PMUSER

Proceedings of Manitoba's Undergraduate Science and Engineering Research

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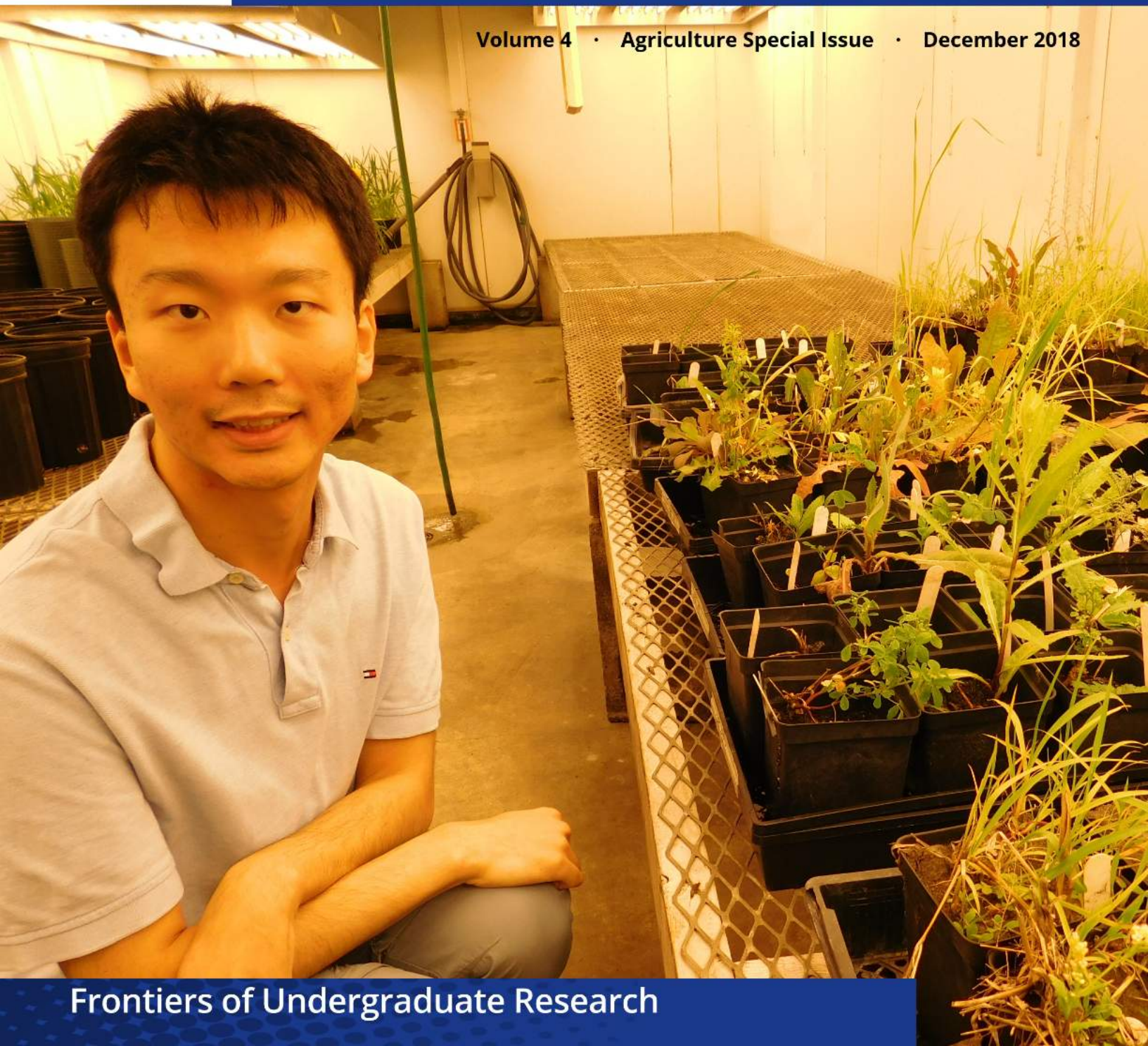

Frontiers of Undergraduate Research

Inside

From the Editor-in-Chief

Volume 4 of *PMUSER* brings a number of firsts, including our first-ever special issue. And I'm excited to share this Agriculture-themed special issue with you! Agriculture is a large and vital part of Manitoba's economy and so, with our focus on undergraduate research related to science throughout Manitoba, this is a meaningful first special issue.

Inside you'll find undergraduate student perspectives on research in agriculture, a photo feature of graduate students reflecting on the value of research, and a feature article on a beef cattle research program. Join me in flipping the page to recognize the students and their research featured within, and in eagerly awating the next special issue which, along with every issue *PMUSER* publishes, will continue to showcase students and their successes while we provide opportunities for authors, peer-reviewers, and editors.

Thanks for reading,

Matthew J. D. Doering
PMUSER Editor-in-Chief

Proceedings of Manitoba's Undergraduate Science and Engineering Research

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About PMUSER

Proceedings of Manitoba's Undergraduate Science and Engineering Research (*PMUSER*) is an open-access refereed journal that is published annually and hosted by the University of Manitoba. The journal accepts research or review manuscripts written by undergraduate students from any science or engineering related faculty or manuscripts on any topic concerning or related to science or engineering. Upon submission, each manuscript undergoes a double blind peer-review process by two undergraduate/graduate students from a pool associated with the respective research area. Our mission is to provide opportunities for student communities to explore the frontiers of undergraduate research and add additional value and learning opportunities to students' degree programs through rigorous exploration, analysis, and presentation.

