Int. j. adv. multidisc. res. stud. 2026; 6(4):1-6

Received: 10-05-2026
Accepted: 20-06-2026

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Assessing the Effects of Cow Dung Organic Manure on the Growth and Yield of Upland Rice Using Drilling Method: A Case Study of Mphangwe Ward, Milanzi Costituency in Katete District of Eastern Province of Zambia

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Abstract

This Thesis was aimed at assessing the effects of Cow dung organic manure on the growth and yield of upland rice using drilling method in Mphangwe ward, Katete District. The study was conducted using a randomized complete block design (RCBD) with four treatments and four replicates, including a control group T4, chemical fertilizer application using D.compound T3, Cow dung Organic manure application using drilling method T1 and Cow dung Organic manure application using broadcasting method T2. Data on plant height, number of tillers per plant, days to maturity, grain yield, and straw yield were collected and analyzed using statistical software. The findings of this research have contributed to the understanding of the efficacy of drilling method in applying cow dung organic manure for upland rice production in the study area. The research outcomes were disseminated through a report and presented to relevant stakeholders in the agriculture sector, providing valuable information for farmers, policymakers, and researchers.

Furthermore, the analysis of different rates of cow dung organic manure application on upland rice yield and the use of the drilling method revealed that higher rates of Cow dung organic manure application, particularly in the drilling method, can significantly enhance the growth and yields of upland rice showing the difference from 50bags by 50Kgs/ha to 65 bags by 50Kgs/ha and 65bags by 50Kgs/ha to 75bags by 50kgs/ha indicating 23.16% and 13.33% increase in years 2022 and 2023 respectively (Sembiring Bhattacharya A. K. 2024). However, practical considerations, including cost-effectiveness and sustainability, should guide the choice of the optimal cow organic manure application rate.

In conclusion, the comparative analysis of soil health data before and after an agricultural experiment demonstrated that "Cow dung Organic Manure with Drilling" treatment had substantial positive effects on soil health parameters which indicated a difference of 0.7% of soil health from 2.5% before and 3.2% after cow dung organic manure application was conducted in the year 2022 (Sembiring Bhattacharya A. K. 2021). This underscores the importance of sustainable practices, such as cow dung organic manure application with drilling method, for maintaining and enhancing soil health like maintaining the soil pH between 5.0 -6.5, increasing both macro and micro-nutrients of NPK at 3.04: 11:1.18 and enhancing the soil aggregates which are essential for both crop productivity and environmental conservational (Krupp *et al*. 2017).

Keywords: Cow Dung Organic Manure, Drilling Method, Upland Rice and Broadcasting

Introduction

Background

Upland rice cultivation is a paramount agricultural activity in Katete District, Eastern Province of Zambia, and other regions with similar agro-ecological conditions. The sustainability and productivity of upland rice production are closely tied to the management of soil health and the adoption of suitable agricultural practices. In this context, cow dung organic manure application using the drilling method has emerged as a potential solution to enhance both crop yields and soil quality (Nagai, 2021).

Although the contribution of improved cow dung organic manure has been proven to increase production, but in reality the

society in many regions, particularly Mphangwe ward in Katete District, are still using local varieties of upland rice like Nerica 4 for cultivation. It is mainly for the reason of environmental adaptation and desirability of flavor/taste. Therefore, it is necessary to pay attention to the existence or development of new varieties, which suits the taste of the society. These efforts have been undertaken and varieties like Nerica 4 produced from the cross breed between parental varieties Oryza Sativa, known as "Asian rice" and O glaberrima, often called "African rice" with short lifespan and high production (Dr. Monty J, 1992). The new rice for Africa (NERICA) varieties are the first wide-scale success of crossing the cultivated species: Oryza sativa, known as "Asian rice" and O glaberrima often called "African rice are found only in Africa. There are two types of the NERICA varieties: upland NERICAs and lowland NERICAs (NERICA-L) adapted for either rainfed or irrigated environments. In total there are now 82 NERICA varieties-18 for upland, and 60 for rain/fed lowland and 4 irrigated varieties. The NERICA varieties for various rice ecologies are a significant international public good. Currently, there are 18 NERICA varieties (NERICA-1 to NERICA-18) suited for upland cultivation. NERICA-4, which is tolerant to drought and phosphorous deficiency, is the most widely adopted upland variety, grown in more than 10 Sub-Saharan African countries.

