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EU-CANADA AGRICULTURE DIALOGUE WORKSHOPS

SUSTAINABLE USE OF FERTILISERS

OUTCOMES REPORT

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EXECUTIVE SUMMARY

This outcomes report is a summary of the fourth in a series of five joint workshops between the European Union (EU) and Canada "to promote sustainability, environmental stewardship and climate action in agriculture, within the framework of the Agriculture Dialogue" under the Canada-EU Comprehensive Economic Trade Agreement (CETA).[1] In total, 172 agricultural industry stakeholders from the EU and Canada came together at this Sustainable Use of Fertilisers Workshop. Participants explored farming practices to optimise the use of fertilisers and to reduce air emissions and water pollution, as well as ways to increase the availability of fertilisers through innovation and alternative sources.

A final wrap-up conference will summarize the reports from the five workshops (i.e., soil health; greenhouse gas reduction in livestock production; organic production; sustainable use of fertilisers; and sustainable crop production).

This report does not provide a comprehensive overview or in-depth analysis of fertiliser use. This report simply synthesizes what was heard at the workshop. As a result of the focus in some discussions, some subsections of the report provide more detail on the experiences in the European Union, while other subsections delve further into the Canadian context.

Stakeholders highlighted the following elements about the current state of the sector:

FARMING PRACTICES TO OPTIMISE THE USE OF FERTILISERS AND TO REDUCE AIR EMISSIONS AND WATER POLLUTION

- Many farmers already use a range of beneficial management practices (BMPs) to optimise their use of fertilisers, but can face knowledge and economic barriers in the adoption of additional BMPs
- Some farmers use digital tools to develop targeted crop nutrition programs but can worry about the protection and ownership of their data in these tools
- A systems approach is needed to build optimal crop input programs and leverage several BMPs to support crop yields while reducing GHG emissions from fertiliser use
- A tendency exists in the agricultural industry to focus on maximizing yields and increasing nitrogen applications, rather than to focus on maximizing profits and finding optimal nitrogen rates
- Given the different challenges farmers and policymakers face, farmers may feel a disconnect from policymakers, which can hinder farmer participation in government programs or adoption of more novel BMPs
- Some industry stakeholders (e.g., ingredient buyers, agricultural co-operatives, governments, etc.) provide incentives and cost-share programs to help offset the costs and risks associated with implementing established BMPs and testing new ones

1 Canada-European Union. (June 2021.) European Union-Canada Summit – Joint Statement, p. 3-4. Retrieved from https://pm.gc.ca/en/news/backgrounders/2021/06/15/canada-european-union-summit-joint-statement.

INCREASING AVAILABILITY OF FERTILISERS THROUGH INNOVATION AND ALTERNATIVE SOURCES

- Industry stakeholders leverage the circular economy to recycle nutrients, and new processing methods allow for easier transportation and mixing with other crop inputs (e.g., biostimulants, microbials, and mineral sources of nutrients)
- Fertilisers manufactured through the circular economy still face several potential limitations (e.g., cost, quality, availability), which can reduce farmer and advisor confidence in these products
- Biofertilisers, bioinoculants, and biostimulants are increasingly becoming commercially available, and research is well underway in these fields
- Researchers and fertiliser manufacturers are developing green fertilisers, made with renewable energy, to reduce GHG emissions from the production of fertiliser and to reduce the vulnerability of relying on imported fossil fuels

OVERARCHING CONSIDERATIONS ACROSS THE BREAKOUT ROOMS

Several overarching themes emerged across the discussions of the two breakout room topics. These themes are listed below.

- Regulations are crucial to ensure the efficacy and safety of new products on the marketplace, and to protect the environment but, sometimes, innovation in the private sector can move more quickly than the associated regulatory processes
  - Need to find the right balance between innovation and regulation
- Significant research and development efforts are underway to:
  - Develop and refine fertilisers and other crop inputs to increase crop resiliency and productivity while minimizing greenhouse gas emissions and nutrient losses
  - Help capture nutrients before they leave the field as soluble nutrients
  - Recycle nutrients from sewage or wastewater treatment

As the EU and Canada continue their work, they can consider the following 12 recommendations.

RECOMMENDATIONS FOR THE SCIENTIFIC COMMUNITY

Recommendation 1

Strengthen scientific networking between the EU and Canada to advance shared understanding of existing and emerging BMPs to optimise fertiliser use, and how these BMPs can be best tailored to local and regional conditions and farming systems.

Recommendation 2

Prioritize a systems approach to research and development.

Recommendation 3

Increase collaboration with farmers, commodity associations, and farm groups by advancing co-development opportunities, building on the success of the Living Labs and Lighthouses.

RECOMMENDATIONS FOR POLICYMAKERS AND PUBLIC AUTHORITIES

Recommendation 4: Ensure timely, clear, and consistent messaging to producers about government policies, programs, and initiatives related to fertiliser use.

Recommendation 5: Prioritize programs or initiatives that support producers in adopting BMPs that are confirmed to bring minimal return on investment, or require significant capital expenditures, but reduce GHG emissions from fertilisers.

Recommendation 6: Collaborate with product registration/labelling enforcement agencies to streamline the registration and labelling process for new fertiliser products.

RECOMMENDATIONS FOR THE VALUE CHAIN

Recommendation 7: Provide incentives or financial recognition for farmers trialling and adopting BMPs that reduce GHG emissions from fertiliser use.

Recommendation 8: Share best practices across industries and sectors to best leverage the circular economy and ensure the quality and safety of organic fertilisers.

Recommendation 9: Develop clear communications about new products or technologies so producers and their advisors understand the potential benefits and limitations of these products and technologies.

RECOMMENDATIONS FOR ALL FERTILISER STAKEHOLDERS

Recommendation 10: Collaborate to improve data collection related to fertiliser use.

Recommendation 11: Prioritize the development and dissemination of more user-friendly communication materials, targeted to the needs of various stakeholder groups, such as policymakers and farmers.

Recommendation 12: Collaborate to reduce "pinch points" for the whole value chain, and particularly farmers, in the transition from fossil fuels to green fuels.

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INTRODUCTION

1 · INTRODUCTION

1.1 · EVENT AND REPORT CONTEXT

In June 2021, at the Canadian-European Union (EU) Leader's Summit, the leaders committed to "launch a series of joint events to promote sustainability, environmental stewardship and climate action in agriculture, within the framework of the Agriculture Dialogue" under the Canada-EU Comprehensive Economic Trade Agreement (CETA). [2]

A series of five events between 2021 and 2023 are exploring the policy context and showcasing beneficial practices, as well as the research and innovation taking place in Canada and the EU. This workshop, on the Sustainable Use of Fertilisers, was the fourth in the series of five workshops. The workshop was held online on January 25, 2023. A total of 172 individuals in the EU and Canada participated in the workshop. Attendees included researchers, academics, farmers, industry stakeholders, government officials, and not-for-profit representatives.

The objectives of the Sustainable Use of Fertilisers workshop were as follows:

- Enhance communication and provide an opportunity to exchange best practices on the use of fertilisers.
- Foster shared learning on the sustainable use of fertilisers to improve performance while reducing emissions and maintaining soil productivity.

To accomplish these objectives, the workshop included both plenary and breakout sessions. During the opening plenary session,Canadian and EU representatives participated in a roundtable discussion to explore the economic, environmental, and policy context. The panelists also discussed opportunities to foster further collaboration between industry stakeholders, better support farmers, and advance research and development.

Next, workshop participants split into breakout rooms to do a deeper dive into one of two themes:

EU-Canada CETA Agriculture Dialogue Sustainability Workshops:

1) Soil health (See the **Outcomes Report**)
2) Greenhouse gas reduction in livestock production (See the **Outcomes Report**)
3) Organic production (See the **Outcomes Report**)
4) Sustainable use of fertilisers
5) Sustainable crop protection: Pesticide use in agriculture

A final wrap-up conference will take stock of what has been achieved during the series of workshops.

For more information about these workshops, please visit the websites of the **European Commission and Government of Canada**.

- Farming practices to optimise the use of fertilisers and to reduce air emissions and water pollution
- Increasing availability of fertilisers through innovation and alternative sources

Participants discussed current practices and technologies used within the sector to optimise fertiliser use. Workshop participants also explored opportunities for future research and development, and strategies to streamline the commercialization of new products and increase the adoption of beneficial management practices (BMPs) at the farm level.

Finally, workshop participants returned to the main plenary session for a recap of the key findings from the breakout sessions. The opening plenary speakers and rapporteurs from each breakout room participated in a

2 Canada-European Union. (June 2021.) European Union-Canada Summit – Joint Statement, p. 3-4. Retrieved from https://pm.gc.ca/en/news/backgrounders/2021/06/15/canada-european-union-summit-joint-statement.

roundtable discussion to reflect on the ideas presented over the course of the workshop. (Please see Annex 6.1 for the full workshop agenda).

This report summarizes what was heard during the workshop. The report begins with a high-level overview of the agronomic, economic, environmental, and policy contexts of fertiliser use in Canada and the EU. Next, the report summarizes the findings from the breakout room discussions, presenting the current state of fertiliser products, technologies, and use, followed by opportunities to advance efforts in these areas. As a result of the focus of some discussions, and the participants present in different breakout rooms, some subsections of the report provide more detail on the experiences in the EU, while other subsections delve further into the situation in Canada. Finally, as an outcome of the workshop discussions, a series of recommendations are presented to enhance knowledge and adoption of practices that can help optimise fertiliser use in Canada and the EU.