Aims & Scope

The focus of *PMUSER* is three fold: author, reviewer, editor. Through preparing and revising a manuscript, students are recognized for their research, have an opportunity for out-of-classroom learning, and further develop communication skills. Through learning the role of a peer-reviewer and reviewing manuscripts, students learn to critically evaluate the scientific literature and to critique ideas in the broader world. Through the editorial board, an interdisciplinary team arises to provide mentorship to undergraduate students and valuable leadership and teamwork skills. The three prongs of our focus unite in preparing students for careers in science or beyond, and the stepping stones to get there. Available online: http://ojs.lib.umanitoba.ca/pmuser/about/editorialPolicies#focusAndScope.

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Instructions for Authors

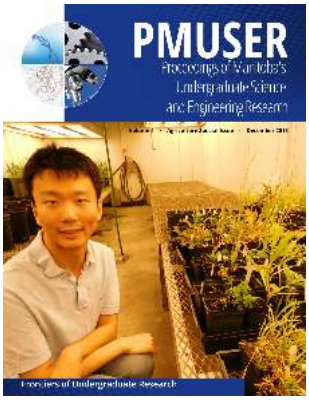
Undergraduate authors are encouraged to submit research or review articles in or related to any science or engineering discipline. Detailed instructions are available online: http://ojs.lib.umanitoba.ca/pmuser/about/submissions.

Peer-Reviewers

PMUSER's peer-reviewers apply each year and are primarily graduate and undergraduate students, with expertise supplemented by faculty. Training is provided through a University of Manitoba Co-Curricular Record certified workshop. Those interested in reviewing for the journal should email the editor-in-chief for application forms. Peer-reviewers for Volume 4 were: John P. Aguilar, Sarah Arnold, Jun Bae, Kevin R. Bairos-Novak, Tom Booth, Jennifer Doering, Keri Everitt, Kristen Fleet, Andrew Hogan, Kat Kratzer, Janelle Boram Lee, Duc Minh Nguyen, Franklin Ogidi, Michaela Palmer, Davinder Partola, and Rani Ramachandran.

About the Cover

The cover image features Zijing Guo, 2018 graduate of the agroecology program of the Faculty of Agricultural and Food Sciences at the University of Manitoba. Guo is featured in a profile in this special issue and submitted a research paper, based on his undergraduate research project, to *PMUSER* in 2018.



Proceedings of Manitoba's Undergraduate Science and Engineering Research
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Editorial

Agriculture Production and Quality of the Environment

Nicholson N. Jeke[1]

[1]Dept. of Soil Science, Faculty of Agricultural & Food Sciences, University of Manitoba, Winnipeg, MB, R3T 2N2
Corresponding Author: N. Jeke (jeken@myumanitoba.ca)

Increasing intensity of agriculture production while minimizing the environmental footprint is one of the challenges facing the agricultural sector. Canada is one of the largest agriculture producers and exporters in the world. As the global population increases, it is essential to provide more food, fuel, and fiber for the increasing demand, while maintaining the quality of the environment.

Farmers are increasingly aware of the impacts that agriculture production can have on the quality of soils, water, air, and biodiversity. Information systems to help decision making, policies, and programs have been put in place to achieve environmental sustainability of Canadian agriculture. How has Canadian agriculture performed in achieving environmental sustainability?

Agri-environmental indicators have been developed to measure the agriculture and agri-food sector's environmental performance for soil, water, and air quality and farmland management. According to the Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series — Report #4 (2016), soil quality, as indicated by soil erosion, organic matter, and salinization indicators, has improved considerably over the last 30 years. This was attributed to improvements in land management practices such as reduced tillage, no-till practices, and a reduction of the area under summerfallow. On the other hand, indicators of water quality showed a trend of increasing risk of water contamination as shown by the deteriorating nitrogen, phosphorus, pesticides, and coliforms indicators.

Risk of water contamination was attributed to the increased application of nitrogen and phosphorus as fertilizer and manure, and the increased use of pesticides. Considering various agricultural emissions together (agricultural greenhouse gas, agricultural ammonia, and particulate matter indicators), agricultural performances in air quality have been relatively stable between 1981 and 2006, and significantly improved to 2011. In general, these findings indicate that the Canadian agriculture sector is progressing towards environmental sustainability.

Farmers are good environmentalists and are doing their part in taking care of the land. While further efforts are needed to maintain the quality of the environment, it appears that more effort is needed in nutrient management to reduce water quality issues. Is there room left for nutrient management within the existing agricultural production systems?

The flow of nutrients such nitrogen and phosphorus into lakes and rivers can increase algal blooms and reduce water quality. In Manitoba, nutrient loading is a huge problem on Lake Winnipeg, and many waterbodies throughout its drainage basin. Agriculture has a role to play in nutrient management and agriculture's share of nutrient loading comes from commercial fertilizers, livestock manure, vegetative residues and the soil. Researchers are developing practices to increase nitrogen and phosphorus use efficiency, reduce runoff, and retain these valuable nutrients on farmland.

Manitoba has some of the most stringent nutrient management regulations in Canada which aim to maximize agronomic benefits while minimizing environmental risks. Regulation of phosphorus application, restriction of winter application of fertilizer, manure and biosolids, and encouraging manure injection and incorporation are some of the several paths that aim to reduce nutrient loses from farmland in Manitoba.