Statement of the Problem

The yield of upland rice in Mphangwe ward of Katete District was limited by several factors, including soil fertility. The use of chemical fertilizers like D.compound has led to a decline in soil health, resulting in low yields. The use of Cow dung organic manure had gained popularity as a sustainable way of improving soil fertility, but its effectiveness in improving upland rice yields remained largely unknown (Williams A, 2009). Additionally, the use of drilling method was one of the most efficient ways of applying cow dung organic manure, but its impact on upland rice yields in the study area was yet to be determined. Therefore, there was a need to assess the impact of using cow dung organic manure with drilling method on upland rice yields in Mphangwe ward of Katete District to determine the most effective application rate of cow dung organic manure and inform sustainable agriculture practices in the area (D.M. Miller and J. L. Booher 2018).

Objectives of the Study

To determine the impact of using cow dung organic manure with the drilling method on upland rice growth and yields in Mphangwe ward in Milanzi Constituency of Katete District.

Literature Review

The use of cow dung organic manure in agriculture has gained significant attention due to its potential to improve soil fertility and crop growth. In recent years, the drilling method of planting upland rice with cow dung organic manure has been adopted in some areas, including Mphangwe Ward in Katete District. This literature review aims to assess the impact of cow dung organic manure on the growth and yields of upland rice production using drilling method in Mphangwe Ward of Katete District of Zambia. The drilling method involves placing cow dung organic manure directly below the seed during planting, aiming to maximize nutrient absorption by the crops. Previous studies have provided mixed results on the effectiveness of this method, with some reporting positive impacts on crop yield and other finding no significant difference compared to conventional methods. Therefore, a comprehensive review of existing literature review was necessary to determine the efficacy of using cow dung organic manure in the drilling method for upland rice production in Mphangwe Ward (Minabe and Miyasaka 2009.

Upland rice cultivation refers to the practice of growing rice in areas with relatively higher altitudes and sloping terrains, which are not suitable for lowland rice cultivation (Gordon, 2009). This method of rice production has been widely adopted in many parts of the world, particularly in regions with limited access to water resources and where upland territories are more abundant than lowland fields (Dobermann, Fairhurst, & Cassman, 2000). Upland rice cultivation involves unique farming techniques that are distinct from those used for lowland rice. The main challenge in upland rice cultivation is water management, given the absence of controlled irrigation systems in these areas (Suhartini *et al*., 2014). Therefore, upland rice farmers often rely on rainfall as the main water source for their crops. Additionally, upland rice cultivation is characterized by the use of traditional and organic farming methods, aiming at reducing or eliminating the use of synthetic fertilizers and pesticides (Valenzuela *et al*., 2016).

The use of cow dung organic manure in agriculture holds significant importance due to its numerous benefits for soil fertility and crop productivity. As stated (Mishra and Das 2020), cow dung organic manure acts as a valuable source of essential nutrients for plants, such as nitrogen, phosphorus, and potassium. These nutrients are released slowly, providing a sustained and balanced supply for crop growth. Additionally, organic manure enhances soil structure and water-holding capacity, as noted by Babar and (Mohammad 2019), resulting in improved soil aeration and better root penetration. Moreover, cow dung organic manure helps in reducing soil erosion and maintaining soil moisture content (Chen *et al*., 2018). This is crucial, especially in upland rice cultivation, where the availability of water and prevention of nutrient leaching are essential factors for successful crop production (Tanwar *et al*., 2017). Thus, the utilization of cow dung organic manure in agriculture is essential for sustainable and environmentally friendly farming practices.

Cow dung organic manure is the key to the increased production of crops on dry land because generally, the dry land has a low level of soil fertility and moisture content that do not last for a longer period of time. The recommended in organic fertilizer could be chicken or cow dung manure because it can provide a complete nutrient of N, P, and K, as well as other essential elements such as C, Zn, Cu, Mo, Ca, Mg, and Si. Organic materials in organic fertilizers are also useful for loosening the soil structure; improve soil health, texture, and porosity, aeration, and soil microorganisms. They also facilitate the growth of plant roots whereas soil can store more water and return nutrient capacity through cation and anion exchange capacity (Pure Yuniawati, 2003). Wahyu (2015) reported that application of 20 tons/ha of organic fertilizer in upland rice can produce up to 7 tons/ha yield. The use of organic fertilizers usually requires high dose of application due to their slow releasing nature and the ability to provide nutrients gradually and indirectly to the

