFEE AGROFORESTRY WATER RELATIONS....	21
CHAPTER III.....	22
ROOT DISTRIBUTION AND WATER USE IN COFFEE SHADED WITH <i>TABEBUIA ROSEA</i> BERTOL. AND <i>SIMAROUBA GLAUCA</i> DC. COMPARED TO FULL SUN COFFEE IN SUB- OPTIMAL ENVIRONMENTAL CONDITIONS.....	22
3.1. INTRODUCTION.....	23
3.2. MATERIAL AND METHODS.....	25
3.2.1. Site description.....	25
3.2.2. Experimental design.....	27
3.2.3. Tree species studied.....	29
3.2.4. Fine root distribution.....	29
3.2.5. Soil water content.....	30
3.2.5. Data analysis.....	31
3.3. RESULTS AND DISCUSSION.....	32
3.3.1. Coffee and tree fine root distribution.....	32
3.3.2. The effect of talpetate on coffee root distribution.....	34
3.3.3. Soil water content.....	35
3.3.4. Soil water uptake.....	37
3.4. CONCLUSIONS.....	38

3.5. REFERENCES.....	39
CHAPTER IV.....	43
RAINFALL INTERCEPTION, STEMFLOW AND THROUGHFALL IN A COFFEE SHADED WITH <i>TABEBUIA ROSEA</i> BERTOL. AND <i>SIMAROUBA GLAUCA</i> DC. COMPARED TO FULL SUN COFFEE.....	43
4.1. INTRODUCTION.....	43
4.2. MATERIALS AND METHODS.....	45
4.2.1. Site description and experimental design.....	45
4.2.2. Species studied.....	46
4.2.3. Rainfall.....	47
4.2.4. Leaf area index.....	48
4.2.5. Stemflow.....	49
4.2.6. Throughfall.....	49
4.2.7. Interception loss.....	51
4.2.8. Statistical analysis.....	51
4.3. RESULTS.....	51
4.3.1. Leaf area index.....	51
4.3.2. Stemflow.....	52
4.3.3. Throughfall.....	54
4.3.4. Rainfall interception.....	58
4.3.5. Rainfall interception modeling.....	61
4.4. DISCUSSION.....	65
4.4.1. Stemflow.....	65
4.4.2. Throughfall.....	66

4.4.3. Interception loss.....	67
4.5. CONCLUSIONS.....	69
4.6. REFERENCES.....	69
CHAPTER V.....	73
WATER LOSS BY PLANT TRANSPIRATION AND SOIL EVAPORATION IN COFFEE SHADED BY <i>TABEBUIA ROSEA</i> BERTOL. AND <i>SIMAROUBA GLAUCA</i> DC. COMPARED TO UNSHADED COFFEE IN SUB-OPTIMAL ENVIRONMENTAL CONDITIONS.....	73
5.1. INTRODUCTION.....	73
5.2 MATERIALS AND METHODS.....	74
5.2.1 Site description and experimental design.....	74
5.2.2 Species studied.....	76
5.2.3 Climate.....	77
5.2.4. Soil water content.....	77
5.2.5. Coffee and tree leaf area index.....	77
5.2.6. Coffee and tree transpiration.....	79
5.2.7. Leaf water potential.....	81
5.2.8. Soil evaporation.....	81
5.2.9. Data analysis.....	82
5.3. RESULTS.....	82
5.3.1. Climate.....	82
5.3.2. Soil water content.....	84
5.3.3. Coffee and tree leaf area index.....	84
5.3.4. Coffee and tree transpiration.....	86
5.3.5. Soil evaporation.....	90