Current scientific knowledge of nutrient management and water quality supports the importance of using the right rates, timings and placements of all sources of agriculture nutrients. Continuing investing in research will help to monitor and refine nutrient management practices. Researchers have opportunities to contribute to developing public policy on the issues affecting water quality while serving on various committees and task forces.

Studies in Manitoba have shown that managing phosphorus loss with traditional soil and water conservation beneficial management practices (BMPs) which reduce soil erosion may increase loss of dissolved phosphorus loss to surface waters, where erosion is not the main cause of phosphorus loss. For example, keeping crop residue on the soil surface or having vegetation buffers may reduce soil erosion, but vegetative phosphorus loss can occur during snowmelt as phosphorus dissolves from plant matter into the water.

Therefore, BMPs used to address water quality problems will differ with different environments e.g. rainfall dominated systems with soil erosion issues vs snowmelt runoff on prairies. No beneficial management practice will be a solution for all issues associated with water quality problems. Scientific knowledge to maximize benefits and minimize trade-offs of BMPs is crucial. This may require the evaluation of each problem and potential management practices need to be evaluated to consider all the benefits and side effects.

Agri-environmental indicators suggest that at the national level, the Canadian agriculture sector is progressing towards environmental sustainability. However, objective and useful information will continue to be required to help inform decision making on the farm and for policy and program development. Development of appropriate BMPs that are suited for local environments will be important.

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Perspectives

Agroecology is Important to Ecological Practices

Karine Ferguson[1]

[1]Dept. of Soil Science, Faculty of Agricultural & Food Sciences, University of Manitoba, Winnipeg, MB, R3T 2N2
Corresponding Author: K. Ferguson (karine.ferguson@hotmail.com)

What is Agroecology? This is a question I've been asked many times by family and friends wondering what I've been studying in university. When I first said I'd be transferring from the science program at the University of Saint-Boniface to Agroecology at the University of Manitoba I got a few quizzical looks. As a person who grew up in Winnipeg, this program intrigued me because I wanted to learn more about my surroundings here in southern Manitoba — which is largely agricultural land. The combination of studying agriculture and striving to protect the environment seemed ideal to me.

Over the years, I have come to understand that Agroecology is an approach to integrate more ecological practices into our food production systems. An important part of this system is to find ways to deal with the waste and end-products. This topic was interesting to me and was the focus of my undergraduate research project. With the mentorship of Dr. Francis Zvomuya in the Soil Science Department, I set up a growth room experiment using switchgrass to examine phytoremediation of biosolids as an alternative method to spreading biosolids on agricultural land when municipal lagoons are decommissioned.

Municipal lagoons are a common form of wastewater treatment in small and medium-sized communities. Sludge accumulation at the bottom of municipal lagoons gradually reduces wastewater treatment efficiency and will eventually require removal. Biosolids (stabilized sewage sludge) provide beneficial plant nutrients and can reduce the need for commercial fertilizers, thus providing an economic benefit to farmers. However, finding suitable land within economic distances to spread the biosolids can be difficult in Manitoba because land application of biosolids faces competition for land from hog manure production. Another alternative, trucking of biosolids to landfills, can be unaffordable for small communities with limited budgets. Therefore, the use of plants to remove nutrients and contaminants from biosolids is a promising alternative to land spreading and landfilling of biosolids. My research project therefore looked at the potential of using switchgrass (a native perennial grass in the prairies) for the remediation of heavily contaminated soils such as biosolids.

Undertaking a research project as an undergraduate student had many personal and professional benefits. It broadened my professional network because I had the opportunity to work with professors, technicians, and students in the Soil Science Department that I wouldn't have interacted with or met otherwise. This experience therefore taught me how to balance independence and collaboration in the lab. For students who are just starting their research project, I would tell them to seek feedback and guidance from their advisors as often as possible. They have years of experience conducting research and are so knowledgeable.

Karine Ferguson (left) and Morgan Hope (right) collecting biosolids at the municipal lagoon in Niverville, MB.

An undergraduate research project also taught me important time management skills. Adding a research project to classes and extracurricular activities forced me to manage numerous responsibilities at once. I therefore learned how to manage my time efficiently without completely stressing myself out. For me, one of the most difficult parts of the project was understanding and analyzing the statistical results. This takes a lot of patience and it is important to remember that it is impossible to do everything at once. An undergraduate research project therefore helped me understand published works and statistical analysis. This will be incredibly beneficial for me if I decide to take on a master's program.

Finally, undertaking an undergraduate research project can seem like a daunting task and it's true that it is a lot of work, but it is worth it in the end. Presenting your work to an audience is intimidating, but it is a great opportunity to practice your public speaking skills in a professional setting. Looking back, I know that my perseverance and organization skills were key in completing this project and obtaining the Agroecology medal at my graduation. If everything goes well (and it will in the end), working on a research paper will feel like a very rigorous yet satisfying lab where you accomplish something that you are proud of.

Program Profile

U of M Agroecology Program Fosters Undergraduate Research

In the 2016 report of its strategic research plan, the University of Manitoba's Faculty of Agricultural and Food Sciences identified its strengths, and its plans to ensure that research remained central to its priority: "Driving Discovery and Insight".

This plan was part of the effort to maintain innovative research and uphold a reputation that will promote intra- and inter-faculty collaborations, as well as external collaborations. The faculty recognizes the importance of the strategic research plan not only in the ever-changing Canadian agricultural and food industry, but also in the diminishing baseline of resources in the university.