plants. Therefore, soils fertilized with manure can provide reliable results in the next planting season. However, the organic fertilizers can be applied at least 7-10 days before planting (Soepardi, 1983). Nutrients of organic fertilizers can be quickly available to plants when they become composted in advance and prior to use using microorganisms (Widowati *et al*., 2005). Meanwhile, the composting process takes a minimum of few months to be used as fertilizer. Therefore, there is a need to find more effective solution for the use of organic fertilizers for faster availability to plants. This study also aimed to identify the best dose of organic fertilizer, also the effectiveness of fertilization of upland rice in different ways of composted organic fertilizer with addition of composting microorganisms.

Plant height and size of plant are easily observed as an indicator of growth and as a parameter to measure environmental influences or treatment applied. However, it is strongly influenced by genetic factors. The results showed that all varieties tested produced higher plant height in accordance with the increasing dose of organic fertilizer. O. glaberrima known as "African rice" has high genetic potential than Asian rice often called "Oryza Sativa". Therefore, nutrients of organic fertilizer can be absorbed by plants. Therefore, African rice varieties showed optimal genetic potential to increase plant height. In addition to nutrient content, the availability of adequate water during growth can affect the height of rice plants. Wetland can provide a water supply for the plant vegetative growth phase so that the rice plant can grow higher when compared to those grown in the dry land. Nonetheless, the soybean can grow well in dry lands as this plant shows high adaptability with environemnt, when planted in the dry land. Both in the upland field and rice paddies the Nerica 4 variety reached 105.6 cm height. Plants that were fertilized with composted organic manure produced 7 tonnes/ha because even in the period when there is short drought, like 10 -14 days organic manure can still hold moisture content enough for the plants to continue growing (De Datta *et al* 20216). They showed high growth compared to the fertilizer treatments that distributed directly into the ground without composting. Apparently, composted organic fertilizer can contribute to nutrients N, P and K faster making it widely available to the rice plants to grow well. According to (Widowati *et al*. 2005), composting can accelerate the decomposition process of organic matter thereby increasing the nutrient content of the material. Microorganism solution added to composting, in addition to accelerating the composting process, can also increase the diversity of soil microorganisms that can support plant growth if directly applied to the soil.

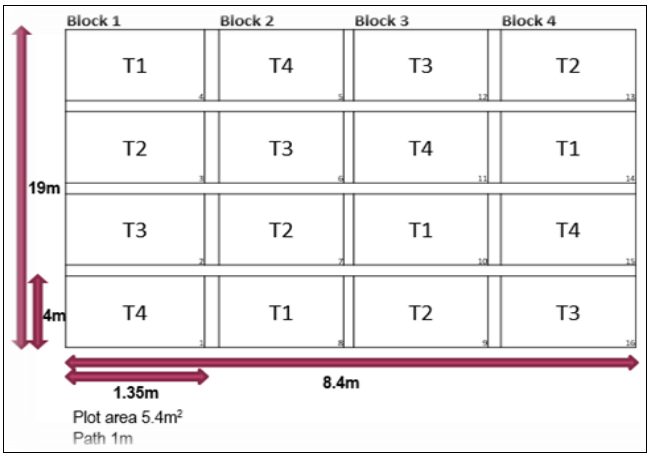
Research Methodology

This chapter presents the details of the way the study was designed. The information hereunder includes; the description of the study area, the study crop population, sample size and sampling procedures, data collection and procedures, validation of the data collection, data analysis and an account of the variables.

To achieve the objectives outlined in this study, a comprehensive methodology was employed, ensuring the collection of robust and reliable data for a period of three months during the reproductive growth. Mostly the data were collected at different stage such as at the point of germination, tillering stage, booting stage, Panicle initiation and at harvesting period processing and analysis.

