Emergence of the Global Research Alliance on Agricultural Greenhouse Gases

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> "Member countries of the Alliance recognize opportunities to reduce GHG emissions and sequester carbon in soil by improving the efficiency and productivity of agricultural systems through robust ecologically based management practices and technologies, as well as developing novel approaches."

Steven R Shafer, Charles L Walthall, Alan J Franzluebbers† *et al.*

At the turn of the millennium, approximately 34% of the Earth's ice-free land surface was occupied by crops and pasture [1]. Our land currently feeds over 6 billion people, but by mid-century, it will be expected to feed approximately 9 billion people; either by expanding agricultural land to areas that are currently uncultivated, increasing production from current agricultural land, increasing harvest of aquatic life or a combination. This increasing human pressure on the Earth is of great concern and a key reason why agricultural and natural resource sciences must be fully engaged to develop solutions for a sustainable future.

In response, the Global Research Alliance on Agricultural Greenhouse Gases (Alliance) was conceived when government ministers from 21 countries endorsed a joint ministerial statement establishing the alliance during the December 2009 United Nations Conference of Parties in Copenhagen, Denmark [101]. An edited video of the ministerial statement can be viewed at [102]. The Alliance will formally start its work with the expected signing of the charter on 24 June 2011 at the inaugural Alliance Ministerial Summit in Rome, Italy. The Alliance recognizes that productive and efficient agriculture is essential for food security, poverty reduction and sustainable development. It also recognizes that agriculture has an important global role in mitigating greenhouse gas (GHG) emissions, while at the same time, needing to overcome the significant technological, social and economic challenges posed by the expected increase in global food demand and impacts of climate change on agricultural production itself.

Current and expected future agricultural GHG emissions are not trivial, given the large historic change in atmospheric CO_2 concentration (averaging an increase of 5.4 Pg CO_2/year since 1850. It is noteworthy that actual anthropogenic CO_2 emissions have increased exponentially with time. In 2008, CO_2 emissions were 36.3 ± 3.3 Pg CO_2/year, not including CH_4 and N_2O emissions (as CO_2 equivalents) [2]). Globally, agriculture produces approximately 14% (6.1 Pg CO_2e/year) of GHG emissions [103], which is approximately the same as the transport sector or the stationary energy sector (It is noteworthy that this estimate uses global warming potential based on 100-year time period and other metrics to compare GHGs exist and they could result in different weightings of agricultural emissions relative to the global total [3]). Agricultural emissions of GHGs could increase to 7.9–8.5 Pg CO_2e/year by 2050, as the

†Author for correspondence: USDA. Agricultural Research Service, 1420 Experiment Station Road, Watkinsville GA 30677, USA;
Tel.: +1 706 769 5631; Fax: +1 706 769 8962; E-mail: alan.franzluebbers@ars.usda.gov
*Full affiliations provided at the end of the article.

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agricultural sector seeks to meet an expected doubling of food demand. Agriculture has inherent GHG sources that are unavoidable consequences of production:

- Methane (CH_4) emissions from animal manure, enteric fermentation in ruminants and paddy-rice cultivation;
- Nitrous oxide (N_2O) emissions from agricultural soils amended with fertilizer, legumes and animal manures;
- CO_2 emissions from on-farm biochemical processes, energy expenditures and embodied emissions in machinery, buildings and chemical inputs.

These GHG emissions cannot be expected to be elimintaed, but there are opportunities to reduce GHG intensity per unit of land and per unit of food product [4] and to reduce existing net CO_2 emissions via increased sequestration of carbon in agricultural soils [5]. There may also be opportunities to use bio-based agricultural products to substitute for more GHG-intensive fuels and materials produced from fossil fuels.

Member countries of the Alliance recognize opportunities to reduce GHG emissions and sequester carbon in soil by improving the efficiency and productivity of agricultural systems through robust ecologically based management practices and technologies, as well as developing novel approaches. By capturing these opportunities, not only will agricultural GHG emissions be mitigated, but resiliency and adaptive capacity of agriculture to meet the growing demand for food in a sustainable manner amidst global-environmental changes will be an expected outcome.

