COMPARATIVE ANALYSIS OF THE INFLUENCE OF WATERING REGIME AND SOIL PROPERTIES ON GREENHOUSE GAS EMISSION IN MWEA IRRIGATION SCHEME, KIRINYAGA COUNTY, KENYA.

YVONNE NJOKI NDARU

A Thesis Submitted to the Graduate School in Partial Fulfillment of the Requirements for the Award of the degree of Master of Science in Environment Science of Chuka University

CHUKA UNIVERSITY

OCTOBER, 2024

DECLARATION AND RECOMMENDATIONS

Declaration

This thesis is my original work and has not been presented for an award of diploma of conferment of degree in any other University

Signature _____ Date 17/10/2024

Yvonne Njoki Ndaru
NM11/51385/21

Recommendations

This thesis has been examined, passed and submitted with our approval as University supervisors.

Signature _____ Date 17/10/2024

Dr. Evans Mutuma
Chuka University

Signature _____ Date 17/10/24

Dr. Maina Kariuki
Chuka University

Co-supervisor

Signature _____ Date 17/10/2024

Dr. Daniel Menge
International Rice Research Institute (IRRI)

DEDICATION

To my beloved parents, Paul and Julita Ndaru, my siblings, and my nieces and nephews, for their unwavering support of my accomplishments.

ACKNOWLEDGEMENT

I sincerely appreciate my supervisors, Dr. Evans Mutuma and Dr. Joseph Maina Kariuki, Chuka University, and Dr. Daniel Menge from the International Rice Research Institute (IRRI). They patiently spent days guiding me through the entire process of conducting my research work and writing this thesis. I appreciate the valuable input from Dr. Rosemary Murori of the International Rice Research Institute (IRRI), Dr. Zhu Yuhao of the Mazingira Centre-ILRI, Dr. Jafford Rithaa, Dr. Agatha Nthenge, and Madam Virginia Kavuu of Chuka University.

A special expression of gratitude goes to the International Rice Research Institute (IRRI) and Mazingira Centre, International Livestock Research Institute (ILRI). This study was carried out as part of the SCALEDIRECT project. Special thanks to Dr. Leitner Sonja for her beneficial input, and for accommodating me at the Mazingira Centre. I also want to thank the entire Mazingira team for their help. My sincere appreciation to Mr. Paul Mutuo for aiding me in both chromatographic analysis and flux calculations. Special thanks to Mr. Francis and his colleagues for helping me with soil sample analysis. Additionally, I am sincerely indebted to the Nagoya University team (Prof. Daigo Makihara, and Dr. Rena Tomita) for their help.

I am deeply thankful to several anonymous staff at KALRO-Mwea for their unwavering assistance throughout the entire process. My sincere thanks go to my parents, Mr. and Mrs. Paul Ndaru, along with my siblings, for their consistent moral and financial support during my studies.

ABSTRACT

The nexus of climate change and enhancing food sufficiency requires a better comprehension of how to balance food demand with climate change mitigation to promote sustainability. This study quantifies the influence of watering regimes, crop establishment methods, and soil properties on greenhouse gas emissions in rice fields, specifically within the Mwea irrigation scheme in Kenya. The study aimed to analyze the influence of two different watering regimes namely alternate wetting and drying (AWD), and continuous flooding (CF) on greenhouse gas emissions in transplanted rice (TPR) and direct-seeded (DSR) rice. Additionally, it investigated the influence of soil properties on greenhouse gas emissions. To accomplish this, an on-station experiment with four treatments: CF + TPR, CF + DSR, AWD + TPR, AWD + DSR, and four replications were performed for one season. The experiment was laid out in a randomized complete block design with a split-plot arrangement where the watering regimes were the main plot and the crop establishment methods were the subplots. 60ml propylene syringes were used to collect the gas samples from the closed static gas chamber method, after which the samples were then transferred into 40-ml glass vials. The gas samples were transported to the Mazingira Centre laboratory and analyzed for (CH_4, N_2O, and CO_2) using a gas chromatograph (GC; model SRI 8610C). Soil samples were collected using a soil corer (8cm height) at a depth of 0-16cm and 17-32cm and analyzed for pH, CN, PSA, water content, ammonium, nitrate, and phosphorus using the globally recognized protocols at the Mazingira Centre, within the International Livestock Research Institute (ILRI) in Nairobi, Kenya. The results on the influence of watering regimes, crop establishment methods, and their interactions on greenhouse gas emissions were statistically subjected to a two-way analysis of variance (ANOVA) test followed by a Turkeys multiple comparison test where the influence was found to be significant. Additionally, to determine the influence of soil properties on greenhouse gas emissions the results were statistically analyzed using a Pearson's correlation test. Both watering regimes and crop establishment methods and their interactions significantly influenced the emission of CH_4 ($P < 0.01$). Crop establishments significantly influence the emission of CO_2 ($P< 0.05$) with higher emissions in DSR subplots irrespective of the watering regime. However, there was no significant influence of the watering regimes, crop establishments, or their interactions on the emission of N_2O. Watering regimes greatly influenced the global warming potential. Regardless of the crop establishment method, AWD decreased the potential for global warming compared to continuous flooding. However, the interaction between AWD and DSR had a higher global warming reduction potential compared to other treatments. Sand content showed strong negative and positive correlations with CH_4 ($P < 0.05$) and CO_2 ($P < 0.01$) respectively. The nitrate content and N_2O exhibited a strong positive correlation ($P < 0.01$). Regarding water use, AWD saved 64% of the water used compared to CF. In conclusion, this study found AWD to be a preferable way to continuous flooding to mitigate the potential for global warming while direct-seeding rice under alternate wetting and drying was proven to be a more effective practice to reduce global warming potential (GWP).