Undergraduate programs in the Faculty of Agricultural and Food Sciences have always placed importance on undergraduate research, but its Agroecology program fosters undergraduate research in a remarkable way.

On March 23, 2018, this year's batch of Agroecology undergraduate thesis students presented their original research findings at the Ellis building, Department of Soil Sciences and Food Sciences, University of Manitoba. In its endeavor to highlight undergraduate research, research-related events, and researcher profiles, *PMUSER* interacted with the thesis course instructor and this year's undergraduate thesis students.

Dr. Brian Amiro, U of M Faculty of Agricultural and Food Sciences professor, has been the instructor of the thesis course for 12 years and he described the structure of the thesis program that makes it an invaluable experience for the students.

> It's more than just a thesis, it's really preparing that student for a future career

PMUSER: What is unique about the Agroecology program?

Amiro: All the programs in the Faculty of Agricultural and Food Sciences are four-year degrees, but the Agroecology program is the only one with a thesis; other programs have projects or practicums.

In this program, we start getting students ready for their thesis project in their third year. We do that in a formal course (AGEC 3510) that's required for students in the program, and in that course, there's a literature review required. In that time, we set them up with a mentor who will be working in their basic area of interest [...] where they develop their ideas. This prepares them for their fourth-year thesis [in the AGEC 4550 course]. When students at the university do a thesis, they are actually producing original work [...] it is what you call a very high learning outcome level. In our program, the ability to do this has been kept alive by very dedicated mentors.

In the fourth-year formal course [AGEC 4550], spanning the fall and winter terms, we help students produce that thesis research product. As part of the course we also have sessions, typically every two weeks, where we address other learning outcomes like ethics and professionalism, how to do a presentation, how to interpret an advertisement for a job, and how to go about applying for a job. It's more than just a thesis, it's really preparing that student for a future career.

PMUSER: What opportunities are there in the Agroecology program?

Amiro: We have a large range of possible projects depending on student interests and on what the mentors and the students actually discussed together. The students, depending on who your mentor is, may work in the fields, or in the laboratory, or in data mining. Over the years, the mix [of possible projects] has changed a bit.

We try to accommodate what students are doing with activities, for example if they have a summer job and can collect a dataset, that might be suitable for [their] thesis. Other students may work with the mentor's graduate students or technicians. The students may also build on the dataset that someone else collected and do some original work.

Undergraduate theses presented March 2018

Lindsey McKenty (Advisor: Dr. David Lobb, Soil Science): *Testing Soil Pre-treatment Handling Techniques for Total Phosphorus in Wetland Soils*

Carley Van Osh (Advisor: Dr. Brian Amiro, Soil Science): *Ecosystem Impacts of Autonomous Chicken Coops*

Samuel Steinmann (Advisor: Dr. Mario Tenuta, Soil Science): *Four Crops Grown in Manitoba and the Nitrogen Use Efficiency*

Zack Koscielney (Advisor: Dr. Emma McGeough, Animal Science): *Suitability of Seven Annual Crops for Stockpile Grazing on the Canadian Prairies*

Zijing Guo (Advisor: Dr. Rob Gulden, Plant Science): *Study of Competitiveness Between Reed Canary Grass and Purple Loosestrife in a Replacement Series*

— David Zirangey

Originally published at pmuserjournal.wordpress.com

"Research provides the potential for breeding and the development of cultivars with specialized seed protein characteristics. With an increasing population, it is important to develop more diverse sources of plant-based protein."

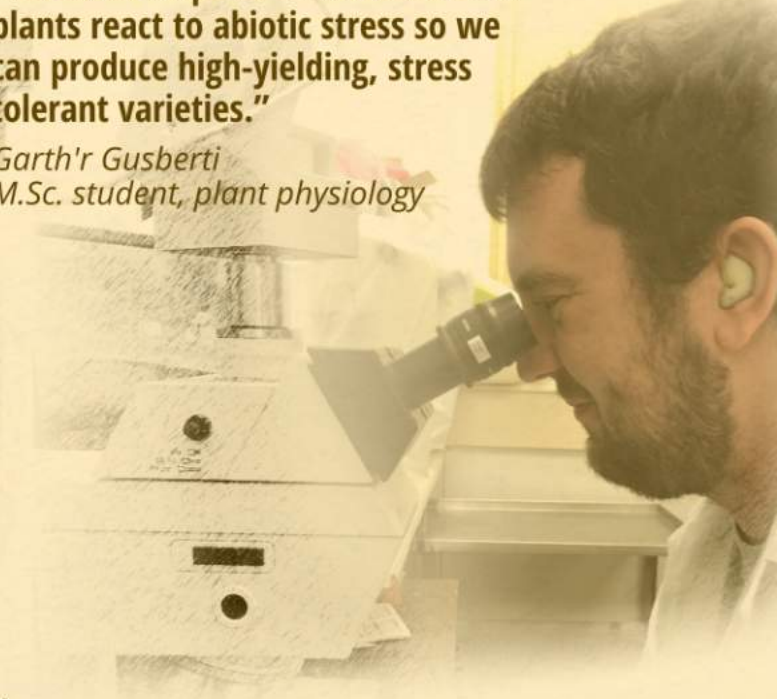
Ashley Ammeter
M.Sc. student, canola breeding

"Research drives agricultural production."