Specific objectives of the Alliance are to [104]:

- Improve knowledge sharing, as well as access to and application of the numerous GHG mitigation and carbon sequestration best management practices and technologies among farmers, many of which can also enhance productivity and resilience;
- Facilitate the exchange of information among scientists around the world;
- Help scientists around the world gain expertise in mitigation knowledge and technologies through new partnerships and exchange opportunities;
- Develop the science and technology needed to improve the measurement and estimation of GHG emissions and carbon sequestration in different agricultural systems;
- Promote consistent methodological approaches for the measurement and estimation of GHG emissions and carbon sequestration to improve research coherence and the monitoring of mitigation efforts;
- Enhance synergies between adaptation and mitigation efforts;
- Build partnerships among farmers and farm organizations, the private sector, international and regional research institutions, foundations and other relevant government and non-governmental organizations, to facilitate and enhance the coordination of research activities and dissemination of best practices and technologies.

Research groups

The Alliance currently supports three research groups: croplands, livestock and paddy rice. Connecting these three research groups are cross-cutting teams devoted to: soil carbon/nitrogen cycling and inventories/measurement. The three research groups were formed in Wellington, New Zealand at the first senior officials neeting during April 2010. The purpose of the initial meeting was to convert enthusiasm into action and to decide what governance and administrative arrangements would be required to ensure that the Alliance functions effectively. Each of the research groups met separately in 2010 to further organize research efforts. The paddy rice research group met in Tsukuba, Japan on 2 September 2010 to organize members, take stock of research capabilities in each member country and formulate a coordinated work plan for the future. Similarly, the livestock research group met in Banff, Canada on 8–9 October 2010 and the croplands research group met in Long Beach, California, USA on 4 November 2010. The research groups also met on 1 March 2011 in Grignon (croplands and paddy rice) and in Clermont-Ferrand (livestock), prior to the second Senior officials meeting in Versailles, France which took place on 2–3 of March 2011.

Croplands research group

The croplands research group is coordinated by the USA. To date, the croplands research group has set specific goals of:

- Taking stock of key scientific projects and personnel involved in GHG emissions and soil carbon sequestration of cropping systems;
- Developing a searchable literature database relevant to agricultural GHGs and soil carbon sequestration;
- Assembling protocols, guidelines and methods for determining soil carbon, GHG fluxes, and assessing temporal and spatial variations among measurements [105];
- Developing sub-group teams to address GHG emissions and changes in soil carbon in agricultural peatlands and wetlands, using simple and complex

models to evaluate carbon and nitrogen emissions, and assessing net GHG emissions and soil carbon sequestration with cropland management practices;

- Identifying funding opportunities for cross-national research collaboration;
- Cataloging best management options and recommendations for different environments.

The croplands research group covers GHG emissions research from arable-annual crops (except paddy rice), agroforestry, perennial fruits, vegetables and forages. The diversity of management systems and environmental conditions addressed by this research group matches the diversity of crops and their spatial and temporal arrangements. Indeed, this diversity is a major reason for the Alliance to share scientific resources globally in order to make more rapid changes towards the adoption of best management practices for greater productivity and preservation of environmental quality, under the diversity of agricultural conditions in the world. Adopting an approach similar to that of the United States Department of Agriculture (USDA) Agricultural Research Service's GRACEnet [106], one of the croplands research group's aims is to build a global network of reputable GHG emission and soil-carbon-sequestration data from specific management approaches so that appropriate synthesis evaluations can be undertaken, along with validation and testing of process-based models across a diversity of environments. The capacity for global research advancement will be greatly enhanced, and the realization of positive management changes arising from international research will be based on member countries' commitment and investment in the Alliance. We are excited by the possibilities for advancing our knowledge of agricultural GHG emissions and mitigation along a continuum of research that explains how GHGs are emitted in agricultural systems and predicts how emissions change under different environmental and management scenarios. Ultimately, this will support decision making by farmers, resource managers and policy makers.

The next meeting of the croplands research group is planned for 20 October 2011 in association with the Annual Meeting of the American Society of Agronomy-Crop Science Society of America-Soil Science Society of America in San Antonio, Texas, USA [107].