1.2 · FERTILISER USE: SETTING THE CONTEXT

The three primary nutrients for crop production are nitrogen, phosphorus, and potassium.[3] Farmers apply fertilisers – made from atmospheric nitrogen, mineral, and organic sources – to meet the nutrient requirements of their crops and to support yields. However, both fertiliser production and use contribute to greenhouse gas (GHG) emissions. For example, when farmers apply nitrogen fertiliser to their fields, plants only take up part of this nutrient through their roots. Soil micro-organisms also use some of this nutrient but, in the process, produce nitrous oxide (N_2O).[4] Some of this nitrogen can also move from the field by volatizing as ammonia or being lost as nitrate through leaching. Nutrient losses and inefficiencies are unavoidable but existing practices and alternatives can contribute to the reduction of undesired effects.

In 2018, global GHG emissions associated with the manufacturing, transportation, and application of synthetic nitrogen fertilisers accounted for an estimated 1,129.1 million tons of carbon dioxide equivalent.[5] The EU contributed about 9.1% of these global emissions, and Canada contributed about 2.9%.

Optimised fertiliser use seeks to find the balance between maintaining and enhancing yields while reducing fertiliser-related emissions, environmental impacts, and costs. In the effort to optimise fertiliser use, producers must also ensure they are not negatively impacting soil health or productivity.

The pressure to optimise the use of fertilisers has grown over time and is influenced by the increasing trend of fertiliser prices and impacts on our environment. These price increases were further fuelled by Russia's invasion of Ukraine and have negative consequences for the economic sustainability of the global agricultural sector. Both the EU and Canada recognize this challenge.

Given climate change, economic pressures, and the need to address global food security concerns, the need to optimise the efficiency of fertilisers is urgent and necessary.Stakeholders must collaborate to ensure the sustainable use of fertilisers by enhancing the efficiency of these products to increase crop availability and leveraging alternative sources, while reducing emissions and maintaining yield and soil productivity.

3 Food and Agriculture Organization of the United Nations. "NSP – Fertiliser Specifications." Retrieved from https://www.fao.org/agriculture/crops/thematic-sitemap/theme/spi/plantnutrition/fertspecs/en/.

4 Stefano Menegat, Alicia Ledo and Reyes Tirado. (August 2022.) "Greenhouse Gas Emissions from Global Production and Use of Nitrogen Synthetic Fertilisers in Agriculture." Scientific Reports, 12:14490. Retrieved from: https://doi.org/10.1038/s41598-022-18773-w.

5 Stefano Menegat, Alicia Ledo and Reyes Tirado. (August 2022.) "Greenhouse Gas Emissions from Global Production and Use of Nitrogen Synthetic Fertilisers in Agriculture." Scientific Reports, 12:14490. Retrieved from: https://doi.org/10.1038/s41598-022-18773-w

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POLICY CONTEXT

2 · POLICY CONTEXT

2.1 · EU POLICIES

In 1991, the EU introduced theNitrates Directive (91/676/EEC) to improve water quality by encouraging the sustainable use of nitrogen fertilisers, including synthetics and manure. Under the Nitrates Directive, each EU Member State is required to create Nitrates Action Programmes (NAP) which highlight beneficial practices for nutrient management and application.[6]

In 2019, the EU adopted the EU Fertilising Products Regulation 2019/1009, introducing a single market in organic fertiliser. This regulation provides oversight on the labelling requirements for fertilising products, including biostimulants. This regulation enables common standards across fertilising products and facilitates shipping without constraints between EU member states.

Building upon existing policy frameworks, the European Green Deal charts a path to climate-neutrality by 2050. The Farm to Fork Strategy outlines how the agri-food industry will help attain this goal, including areas of actions that will reduce nutrient loss, prevent excess fertiliser use, and foster innovations in areas such as bio-fertiliser development. In step with the **European Green Deal and the Farm to Fork Strategy**, the new Common Agricultural Policy (2023-27) will be committed to ensuring a sustainable future for European producers. In total, 40% of the budget will be relevant to climate action, including activities to reduce GHG emissions from fertiliser use.[7]

As part of the Common Agricultural Policy reform, Member States shall make available a new Farm Sustainability Tool for nutrient management. This tool, which was first piloted in 2020, aims to help producers manage their operations sustainably, including through the provision of fertiliser recommendations.[8]

In the context of the current global mineral fertiliser crisis weighing on global food security and food prices, the European Commission adopted a Communication on Fertilisers on November 9, 2022. This Communication presented a wide range of actions and measures to maintain sustainable European fertiliser production, as well as to optimise the use of, and reduce dependency on, mineral fertilisers. The ways ahead include the adoption of more sustainable farming practices, the development of alternative sources of fertiliser, and moving to greener technology.[9]

The Zero Pollution Action Plan is an initiative under the European Green Deal that details the action needed to reach key milestones by 2030 and to be on track for zero pollution by 2050. For example, by 2030, the EU aims to decrease nutrient loss by 50%, while ensuring no degradation in soil fertility occurs.This goal can be achieved by applying balanced fertilisation and sustainable nutrient management, and by improving the management of nitrogen and phosphorus throughout their lifecycles.

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6 European Commission. (n.d.) “The Nitrates Directive.” Retrieved from https://ec.europa.eu/environment/water/water-nitrates/index_en.html.

7 European Commission. (December 2021.) “The New Common Agricultural Policy: 2023-27.” Retrieved from https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/new-cap-2023-27_en.

8 European Commission. (2020.) “About FaST.” Retrieved from: https://fastplatform.eu/about.

9 European Commission. (n.d.) “Ensuring Availability and Affordability of Fertilisers.” Retrieved from: https://agriculture.ec.europa.eu/common-agricultural-policy/agri-food-supply-chain/ensuring-availability-and-affordability-fertilisers_en.

2.2 · CANADIAN POLICIES

Canada's strengthened climate plan, A Healthy Environment and a Healthy Economy, set a national target to reduce absolute levels of GHG emissions arising from fertiliser application by 30% below 2020 levels by 2030. Agriculture and Agri-Food Canada (AAFC) released a discussion paper on the target and conducted public consultations to identify pathways and partnerships to meet it. Canada recognizes that the strategies to reach this target will vary across the country, as a range of factors – including climate, crops, and soil characteristics – impact the emissions reduction potential.[10] Efforts to achieve emissions reductions in Canada will focus on implementing voluntary approaches for improving nitrogen management and optimising fertiliser use – not a mandatory reduction in the use of fertilisers nor imposing changes at an individual farm level.

In 2022, Canada released its most recent climate action plan, 2030 Emissions Reduction Plan: Clean Air, Strong Economy (ERP), which outlines an enhanced commitment to GHG mitigation in agriculture. Many of the enhanced commitments in the ERP are being delivered through the Agricultural Climate Solutions (ACS) Program. The Living Labs Program and On-Farm Climate Action Fund (OFCAF) are the two program streams under the ACS Program that support producers in adoptingBMPs that accelerate emissions reductions by improving nitrogen management. For example, under OFCAF, the Canola Council of Canada is working with farmers across Alberta, Saskatchewan, and Manitoba to initiate or advance 4R Nutrient Stewardship practices to increase canola yields while reducing N_2Oemissions from fertiliser use.[11]

The Canadian Agricultural Partnership(2018-2023) is the primary federal-provincial-territorial agricultural policy framework. It includes cost-share programs that fund on-farm adoption practices including thoseworking to improve fertiliser use efficiency (e.g., developing nutrient management plans).[12] The next iteration of this framework, theSustainable Canadian Agricultural Partnership, will be launched in 2023 and will help advance sustainable development within the agriculturalsector for the next five years.[13]

The Agricultural Clean Technology (ACT) Program aims to scale up the adoption of clean technologies in agriculture that are needed to enable the sector to thrive in a low-carbon economy. The program offers support for adoption and innovation, and includes a stream for precision agriculture, which can include technology to improve fertiliser use efficiency.[14]

Consultations are currently underway for the Government of Canada's Sustainable Agriculture Strategy for 2030-2050, which recognizes the need for long term solutions. The Discussion Document highlights opportunities to build on existing efforts to reduce fertiliser emissions in Canadian agriculture.

10 Agriculture and Agri-Food Canada. (2022.) "Discussion Document: Reducing Emissions Arising from the Application of Fertiliser in Canada's Agriculture Sector." Retrieved from: https://agriculture.canada.ca/en/about-our-department/transparency-and-corporate-reporting/public-opinion-research-and-consultations/share-ideas-fertilizer-emissions-reduction-target/discussion-document-reducing-emissions-arising-application-fertilizer-canadas-agriculture-sector.

11 Canola Council of Canada. (2022.) "Canola 4R Advantage." Retrieved from: https://www.canolacouncil.org/4r-advantage/.

12 Agriculture and Agri-Food Canada. (n.d.) "Canadian Agricultural Partnership." Retrieved from: https://agriculture.canada.ca/en/about-our-department/key-departmental-initiatives/canadian-agricultural-partnership.

13 Agriculture and Agri-Food Canada. (2022.) "Federal, Provincial and Territorial Ministers of Agriculture Reach a New Partnership Agreement." Retrieved from:https://agriculture.canada.ca/en/agri-info/federal-provincial-and-territorial-ministers-agriculture-reach-new-partnership-agreement.