5.3.6. Coffee leaf water potential.....	94
5.3.7. Total evapotranspiration.....	95
5.4. DISCUSSION.....	97
5.4.1. Coffee water use.....	97
5.4.2. Shade tree water consumption.....	98
5.4.3. Soil surface evaporation.....	100
5.4.4. Total evapotranspiration.....	101
5.5. CONCLUSIONS.....	102
5.6. REFERENCES.....	102
CHAPTER VI.....	107
6. GENERAL DISCUSSION AND CONCLUSIONS.....	107
6.1. Study site and experimental design.....	107
6.2. Complementarity and competition for water in coffee shaded with <i>Tabebuia rosea</i> and <i>Simarouba glauca</i> in sub optimal environmental condition.....	108
6.2.1. Below-ground interactions.....	108
6.2.2. Coffee water use.....	110
6.2.3. Shade tree water use.....	112
6.2.4. Shade tree effects on coffee production in sub optimal environmental condition for coffee cultivation.....	113
6.3. Water dynamics and use in coffee agroforestry in sub optimal condition.....	115
6.3.1. Evapotranspiration partitioning.....	115
6.3.2. Evapotranspiration by directly and indirect estimation compared.....	118
6.4. GENERAL CONCLUSIONS.....	120
6.4.1. TESTING THE RESEARCH HYPOTHESES.....	121

6.4.1.1. Roots distribution and water use in coffee shaded by <i>Tabebuia rosea</i> and <i>Simarouba glauca</i> compared to full sun coffee in sub optimal environmental conditions.....	121
6.4.1.2. Rainfall interception, stemflow and throughfall in a coffee shaded by <i>Tabebuia rosea</i> Bertol. and <i>Simarouba glauca</i> DC.....	122
6.4.1.3. Evapotranspiration in a coffee shaded by <i>Tabebuia rosea</i> and <i>Simarouba glauca</i> timber tree species compared to unshaded coffee in sub optimal environmental conditions.....	122
6.5. CONSIDERATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH ON COFFEE WATER RELATIOS IN AGROFORESTRY.....	123
REFERENCES (Chapters I, II, VI).....	125

LIST OF TABLES

Chapter IV

4.1. LAI of coffee in FS, coffee in AFS, <i>Tabebuia rosea</i> and <i>Simarouba glauca</i> in the three consecutive periods studied: May-June, July-August and September-October 2013. (Mean ± standard error).....	52
4.2. Stemflow as a percentage of gross rainfall (or throughfall) in coffee FS, coffee AFS, <i>Tabebuia rosea</i> (TR) and <i>Simarouba glauca</i> (SG) for five magnitudes of rainfall over the period of study. SE is the standard error of the mean.....	52
4.3. Throughfall as a percentage of gross rainfall (or throughfall) by coffee FS, coffee AFS, <i>Tabebuia rosea</i> (TR) and <i>Simarouba glauca</i> (SG) for five magnitudes of rainfall. SE is the standard error of the mean.....	55
4.4. Rainfall interception expressed as a fraction of rainfall or tree throughfall in coffee FS, coffee AFS, <i>Simarouba glauca</i> and <i>Tabebuia rosea</i> over the period of experiment.....	60
4.5. Rainfall partitioning in throughfall, stemflow and interception expressed as a fraction of rainfall or tree throughfall in coffee FS, coffee AFS, <i>Simarouba glauca</i> and <i>Tabebuia rosea</i> over the period of experiment.....	61
4.6. Coefficients for coffee FS, coffee AFS, <i>Tabebuia rosea</i> (TR) and <i>Simarouba glauca</i> (SG) interception (RI) by the equation: $I = a * b / a + b$	64
4.7. Regression coefficients for <i>Tabebuia rosea</i> (TR) and <i>Simarouba glauca</i> (SG) stemflow (Sf).....	64
4.8. Interception as a percentage of gross rainfall over the dry and wet seasons in 2012 and 2013 in shaded (AFS) and unshaded (FS) systems.....	65