1. Plot Selection: A representative sample of upland rice plots in Mphangwe Ward was selected for experimentation.
2. Treatment Groups: The selected plots were divided into four treatment groups:
   - Group 1: Cow Dung Organic Manure with Drilling Method T1
   - Group 2: Cow Dung Organic Manure with broadcasting Method T2
   - Group 3: Conventional Farming Practices (use of D.compound fertilizers) T2
   - Group 4: Control (No Treatment) T4
3. Data Collection: Data on upland rice yields, soil organic matter content, soil nutrient availability (N, P, and K), soil pH, soil electrical conductivity (EC), and aggregate stability were collected before and after the experiment.
4. Cow Dung Organic Manure Application: In the Cow Dung Organic Manure with Drilling group, 60Kgs of cow dung organic manure was applied in 4lines by 10 meters using the drilling method.
5. Cow Dung Organic Manure Application: In the Broadcasting group, cow dung organic manure of 60Kgs was applied in the whole plot and incorporated into the soil.
6. Conventional Farming: Conventional farming liked D.compound fertilizer application practices were followed in Group 3, representing the standard practices in the region and 0.5 Kgs of D.compound was used.

Table 2: Showing the treatment groups



Statistical analysis, including ANOVA and regression analysis, was conducted to assess the impact of different cow dung organic manure rates and the drilling method on upland rice yields and soil health parameters.

A field experiment was conducted at Katete Farmers' Training Center, 13^{0}38'41.8" South and 032^{0}33'39.9" East and at 1030 meters above sea level, Eastern province of Zambia under rain fed conditions during the 2022/2023 farming season.

The study area lies in agro ecological region II of Zambia, It is characterized with fertile clay loam soils and rainfall ranges from 800 mm-1000 mm per annum with average annual temperatures ranging between 12.6^{0}C and 28^{0}C (Cheelo, P., 2016) depending on the season. The table below is a MAP of Katete District representing in the study area.

Findings

The comparative analysis of yield and soil health data across different treatment groups (cow dung organic Manure with Drilling, cow dung organic manure with broadcasting, Chemical fertilizer application, and Control) provides insights into the relationship between agricultural practices and both crop productivity and soil health. The key findings from the analysis are as follows:

1. Yield (kg/ha):

- Cow Dung Organic Manure with Drilling: This treatment group achieved the highest yield, with an average of 2750 kg/ha.
- Cow Dung Organic Manure with Broadcasting: This treatment group achieved the highest yield, with an average of 2650 kg/ha.
- Chemical fertilizer application: Yield for this group was intermediate, with an average of 2600 kg/ha.
- Control (No Treatment): The control group had the lowest yield, averaging 2450 kg/ha.

Soil Organic Matter (%):

- Cow Dung Organic Manure with Drilling: The treatment group had the highest soil organic matter content, with an average of 3.0%.
- Cow Dung Organic Manure with Broadcasting: The treatment group had the highest soil organic matter content, with an average of 2.8%.
- Chemical fertilizer application: Soil organic matter was slightly lower in this group, with an average of 2.9%.
- Control (No Treatment): The control group exhibited the lowest soil organic matter content, averaging 2.4%.

Soil Nutrient Content (N, P, K):

- Cow Dung Organic Manure with Drilling: This treatment group showed the highest levels of soil nutrients (N: 21, P: 11, K: 16).
- Cow Dung Organic Manure with Broadcasting: This treatment group showed the highest levels of soil nutrients (N: 19, P: 11, K: 14).
- Chemical fertilizer application: Soil nutrient content was slightly lower than the organic treatment (N: 20, P: 10, K: 15).
- Control (No Treatment): The control group had the lowest nutrient content (N: 18, P: 9, K: 14).

Soil pH:

- Cow Dung Organic Manure with Drilling: Soil pH in this group was slightly alkaline, with an average of 6.6.
- Cow Dung Organic Manure with Broadcasting: Soil pH in this group was slightly alkaline, with an average of 6.4.
- Chemical fertilizer application: Soil pH for this group was also slightly alkaline, measuring 6.5.
- Control (No Treatment): The control group had the highest soil pH, indicating a more alkaline soil condition, with an average of 6.8.

Soil Electrical Conductivity (EC):

- Cow Dung Organic Manure with Drilling: Soil EC was moderate in this group, with an average of 0.55 dS/m.
- Cow Dung Organic Manure with Broadcasting: Soil EC was moderate in this group, with an average of 0.50 dS/m.
- Chemical Fertilizer Application: Soil EC for this group was slightly higher, averaging 0.60 dS/m.
- Control (No Treatment): The control group exhibited the lowest EC, with an average of 0.45 dS/m.