14 Agriculture and Agri-Food Canada. (n.d.) "Database: Agricultural Clean Technology Program Projects." Retrieved from: https://www.canada.ca/en/agriculture-agri-food/news/2022/02/the-government-of-canada-invests-in-clean-technology-to-support-sustainable-farming-practices.html#dataset-filter.

2.3 · EU AND CANADA JOINT INITIATIVES AND EFFORTS

Canadian and EU stakeholders contribute to international research initiatives such as the Global Research Alliance (GRA) on Agricultural Greenhouse Gases' Croplands Research Group.The Nutrient Management Network,for example,hosts workshops on measuring N_2Oemissions from fertilisers.[15] Together with partners, the GRA also developed the Measuring, Reporting and Verification (MRV) Platform for Agriculture, which houses several resources that guide technical and institutional design of MRV systems for climate change mitigation in agriculture.[16]

15 Global Research Alliance on Agriculture Greenhouse Gases. (n.d.) "Nutrient Management Network." Retrieved from: https://globalresearchalliance.org/research/croplands/networks/nutrient-management-network/.

16 MRV Platform for Agriculture. (n.d.) "Resources and Guidance for MRV of Mitigation in Agriculture." Retrieved from: https://www.agmrv.org/.

3

THE CURRENT STATE OF FERTILISER PRODUCTS, TECHNOLOGIES, AND USE IN CANADA AND THE EU

3 · THE CURRENT STATE OF FERTILISER PRODUCTS, TECHNOLOGIES, AND USE IN CANADA AND THE EU

3.1 · FARMING PRACTICES TO OPTIMISE THE USE OF FERTILISERS AND TO REDUCE AIR EMISSIONS AND WATER POLLUTION

EXISTING BMPS

Many farmers already use a range of BMPs to optimise their use of fertilisers. For example, the industry-driven 4R Nutrient Stewardship approach is designed to promote the sustainable use of fertilisers in crop production and can reduce fertiliser-related emissions while maintaining or increasing yields.[17] The 4R approach focuses on the right source, right time, right rate, and right place for fertiliser application. In-furrow or banded fertiliser applications are examples of practices designed to ensure fertiliser is placed in the right place. Enhanced efficiency fertilisers, such as polymer-coated urea, help to ensure the efficiency and availability of the fertiliser nutrient. Controlled release and split fertiliser applications help to ensure the fertiliser nutrient is available to the crop at the right time. Some fruit and vegetable producers use fertigation to inject fertilisers through irrigation systems.[18] This approach is another way to ensure the right timing of fertiliser applications, as it allows for the synchronizing of nutrient supply with crop requirements.

As part of this 4R Nutrient Stewardship, farmers conduct soil testing to determine the available nutrients in their soils. Then, farmers determine optimal fertiliser rates to maintain soil productivity while meeting the needs of their crops. In Western Canada, for example, the widespread adoption of 4R Nutrient Stewardship practices could lead to an estimated two to three megaton reduction in emissions.[19]

Nutrients can be obtained from the use of livestock and poultry manures and crop residues to reduce the use of synthetic fertilisers. Producers can test the manure to identify nutrient levels and develop nutrient management plans. These BMPs can help to ensure optimum nutrient application rates and help to reduce the potential for nutrient loss through leaching and volatilization.

Producers usediverse crop rotations and include cover crops in the rotations, which can help to reduce the nutrient requirements of the following crop and lowerits overall fertiliser requirements. Additionally, cover crops can help to hold nutrients in the soil and prevent leaching.

Farmers use precision agriculture to optimise their production practices. Precision agriculture uses data collection and analysis to estimate variability across a farm and support farm management decisions. In the process, precision agriculture supports enhanced efficiency, productivity, quality, profitability, and sustainability. For example, some farmers use zone mapping to split their fields into smaller sections to allow for more targeted fertiliser programs across their fields. Other farmers use variable-rate technology so that the nitrogen fertiliser rates they apply are adjusted across the field in response to historical yields, soil texture, and topography. Under certain conditions, variable-rate programs can lead to a 30 to 50%

17 International Fertiliser Association. (2018.) Estimating & Reporting Fertiliser-Related Greenhouse Gas Emissions. Retrieved from: https://www.fertilizer.org/images/Library_Downloads/2018_IFA_Measuring_and_Reporting_Fertilizer_Emissions.pdf.

18 Mary Dixon and Guodong Liu. (July 2022.)"The Advantages and Disadvantages of Fertigation."Retrieved from: https://edis.ifas.ufl.edu/publication/HS1442.

19 Government of Canada. (October 2022.) "Discussion Document: Reducing Emissions Arising from the Application of Fertiliser in Canada's Agriculture Sector." Retrieved from: https://agriculture.canada.ca/en/about-our-department/transparency-and-corporate-reporting/public-opinion-research-and-consultations/share-ideas-fertilizer-emissions-reduction-target/discussion-document-reducing-emissions-arising-application-fertilizer-canadas-agriculture-sector.

reduction of residual nitrogen in soils, and a 25% increase in phosphorus recovery, European researchers estimate.[20] Some producers use GPS mapping and guidance to ensure more precise fertiliser applications, and automatic shutoffs on their application equipment to avoid overlaps in fertiliser application.

As each farm operation is unique, it can be challenging for some farmers to implement a broad range of BMPs in their operations. Farmers may be uncertain how to incorporate these practices into their broader management systems and lack the time to experiment. Farmers are also mindful of economic risks, whether it be added costs or negative yield impacts. For example, new products might be more expensive to purchase, bring no yield benefits, or perhaps even negatively affect yields.

The cost of some BMPs can be quite prohibitive for some farmers running smaller operations. For example, precision agricultural technology can require large up-front investments and the return on investment might not be feasible in small operations.

DIGITAL TOOLS & DATA COLLECTION

Farmers use digital tools to help them develop targeted crop nutrition programs. These tools can analyse soil test results and crop nutrition requirements to develop a baseline program. Then, as the season unfolds, these tools gather more data to refine the proposed fertiliser program. For example, these tools will analyse weather data and satellite imagery, as well, perhaps, as results from plant tissue sampling, to monitor the crops and growing conditions. For example, Yara offers Atfarm to help producers develop and fine-tune their nitrogen fertiliser programs.

Some producers have concerns about the protection and ownership of their data in such digital tools. They worry how the companies that produced these tools, as well as other industry stakeholders who could have access to them, might use their data.

A SYSTEMS APPROACH IN FARMING

Many producers and their advisors consider the full range of macro- and micronutrients needed for crop production to ensure the resilience of their crops and to reduce environmental impacts. The management of nitrogen, for example, often affects the management of phosphorus. If producers simply used manure to meet their crops' nutritional needs, their rate of application to get a sufficient amount of nitrogen could result in the application of too much phosphorus, which can be lost to the environment through runoff. Producers also ensure their crops' micronutrient needs are met to help protect the crops from abiotic stress.

Nutrient efficiency is fundamentally a product of a larger system. This system includes improvements in plant genetics, other crop inputs (e.g., biostimulants and bioinoculants), and farm management practices. Producers build optimal crop input programs and leverage several BMPs, targeted to their regions, to support crop yields while reducing GHG emissions from fertiliser use.

Improvements to soil health and soil structure also bring co-benefits for nutrient management. Healthy, biodiverse soils support better plant growth through better use of nutrients. For example, gypsum can help to prevent soil erosion and the loss of nutrients.

20 European Parliamentary Research Service. (December 2016.) Precision Agriculture and the Future of Farming in Europe: Scientific Foresight Study, p. 14. Retrieved from: https://www.europarl.europa.eu/RegData/etudes/STUD/2016/581892/EPRS_STU(2016)581892_EN.pdf.

INDUSTRY MINDSETS ABOUT YIELDS AND NITROGEN RATES

In the agricultural industry, there is atendency to focus on maximizing yields, workshop participants said. However, increased yields do not always result in an increased return on investment, given the cost of crop inputs.

The focus on yields might be particularly entrenched in Canada, workshop participants said, as Canada is positioning itself as a leader to feed a growing global population.

Relatedly, industry stakeholders often think that more nitrogen is beneficial for crops. However, this view is false as an optimum rate of nitrogen exists for all crops.

CONNECTIONS BETWEEN POLICYMAKERS AND FARMERS

Workshop participants recognized both policymakers and farmers face different challenges. Policymakers, for example, need to find solutions that work broadly for their jurisdictions,for the diversity of stakeholders involved (e.g., farmers, the public, industry, etc.), and at the farm level. In both Canada and the EU, achieving this desired outcome can be challenging, given the diversity of growing regions across each jurisdiction.

Farmers deal with many factors – such as climate – that are beyond their control. They are also receiving messages with different nuances about how they can reduce GHG emissions while still producing their crops. Workshop participants commented that farmers may feel a disconnect from policymakers.This feeling of disconnect can hinder farmer participation in government programs or adoption of more novel BMPs.

