



UvA-DARE (Digital Academic Repository)

Greening with black

Biochar-soil amendment for low-emission agriculture

Fungo, B.L.

Publication date

2019

Document Version

Other version

License

Other

[Link to publication](#)

Citation for published version (APA):

Fungo, B. L. (2019). *Greening with black: Biochar-soil amendment for low-emission agriculture*. [Thesis, externally prepared, Universiteit van Amsterdam].

General rights

It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: <https://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, P.O. Box 19185, 1000 GD Amsterdam, The Netherlands. You will be contacted as soon as possible.

Greening with Black

Biochar-Soil amendment for low-emission agriculture

Bernard Fungo



2019

Publisher: Universiteit van Amsterdam, IBED), Amsterdam

ISBN/EAN: 978-94-91407-76-5

Print: Ridderprint | www.ridderprint.nl.

© 2019

Greening with Black: Biochar-Soil Amendment for Low-Emission Agriculture

ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad van doctor

aan de Universiteit van Amsterdam

op gezag van de Rector Magnificus

prof. dr. ir. K.I.J. Maex

ten overstaan van een door het College voor Promoties ingestelde commissie,

in het openbaar te verdedigen in de Agnietenkapel

op woensdag 30 oktober 2019, te 14.00 uur

door Bernard Lukoye Fungo

geboren te Kampala

Promotiecommissie:

| | | |
|-----------------------|-----------------------------|---------------------------------|
| <i>Promotores:</i> | prof. dr. K. Kalbitz | Technische Universität Dresden |
| | dr. B. Jansen | Universiteit van Amsterdam |
| <i>Copromotores:</i> | prof. dr. P.C. de Ruiter | Universiteit van Amsterdam |
| <i>Overige leden:</i> | prof. dr. J. Lehmann | Cornell University |
| | dr. H. Neufeldt | Technical University of Denmark |
| | prof. dr. ir. F.T. de Vries | Universiteit van Amsterdam |
| | prof. dr. R.A.P.F. Bol | Universiteit van Amsterdam |
| | dr. L.H. Cammeraat | Universiteit van Amsterdam |

Faculteit der Natuurwetenschappen, Wiskunde en Informatica

Fieldwork for this thesis was carried out at the World Agroforestry Center (ICRAF) in Kenya and the laboratory experiment was undertaken at the Institute of Meteorology and Climate Research, Institute of Atmospheric Environment Research (IMK-IFU), Karlsruhe Institute of Technology (KIT), Germany. The funds for this study were made available from the Bill-Melinda Gates Foundation under the project “Basic Research to Enable Agricultural Development (BREAD) in a partnership between Cornell University and ICRAF.

Contents

| | |
|--|-----------|
| CHAPTER ONE: General Introduction | 1 |
| 1.1 Climate Change, Agriculture and Food Security | 1 |
| 1.2 Agriculture and greenhouse gas emissions | 1 |
| 1.3 Biochar and greenhouse gas emissions from agricultural soils..... | 2 |
| 1.4 Mechanisms and controversy surrounding biochar effects on GHGs in soils | 3 |
| 1.5 Research problem..... | 11 |
| 1.6 Objectives of the study | 11 |
| 1.6 Significance of the study | 12 |
| 1.7 Study area | 12 |
| CHAPTER TWO: N₂O and CH₄ emission from soil amended with steam-activated biochar | 15 |
| 2.1 Introduction | 15 |
| 2.2 Materials and Methods | 16 |
| 2.3 Results and Discussion..... | 19 |
| 2.4 Conclusions and Recommendations..... | 23 |
| CHAPTER THREE: Nitrogen turnover and N₂O/N₂ ratio of three contrasting tropical soils amended with biochar | 25 |
| 3.1 Introduction | 25 |
| 3.2 Materials and methods..... | 27 |
| 3.3 Results | 33 |
| 4 Discussion | 41 |
| 3.5 Conclusion and recommendations..... | 45 |
| CHAPTER FOUR: Aggregate size distribution in a biochar-amended tropical Acrisol under conventional hand-hoe tillage..... | 47 |
| 4.1 Introduction | 47 |
| 4.2 Materials and Methods | 50 |
| 4.3 Results | 55 |
| 4.4 Discussion | 61 |
| 4.5 Conclusions and recommendations..... | 65 |
| CHAPTER FIVE: Emissions intensity and carbon stocks of a tropical Acrisol after amendment with Tithonia green manure, urea and biochar..... | 67 |
| 5.1 Introduction | 67 |
| 5.2 Materials and Methods | 69 |
| 5.3 Results | 75 |
| 5.4 Discussion | 84 |
| 5.5 Conclusions and Recommendations..... | 92 |

| | |
|--|------------|
| CHAPTER SIX: Ammonia and nitrous oxide emissions from a field Acrisol amended with tithonia green manure, urea, and biochar | 93 |
| 6.1 Introduction | 93 |
| 6.2 Materials and methods..... | 96 |
| 6.3 Results | 103 |
| 6.4 Discussion | 112 |
| 6.5 Conclusion and recommendations..... | 117 |
| CHAPTER SEVEN: Synthesis and general discussion | 119 |
| 7.1 Key findings | 119 |
| 7.2 Mechanisms of biochar effect on GHG emissions | 121 |
| 7.3 Practical potential of biochar..... | 124 |
| 7.4 Further observations | 126 |
| 7.5 General conclusions and recommendations | 128 |
| 8.0 REFERENCES | 133 |
| SUMMARY IN ENGLISH..... | 167 |
| SAMENVATTING IN HET NEDERLANDS | 173 |
| ACKNOWLEDGEMENTS | 179 |
| BIOGRAPHY | 181 |