Proposal Application Form
2022–2023 TWRI Graduate Student Research Programs

Basic Information

1. **Title** of proposal.

   Evaluating the Influence of Cover Crop Selection on Agricultural Runoff Quality and Nutrient Leaching in Soils for Crop Production

2. **Student** name, contact information (email and phone number), university, department, degree being pursued as well as degree starting year and expected year of graduation.

   Stephanie deVilleneuve, ruff724@tamu.edu, 512-221-7498 (cell)
   Texas A&M University/Soil and Crop Sciences/PhD. in Soil Science
   Started January 2021, anticipated graduation is December 2024

3. **Faculty advisor or committee chair** name, title, contact information (email and phone number), university and department.

   Advisor: Dr. Julie Howe, Professor (julie.howe@ag.tamu.edu, 979-845-3814), Texas A&M University, Soil and Crop Sciences

4. **Which program(s) are you applying for (only select one option)?** In addition, please also indicate, if applicable, if you are not eligible for Mills due to eligibility restrictions.

   _X_ Mills Scholarship Program (Texas A&M, Galveston or Qatar only; tuition only)

5. **Have you received either the Mills Scholarship or USGS Research Program funds before?**

   No

6. **Would these funds be initiating new research or supporting ongoing research?**

   The funds would be initiating new research. Currently, I am in the process of setting up my experiments in a greenhouse on campus and completing a literature review of the research topic. I plan to begin my greenhouse experiments in Fall 2022.

7. **Focus Categories**. Choose a maximum of three focus categories from the list provided (Attachment A) with the most preferred focus category first.

   Agriculture, Water Quality, Nutrients

8. **Research Category**. Choose one category from the following list that most closely applies:

   Water Quality

9. **Keywords**. Enter keywords of your choice that are descriptive of the proposed work.

   Cover crops, nutrients, runoff, water quality, leaching, mineralization, greenhouse, lysimeter, residues, C:N, lignin, soil

10. **Congressional District** of the university where the work is to be conducted.

    Texas' 17th Congressional District

11. **Abstract**. Please provide 200 words or less about your proposed research problem, methods and objectives, and describe how your research will address the research priorities.

    Helping stakeholders find new ways to combat nutrient concerns in local water bodies is a constant struggle for watershed coordinators. Previous studies have shown that implementing cover crops as a

management strategy will help reduce nutrients in runoff and prevent leaching, but few have investigated the potential impacts of the cover crop residue characteristics on water quality. As a response to this data gap, the main objective of this proposed research is to identify the characteristics of selected winter cover crops' residues that may help reduce nutrient quantities in runoff and mitigate leaching. To accomplish this goal, leachate and runoff will be collected from 24 greenhouse lysimeters containing soil and six different treatments of cover crop types/mixes. Each treatment will be replicated four times using a Randomized Complete Block Design (RCBD). Samples from all treatments (cover crops, residues, and subsequent crop) will be analyzed for nitrate, ammonium concentration, Total N, and the atom percent of 15N fertilizer in the leachates. The residues will be analyzed to evaluate total biomass, nutrient content (N, P, K), C and lignin content. C:N ratios will also be calculated for each residue type.

12. **Description of your research proposed research**, emphasizing how it will address water resources-related concerns (particularly how, if possible, it will benefit Texas), including:
    a. **Statement of critical regional or state water problem**. Describe how your research will address RFP research priorities and explain the need for the project, who wants it and why.

    According to the *2020 Texas Integrated Report* (TCEQ, 2020), 403 stream segments and reservoirs out of the 864 assessed were listed as having nutrient concerns. While the State of Texas does not currently have approved numeric criteria for nutrients it is still important to watershed coordinators and stakeholders to prioritize the protection of water bodies from excessive nutrient loadings. If too many nutrients, particularly nitrogen and phosphorus, are added to surface water they can cause severe algal growth (NOAA, 2009). When algae decay, the oxygen in water is depleted overtime which can lead to the death of fish and other aquatic animals. This process is known as eutrophication.

    There are many natural and human-influenced factors that contribute to elevated levels of nutrients in surface water. This research will focus on nutrient inputs from agricultural runoff. A 2011 study concluded that one of the largest contributors of nitrogen (N) in Lower Mississippi Texas-Gulf region streams was commercial fertilizer (20%) (Rebich et al., 2011). The application of fertilizer is a major component in farming operations because it is used to promote crop growth and enhance soil health. If watershed producers are open to implementing conservation-oriented agricultural practices, they can help mitigate fertilizer runoff and leaching by planting cover crops between regular growing seasons to act as a "trap crop" for nutrients. There have been numerous studies (Zhu et al., 1989; Sharpley and Smith, 1991; Gómez et al., 2011; Weyers et al., 2020; Hanrahan et al., 2021) that demonstrate the benefits of using cover crops to reduce leaching and nutrient quantities in runoff, but there is a gap in the research when it comes to identifying specific characteristics of cover crop residues that may impact runoff quality and leaching differently. Some examples of specific cover crop residue characteristics are lignin content and C:N ratios.