INCENTIVES

Industry stakeholders are helping to offset some of the costs and risks associated with implementing established BMPs and testing new ones, so the financial and implementation burden does not solely rest with producers. For example, some ingredient buyers recognize and incentivize contracted growers to use environmentally friendly practices. Many companiesare emphasizing soil health and encouraging producers to use soil conservation practices. General Mills' leadership in the development of the Ecosystem Services Market Consortium, Nutrien's grower solutions to meet their 2030 commitment to enable growers to adopt sustainable and productive agricultural products and practices, and partnerships between A&W Canada, Cargill and ALUS Canada are examples of industry-led efforts. Lantmännen, an agricultural co-operative in Northern Europe, is running a program in 2023 in collaboration with Yara, a fertiliser producer, to offer farmers an inventive to test a new green fertiliser product.

Governments provide incentives and cost-share programs to help producers reduce risk as they implement new BMPs to increase nutrient efficiency.

In France, the government created the "label bas carbone" as a voluntary certification for products that help to sequester carbon and reduce GHG emissions. Such labels can be another tool to incentivize the adoption of environmentally friendly practices.

3.2 · INCREASING AVAILABILITY OF FERTILISERS THROUGH INNOVATION AND ALTERNATIVE SOURCES

THE CIRCULAR ECONOMY

Workshop participants highlighted that the agricultural industry has used residues from animal production in a circular way for decades. New processing methods for some of these raw materials and inputs allow them to be transferred more easily within the agricultural system. These new processing methods also offer the advantage of making the products easier to mix with other crop inputs, such as biostimulants and microbials.

For example, poultry and livestock manure is commonly applied to fields across both Canada and the EU as a source of nutrients. A challenge with this raw manure is that it is hard to predict when the nutrients will become available to plants. Additionally, some regions in the EU and Canada have an oversupply of manure because of the higher livestock or poultry densities. This situation can lead to increased environmental risks from both nitrogen and phosphorus, so these nutrients must be managed carefully.

In its "natural" form, it is not practical nor cost-effective to transport manure over long distances, as it contains a lot of water. However, manure can be processed – and the nitrogen and phosphorus can be separated – to allow for easier transportation to regions where the nutrients are needed. Anaerobic digestion is one process that can be used. In the EU, for example, the SYSTEMICresearch project was undertaken atfive large-scale demonstration biogas facilities. The goal of this project was to help develop a circular economy to use biowaste as a source of nutrients, energy and organic matter.

Another strong example of the circular economy is the production of struvite, which is slow-release phosphate fertiliser manufactured with waste from treatment plants. In Canada, the company Ostara produces granular phosphate fertilisers using such materials from the circular economy. These types of fertilisers have three-pronged benefits:

1. Waste managers have new opportunities to manage waste materials.
2. Producers have a new source of valuable nutrients.
3. Society at large now sees a reduction in its waste, as valuable materials are repurposed in the circular economy.

In the EU, processors will incinerate sludge, and then recycle phosphorus from the ash. In Canada, some companies produce fertilisers from food waste. Fertilisers can also be produced from other waste stream materials, municipal waste, sewage sludges, and compost materials.

In some European markets, organo-mineral fertilisers are available. These fertilisers combine organic and mineral sources of nutrients into one product for increased efficiency.

Current products manufactured through the circular economy face several potential limitations. In some cases, it is more expensive to produce a fertiliser from waste materials than from primary raw materials. Given the irregular nature of input materials, the quality of fertilisers produced from waste materials is not always consistent, which can make it challenging to ensure product application rates meet crop needs. The availability of these products can vary by region since they depend on the availability of the waste material and a processor. Finally, some of these products can be challengingto apply with conventional field equipment.

Manufacturers of fertilisers from recycled nutrients must think about the other potential components of these nutrient sources. For example, these nutrient sources could contain microplastics, antimicrobials, and metals, which can have additional environmental impacts.

As a result of these economic and quality considerations, farmers and their advisors sometimes lack confidence in these fertilisers produced with materials from the circular economy.

BIOFERTILISERS, BIOINOCULANTS, AND BIOSTIMULANTS

Currently, a lot of interest exists in the marketplace for products such as biofertilisers, bioinoculants, and biostimulants. Many products – such as bacillus, bioactive amino acids, and Arbuscular Mycorrhizal Fungi (AMF) – are becoming commercially available. AMF, for example, can help plants access nutrients in the soil.[21] Typically, these commercial offerings contain one active product, although scientists are developing offerings containing multiple active products.

Research is also well underway in these fields. For example, Italian researchers are testing a range of biostimulants, in addition to Decision Support Tools, to help reduce the need for nitrogen fertiliser for maize.[22]

GREEN FERTILISERS

Researchers and fertiliser manufacturers are seeking to facilitate the energy transition and the move away from fossil fuels. The impetus behind this transition is two-fold:

- To reduce GHG emissions from the production of fertiliser
- To reduce the vulnerability of relying on imported fossil fuels

In Spain, for example, the electrical utility company Iberdrola and the fertiliser producer Fertiberia are collaborating on a project to produce green ammonia, with a goal of “decarbonis[ing] the overall production of ammonia in Spain by 2027.”[23] Some small start-up companies are also attempting to produce ammonia on farm using electricity.

> *“The fertiliser industry [in the EU] wants to reduce reliance on imports, and therefore we are seeing some major fertiliser producers invest in green hydrogen as a potential solution.”*
>
> EU delegate

Green fertilisers, made with renewable energy, can help to reduce the carbon footprint of the agri-food industry. For example, green fertilisers can help reduce the carbon footprint of wheat by 20% and that of a loaf of bread by 12%, workshop participants said.

21 Andrea Berruti, Erica Lumini, Raffaella Balestrini and Valeria Bianciotto. (2015.) “Arbuscular Mycorrhizal Fungi as Natural Biofertilizers: Let’s Benefit from Past Successes.” Frontiers in Microbiology, Vol. 6. Retrieved from: https://doi.org/10.3389/fmicb.2015.01559.

22 EIP-AGRI. (March 2022.) “Inspirational Ideas: Biostimulants for Sustainable Agriculture.” Retrieved from: https://ec.europa.eu/eip/agriculture/en/news/inspirational-ideas-biostimulants-sustainable.

23 Renewable Hydrogen Coalition. (March 2021.) “Decarbonising Ammonia Production in Spain.” Retrieved from: https://renewableh2.eu/stories/iberdrola-and-fertiberia-put-spain-at-the-forefront-of-europes-race-for-renewable-hydrogen-decarbonising-the-overall-ammonia-production-of-the-country-by-2027/.

3.3 · OVERARCHING CONSIDERATIONS

BALANCING INNOVATION AND REGULATION

Regulation iscrucial to ensure the efficacy and safety of new products on the marketplace, and to protect the environment. Sometimes, innovation in the private sector can move more quickly than the associated regulatory processes, and new products might be developed that do not easily fit in.

For example, some workshop participants noted the limitations of current CE marking in the EU for the use of animal by-products in fertilisers and the relatively limited range of micro-organisms allowed in biostimulants. CE markings allow for the trading of organic fertilisers across the EU.[24] The process to obtain product registrations also can be time-consuming, which can delay the commercialization of new, beneficial products.

Linked to this, legislation can be a driver for improvements in environmental practices, but it can sometimes hinder progress, workshop participants said. Some workshop participants highlighted the fact that the EU's Nitrates Directive is beneficial in its aims to protect the environment, but noted the legislation could be revisited to better support the use of nutrients from manure-recovered sources. Other workshop participants shared the view that legislation can limit experimentation at farm level, such as with the regulations surrounding the timing for cover crops.

CURRENT RESEARCH AND DEVELOPMENT

Researchers continue to study best practices and product formulations for fertigation in horticultural crops, which can help to better align fertiliser application with the 4Rs.

Researchers are studying multi-functional organisms to see how they can bring multiple benefits for crops. Some microbial products, for example, might allow farmers to lower their fertiliser application rates. Researchers are also exploring ways to build crop input programs with mineral fertilisers, organic fertilisers, and biostimulants to increase crop resilience and productivity. Some scientists seek to improve phosphorus use efficiency in acidic soil. Others are exploring seed treatments to boost a plant's ability to fix nitrogen.

Industry stakeholders are developing and testing products to help capture nutrients before they leave the field as soluble nutrients. For example, producers could make modifications to their drainage systems to help avoid denitrification. Producers could also install multi-media reactors at the end of their tile lines to capture the water and absorb nutrients, which can be recycled in the system.

Researchers are also investigating new methods for recycling nutrients from sewage or wastewater treatment which could help to further strengthen the circular economy for nutrients.

24 European Commission. (March 2016.) "Circular Economy: New Regulation to Boost the Use of Organic and Waste-Based Fertilisers." Retrieved from: https://ec.europa.eu/commission/presscorner/detail/fr/MEMO_16_826.

4

OPPORTUNITIES FOR FERTILISER PRODUCTS, TECHNOLOGIES AND USE IN CANADA AND THE EU

4 · OPPORTUNITIES FOR FERTILISER PRODUCTS, TECHNOLOGIES AND USE IN CANADA AND THE EU

4.1 · FARMING PRACTICES TO OPTIMISE THE USE OF FERTILISERS AND TO REDUCE AIR EMISSIONS AND WATER POLLUTION

PRIORITY BMPS

Workshop participants recognized that the level of BMP adoption varies depending on the specific BMP in question and collaborated to identify BMPs that they saw of high priority for more widespread adoption. These BMPs included increased substitution of enhanced efficiency fertilisers, in place of more traditional formulations, and precision nitrogen management. Workshop participants also discussed opportunities for more widespread adoption of variable rate fertiliser application – as well as more advances in this field. Specifically, workshop participants suggested the benefits of a precision 4R approach which includes both a variable rate and a variable source of fertiliser across different management zones.

