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Junior Scientists Tandems
Final Report

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Introduction

Germany has a thriving agricultural industry that is pivotal to the county's socio-economic development. With more than half of the land used for agricultural production, Germany is one of the largest agricultural producers in the European Union (European Union, 2021; Federal Ministry of Food and Agriculture, 2020). Animal breeding and husbandry are significant building blocks of the country's agricultural sector having direct impacts on natural resources. Nonetheless, agricultural practices characterized by a decoupling of animal husbandry and crop production lead to unbalanced soil organic carbon (SOC) and nitrogen (N) budgets. Other practices limiting the sustainability of the systems include monoculture systems, intensive tillage, and excessive use of manure to produce fodder in animal husbandry. Consequently, environmental pollution and climate change are major implications of the decoupling of SOC (Jacobs et al., 2020) and N (Häußermann et al., 2020) cycles.

Organically managed mixed crop-dairy farming systems are possible solutions to close the decoupled carbon and nitrogen cycles. Carbon and nitrogen consumed by livestock from the crops are recycled into the soil in the form of manure. Moreover, proper use of manure reduces the need for inorganic fertilizers and improves soil quality coupled with reduced surface and ground water contamination (Government of Canada, 2014). Ultimately, mixed crop-dairy systems under organic farming can enhance sustainable agriculture. However, organic farming is limited by the fact that it requires more area compared to conventional farming, and it exists at various forms and levels of productivity. These variations offer extensive opportunities, thus the need to establish the best compromise for animals, humans, and the environment. This balance can be struck between higher intensity and productivity on one hand, and lower intensity and productivity on the other. GreenDairy aims to determine the most favorable approach for mixed crop-dairy systems in terms of both unit production and land utilization.

Participation in the Junior Scientists tandem program involved supporting the sub-project C3 'Soil Carbon and Nitrogen Dynamics of Integrated Animal-Plant-Agricultural Ecosystems of Different Land Use Intensities' under the Green Dairy project whose aim is to develop integrated animal-plant-agriculture systems that are both ecologically and economically sustainable, as well as enabling a special degree of animal welfare and thus gaining a high

level of acceptance in society. The sub-project's focus is on carbon and nitrogen dynamics of high and low input dairy farming systems. The high input system involves grazing alongside a high proportion of on-farm corn silage and grain. On the other hand, the low input system involves grazing and predominantly roughage sourced from grassland. The sub-project is currently at the preliminary phase involving baseline data collection and analysis for establishing the foundation of the research.

Table 1 summarizes my activities at the Department of Soil Science and Soil Conservation at JLU-Giessen from March to August 2023.

Table 1: Activity Involvement Summary

Activities	Bi-weekly schedule											
	2	4	6	8	10	12	14	16	18	20	22	24
Grassland soil samples												
• Soil sampling												
• Preparation of air dried samples for physical and chemical analyses												
• Soil moisture analsyis												
• Digitization of data												
Tea Bag Index trial (Project BP71)												
• Studying and preparation												
• Weighing of tea bags												
• Burial of tea bags												
• Excavation of buried tea bags												
Soil column trails (Project MP148)												
• Studying and preparation												
• Attendance of students' preseenation and discussions												
• Cleaning of soil colums, sand and stands												
• Sampling at Gladbacher Hof												
• Leachates and gas sampling												
• fluorescence measurements of leachates												
Other activities												
• Thesis writing/corrections												
• Progress report preparation												
• Social engagements												
• Preparation and submission of final report												

Grassland soil samples preparation

A total of 216 grassland soil samples were collected from Gladbacher Hof under high input manure application. These samples were collected from 16 plots consisting of 3 soil cores per plot. Each core was then divided into 4 segments resulting in a total of 192 samples. Additionally, 24 samples were gathered around the plots to consider spatial variability and distribution of soil properties**.**

Preparation of the samples for analysis of soil moisture, texture, water-extractable organic matter, fine particulate organic matter, and C:N ratio involved the following routine activities:

- Sorting of roots/ stones and weighing them
- Sieving samples
- Ball milling samples

Project MP148

I supported a group of master's students in conducting the N losses soil column experiments in collaboration with Dr. Mulder.

Project overview: Application of animal manure in livestock systems is common to boost soil fertility (Jiménez et al., 2023) for improved crop yields (Xu et al., 2016). Manure contributes to soil organic matter (SOM), a major constituent of production that affects soil physical, chemical, and biological conditions. However, excessive or unbalanced application of manures and fertilizers owing to agricultural intensification in Germany pose a threat to the environment. Nitrate (NO_3) leaching is prevalent in agricultural soils (Srivastava et al., 2020) leading to water pollution (Jiménez et al., 2023; Srivastava et al., 2020; Xu et al., 2016), soil fertility depletion, soil acidification and diminished crop yields. Production in grasslands may also contribute to greenhouse gas emissions enhancing climate change (IPCC, 2022; Troy et al., 2013) particularly CO_2 and N_2O due mineralization of SOM (Danevčič et al., 2010). Urgent action is necessary to address nitrate leaching, and CO_2 and N_2O emissions in mixed dairy systems. The study compared raw and thin manures.