Daniel Chan
M.Sc. student, canola breeding

"Research helps us understand how plants react to abiotic stress so we can produce high-yielding, stress tolerant varieties."

Garth'r Gusberti
M.Sc. student, plant physiology



"Research helps us better understand herbicide resistance and plan weed control for the future."

Deanna McLennan
M.Sc. student, weed science

Seeing the Value of Re

By Kenny So, Ph.D. candidate, Dept. of Plant Science, Facult

"Research helps us improve production practices to reduce the influence of plant stress on yield"

Leanne Koroscil
M.Sc. student, weed science

"Research helps breeders make faster and more informed decisions so they can produce better varieties for farmers."

Jia Sun
Ph.D. candidate, canola breeding

"Research helps develop disease resistant varieties for farmers to reduce fungicide use."

Yang Lin
Ph.D. candidate, wheat breeding

"Research helps farmers to improve weed management practices on their farms to delay herbicide resistance."

Jonathan Rosset
M.Sc. student, weed science

esearch in Agriculture

y of Agricultural and Food Sciences, University of Manitoba

Features

Research Team Tackles Global Warming Using Inedible Grain By-Products

It is mid-July at the Glenlea Research Station, just east of highway 75. The station is home to the U of M Faculty of Agricultural and Food Sciences research, teaching, and outreach facility where the Agricultural Greenhouse Gas Program (AGGP) is underway. AGGP will advance our understanding of how cattle production systems can be better managed to reduce the emission of the greenhouse gases (GHGs) methane (CH_4) and nitrous oxide (N_2O).

U of M master's student Rhea Teranishi is leading the tour of the station where the AGGP research steers are housed. Approaching the pens, the unmistakable scent of cattle farm gently caresses your nostrils, an inextricable concoction of fresh manure, hay, and cattle. It is almost 10 a.m. A concrete platform lies adjacent to the pens; it doubles as a work area and as storage for equipment and dry hay. The roof of the platform provides shade for the cattle at midday, but, farthest from the roofed platform, the pens remain unshaded to allow the cattle to move between the shaded and unshaded areas as they cool off and warm up. There are 24 steers in total, eight per pen. On entering the platform two more silhouettes appear and quickly become visible — they are undergraduate students Kara Fulawka and Melanie Roulin.

Having spent the last few days doing lab work and data analyses at the U of M animal science department, being in the field is one of the best parts of working on the AGGP.

This morning Fulawka and Roulin are emptying uneaten hay from feed bins and replenishing with fresh hay.

Both Fulawka and Roulin, along with a third undergraduate student — Katherine Green — worked with master's student Sidonie Robinson on an earlier part of the project where they sampled rumen from the stomachs of steers.

The rumen is one of the four stomach compartments of ruminant animals like cattle. When they first consume feed, the partially-chewed feed goes to the rumen — the first and largest of the four stomach compartments — for the first round of digestion. In a process unique to ruminant animals, the partially-digested feed is returned to the mouth for further and more thorough chewing. The animal swallows the feed and it returns to the rumen, then the other three stomach compartments for complete digestion. The rumen, also called a fermentation vat, contains acidic digestive fluid and is rich in billions of microbes that help break down feed. One major by-product of the digestion and bacterial activity in the rumen is CH_4 gas — one of the greenhouse gases whose excess in the atmosphere is causing global warming.

In the rumen-sampling phase, the team — led by Kim Ominski, U of M animal science professor — compared different by-products from cereal and oilseed processing to see which ones were most digestible, released the least amount of CH_4, and had the highest efficiency in releasing nutrients to the animals. The AGGP project is now at the "animal trial and selective feed technology" phase where these grain by-products have been compressed into pellets and are being fed to the steers. The steers are then monitored to see which experimental treatments they find most appealing. Their breath will be collected to measure how much CH_4 is released from their rumen during the digestion of the pellets. The hay bedding of the pens is also high in microbial activity. The warmth of the bedding favors the growth of these microbes which naturally help breakdown cattle feces, releasing nutrients into the soil and N_2O, a by-product, into the atmosphere. The hay bedding will also be studied to measure how much N_2O is normally released and how each feed supplement influences the amount released during the microbial breakdown of feces in the bedding. Like in fecal decay, many sources of N_2O are from natural bacterial activity on nitrogen and nitrogenous compounds in the soil. Excess use of nitrogenous fertilizers are a major source of N_2O.

GHGs in moderate amounts provide a protective layer in the earth's atmosphere to trap ultraviolet (UV) radiation from the sun, thereby protecting the earth from damaging effects of UV radiation. In excess amounts, however, these gasses trap excess UV and store it as heat, causing 'global warming' with effects manifesting as 'climate change'. The three GHGs that significantly contribute to global warming are carbon dioxide, CH_4, and N_2O. Methane and N_2O are 23 and 296 times more potent than carbon dioxide in trapping UV radiation. Current agricultural systems in Manitoba are overwhelmingly responsible for the production these two high global-warming-potential gases. But our transport and energy sectors are equal culprits in the total greenhouse gas production, together accounting for more than half of total greenhouse gas emissions.

Ominski and her students are conducting this study to monitor if and how diet changes affect CH_4 emission from cattle and N_2O emission from stockpiled manure.

Back at the station tour with Teranishi, Fulawka and Roulin are almost done replenishing the bins; the steers have not glanced their way. The fresh hay does not interest them; they're distracted. Fulawka and Roulin are unsurprised. At the other side of the pens the sound of hooves shuffling against the hay-bedding betrays the excitement among the herd. The rhythmic opening and shutting of metallic sensor-controlled gates is as audible as the shuffling. The steers have

all rallied around a new piece of technology, the SmartPro feed delivery systems, as it dishes out tasty treats.