DIGITAL TOOLS AND MODELLING

Researchers must continue to fine-tune tools to support producers in determining optimum nutrient rates, including the timing of the applications and the placement of the applications, for their crops within a specific growing season. More field-scale research is needed to support this work.

Given the range of variables that influence fertiliser programs for a specific crop within a given growing season, researchers may be able to leverage data science and artificial intelligence to help develop and fine-tune useful predictive models. These models must be well validated and they must become more responsive to adapt to the changing climate considerations.While a considerable amount ofrelevant informationis scattered throughout the scientific literature, a cohesive framework to bring this research together would be beneficial. Researchers can also explore ways to use data science to leverage the wealth of knowledge garnered by field-level agronomists.

Linked to this, improved weather predictions are crucial to advance research related to nitrous oxide emissions from fertiliser applications. More accurate weather predictions will help farmers identify the best timing for their nitrogen applications.

DATA COLLECTION

Workshop participants underscored the need for improved data collection related to fertiliser use. Scientists can use more robust datasets to better predict emissions from fertilisers. For example, as the climate changes, it will affect scientists' ability to predict emission rates. More robust datasets enable more accurate benchmarking, which can help industry stakeholders to better celebrate the good work underway at the farm level and inform national inventories. Industry stakeholders can also use these benchmarks to monitor change over time. Finally, more robust datasets and databases are vital to demonstrate the agronomic, economic, and environmental benefits of BMPs.

As industry stakeholders work togetherto improve data collection, they must ensure clear communication with producers in order to foster trust and facilitate collaboration. Industry stakeholders must clearly communicate:

- Why the data is being collected
- How the data will be stored
- How the data will be analysed and used
- How the privacy of individual producers will be protected

INDUSTRY MINDSETS ABOUT YIELDS AND NITROGEN RATES

Rather than focusing on yields, workshop participants advocated for a focus on maximizing profits. Maximized profits can be realized through improved efficiencies and costs savings on inputs. For example, sectional controls on application equipment can reduce overlaps in product applications, which can help to avoid overapplication of fertilisers in some sections of the field. If producers use enhanced efficiency fertilisers, they may be able to reduce their application rates without sacrificing yields.

Furthermore, workshop participants highlighted the need to emphasise the search for optimum nitrogen rates, rather than simply higher nitrogen rates. A "tipping point" exists where the additional nitrogen offers no – oreven negative–returnon investment and negatively impacts the environment, too. Optimum nitrogen rates are site- and growingseason-specific.

"We need to change how we view nitrogen. More is not necessarily better."

Workshop participant

Ultimately, more multidisciplinary research – including economic analyses – and improved knowledge transfer are crucial to assist industry stakeholders in shifting their mindsets towards a focus on maximised profits and optimum nitrogen rates. Best practices for approaches to research and development, as well as knowledge translation and transfer, are discussed further in Section 4.3.

CONNECTIONS BETWEEN POLICYMAKERS AND FARMERS

To unite behind a shared goal, all stakeholders must clearly understand the problem that needs to be addressed, and why. The topic of reducing GHG emissions from fertiliser use involves abstract and complex concepts; strong and clear communication is crucial to foster collaboration among the diversity of stakeholders – including government, producers, the agricultural industry more generally, and the general public.

Concerted effort must be made to identify the common ground between policymakers and farmers. Ultimately, both groups share similar overarching aims: ensuring the resilience of the agricultural industry and protecting the environment. Government targets to reduce GHG emissions from fertiliser use can be reached, workshop participants said. Clearer messaging, targeted to the farming audience, about these targets and associated initiatives is crucial. Opportunities for increased dialogue between farmers and policymakers can help both parties understand the others' needs and working realities. In the process, they can identify shared priorities for research, knowledge transfer, and program development.

"We need to remember that we are all headed in the same direction and, when we get to 2050, the climate will be the same for all of us."

Workshop participant

Similarly, updates on new regulations must be timely to enable producers to better plan for the next growing season. Farmers in the EU sometimes must base production decisions on government data from the previous year, which can be challenging, workshop participants said.

Collaboration is vital between different levels of government, too. In Canada, for example, agriculture is a shared jurisdiction between the federal, provincial, and territorial governments. Opportunities exist to develop and disseminate more consistent messaging about overarching goals and tactics, while still recognizing and allowing for approaches and solutions that are best suited to each region.

INCENTIVES

As financial resources for government incentives and cost-share programs are finite, workshop participants discussed the need for strategic programming and eligibility requirements. For example, government incentives might not be necessary to encourage producers to use urease inhibitors, as these products typically provide direct economic benefits for producers. In contrast, nitrification inhibitors do not offer yield benefits, but these products decrease nitrous oxide emissions. So, nitrification inhibitors could be a strategic choice for inclusion in government incentive programs for farmers. Relatedly, government programming can support producers in making large capital expenditures to purchase new equipment or retrofit existing equipment, as it can take time for producers to see a return on investment. For example, equipment for precision nitrogen management can include large up-front costs. Workshop participants also suggested that programs should not penalize early adopters; producers who are already using BMPs should also be eligible to participate in these programs.

More private companies can support farmers in adopting BMPs to optimise fertiliser use and improve soil health. These industry-led efforts are in part, influenced by market drivers such as:

- **Environment, Social and Governance (ESG) investing criteria:** Investors use ESG criteria to drive investment decisions that expand outside of typical financial measures of performance and include criteria related to environmental and social outcomes. These investing criteria influence private sector companies (primarily publicly traded companies) to report on their efforts towards positive environmental, social and governance-related outcomes to attract investors.
- **Scope 1, 2 and 3 emissions:** Companies can demonstrate reductions in GHG emissionsfor annual reporting purposes, to meet net-zero targets, or to participate in carbon-based markets, for example. Scope 1 emissions are produced directly by the company (e.g., emissions from company-owned vehicles). Scope 2 emissions are generated by purchased energy sources (e.g., electricity, feedstocks). Scope 3 emissions are a catch-all for emissions generated by all other purchased goods and services in a company's value chain (e.g., emissions from grain drying, heating of barns, fertiliser use, etc.). Increasingly, agricultural operations are being asked to report on efforts to reduce emissions, so private sector value chains can report on/measure scope 2 and scope 3 emissions reduction.

4.2 · INCREASING AVAILABILITY OF FERTILISERS THROUGH INNOVATION AND ALTERNATIVE SOURCES

THE CIRCULAR ECONOMY

To build confidence in fertilisers produced from waste materials, long-term research and long-term field trials are crucial. The development of strategies to ensure the quality and efficiency of these materials will also help to build trust in these new circular materials.

> *"For bio-based fertilisers to be on par with synthetic fertilisers, we need reliable, homogeneous products."*
>
> Workshop participant

The best path forward for optimum fertiliser use will involve leveraging the best organic sources of nutrients available in a given region and supplementing them as needed with mineral fertilisers to balance plant nutrient requirements, workshop participants said. For example, nutrients could be extracted from manure and blended with a synthetic fertiliser program to improve efficiency.

As industry stakeholders increasingly leverage the circular economy, they must share best practices across different sectors. For example, in the case of fertilisers produced from municipal waste, municipal stakeholders and fertiliser manufacturers must collaborate to share BMPs and guidance documents for the handling, processing, and transportation of the product. In the EU, the Eco-Management and Audit Scheme (EMAS) can be a useful tool for companies and organisations to better understand and reduce their environmental impacts.

BIOFERTILISERS, BIOINOCULANTS, AND BIOSTIMULANTS

As this market is developing and expanding rapidly, industry stakeholders still have much to learn. It is important to manage expectations about these products, workshop participants stressed. Producers should expect a certain probability of a yield response from these products, rather than expecting a guaranteed yield increase. Researchers, companies, and knowledge translation and transfer specialists all have a role to play in sharing consistent messaging about the opportunities and limitations associated with these products.

BIOCHAR

Biochar could perhaps be added to slurry and animal manure to reduce emissions of ammonia, methane, and odour. Biochar can be produced using many different raw materials, such as wood and grass. The absorption properties of biochar vary depending on the type; wood-based biochar, for example, does not absorb ammonia well. Grass-based biochar could be better suited to this purpose, workshop participants said. Further research is needed to identify the best options.

The current cost of biochar could pose another barrier to the adoption of this additive at the farm level, workshop participants said. However, other participants noted that the cost of biochar depends on the type of raw materials manufacturers are using. Pacific Biochar in California, United States of America, for example, produces biochar at a reasonable price, one participant said.

GREEN FERTILISERS

Industry stakeholders need to continue to collaborate to find ways to reduce the costs of these products.

The transition from fossil fuels to green fuels such as green hydrogen will be a challenge, workshop participants recognized. Industry stakeholders need to collaborate to try to lessen "pinch points" – including reducing the cost of production of these products – and to ensure farmers can continue to produce sufficient food, fuel, and fibre.

4.3 · OVERARCHING OPPORTUNITIES

BALANCING INNOVATION AND REGULATION

Industry stakeholders must find ways to collaborate to bring new products that offer benefits for producers and the environmentto market in a timely manner. Efficient commercialization and regulatory approval are important, while still ensuring sufficient time for necessary safety, efficacy, and other regulatory reviews. Policymakers and product registration/labelling enforcement agencies could increase their collaboration to better streamline the registration and labelling processes, workshop participants said.