    Expanding on available knowledge from previous studies this research will investigate how aspects of different cover crop residue selections influence agricultural runoff quality and nutrient leaching. With nearly 50% of Texas water bodies categorized as having nutrient concerns it is imperative for researchers to find new ways for stakeholders and watershed coordinators to reduce the negative impacts of excessive nutrient loadings on aquatic ecosystems. This research objective directly addresses the Institute's research priorities in "addressing major water quality impairments in Texas, which include bacteria, dissolved oxygen, mercury and other hazardous contaminants"

Gómez, J.A., Llwellyn, C., Basch, G., Sutton, P.B., Dyson, J.S., Jones, C.A., 2011. The effects of cover crops and conventional tillage on soil and runoff loss in vineyards and olive groves in several Mediterranean countries. Soil Use and Management, 27: 502-514.

Hanrahan, B.R., King, K.W., Duncan, E.W., Skedekar, V.S., 2021. Cover crops differentially influenced nitrogen and phosphorus loss in tile drainage and surface runoff from agricultural fields in Ohio, USA. Journal of Environmental Management, 293: 112910.

Rebich, R.A., Houston, N.A., Mize, S.V., Pearson, D.K., Ging, P.B., Hornig, C.E., 2011.Sources and Delivery of Nutrients to the Northwestern Gulf of Mexico from Streams in the South-Central United States. Journal of the American Water Resources Association, 47: 1061-1086.

Sharpley, A.N., Smith, S.J., 1991. Effects of cover crops on surface water quality. Cover crops for clean water, 41-49.

TCEQ, 2020. 2020 Texas Integrated Report of Surface Water Quality for the Clean Water Act Sections 305(b) and 303(d). Retrieved from: https://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/20txir/2020_303d.pdf. (Accessed 22 March 2022).

US Department of Commerce, NOAA, 2008. What Is Nutrient Pollution?. NOAA's National Ocean Service. Retrieved from: https://oceanservice.noaa.gov/facts/nutpollution.html. (Accessed 18 March 2022).

Weyers, S.L., Gesch, R.W., Forcella, F., Eberle, C.A., Thom, M.D., Matthees, H.L., Ott, M., Feyereisen, G.W., Strock, J.S., 2020. Surface runoff and nutrient dynamics in cover crop–soybean systems in the Upper Midwest. Journal of Environmental Quality, 50: 158-171.

Zhu, J.C., Gantzer, C.J., Anderson, S.H., Alberts, E.E., Beuselinck, P.R., 1989. Runoff, Soil, and Dissolved Nutrient Losses from No-Till Soybean with Winter Cover Crops. Soil Science Society of America Journal, 53: 1210-1214.

b. **Statement of expected results or benefits**. Specify the type of information that is to be gained and how it will be used.

The expected result from this study is the identification of specific cover crop residue traits that influence nutrient leaching and runoff quality. The results from measurements taken during the life cycle of the cover crops and subsequent cash crop will also be compared to the residue data to determine which phase has the greatest impact on runoff quality and the reduction of leaching. Overall, the information gained will give more context to watershed producers when they are making decisions about which cover crops and residues they should utilize to help reduce their contributions to surface water nutrient loadings.

c. **Nature, scope and objectives of the research, including a timeline of activities**. This is the major emphasis of your proposal

The influence of cover crop residue characteristics on runoff quality and leaching remains poorly understood. The scope of this study is to use lysimeters in a greenhouse to test differences between types of winter cover crops/mixes (winter pea-oat/rye) on nutrient quantities in runoff and leaching. While it is well known that cover crops help with both the reduction of nutrient

leaching and the minimizing of runoff in between regular growing seasons, having more insight regarding the influence of their residues on water quality during this time is important for a wholistic understanding. This is especially true if producers are concerned about nutrient loadings in surface water. The goals of the research are as follows: a). investigate the relationship between cover crop residue selection and nutrient leaching as well as runoff quality; b). determine the effect of cover crop residue selection on nitrogen mineralization and nutrient availability for the subsequent crop. Another objective of the project is to compare runoff and leaching analysis data for each phase of the treatments (cover crop, residues, and subsequent crop). This comparison will provide more information about the timing of nutrient losses. This project will be completed over the course of two years. Cover crop planting in the greenhouse will begin in Fall 2022 for year one. All measurements will be collected and analyzed by Spring of 2023. The data for year two will be collected during the same time frame to ensure it's comparable.

d. **Methods, procedures and facilities**. Provide enough information to permit evaluation of the technical adequacy of the approach to satisfy the objectives.