Livestock research group

The livestock research group is coordinated by the Netherlands and New Zealand. The scope of the group is to characterize GHG emissions (CO_2, CH_4 and N_2O) from four general components of the industry, namely housing, feed, manure and grazing lands. Formation of research teams was derived from the nature of the animals of investigation: ruminants and non-ruminants. Goals for the livestock research group include: sharing and exchange of information and methodologies; identifying critical factors related to GHG emissions; identifying options for the measurement and mitigation of GHG emissions; and identifying possibilities for joint research and concerted actions. Common understanding and concerted actions are sought on the issues of:

- Current research capacities – taking stock of member capacities;
- Research data inventories – providing links to the rumen microbial genomics network, developing a global database of rumen microbial community structure, sharing of data on animal genetics and genomics, encouraging a global N_2O network, establishing a manure-management network and establishing a network on feed and nutrition;
- Information and technology transfer – developing best practice guides for CH_4 measurements with SF_6-tracer technique and for N_2O measurements using soil chambers, developing a technical manual for alternative designs for low-cost CH_4 respiration chambers, and cataloging existing GHG-mitigation technologies;
- Research capacity development – working with FONTAGRO to reduce uncertainty and test mitigation options [108], promoting GRASS awards to develop partnerships between New Zealand and other countries [109], providing LEARN trainee and post-doctoral fellowships [110] and advertising about training courses and fellowships;
- Research collaboration – conducting rapid, low-cost automated enteric CH_4 measurements, linking to the European Joint Programming Initiative on food security, agriculture and climate change, identifying opportunities for collaboration, and extending the participation in the Animalchange project [111];
- Policy support – supporting the Intergovernmental Panel on Climate Change
- 5th Assessment Report, developing technical synthesis reports on feeding options and manure management, and identifying critical factors related to GHG emission and mitigation.

The next meeting of the livestock research group is planned for 4–5 November 2011 in association with the 6th International Conference on non-CO_2 Emissions in Amsterdam, the Netherlands [112].

Paddy rice research group

Paddy rice has unusually high emission of CH_4 compared with other cropping systems and, thus, Alliance member countries saw a need to establish a separate research group on this globally-important crop. Three overarching elements were used to frame goals in a holistic manner for the group: maintaining and improving productivity to increase food security; ensuring production was carried out in a sustainable manner, including reduction in GHG emissions; and enhancement of opportunities for farmers to adopt new technology and solutions to problems. While trade-offs among various aspects of a production system might be needed, a key underlying process is to have robust scientific data to understand the impacts of management decisions. Goals for the paddy rice research group, coordinated by Japan and Uruguay, include:

- Standardization of measurement techniques – identifying good practice and gaps in current knowledge, developing improved country-specific emission factors and mitigation options, scaling up information and extrapolating to the long term;
- Development of literature and data bases on alliance website;
- Increase scientific partnerships with International Rice Research Institute, Africa Rice Center, Global Rice Science Partnership, Asian Development Bank, Association of Southeast Asian Nations and International Development Bank;
- Increase membership from additional countries;
- Long-term aspirations of: mitigating GHG emissions from water management, organic matter and fertilizers, cultivar selection and use of amendments; developing an experimental protocol for a multi-site, multi-country field experiment; quantifying efficiencies of water and nutrients (e.g., calculating kg rice m^{-3} water kg^{-1} CO_2e), tradeoffs among CO_2, CH_4 and N_2O, and co-benefits of the options (e.g., life cycle, carbon footprint and/or economic analyses).

The next meeting of the paddy rice research group is planned for 18 November 2011 in association with the Monsoon Asia Agro-Environmental Research Consortium Workshop on Agricultural Greenhouse Gas Mitigation in Tsukuba, Japan [113].