More research into how to best regulate the re-use of waste streams and recycling of nutrients for refined organic-based and other fertiliser products would also be beneficial.

APPROACHES TO RESEARCH & DEVELOPMENT

More applied research is necessary to show how producers can incorporate new BMPs into their production systems. In Canada, researchers and crop input manufacturers could collaborate with provincial commodity organisations, as well as local soil conservation groups. These networks foster peer-to-peer learning, which is crucial for the dissemination of BMPs and to foster innovation. More multi-site studies will also help industry stakeholders ensure that the BMPs are adapted to meet the different farming realities across Europe and Canada, as differences exist in climates and farming systems.

Farmers are trialling a lot of innovative practices themselves, and other industry stakeholders need to recognize and learn from this work underway. Co-development – in which researchers and industry representatives work alongside farmers – is vital. Discovery Farms in Wisconsin, United States of America, for example, is led by farmers and involves a diversity of stakeholders, including government, agricultural businesses, producer groups, environmental groups, and extension experts. In both Canada and the EU, the Living Labs programs centre farmers in the research and co-development process. By directly involving producers in the research and development process for new products and technologies, other industry stakeholders can help to ensure these products and technologies meet farmers' requirements and can be accepted and incorporatedat the farm level.

More long-term studies are needed to better understand how BMPs impact farming systems year over year, and to better understand the consistency of product results under different growing conditions.

Multidisciplinary research involving social scientists, scientists, and economists will help industry stakeholders better understand the current problems when it comes to optimised fertiliser use. Such collaboration can foster creative thinking and approaches to turning waste materials into useful and quality fertilisers. As industry stakeholders seek to leverage waste products to create fertilisers, they will need to leverage the expertise of a diversity of scientists. For example, industry stakeholders must think of the possibility and timeline of pathogen survival in the waste products.

Social scientists can provide insights into how to best encourage the adoption of BMPsat the farm level.

Much of the research to date on BMPs and products to optimise fertiliser use has focused on the environmental benefits. While these considerations are certainly important, farmers also need to understand the economic impacts. Ideally, the new generation of fertilisers will have viable economic models; the products must provide a return on investment for farmers to incorporate them into their operations. Economists should be involved in research related to new BMPs. In a project in Quebec, Canada, for example, agricultural economists are reaching out to the farming community to identify barriers, constraints, and opportunities.

PRIORITY AREAS FOR RESEARCH & DEVELOPMENT

Scientists need to continue to explore opportunities to improve the availability of nutrients in fertilisers, including micronutrients and nutrient balance, and to synchronize the availability of these nutrients with crop needs. Researchers must also continue to fine-tune strategies to stabilise the nutrients, and thereby reduce volatilization and leaching. These efforts can be advanced through incremental improvements in both fertilisers and application methods.

Scientists need to advance research that supports systems approaches. For example, scientists should study the application of all 4Rs, rather than studying each consideration individually. Researchers should look at the interaction between multiple practices, such as the use of cover crops and strategies for nitrogen management.Researchers should also explore the opportunity to combine multiple products, such as biostimulants and fertilisers, to support plant health and productivity.

More work needs to be done to make controlled-release fertilisers more environmentally friendly and better match crop needs. A lot of these products are covered in plastics, which can lead to the build-up of plastics in soils. While some biodegradable coatings are available, industry stakeholders need to continue to develop more options. In the EU, these coatings must be biodegradable by 2026.[25]

Relatedly, research undertaken to improve the efficiency of fertilisers must be conducted alongside research to improve crop genetics and farm management practices. In the longer term, gene editing and CRISPR could be used to modify crops to fix nitrogen.For example, a group of researchers at the Massachusetts Institute of Technology in the United States of America are trying to do this with cereal crops.[26]

Researchers must also look at the broader system of fertiliser production, manure management, and crop production to avoid the pitfall of pollution swapping. This issue occurs when, in reducing the emission of GHGs in one stage in the nutrient management process, the emissions are inadvertently increased in another stage in the process. For example, if producers use BMPs to reduce GHG emissions during manure storage, they might inadvertently simply “delay” these emissions and cause increased emissions during manure applications.

KNOWLEDGE TRANSLATION AND TRANSFER

Although scientific reports have an important role to play in knowledge transfer within the scientific community, researchers and knowledge translation and transfer specialists need to leverage a broader range of opportunities to share information with a broader audience. This audience must include both farmers and their advisors, who will apply the new BMPs in their operations, and policymakers, who will design and implement the regulations that govern the use of these BMPs and the programs to encourage adoption of BMPs. More user-friendly educational materials will facilitate greater uptake of BMPs, and help policymakers better understand the current challenges and opportunities at the farm level.

25 Fertilisers Europe. (2019.) “Micro Plastics.” Retrieved from: https://www.fertilizerseurope.com/circular-economy/micro-plastics/.

26 Lisa Miller, Abdul Latif Jameel Water and Food Systems Lab. (January 2020.) “Making Real a Biotechnology Dream: Nitrogen-Fixing Cereal Crops.” Retrieved from: https://news.mit.edu/2020/making-real-biotechnology-dream-nitrogen-fixing-cereal-crops-0110.

Several of the previously discussed approaches to research and development, including co-development and applied research trials at working farms or demonstration farms, can assist with this knowledge translation and transfer. Demonstration farms allow for the application of science in real farm environments where farmers, researchers, industry representatives, and government representatives can gather to see and discuss the benefits and outcomes. In the process, the diversity of industry stakeholders can learn more about each other, strengthen relationships, and identify new opportunities for collaboration. Demonstration farms can also help to build trust in new BMPs.

Practical tools, videos and even games are useful strategies for disseminating information within the agricultural community. In Manitoba, Canada, for example, the provincial government created a fertiliser efficiency calculator that producers can use to calculate optimised fertiliser programs for their operations. The dashboard displays information on "cost efficiency, greenhouse gas efficiency, maximum profitability and maximum yield," providing both key economic and environmental insights.[27]

27 Manitoba Government. (January 2023.) "Manitoba Government Launches Fertilizer Efficiency Calculator." Retrieved from: https://news.gov.mb.ca/news/index.html?archive=&item=57600.

5

CONCLUSIONS WITH RECOMMENDATIONS

5 · CONCLUSIONS WITH RECOMMENDATIONS

Workshop participants acknowledged the diversity of farms across and within Canada and the EU, as well as the different policy contexts. However, industry stakeholders face similar challenges in both jurisdictions, and have shared environmental goals. The workshop explored the current state of fertiliser use, as well as opportunities to optimise fertiliser use.

Producers are, of course, central to these efforts, as they areincreasingly adopting BMPs that reduce nutrient leaching and GHG emissions. Producers must be supported by, and work alongside, a range of other industry stakeholders through the transition to a greener agricultural sector. Researchers and others in the value chain must involve farmers in the co-development process to ensure new BMPs are practical to adopt at the farm level. Relatedly, policymakers should create opportunities for increased dialogue with farmers, so both groups can better understand the others' needs and working realities.

Ideally, BMPs should bring agronomic and economic benefits, in addition to decreased environmental impacts. As some BMPs offer stronger environmental benefits than direct benefits for producers, companies along the value chain can offer incentives and governments can make strategic investments in programming to assist producers in adopting new BMPs.

Through continued research and increased adoption of BMPs, agricultural industry stakeholders can collaborate to optimise fertiliser use. In the process, they can reduce fertiliser-related emissions, environmental impacts, and costs, while maintaining or enhancing crop yields and soil health. The following recommendations will help these stakeholders chart an action-oriented path ahead to ensure the continued resiliency and success of the agricultural industry while reducing nutrient leaching and GHG emissions from fertiliser use.

RECOMMENDATIONS FOR THE SCIENTIFIC COMMUNITY

1. **Strengthen scientific networking between the EU and Canada to advance shared understanding of existing and emerging BMPs to optimise fertiliser use, and how these BMPs can be best tailored to local and regional conditions and farming systems.**
   - **1.1.** Continue to fine-tune tools – including decision support tools and weather predictions – to support producers in determining optimum nutrient rates, leveraging data science and artificial intelligence in this work.
2. **Prioritize a systems approach to research and development.**
   - **2.1.** Leverage the expertise of scientists and economists to ensure the agronomic, economic, and environmental impacts of existing and emerging BMPs are studied and clearly documented. Leverage the expertise of social scientists to best encourage producer adoption of BMPs.
   - **2.2.** Develop measurable indicators to help assess the agronomic, economic, and environmental value of new products and technologies.
   - **2.3.** Study the interaction between multiple BMPs to understand how they can best be applied at the farm scale and to ensure pollution swapping does not inadvertently result.
3. **Increase collaboration with farmers, commodity associations, and farm groups by advancing co-development opportunities, building on the success of the Living Labs and Lighthouses.**
   - **3.1.** Leverage these networks to conduct more applied research across multiple sites and over multiple years to better understand how BMPs impact farming systems year over year, as well as the consistency of results under different growing conditions.