"What each [steer] has is a Radio Frequency Identification (RFID) tag," began Teranishi, as she showed the research setup. "In the smart feed system there is a sensor in there that will read the tag, see if it is that certain animal, and will let them into the feeder."

The SmartPro is a programmable feeding system loaded with grain pellets and programmed to allow each steer 1 kg of grain pellets per day. The steers are, however, allowed unlimited access to regular hay. There are three feed systems, one per pen, and each has a set of automated gates that allows only one steer access at a time. The RFID tag on the left ear of each steer keeps track of this allotment. When a steer approaches the system, sensors around the gates read the RFID tags and the gates instantaneously slide open to allow access. Each steer will return to the feed system multiple times.

"It is like they have an internal clock. They will recognize at 10:00 [every morning] that it is time to eat again," explained Kara Fulawka. "All eight [steers] per pen would have eaten their [1 kg feed pellet allotment] in 20 minutes." This is quite fast, given that they spend the rest of their day chewing their food a second time after it has been partially-digested in the rumen.

The system is so accurate it can keep track how much the steers eat over multiple feeding attempts, shutting it out once it has reached its 1 kg limit — only allowing steers that have yet to reach their daily allotment. Nevertheless, they will try a few more times after they are denied access.

At the start of the summer, all three undergraduate students started working with U of M master's student Brandon Hanson to track the health and vitals of the steers and to monitor their feed intake and weight progress using another system called GrowSafe. This system works in tandem with the SmartPro. The system has feed bins where hay is replenished regularly. Like the SmartPro, each feed bin also has a sensor which reads the RFID tags of the steers. Their daily intake and weight progress are tracked. The bins also have load cells that measure the amount of hay consumed by the steers based on the weight changes of the bins. The combination of the SmartPro feed, GrowSafe systems, and the frequent vitals and blood work helps to keep track of the health and wellbeing of the steers.

Manitoba is responsible for up to 90% of Canada's annual sunflower seed production, up to 75% of faba beans, 20% of flaxseed crop, 15% of wheat, 10% of barley, 20% of rye, and 25% of Canada's oats crop production. Manitoba also processes many of these grains and oilseeds.

These crops are processed into, for example, flour, pasta, bread, cooking oil, and malt to support domestic food production. Many of these cereal and oil seeds also generate export revenue. In 2017, exports from grain and oilseed milling in Manitoba generated revenue of over $1 billion, accounting for 38% of the total revenue from the exports of processed food and beverage products from Manitoba.

By 2020, the $400 million Roquette pea processing plant will begin operations in Portage la Prairie. The project will further strengthen Canada's position as one of the global leading pea producers and will increase the availability of by-products from processed grains. Some by-products cannot be consumed by humans but they can be used to supplement livestock diets. Processing of grains and oilseeds in Manitoba has made low-cost, by-products readily available to supplement cattle nutrition.

Some of these by-products are low quality while others are high quality. Ominksi's project is also exploring the digestibility of these different quality by-products as well as the amount of CH_4 produced during the digestion of different types of by-product. The potential of these grain by-products to be used to supplement cattle diet is being monitored with the aim of reducing the amount of CH_4 and N_2O that our current cattle production systems produce.

Cattle production systems are complex, often involving ever-changing management strategies in order to enhance beef production, animal health, and the health of the soil. However, the impact of these changes on GHG emissions is not entirely known. The AGGP project will measure net emission of CH_4 and N_2O from beef cow-calf production systems by tightly monitoring the feed intake and manure production of the steers.

In the next phase of Teranishi's project, the by-products that performed the best in the *in vitro* studies will be fed to the steers. The CH_4 released by the steers will then be measured using a technique called the sulphur hexafluoride (SF6) technique. A fingertip-sized permeation tube, filled with the SF6 gas, is placed in the rumen of the cattle; the rate of release of the SF6 is determined prior. A halter with a negative pressure vacuum collection canister is placed around the steer's head and this canister is connected to a tube passing over the bridge of the steer's nose and slightly protudes in front of the mouth. The tube collects air from the steer's mouth when they belch; the air will contain a mixture of the SF6 from the permeation tube and the CH_4 released during the digestion of food in the rumen. The quantity of CH_4 present can be determined based on its ratio to SF6 in the canister.

Monitoring the amount of N_2O produced in hay bedding, another phase in this multi-level diet and manure management study, will involve a collaboration between Ominki's lab and the lab of Mario Tenuta, U of M soil science professor. A technique called Fourier transform in-

frared (FTIR) spectroscopy will be used to measure N_2O released from the bedding during the decay of manure.

Working with beef cattle has been a fun, but vastly different, experience for Roulin, who grew up on a dairy farm.

"Dairy, I know it and I can do it so easily. Beef, I was thinking was going to be similar [...] but the temperament, how you manage them was very different," she added. "I realized [on the first day] that this is not going to be like on my farm where I can just think 'oh I need this animal, I'll just go over and get them'. You have to respect their flight zone and their area," Roulin warned.

Initially looking to see whether doing a master's program was a good next step after her undergraduate degree, Roulin decided it was a good idea to shadow a master's student first.