Soil column experiments are significant for studying the fate and movement of NO_3 as well as greenhouse emissions. Moreover, the trials allow for precise measurement owing to the controlled environment and are cost-effective contrary to field studies. While the overall focus of the sub-project C3 is on soil carbon and nitrogen dynamics, this study enhanced collaboration with the team from sub-project C2. Sub-project C2 focuses on 'influence of organic fertilization intensity and crop rotation on greenhouse gas emissions.'

Collaboration with the students was done through:

- Experimental design and set-up
- Discussions on sampling strategy for NO_3, CO_2 and N_2O
- Lab analyses including fluorescence measurements of excitation emission matrices (HORIBA, Aqualog) for dissolved organic matter and NO_3
- Discussions on students' findings

General summary of results

The MP148 trials established in June 2023 involved data collection throughout the month (T0-T8) consisting of application of slurry and liquid manure, irrigation, as well as sampling of gas and leachates. Application of manure on grassland soil columns was done randomly. This report primarily focuses on findings related to the leachates. (Rohgülle-Raw, Dünngülle-Thin).

Analysis of variance (ANOVA) was done using R statistical software considering the different times of sampling. Tukey's Honestly Significant test was used for mean separation. Statistical significance was considered at $P \leq 0.05$. For uniformity/consistency data from T2 to T8 were evaluated.

Table 2 and Figure 1 and provide summaries of the project's results:

Table 2: Total N, ammonium N and nitrate N (mg/L) as influenced by manure application

Manure	Total N	Ammonium N	Nitrate N
Rohgülle High	3.5795ab	0.2852b	1.0181ab
Dünngülle High	4.1762a	0.2348b	1.2557a
Dünngülle Low	3.8433a	0.7800a	0.9362ab
Control	2.0848b	0.1124b	0.7547b
Significance level			
Manure	**<0.01**	**<0.001**	0.0107
Time	**<0.001**	0.0237	**<0.001**
Manure*Time	**<0.001**	**<0.001**	0.7216

Different letters within the columns indicate significant differences at 5% probability level. Bold P-values are significant at P < 0.05

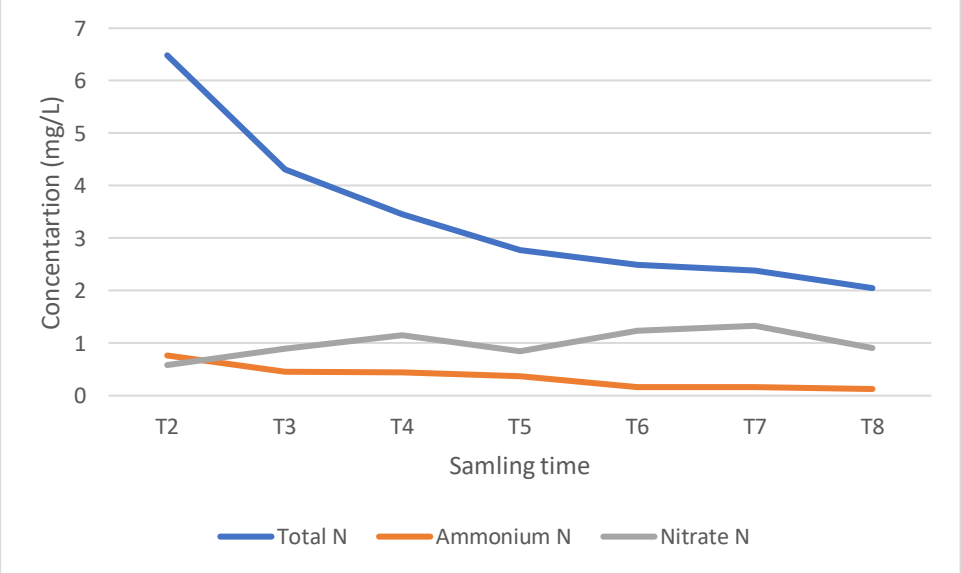

Figure 1 :Total N, ammonium N and nitrate N (mg/L) as influence by sampling time

Way forward: Further statistical analyses and review of relevant literature using the datasets from this project shall be done in consultation with Dr. Mulder. Depending on the data's quality, there's potential for a publication to emerge with a working title 'Nitrate Leaching and Greenhouse Gas Emissions under High Input Cattle Feeding Regime in a Grassland: A Soil Column Study.'