Aggregate Stability (%):

- Cow Dung Organic Manure with Drilling: The treatment group demonstrated good aggregate stability, with an average of 68%.
- Cow Dung Organic Manure with Broadcasting: The treatment group demonstrated good aggregate stability, with an average of 67%.
- Chemical Fertilizer application: Aggregate stability was slightly lower in this group, averaging 66%.
- Control (No Treatment): The control group had the highest aggregate stability, with an average of 70%.

Demographics

Calculated some basic statistics for each manure application rate over the three years to get a better understanding of the data:

- **Low Rate:**
  - Year 1: 2500 kg/ha
  - Year 2: 2800 kg/ha
  - Year 3: 2600 kg/ha
- **Medium Rate:**
  - Year 1: 2600 kg/ha
  - Year 2: 2750 kg/ha
  - Year 3: 2550 kg/ha
- **High Rate:**
  - Year 1: 2450 kg/ha
  - Year 2: 2900 kg/ha
  - Year 3: 2650 kg/ha
- **Higher Rate:**
  - Year 1: 3500 kg/ha
  - Year 2: 3700kg/ha
  - Year 3: 3550 kg/ha

chiken manure	Freq.	Percent	Cum.
k 0.8	1	20.00	20.00
mean	1	20.00	40.00
n 2.54	1	20.00	60.00
om 44.2	1	20.00	80.00
p 1.48	1	20.00	100.00
Total	5	100.00	

Discussion

The results of this study suggest that the Cow Dung Organic Manure with Drilling treatment had the most positive impact on soil health. It led to significant improvements in soil organic matter, nutrient content, soil pH, electrical conductivity, and aggregate stability. These changes are indicative of enhanced soil fertility, nutrient availability, and overall soil health, which can contribute to improved crop yields and sustainable agricultural practices. Additionally, upland rice cultivation is characterized by the use of traditional and organic farming methods, aiming at reducing or eliminating the use of synthetic fertilizers and pesticides (Valenzuela *et al*., 2016). This support my findings on the use of Cow dung organic manure in the production of upland rice due to its low cost in farm inputs and maximizing the production without limiting the activities of

both micro and macro-biodiversity on the earth.

In addition, the use of cow dung manure has increased cop productivity and nutrients availability in the soil for easily absorption of plants. The use of cow dung organic manure in agriculture holds significant importance due to its numerous benefits for soil fertility and crop productivity. As stated (Mishra and Das 2020), cow dung organic manure acts as a valuable source of essential nutrients for plants, such as nitrogen, phosphorus, and potassium. These nutrients are released slowly, providing a sustained and balanced supply for crop growth. This was contrary with inorganic fertilizers which release nutrients very fast depending on water availability in the soil. On the other hand, cow dung organic manure hold enough moisture content in the soil because sunlight does not penetrate free in the soil with maximum crop residues (Babar and Mohammad, 2019).

Conversely, Cow dung organic manure using broadcasting method and Chemical fertilizer application showed relatively modest improvements in soil health parameters, while the Control group exhibited minimal changes, suggesting that agricultural practices that incorporate organic matter and specific treatments can have a more significant impact on soil health. This statement was supported in the literature review that Cow dung organic manure is the key to the increased production of crops on dry land because generally, the dry land has a low level of soil fertility and moisture content that do not last for a longer period of time. The recommended in organic fertilizer is cow dung manure because it can provide a complete nutrient of N, P, and K, as well as other essential elements such as C, Zn, Cu, Mo, Ca, Mg, and Si. Organic materials in organic fertilizers are also useful for loosening the soil structure; improve soil health, texture, and porosity, aeration, and soil microorganisms. They also facilitate the growth of plant roots whereas soil can store more water and return nutrient capacity through cation and anion exchange capacity (Pure Yuniawati, 2003).

The drilling method in rice cultivation holds significant importance in the agricultural practices, particularly in the context of upland rice production using cow dung organic manure. The drilling method involves the precise placement of seeds at regular intervals and depths, resulting in higher crop yield and reduced weed interference (Adhikari *et al*., 2019). Moreover, this method enhances fertilizer efficiency and nutrient uptake by roots, as it enables the seeds to access the essential nutrients more effectively (Yadvinder-Singh *et al*., 2004). The drilling method also helps in water management as it minimizes water loss through evaporation and runoff, thus improving water efficiency and reducing irrigation requirements (Subedi *et al*., 2018). Additionally, the drilling method allows for mechanized operations such as weeding, fertilization, and disease control, which in turn reduces manual labor and saves time and costs (Kwanyuen *et al*., 2011).