Cross-cutting teams

Each of the three research groups has already recognized common themes related to: understanding and modeling of carbon/nitrogen cycling in soil and improving national GHG inventories/measurement. These themes formed the basis for cross-cutting teams, composed of scientists participating in each of the three research groups. Australia and France will coordinate the theme on carbon/nitrogen cycles. Canada and the Netherlands will coordinate the theme on inventories/measurement. Work will also be required to understand the Alliance's linkages to other international efforts, for example, the Global Carbon Project and on life-cycle analyses, which will be coordinated by the Netherlands. The work of these teams is being coordinated to avoid duplication of efforts among research groups, but also to gain expertise from a broad group of scientists in each of the three research groups. The carbon/nitrogen cycling team met in Orleans, France on 4 March 2011 to initiate collaborative research activities. Topics of discussion included setting common objectives, planning for joint modeling of carbon and nitrogen cycles, and developing work plans. The team will meet again in July 2011 in association with the Third Soil Organic Matter Symposium in Leuven, Belgium [114]. The inventories/measurement team is conducting a review of inventory methodologies and will be meeting in the near future.

Moving forward

The vision for the Alliance is a voluntary network of scientists, policy makers, farmer organizations and others, working together to gain a better understanding of how GHG emission intensity can be reduced, while food security can be increased. Since ministers of 21 countries endorsed the joint ministerial statement in Copenhagen in 2009, 12 additional countries have joined the Alliance. There are no financial obligations associated with membership. Therefore, the Alliance seeks to leverage each member country's existing scientific expertise and resources in different agricultural systems and environments to make a more rapid and robust impact on the global issue of GHG emission and climate change. This is a collaboration to conduct research and share information for mitigating agricultural GHGs. Agriculture as currently practiced generates GHG emissions through natural and man-made processes. However, through bold initiatives to mitigate GHG emissions, we may find ways to change how agriculture is practiced through better integration of agricultural activities with ecological theory and conservation land use.

Human society must continue to recognize that food production is a key ecosystem service that supports society, and without agriculture, fruitful passage to the future will not be plausible [6]. Soil, water, air and the sun, as well as genetic resources, are the essential features of agriculture and ecosystem services, which feed our existence. Investing in high-quality natural resource management is equivalent to investing in

the future [7]. The Alliance was undertaken to transcend the science of natural resource management beyond political borders and on to farms to secure a sustainable future.

Currently, membership in the Global Research Alliance on Agricultural Greenhouse Gases includes Argentina, Australia, Canada, Chile, Columbia, Denmark, Finland, France, Germany, Ghana, India, Indonesia, Ireland, Italy, Japan, Malaysia, Mexico, the Netherlands, New Zealand, Norway, Pakistan, Peru, Philippines, Russia, South Africa, Spain, Sweden, Switzerland, Thailand, the UK, the USA, Uruguay and Vietnam. These members will welcome seeing this list grow. More information is available at the Alliance website [115].

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Affiliations

Steven R Shafer[1], Charles L Walthall[1], Alan J Franzluebbers[2], Martin Scholten[3], Jac Meijs[3], Harry Clark[4], Andy Reisinger[4], Kazuyuki Yagi[5], Alvaro Roel[6], Bill Slattery[7], Ian D Campbell[8], Brian G McConkey[9], Denis A Angers[10], Jean-Francois Soussana[11] & Guy Richard[12]

[1]USDA. Agricultural Research Service, 5601 Sunnyside Avenue, Beltsville MD 20705, USA
[2]USDA. Agricultural Research Service, 1420 Experiment Station Road, Watkinsville GA 30677, USA
[3]Wageningen University, Wageningen, The Netherlands
[4]New Zealand Agricultural Greenhouse Gas Research Centre, Tennent Drive, Private Bag 11008, 5Palmerston North 4442, New Zealand
[5]National Institute for Agro-Environmental Sciences 3–1-3 Kannondai, Tsukuba 305–8604, Japan
[6]National Institute of Agricultural Research, 33000 Treinta y Tres, Uruguay
[7]Department of Climate Change and Energy Efficiency, Constitution Avenue, Canberra, ACT 2600, Australia
[8]Agriculture and Agri-Food Canada, Ottawa, Canada
[9]Agriculture and Agri-Food Canada, P.O. Box 1030, Swift Current, Saskatchewan S9H 3X2, Canada
[10]Agriculture and Agri-Food Canada, 2560 Hochelaga Blvd, Québec G1V 2J3, Canada
[11]INRA, 147 rue de l'Université, 75338 Paris Cedex 07, France
[12]INRA, Centre de Recherche d'Orléans, 2163 Avenue de la Pomme de Pin, 45075 Orleans Cédex 2, France

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