"I didn't want to jump into a master's [program] without having done any research, not knowing what it's going to be like. So, this way I could shadow other master's students to see if it is something I want to lead into for the future."

Roulin received the Natural Sciences and Engineering Research Council of Canada (NSERC) Undergraduate Student Research Award (USRA) to work on the AGGP this summer. Through this project she has enjoyed a mixture of office work, lab work, and farm work over the summer. She is currently completing her entomology and biology minor degrees, in addition to her animal science degree. She plans to continue with a master's program afterwards.

Having lived in the city all her life, Green is getting her first experience with large animal research. She also received the USRA to work on the AGGP this summer.

"My biggest challenge was getting comfortable around cattle. I have not spent much time around cattle before," said Green. "They are huge animals and it's kind of scary at first when they are running around you, but you get used to it and you learn how to handle them," she added.

Working on the AGGP project has been an invaluable experience. It provided Green the research requirement that helped her get accepted into the veterinary medicine program at the Western College of Veterinary Medicine, University of Saskatchewan, this 2018 fall.

"It's like you are in the lab for a class [...] you use the micropipettes like you use in your biochemistry class, but you're actually doing [applied work]," Green added.

Fulawka is a second-year pre-med student in the U of M Faculty of Kinesiology and has been involved with beef research since Grade 9. Last summer she trained Hank, one of the steers used at the Bruce D. Campbell Farm and Food Discovery Centre for demonstrations. Located at the Glenlea Research Station, the Centre is a hands-on interactive facility where people can go the see the ways in which food is produced in Canada.

"He was two months old when we got him. He was tiny, and he was the best little guy ever," said Fulawka, recounting how halter-training Hank was her favourite experience. "You call his name and he would come running to the side of the pen, he would walk beside you [...] when the seniors came they would have a ball of a time because he was like a big dog," she added.

One of the greatest benefits that the students draw from the research project is developing their problem-solving skills. The team is constantly troubleshooting problems that arise during their study. From controlling rogue steer to monitoring data collected by the GrowSafe Systems for inconsistencies, the challenges are ceaseless, and the students are thrilled with each one they surmount.

"The SmartPro system we are using has not gone smoothly, to begin with," said Green, explaining one of the ways the project has challenged them.

"The animals were figuring out that they could stand on their tippy toes and reach the feed when they were not supposed to," Green continued. "We had to work with moving the gates around to make sure they are not accessing the feed when they are not supposed to," she said.

Fulawka also explained that consistent check and balancing is required to adequately monitor the behavior of the steers and to measure their intake.

"If animals are getting more than a kilo, 'Why?'. If animals are not showing up, 'is it because the system is not recording them properly or is it because they are really not interested?'" explained Fulawka.

When the steers are not recorded in the system it could be that they have eaten too much hay and are too full to eat pellets, or there is a system malfunction. Sometimes the cattle are not feeling well. Unwell cattle can be identified early because they will often have reduced appetite days before they fall sick. This helps the research team, and cattle owners, catch illnesses or disease breakouts before they happen.

The goal at this point of the project was to see whether the steers preferred the grain pellets to regular hay, and to monitor their daily intake. The team also want to see whether caramel-flavored grain pellets will be consumed more preferably over the unflavored ones.

So far, the tasty pellets dished out by the SmartPro is the clear favorite over hay, but the flavoring does not make a difference. The steers in all three treatment pens consume the pellets in about the same amount of time.

Back at the pens, it is now calm as the excitement has slowly come to an end — most steers have had their 1 kg treat. It won't be until 10 a.m. tomorrow before the party begins again. In the meantime, they will have to munch on regular hay as they casually ruminate over how grain by-products could save the planet from over-heating.

— *David Zirangey*

Student Profile

Feedback and Guidance Essential to Success: Lindsey McKenty

Meet Lindsey McKenty, fourth year student in the Agroecology program, Faculty of Agricultural and Food Sciences, University of Manitoba. She is a part-time reservist in the Royal Canadian Navy, and took the winter 2017 semester off to go sailing with the navy out in Victoria. McKenty's thesis research, entitled *Testing Soil Pre-treatment Handling Techniques for Total Phosphorus in Wetland Soils*, was supervised by Dr. David Lobb, U of M Soil Science professor. She gave her final thesis presentation on March 23, 2018.

Researchers have to preserve soil samples collected from outdoors in their most natural state, and in a state that allows for accurate measure of nutrients, until laboratory analyses and treatments can be performed. They do this using various pre-treatment handling techniques including air-drying, oven-drying, freeze-thawing, or freeze-drying the soils. The choice of pre-treatment handling technique depends on the type of soil and the type of nutrient being studied. Little is currently known about the best soil-drying technique when quantifying phosphorus in wetland soils.

> Doing undergrad research opened a lot of doors to many great opportunities and people I wouldn't have interacted with or met otherwise

In her work, McKenty aimed to find which of three different drying techniques — air-drying, freeze-thawing, or freeze-drying — resulted in the most accurate measure of total phosphorus content in various soil types sampled from wetland (soils flooded with water), riparian (soils near water bodies), and field (dry soils, away from water bodies) sites. She also wanted to see whether the accuracy of the three soil drying techniques would vary depending on soil type.

Following chemical analyses, it was found that the air-drying technique gave the most accurate measure of total phosphorus in soils from wetland sites. The choice of pre-treatment technique did not affect the phosphorus measure in soils from the field and riparian sites.