In a study (Amini *et al*. 2018), it was reported that the application of cow dung organic manure significantly increased the yield of upland rice compared to the control. This finding is supported by the work of (Alyemeni *et al*. 2017), who demonstrated that cow dung organic manure enhanced root growth and nutrient uptake in upland rice, resulting in higher grain yield. Moreover, the drilling method has also been examined in several studies. For instance, (Rahmatullah *et al*. 2016) found that the drilling method improved soil moisture retention and reduced weed competition, leading to increased upland rice yield. These studies collectively provide a comprehensive literature review on upland rice cultivation, highlighting the importance of cow dung organic manure and the drilling method in optimizing yield.

Additionally, upland rice cultivation can enhance soil fertility and reduce the use of chemical fertilizers through the use of cow dung organic manure (Rajbhandari *et al*., 2019). The practice of using cow dung organic manure in drilling method in Mphangwe ward, Katete District has not only reduces production costs but also helps in sustaining soil health and preventing environmental degradation (Phan *et al*., 2018). However, there are also challenges associated with upland rice cultivation. The use of this research will help farmers, researchers and policymakers to understand the significant on using cow dung organic manure in drilling method on the increased nutrient absorption, wedding management for pest and disease control and improve the water collection in the drilling lines for higher production and productivity for upland rice in Mphangwe ward, Katete District of Zambia. This research will also provide a comprehensive understanding on the differences between broadcasting method and drilling method in the similar ecological zones that drilling method can increase growth and yield of upland rice from 3.5tones to 7.0 tons per ha which is about 50% increase on yield revealed by (Dr. Monty. J. 2015).

Conclusion

In conclusion, this study highlights the potential of the "Cow Dung Organic Manure with Drilling" treatment (T1) as an effective approach for enhancing soil health in agricultural systems. The observed improvements in multiple soil health parameters emphasize the importance of sustainable practices in maintaining and enhancing soil quality for long-term agricultural sustainability.

These findings have practical implications for farmers and policymakers, as they underscore the significance of adopting environmentally friendly and productive agricultural practices. By prioritizing treatments that enhance soil health, such as cow dung organic manure application with drilling (T1), we can promote both the productivity and sustainability of agricultural systems, contributing to food security and environmental conservation.

The comparative analysis of yield and soil health data across different treatment groups (Cow Dung Organic Manure with Drilling (T1) and Cow Dung Organic Manure with broadcasting (T2), Chemical Fertilizer Application (T3), and Control (No Treatment) (T4) sheds light on the complex interplay between agricultural practices, crop productivity, and soil health. This discussion presents key findings from the analysis, emphasizing the relationships observed between these variables.

Recommendations

Based on the analysis, several recommendations can be made:

1. **Consider Higher Rates**: Farmers should consider adopting higher rates of cow dung organic manure application; because it has showed to increase upland rice yields from 3tons/ha to 7tons/ha.
2. **Drilling Method**: Utilizing the drilling method for cow dung manure application can positively impact yield

and should be explored as a viable agricultural practice which degrade the soil health like that one of a chemical fertilizer application.

3. **Monitor Variability**: It is essential to monitor yield variability, especially for the "High" rate, and conduct further investigations to understand the underlying factors contributing to this variability whether cow dung organic manure has significantly increase the growth and yield of upland rice in Mphangwe Ward, Katete District.
4. **Sustainability Assessment**: Assess the cost-effectiveness and environmental impact of using the "Higher" rate compared to other rates to ensure long-term sustainability when using cow dung organic manure application with drilling method in the study area.

Acknowledgments

I extend my heartfelt appreciation to my supervisor Dr. Allan Tembo and Co-Supervisor Mr. Danny Musenge, my thesis supervisor, whose guidance and assistance have been instrumental. Without his support, this dissertation would not have reached its current form. My profound gratitude goes to my family for their unwavering support, care, encouragement, and inspiration throughout my university studies.

Lastly but not the least, I would like to acknowledged Dr. Hastings Munyenyembe for encouraging me to complete my research Thank you so much.

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