Project BP71

I worked with a group of undergraduate students in conducting a Tea Bag Index for carbon decomposition alongside Mika Hermes. Supporting the students was done through overseeing incubation and excavation of tea bags in the field.

Project overview: Soil organic carbon (SOC) is fundamental for agricultural production and climate change mitigation. Soil organic carbon is a pool for carbon storage and enhances soil physical, chemical and biological properties and processes (Blanco-Canqui et al., 2013). Having significance in the carbon cycle, soils store about 3 times more organic carbon than the atmosphere (Duddigan et al., 2020; Chappell et al., 2016) hence the need for sustainable soil management in agricultural systems. Manuring in mixed dairy systems contributes to SOM having a direct impact on SOC through decomposition. The Tea Bag Index is used to assess carbon decomposition giving insight on carbon sequestration for climate change mitigation (Keuskamp et al., 2013) and soil quality (Dossou-Yovo et al., 2021; Duddigan et al., 2020). The overall hypothesis of the project is application of manure results in changes in carbon decomposition rates and nutrient cycling.

The Tea Bag Index is currently ongoing, and the final excavation of tea bags is scheduled for mid-September 2023. The trial additionally involves microbial analysis to identify microorganisms involved in the decomposition process.

Seminars and trainings

I had the opportunity to attend a few seminars and trainings; presentations were made on the following topics:

i. 'Pharmaceutical assessment in Ishmi River Albania: Water treatment with magnetic biochar clay composites for diclofenac and heavy metals removal' by Aleksander Perquini
ii. 'Phytoremediation of pesticide contaminated soils and the transformation of chlorinated pesticides in plants' by Marigona Morina, JLU
iii. 'Terbuthylazine pesticide sorption on aged microplastics: An empirical evaluation' by Johanness Junck, JLU

iv. ‘Clearing Tropical Forests for Agricultural Production: Unravelling the Paradox’ by Gloria Esther Mbabazi, ATSAF Academy
v. ‘Can agroecology feed the world?’ by Lillian Beck, ATSAF Academy
vi. ‘Zotero referencing tool’ by University of Nairobi
vii. ‘Mentorship for Postgraduate Students’ by University of Nairobi (UON)
viii. ‘Open access resources and UON digital repository’ by UON
ix. ‘Green skills for youth: towards a sustainable world’ by Mastercard Foundation

Social engagements

Some of the social activities included a reception for international visiting scholars by JLU and hiking with the soil science team.

Photos

Setting up samples for ball milling

MP148 trial set up

Buried tea bags around red marker

High (left) and low (right) input cattle herds, Gladbacher Hof

Visiting scholars reception

Hike with soil science team

Outputs and insights gained from activities:

- 216 grassland samples have been processed for analysis of soil moisture, texture, water-extractable organic matter, fine particulate organic matter, and C:N ratio.
- Hands-on experience with soil sampling and preparation for analysis of the aforementioned parameters.
- Involvement in universitarian teaching structure and student work project through:
- Lab and fieldwork guidance to undergraduate students (TBI trial).
- Input to master's students' hypothesis and proposal presentations and methodology for N losses soil column trials
- Gained knowledge and skill in operation of Horiba Aqualog for fluorescence measurement.
- Collaboration and teamwork skills and experience through working with international lecturers, students and other IFZ staff.
- Exposure to German socio-cultural environment through interactions at the institute, seminars, and other social engagements.

Challenges and recommendations

i. Accommodation

Securing a place to stay was quite challenging. While the host institute did make commendable efforts to assist, there is room for improvement. In this regard, I recommend that ATSAF consider establishing collaborative arrangements with host institutes to ensure that accommodations are effectively arranged well in advance of scholars' arrivals. This proactive approach would significantly contribute to a smoother transition for interns and create a more conducive environment for focused engagement in their work.

ii. Communication gaps

Due to the language barrier encompassing both German and English, certain communication challenges became evident. To mitigate potential misunderstandings or lapses in verbal exchange, I propose the provision of resources, particularly lab procedures, in English. This measure would help avoid confusion that might arise due to language differences and eliminate the need for translators, which can introduce a degree of distortion. Hence, it is advisable for the host institute to focus on ensuring that essential resources are accessible and comprehensible in English. Additionally, it's worth noting gaining German language proficiency may not be feasible for short-term visiting scholars.

Conclusion

My time at the Department of Soil Science and Soil Conservation, JLU, marked a transformative phase in my academic and professional journey, facilitating profound growth and learning. The invaluable skills, principles, knowledge, and practical experience I acquired are significant for socio-economic progress and environmental sustainability. I look forward to these insights in practical contexts.

I am optimistic that the suggestions I've provided will lay a firm foundation for the continual enhancement of the Junior Scientists program. I am grateful for the opportunity and support accorded to me by ATSAF Academy, JLU and the Alliance-CIAT.

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