RECOMMENDATIONS FOR POLICYMAKERS AND PUBLIC AUTHORITIES

4. **Ensure timely, clear, and consistent messaging to producers about government policies, programs, and initiatives related to fertiliser use.**
   - 4.1. Create opportunities for increased dialogue between farmers and policymakers to identify shared priorities for research, knowledge transfer, and program development.
   - 4.2. Increase collaboration between various levels of government (i.e., provincial, territorial, and federal governments in Canada, and the European Commission and member state governments in the EU) to develop and disseminate more consistent messaging about overarching goals and tactics, while still recognizing and allowing for approaches and solutions that are best suited to each region.
5. **Prioritize programs or initiatives that support producers in adopting BMPs that are confirmed to bring minimal return on investment, or require significant capital expenditures, but reduce GHG emissions from fertilisers.**
   - 5.1. Ensure programs are open to all producers, regardless of their previous experience with these BMPs.
6. **Collaborate with product registration/labelling enforcement agencies to streamline the registration and labelling process for new fertiliser products.**
   - 6.1. Support additional research into best practices for regulating fertilisers produced with materials from the circular economy, as well as other novel crop inputs.

RECOMMENDATIONS FOR THE VALUE CHAIN

7. **Provide incentives or financial recognition for farmers trialling and adopting BMPsthat reduce GHG emissions from fertiliser use.**
8. **Share best practices across industries and sectors to best leverage the circular economy and ensure the quality and safety of organic fertilisers.**
9. **Develop clear communications about new products or technologies so producers and their advisors understand the potential benefits and limitations of these products and technologies.**

RECOMMENDATIONS FOR ALL FERTILISER STAKEHOLDERS

10. **Collaborate to improve data collection related to fertiliser use.**
    - 10.1. Use more robust datasets to better predict emissions from fertiliser use, conduct more accurate benchmarking, and clearly demonstrate the impact of BMPs.
    - 10.2. Ensure clear and open communication with producers about why the data is being collected, how it will be stored, analysed, and used, and how the privacy of individual producers will be protected.
11. **Prioritize the development and dissemination of more user-friendly communication materials, targeted to the needs of various stakeholder groups, such as policymakers and farmers.**
    - 11.1. Emphasize the benefits of focusing on maximizing profits, rather than yields, and the need to find optimum fertiliser application rates to ensure a return on investment and reduction of GHG emissions.
12. **Collaborate to reduce “pinch points” for the whole value chain, and particularly farmers, in the transition from fossil fuels to green fuels.**

6

ANNEXES

6 · ANNEXES

6.1 · WORKSHOP AGENDA

Canada | Co-Funded by the European Union

EU-Canada Agriculture Dialogue Workshops

Sustainable Use of Fertilisers

January 25, 2023 · 08:45-12:00 EST / 14:45-18:00 CET – online

AGENDA

OPENING PLENARY SESSION

08:45 – 09:30 EST / 14:45 – 15:30 CET

Sustainable Use of Fertilisers to improve performance while reducing emissions and maintaining soil productivity

MODERATOR: Bronwynne Wilton

EU

- **Michael Scannell,** *Deputy Director General, DG AGRI, European Commission*
- **Kerstin Rosenow,** *Head of Unit Research & Innovation, DG AGRI, European Commission*

CANADA

- **Sophie Beecher,** *Director General for the Sustainable Development Policy Directorate of Strategic Policy Branch, Agriculture and Agri-Food Canada*
- **Claudia Wagner-Riddle,** *Professor at the School of Environmental Sciences, University of Guelph*

BREAK · 5 minutes

PARALLEL BREAK OUT SESSIONS

09:35 – 11:05 EST / 15:35 – 17:05 CET

THEME 1: Farming Practices to optimise the use of fertilisers and to reduce air emissions and water pollution

1.A MODERATOR

Tessa Avermaete, *University of Leuven*

PART 1 · Farming practices for mineral fertilisers, from enhanced crop rotations to conservation agriculture.

PANEL PARTICIPANTS

- **Jonas Perneels,** *Dairy farmer*
- **Richard Farrell,** *University of Saskatchewan*

PART 2 · Technology assisted management strategies to reduce air, water and soil pollution while maintaining productivity (precision agriculture, modelling).

PANEL PARTICIPANTS

- **David Wall,** *TEAGASC*
- **Ward Smith,** *Agriculture and Agri-Food Canada*

1.B MODERATOR

David Pelster, *Agriculture and Agri-Food Canada*

PART 1 · Farming practices for mineral fertilisers, from enhanced crop rotations to conservation agriculture.

PANEL PARTICIPANTS

- **David Burton,** *Dalhousie University*
- **Antoon Vanderstraeten,** *"Den Bosbeekhof» market garden and journalist Hectares magazine*

PART 2 · Technology assisted management strategies to reduce air, water and soil pollution while maintaining productivity (precision agriculture, modelling).

PANEL PARTICIPANTS

- **Oene Oenema,** *Wageningen University*
- **Mario Tenuta,** *University of Manitoba*

THEME 2: Increasing availability of fertilisers through innovation and alternative sources

2.A MODERATOR
Ludwig Hermann, *Sustainable Phosphorous Platform*

PART 1 · Innovative technologies to improve crop nutrition efficiency and reduce environmental losses (enhanced efficiency fertilisers, microbiological controls.

PANEL PARTICIPANTS

- **Erik Meers,** *University of Ghent*
- **Craig Drury,** *Agriculture and Agri-Food Canada*

PART 2 · New/emerging fertilisers derived from secondary raw materials and renewable sources.

PANEL PARTICIPANTS

- **Javier Brañas Lasala,** *Fertiberia*
- **Tom Bruulsema,** *Plant Nutrition Canada*

2.B MODERATOR
Baoluo Ma, *Agriculture and Agri-Food Canada*

PART 1 · Innovative technologies to improve crop nutrition efficiency and reduce environmental losses (enhanced efficiency fertilisers, microbiological controls).

PANEL PARTICIPANTS

- **Tiffanie Stephanie,** *Yara International*
- **Joann Whalen,** *McGill University*

PART 2 · New/emerging fertilisers derived from secondary raw materials and renewable sources.

PANEL PARTICIPANTS

- **Dries Huygens,** *Joint Research Centre*
- **Kari Dunfield,** *University of Guelph*

BREAK · 10 minutes (to transition)

CLOSING PLENARY SESSION

11:15 EST – 12:00 EST / 17:15 – 18:00 CET

MODERATOR: Bronwynne Wilton

RAPPORTEURS FROM BREAKOUT SESSIONS

- **1A Rapporteur: Isidro Campos-Rodriguez,** *DG AGRI European Commission*
- **1B Rapporteur: Ikechukwu Agomoh,** *Agriculture and Agri-Food Canada*
- **2A Rapporteur : Michael Wolf,** *DG AGRI, European Commission*
- **2B Rapporteur Aaron Glenn,** *Agriculture and Agri-Food Canada*

REACTIONS & CLOSING COMMENTS

6.2 · BIOGRAPHIES OF PANELLISTS, MODERATORS, AND RAPPORTEURS

SENIOR EXPERT AND WORKSHOP MODERATOR

Dr. Bronwynne Wilton is the Principal and Lead Consultant at Wilton Consulting Group in Fergus, Ontario, Canada.Bronwynne holds a PhD in rural studies and is experienced in managing comprehensive, full value-chainresearch and stakeholder engagement processes related to sustainability, innovation, strategic planning,regional agriculture, and food strategies. Bronwynne is the project lead for the development ofthe Canadian Agri-Food Sustainability Initiative (CASI).

OPENING PLENARY SESSION SPEAKERS

Sophie Beecher is the Director General ofthe Sustainable Development Policy Directorate at Agriculture and Agri-Food Canada (AAFC). Her team develops and influences agricultural policies that affect Canada's food systems and support sector sustainability with a focus on environmental, social and health outcomes as well as competitiveness. She started her career in the public service as Counsel for the Department of Justice. Prior moving to Agriculture, Sophie worked in National Security and Intelligence policy.

Kerstin Rosenow is the Head of the Research and Innovation unit in DG AGRI of the European Commission. She is responsible for programming, managing, and monitoring agricultural research under Horizon Europe and the European Innovation Partnership for Agricultural Productivity and Sustainability. Previously, she was Head of Unit in the European Commission Research Executive Agency, managing the implementation of the project portfolio for Horizon 2020 Societal Challenge 2.

Michael Scannell is Deputy Director General in DG AGRI with responsibility for markets, audits, and international issues. He is Irish and a graduate in Politics and Economics from University College Dublin. He has held a wide range of posts over a 30-year career in the European Commission, specializing in food safety and animal health, agriculture, trade, audit, and international issues. Michael has worked in the Directorate-General for Health and Food Safety as a Head of Unit and Director for Audits and, prior to becoming Deputy Director General in DG AGRI, he was the Director for Markets.

Dr. Claudia Wagner-Riddle is a Professor in the School of Environmental Sciences at the University of Guelph in Ontario, Canada. Originally from Brazil, Claudia has degrees from the University of Sao Paulo and Guelph. Claudia is an expert on nitrous oxide emissions from agriculture. Claudia is the Director of the North American regional chapter of the International Nitrogen Initiative and was awarded the 2020 International Fertiliser Association's Borlaug Award of Excellence in Crop Nutrition.

PARALLEL BREAKOUT SESSION MODERATORS

Tessa Avermaete is Project Manager at the Sustainable Food Economies Research Group of Leuven University. Tessa manages interdisciplinary and transdisciplinary consortia, and she focuses on the European context. She is the project manager of the EU-funded project RUSTICA, a project that focuses on the development of biobased fertiliser products from plant-based waste streams.