This study will be conducted in a temperature regulated greenhouse on campus during the late Fall and Winter months of 2022 and 2023. Twenty-four lysimeters filled with soil will have flumes and tubing to capture runoff and leachate (Figure 1). Before any cover crops are planted the soil will be tested to determine base nutrient content. Six cover crop treatments will then be planted in the lysimeters and replicated four times using a RCBD. The treatments being used in the study are: 100% oat/rye, 100% winter pea, 20%/80% oat/ rye-winter pea, 80%/20% oat/rye-winter pea, 50%/50% oat/rye-winter pea, and none (control). All treatments will be fertilized with 15N fertilizer. Each treatment will receive water every 2 weeks and soil moisture probes will be installed in each lysimeter. When each drainage and runoff event occur, the leachate and runoff will be collected and taken to the lab for nitrate and ammonium concentration analysis. This will be done using ion exchange chromatography and automated flow injection analysis. Total N and the atom percent of 15N in the leachates will be determined by isotope ratio mass spectrometry. Total volumes for leachate and runoff will also be recorded after each event. After eight weeks, the crop will be terminated and the whole residues returned to the soil. During the time the residues are applied, water will be added to the soil to simulate rainfall events. The frequency and duration of these events will be decided based on historical climate data for the area. Leachate and runoff will also be collected and analyzed during this time. A subsequent cash crop (cotton) will be planted two weeks after the cover crops are terminated and the same chemical analysis of runoff and leachate will be conducted for four weeks. Immediately prior to the subsequent crop being planted the residues will be analyzed to evaluate total biomass, nutrient content (N, P, K), C content, and lignin content. C:N ratios will also be calculated for each residue type.

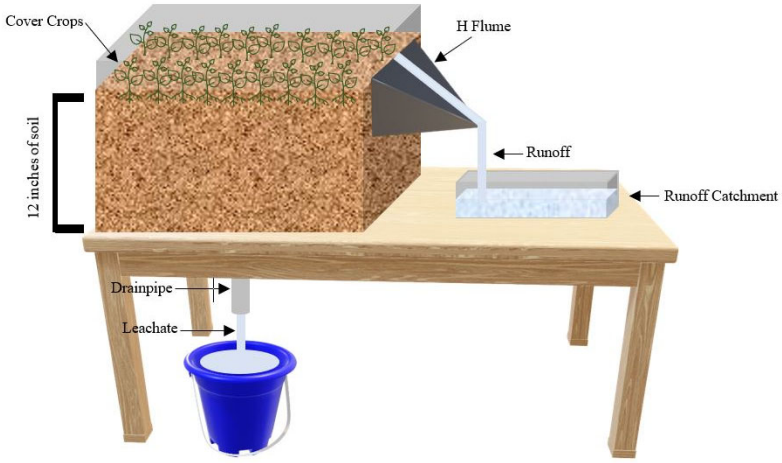

Figure 1. Lysimeter set up

13. **Related research**. Show by literature and communications citations the similarities and dissimilarities of the proposed project to completed or ongoing work on the same topic.

    Kaspar, T.C., Radke, J.K., Laflen, J.M., 2001. Small grain cover crops and wheel traffic effects on infiltration, runoff, and erosion. Journal of Soil and Water Conservation, Soil and Water Conservation Society, 56: 160-164.

    Korucu, Tayfun, Shipitalo, M.J., Kaspar, T.C., 2018. Rye cover crop increases earthworm populations and reduces losses of broadcast, fall-applied, fertilizers in surface runoff. Soil and Tillage Research, 180: 99-106.

    Liu, J., Macrae, M.L., Elliott, J.A., Baulch, H.M, Wilson, H.F., Kleinman, P.J.A., 2019. Impacts of Cover Crops and Crop Residues on Phosphorus Losses in Cold Climates: A Review. Journal of Environmental Quality, 48: 850-868.

    Lozier, T.M., Macrae, M.L., Brunke, R., Van Eerd, L.L., 2017. Release of Phosphorus from Crop Residue and Cover Crops over the Non-Growing Season in a Cool Temperate Region. Agricultural Water Management, 189: 39-51.

14. **Training potential**. Estimate the number of graduate students and undergraduate students, by degree level, who are expected to receive training in the project.

    1 PhD student

15. **Intended career path** you anticipate pursuing.

    Investigating the impacts of nutrients from agricultural practices on both soil health and surface water quality is my research passion and I hope to be able to continue this type of work in my future professional endeavors. I began working as a Graduate Research Assistant with the Texas Water Resources Institute (TWRI) during my Master's and I wanted to explore a different aspect of water quality issues than I had previously by pursing a PhD in Soil Science. Currently, I work full-time at TWRI and I manage projects that primarily focus on mitigating bacteria impairments and nutrient concerns in watersheds across the state of Texas. Through these projects I have been exposed to the importance of collaboration and working towards improving our management of water resources. To continue in this specific field, I intend to pursue a career as a research scientist with an agency.

Ultimately, my goal is to use the skills and knowledge I gain from my doctoral studies to pursue research and extension opportunities that combine both water quality and soil health.

Other Required Information

16. **Academic qualifications of the student:** current degree plan/grades, unofficial transcript or list of courses taken and grades.