Chapter V

5.1. Main characteristics of the two shade tree species in the study site: <i>Tabebuia rosea</i> and <i>Simarouba glauca</i> , over the period of the experiment.....	76
5.2. Total evapotranspiration calculated from transpiration plus soil evaporation in a plot basis (with the standard error of the mean) and as percentage of total	

evapotranspiration in FS and AFS in February, April and July in 2012 and in February, April, July and November in 2013.....	96
5.3. Transpiration partitioning in AFS with coffee, <i>Tabebuia rosea</i> and <i>Simarouba glauca</i> transpiration rate in mm.d-1 and in percentage of the total transpiration in the system. Standard errors of the means are in brackets.....	97

LIST OF FIGURES

Chapter I

1.1. Monthly rainfall distribution from the climate station (in black) and long term mean annual rainfall (in white) in Masatepe, Nicaragua, over the period of study.....5

Chapter III

3.1. Talpetate layer in the soil profile with roots inside the fractures.....26

3.2. Schematic representation of the experimental design of (one quarter of) the shade plot with coffee, *Simarouba glauca* and *Tabebuia rosea* spatial distribution pattern....28

3.3. Coffee root impacts dm^{-2} in the soil profile in full sun coffee (FS) and coffee agroforestry (AFS) from the mean of ten soil profiles in FS plot and 24 in AFS. Errors bars represent the standard error of the mean.....32

3.4. Coffee root impacts dm^{-2} in soil profiles near *Tabebuia rosea* and *Simarouba glauca* trees from the mean of eight soil profiles near each tree. Errors bars represent the standard error of the mean.....33

3.5. Niche differentiation of fine coffee roots and fine tree roots in the agroforestry system from the mean of 24 soil profiles in shade plots. Pictures represent the whole grids where roots were counted in 10cm x 10cm cells.....33

3.6. *Simarouba glauca* and *Tabebuia rosea* fine root distribution from the mean of 24 soil profiles in shade plots. Errors bars represent the standard error of the mean.....34

3.7. Monthly rainfall distribution from climate station, Masatepe, Nicaragua; February 2012 to May 2014.....35

3.8. A comparison of soil water content in the whole soil profile (2000 mm) from the mean of three trenches in the full sun and six trenches in agroforestry in the (a) 2012, (b) 2013 and (c) 2014 dry periods.....36

3.9. Comparison of soil water uptake by the two coffee cropping systems from the whole soil profile 2012 to early 2014. Horizontal bars represent the period lengths under consideration. Errors bars represent standard error of the mean. Probabilities for identical values figure above each comparison (T-test).....38

Chapter IV

4.1. Daily rainfall events over the period of study and in the three periods measured: May-June, July-August and September-October 2013.....	48
4.2. Rain gauge distribution for coffee throughfall monitoring in the full sun and shade plots.....	49
4.3. Rain gauge (circles) distribution for tree throughfall monitoring and spatial weighing for each gauge (m ²) calculated by the Thiessen polygon method in one out of three replications in the shaded plot.	50
4.4. Coffee stemflow as a function of rainfall in FS and tree throughfall in AFS over the period of study. Vertical bars represent the standard error of the mean.....	53
4.5. Tree stemflow as a function of rainfall over the period of study. Vertical bars represent the standard error of the mean.....	54
4.6. Throughfall below coffee trees in FS and AFS as a function of gross rainfall in FS and the tree throughfall in AFS over the period of study. Vertical bars represent standard error of the mean.....	54
4.7. Throughfall below coffee canopies as a function tree throughfall in AFS at different distances from the coffee trunk (0.20 m, 0.60 m and 1.0 m).....	56
4.8. Throughfall below coffee canopies as a function of gross rainfall in FS at different distances from the coffee trunk (0.20, 0.60 and 1.0 m).....	56
4.9. Mean tree throughfall beneath six <i>Tabebuia rosea</i> and six <i>Simarouba glauca</i> as a function of gross rainfall over the period of study. Vertical bars represent the standard error of the mean.....	57
4.10. Spatial distribution of throughfall beneath <i>Tabebuia rosea</i> (TR) as a function of gross rainfall at different distances from the tree trunk (1.0 m, 2.5 m and 5.5 m).....	58
4.11. Spatial distribution of throughfall beneath <i>Simarouba glauca</i> (SG) as a function of gross rainfall at different distances from the tree trunk (1.0 m, 2.5 m and 5.5 m).....	58
4.12. Rainfall interception by coffee trees in FS and AFS over the period of study.....	59