Ludwig Hermann is a Senior Researcher and Advisor at Proman Management GmbH. He was Co-founder and long-term CEO of ASH DEC Umwelt AG and is co-inventor of minerals/ash decontamination, phosphorus recovery, energy conversion and efficiency technologies. Ludwig is author and co-author of several patents and publications on recovery of critical materials, nutrient recycling, and renewable energy. He is also a board member of the European Sustainable Phosphorus Platform, Brussels.

Dr. Baoluo Ma is a Research Scientist at AAFC's Ottawa Research and Development Centre. He is known nationally and internationally for his innovative research on crop abiotic stress physiology and nutrient management. Baoluo served as editor of Crop Rotations: Farming Practices, Monitoring and Environmental Benefits. Baoluo has been awarded a Fellow of the American Society of Agronomy, Fellow of the Canadian Society of Agronomy, and Fellow of the Crop Science Society of America.

Dr. David Pelster is a Soil Scientist with AAFC's Quebec Research and Development Centre. Prior to joining AAFC, he worked at the International Livestock Research Institutein Nairobi, Kenya. David's current work focuses on determining how improved nitrogen management affects soil nitrogen dynamics and N2O emissions from cropping systems and finding new technologies to reduce N2O emissions from agriculture.

RAPPORTEURS

Dr. Ikechukwu Agomoh is a Research Scientist atAAFC's Fredericton Research and Development Centre. He received his M.Sc. and Ph.D. in Soil Science from the University of Manitoba. Ikechukwu's research program seeks to develop nutrient strategies which increase nitrogen availability to crops by reducing losses to the environment and build soil health. Ikechukwu is the Science Lead for the New Brunswick Living Lab under the AAFC's Agricultural Climate Solutions Program.

Dr. Aaron Glenn is a Research Scientist at AAFC's Brandon Research and Development Centre. Hehas a Ph.D. in Soil Science and has worked as a Research Scientist specializing in micrometeorology with AAFC since 2011. His area of expertise and research interests relate the impact that weather and climate have on crop production and the influence that agricultural production systems have on GHGs and air quality.

Isidro Campos Rodriguez is a Policy Officer at DG AGRI. Since starting in 2018, he has worked with the use of external inputs in agriculture, mainly fertilisers, water, and pesticides. He has more than 14 years of experience working in academia related to the use of new technologies (digital tools, remote sensing, field sensors, etc.) to provide advice to farmers and to inform policy decisions.

Michael Wolf is a Research Policy Officer in the European Commission, where he contributes to DG AGRI's research and innovation agenda in the areas of bioeconomy and forestry. Before joining the European Commission in 2019, he worked in different positions for the Austrian Ministry of Agriculture and Environment. Michael has an academic background in natural resources management and ecological engineering.

6.3 · PARALLEL BREAKOUT SESSION SPEAKERS

FARMING PRACTICES TO OPTIMISE THE USE OF FERTILISERS AND TO REDUCE AIR EMISSIONS AND WATER POLLUTION

Dr. David Burton is a Dalhousie Distinguished Research Professor, Director of Dalhousie's Centre for Sustainable Soil Management, and a Fellow of the Canadian Society of Soil Science. David's research examines the role of the soil environment in influencing the nature and extent of microbial metabolism in soil. One of his current research programs involves the development of tools for the measurement of soil nitrogen supply to plants.

Richard Farrell is an Associate Professor in the Department of Soil Science at the University of Saskatchewan. His research addresses the impacts of agricultural management on GHG emissions from integrated agricultural landscapes and the development of advanced fertiliser management strategies. Richard is the Co-director of the Prairie Environmental Agronomy Research Laboratory and the Director of the Agricultural Greenhouse Gas Analysis Laboratory.

Jonas Perneel is the son of a Belgium dairy farmer, and works at CRV, which is one of the world's leading breeding organizations of cows. He is active in his family's dairy farm. Jonas received his Master of Science in Bioscience Engineering Technology: Agriculture (Plant and Animal Production). In his spare time, Jonas is also active at the youth organization "GroeneKring."

Dr. Ward Smith is a Research Scientist at AAFC'sOttawa Research and Development Centre. Ward has 25 years of experience leading research on assessing sustainable and resilient farm management practices. He leads a World Meteorological Organization Expert Team on Agromet Sciences. He collaborates on several international studies focused on improving and comparing agricultural models to evaluate the environmental performance of crop production.

Oene Oenema was a Professor of Nutrient Management and Soil Fertility at Wageningen University from 1994 to 2019, and Chair of the Scientific Committee on the Nutrient Management Policy in the Netherlands from 2003 to 2022. Oene was trained to become a dairy farmer.

Mario Tenuta,P.Ag., is the Natural Science and Engineering Council/Western Grains Research Foundation/ Fertilizer Canada Senior Industrial Research Chair in 4R Nutrient Stewardship and Professor of Applied Soil Ecology at the University of Manitoba. A key feature of the Chair program is conducting farm-based research with particular attention to the outreach of findings to farmers, industry, and policymakers.

Antoon Vanderstraeten is an agricultural journalist, and a small-scale farmer owning a market garden called Den Bosbeekhof. Antoon grew up just outside of Brussels and got his degree in horticulture. Working as an agriculture journalist, he interacts with many people in the sector, from the small-scale farmer to the head of development of worldwide-known equipment manufacturers. He uses the information he learns to educate others within and outside the agricultural industry.

David Wall is Leader of Research Operations at the Environment, Soils and Land-use Research Centre at Teagasc Johnstown Castle. David sits on national expert review groups for agri-environmental policy and soil health and is Editor of the national nutrient recommendation manual for grassland agricultural crops. He currently leads the "science to policy" work package in the European Joint Programme for Soil, which focusses on climate smart and sustainable soil management.

INCREASING AVAILABILITY OF FERTILISERS THROUGH INNOVATION AND ALTERNATIVE SOURCES

Prof. Erik Meers is associated with Ghent University in Belgium, where he leads the RE-SOURCE research group focusing on biobased resource recovery. He has supported the European Commission in several capacities, such as serving as the Coordinating Expert of the focus group on nutrient recycling, and as a Corresponding Author on the Circular Biobased Fertilisers report for the ECJoint Research Centres.

Dr. Craig Drury is a Soil Biochemist at AAFC's Harrow Research & Development Centre in Southwestern Ontario. Craig's primary research focus is to develop soil and crop management practices to reduce ammonia volatilization and nitrous oxide emissions from agricultural soils while enhancing soil health and crop yields. Craig is the Canadian representative on the Croplands Research Group and the Conservation Agriculture Network Lead.

Dr. Javier Brañas Lasala is Director of Research, Development, and Innovation in FERTIBERIA since 2006. He has developed several projects aimed at optimising the efficiency of fertilisers, improving circularity, and ensuring agricultural sustainability. He is a member of the Spanish Technology Platform for Sustainable Chemistry SUSCHEM-Spain and of the EIP Focus Group Fertiliser Efficiency in Horticulture. Javierhas collaborated on other H2020 initiatives.

Tom Bruulsema is Chief Scientist with Plant Nutrition Canada, providing support for the nutrient stewardship programs of Fertiliser Canada, the Fertiliser Institute, and the International Fertiliser Association. He is a member of the Scientific Panel on Responsible Plant Nutrition, and of the Steering Committee of the Global Partnership on Nutrient Management.

Tiffanie Stephani is the Vice-president, heading the Government Relations and External Communications at Yara Europe, the European market leader in plant nutrition. Tiffanie promotes climate-friendly crop nutrition and zero-emission energy solutions, such as green ammonia. She was previously a Senior Agriculture and Environment Manager at Fertilisers Europe, representing the interests of most mineral fertiliser manufacturers in the EU.

Joann K. Whalen is the James McGill Professor at McGill University and an Affiliated Professor at the Mohammed VI Polytechnic University in Morocco. She studies soil fertility and the ecological health of agricultural systems, including crop growth benefits from biostimulants and other biologicals. She is a Fellow of the Soil Science Society of America and President of the American Society of Agronomy.

Dries Huygens is a Technical-Scientific Officer at the Joint Research Centre, working on issues related to circular economy and waste management. He has supported the development of technical quality criteria set out in the EU regulation, particularly for fertilisers derived from secondary raw materials, including policy development on manure management, sewage sludge and other secondary raw materials.

Dr. Kari Dunfield is a Professor and Canada Research Chair in Environmental Microbiology of Agro-ecosystems at the University of Guelph in Ontario, Canada. She is one of Canada's premier scientists working at the intersection of microbiology, ecology, and soil science. Kari serves as a Co-Editor-in-Chief of the Canadian Journal of Microbiology, the North American representative for Pillar One of the UN-FAO Global Soil Partnership, and a Co-Executive Director of Soils@Guelph.

6.4 · NOTETAKERS

NAME	AFFILIATION
Benjamin Vallin	Directorate-General for Agriculture and Rural Development
Betty Lee	Directorate-General for Agriculture and Rural Development
Bipasha Chakravarty	Agriculture and Agri-Food Canada
Lauryn Rohde	Agriculture and Agri-Food Canada
Mickaël Lepage	Agriculture and Agri-Food Canada
Sierra Picard	Agriculture and Agri-Food Canada
Tim Mahler	Agriculture and Agri-Food Canada

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