The results of McKenty's research potentially lend a more universal implication for future research that characterize wetlands based on phosphorus content. It contributes to what is currently a sparse body of knowledge about the best pre-treatment handling technique for wetland soils by showing that air-drying before measuring total phosphorus resulted in the most accurate measure.

The greatest challenge McKenty faced during her undergraduate thesis was narrowing down her topic to one that was feasible for an undergraduate level project. Taking into consideration her scientific interests, and the time and resources available, she was able to design a manageable project for the focus of her thesis work.

One of the most significant advantages of the experience, McKenty recounted, was being able to broaden her professional network. "Doing undergrad research opened a lot of doors to many great opportunities and people I wouldn't have interacted with or met otherwise, and for that I am super grateful. As well, I now have experience with research and it has really prepped me for doing a master's program, if I decide to do one."

To students currently doing or considering undergraduate research, McKenty advises seeking feedback and guidance from professors and advisors as often as possible. "They have been down the research road many times and know the ropes." McKenty also stressed the importance of patience and staying organized, adding, "Organization is key."

McKenty takes special pride in the outcome of her research project. "My research project is my baby, I'm proud of it and it's unique to me," she expressed.

However, in her drive to always improve, she admits that she would do a few things differently if she could relive the experience, "I would definitely sample more wetlands and try to diversify the project more by testing different [chemical analyses] for their accuracy in [determining] total phosphorus."

— David Zirangey

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Student Profile

Thinking Sustainably: From Hobby Turtles to Honours Thesis

Zijing Guo has always had a love for exploring beneficial natural processes as solutions to complex problems. In his high school days, back in his home country of China, he gardened and kept turtles.

Because his turtles ate constantly and produced so much waste that he had to clean from their tanks every day, he came up with a system that incorporated natural processes involved in the nitrogen and carbon cycles. He added nitrifying bacteria, denitrifying bacteria, and active carbon to the water tank where he kept his turtles. The nitrifying bacteria converted the ammonia to nitrates that are used by algae growing in the tank. Some of the nitrates, and other inorganic wastes, were absorbed by the active carbon. The denitrifying bacteria converted the nitrogenous compounds in the turtle wastes into nitrogen gas and nitrogen dioxide.

This was a very delicate system, which Guo is still learning. He hopes to perfect the system someday, as it is hard to achieve the constant balance given the consistent care required.

"When done right, the water in the tank can stay clear for up to one month," he explained. "This gave me my first experience of working with natural systems."

Born in Beijing, Guo lived most of his childhood in metropolitan cities and transferred to the University of Manitoba in 2014. In the 2018 winter semester he completed his research project, entitled: *Study of Competitiveness Between Reed Canary Grass and Purple Loosestrife in a Replacement Series*. He graduated spring 2018 from the agroecology program of the Faculty of Agricultural and Food Sciences.

Guo plans to continue in research roles and hopes to work to broaden the understanding of our natural environment, and to help advance the incorporation of natural processes into our agricultural systems.

While volunteering on farms in China, Guo learned much about the agricultural system and realized that some things need improvement, including how the current agricultural system functions with regards to environmental sustainability.

He explained that we mostly think about the cost of inputs — fertilizers, herbicides, and other practices that increase agricultural yield. The cost of output — effects of our agricultural practices on the environment — is not equally regarded. We have NGOs and many different groups that try to save the environment by paying producers the cost of adopting environmentally-friendly agricultural practices.

Guo believes that this system is flawed. The endeavour to protect the environment should not be a cause that people "donate to", rather everyone should pay for the costs of our environmental impact. He thinks that part of the solution should be to distribute these costs throughout the supply chain from producer to consumer.

Guo took interest in his research project topic when he realized through literature searches that there have been very few studies into the interaction between purple loosestrife (*Lythrum salicari*) and reed canary grass (*Phalaris arundinacea*) — despite the fact they often grow in the same ecological niche. He also realized that when biocontrol agents are tested on crops, the efficacy of the bioagents is measured without properly taking into consideration the effect of interspecific and intraspecific plant competition.

Both purple loosestrife and reed canary grass are invasive species in Manitoba. They are both dominant in the wetlands they inhabit and can prevent other plant species from thriving.

Through his small-scale research, Guo hoped to see whether interspecific plant interaction played a role in the competitiveness of these two invasive plant species, and whether varying the population ratio of the two species affected their biomass.

In one germination trial, less than 10% of the reed canary grass seeds germinated. This germination rate was insufficient to start his project. After multiple failed germination tests, Guo was finally able to get his reed canary grass seeds to germinate. His purple loosestrife seed germination test continued to remain unsuccessful.

"I learned a lot from negative feedback," said Guo. "When I tried one thing and it did not work, I looked at the literature to find something else that might work."

Natural systems may not always respond as anticipated, but persevering through setbacks is one of the keys to a successful research project. Having overcome initial seed germination failures, Guo got his project on the road in November 2017. It had been approved in August.

The main result was that as the reed canary grass was replaced by increasingly more purple loosestrife, the biomass of the reed canary grass increased. This result suggested that the competitiveness of reed canary grass was affected more by intraspecific competition than by its competition with purple loosestrife.

"The ultimate practical value of understanding competitive mechanisms of invasive species is to find a management strategy," said Guo.

— David Zirangey

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"Doing undergrad research opened a lot of doors to many great opportunities and people I wouldn't have interacted with or met otherwise"

Lindsey McKenty

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pmuser@umanitoba.ca
ojs.lib.umanitoba.ca/pmuser