4.13. Interception by <i>Tabebuia rosea</i> (TR) and <i>Simarouba glauca</i> (SG) canopies as a function of rainfall. Vertical bars represent the standard error of the mean.....	60
4.14. Interception measured and modelled by coffee tree canopies in FS.....	62
4.15. Rainfall interception measured and modelled by <i>Simarouba glauca</i> canopy.....	63
4.16. Rainfall interception measured and modelled by <i>Tabebuia rosea</i> canopy.....	63

Chapter V

5.1. Daily reference evapotranspiration in the dry and wet seasons over the period of the experiment.....	83
5.2. Mean soil water content (from 3 profiles in FS and 6 profiles in AFS) in the whole soil profile (0-2.0m) and rainfall over the period of the experiment.....	84
5.3. Coffee leaf area index in the dry (February – April) and wet seasons (July – November) in AFS and FS over 2012 and 2013. Vertical bars represent the standard error of the mean.....	85
5.4. <i>Tabebuia rosea</i> and <i>Simarouba glauca</i> leaf area index in the dry (February – April) and wet seasons (July - November) in 2012 and 2013. Vertical bars represent the standard error of the mean.....	86
5.5. Typical diurnal trends in coffee transpiration on a leaf area basis from mean of four coffee trees each in FS and AFS over five consecutive days in the 2012 dry (a) and wet season (b) and 2013 dry (c) and wet season (d).....	87
5.6. Plot level mean daily coffee transpiration (mm d ⁻¹) in FS and AFS and reference evapotranspiration in the dry (Feb-April) and wet seasons (July-Nov) in 2012 and 2013. Bars represent the standard error of the mean.....	88
5.7. Plot level mean tree transpiration and reference evapotranspiration in the dry (Feb-April) and wet seasons (July-Nov) in 2012 and 2013. Bars represent the standard error of the mean.....	89
5.8. Diurnal patterns of transpiration (L.h ⁻¹) by <i>Tabebuia rosea</i> and <i>Simarouba glauca</i> trees and VPD (kPa) from mean of five consecutive days in the 2012 dry (a) and wet seasons (b) and in the 2013 dry (c) and wet seasons (d).....	90

5.9. Soil evaporation (mm.d ⁻¹) from lysimeters in FS and AFS from April 2012 to April 2014. Vertical bars represent the standard error of the mean. Daily rainfall (right axis) and ET ₀ (left axis) are indicated as references.....	91
5.10. Daily soil evaporation from lysimeters located in the row or interrow over the dry monitoring periods in 2012 and 2014 and over the 2013 wet period.....	92
5.11. Daily soil evaporation rate measured and modelled by Ritchie soil evaporation model, in FS and AFS from April 2012 to April 2014.....	93
5.12. Soil evaporation measured and modelled in FS coffee. Regression equation: $y=0.759x + 0.5385$; $R^2=0.44$	93
5.13. Soil evaporation measured and modelled in AFS. Regression equation: $y=0.9804x + 0.3857$; $R^2=0.62$	94
5.14. Mean coffee leaf water potential at predawn and midday from three days consecutive measurements in the dry (February and July) and wet seasons (July and November) in 2012 and 2013. Bars represent the standard error of the mean.....	95
Chapter VI	
6.1. Daily soil water uptake directly estimated (by soil evaporation and plant transpiration measuring) and indirectly estimated (by changes in the soil water stock) in FS and AFS and reference evapotranspiration over the period of study. Vertical bars represent the standard error of the mean.....	119