

Project Statement - Dr John Kirkegaard FAA

Sustaining productive wheat cropping systems in a climate-constrained world – success from system synergy

Background

Wheat and wheat-farming systems are not only at the centre of global food security, but also underpin the economic and social prosperity of the rural communities in which they operate. Australia and Kansas (along with neighbouring states in the US Great Plains), represent some of the most intensive and important wheat-farming areas of the world. In both, capturing and storing rainfall effectively in the soil and converting it efficiently into grain or forage (i.e. improved water-use efficiency) is not only the pathway to higher productivity but is also the key to reduce the environmental damage caused by water loss through run-off and erosion, or deep drainage – a win-win for productivity and the environment.

The importance of water and its efficient use in Australian and US Great Plains wheat production systems is exacerbated by the unpredictable and extremely variable nature of seasonal rainfall, an effect that will become more pronounced under future climate change. Yet despite this dependence on rainfall for crop production, yield gap analysis (i.e., the difference between current farmer yield and the potential yield under optimum management) in both areas suggest we are achieving only ~60% of water-limited wheat yield potential, and even less at the cropping system level. Rather than a lack of rainfall, inefficiencies in the capture, storage and use of rainfall by crops is responsible. This represents a huge opportunity for farmers to improve their management to increase productivity and profitability, reduce the risks of environmental damage and develop more resilient systems in the face of climate change. But where to focus research attention?

Typically, research for proposed transformative changes focus on one component of a system – a new genetically modified crop, a more effective biological fertiliser, or a new satellite-guided planter – often by largely disconnected research disciplines. In reality, and throughout history, few individual technologies have been singularly transformational in the scale or speed with which they have influenced agricultural productivity. Rather, step changes in productivity have come when combinations of technologies synergize within a system in a process termed “incremental transformation” (Kirkegaard 2019). In practice, this means researchers must be alert when working on new ideas and technologies as to what else might be needed to increase impact. Often referred to as the G (genotype) × E (environment) × M (management) approach to research, this systems approach recognises the need for effective interaction across multidisciplinary specialists working closely with farmers to achieve adoption and impact.

Research teams led by Dr John Kirkegaard (CSIRO Australia) and Dr Romulo Lollato (Kansas State University) have embraced and apply this holistic system-based approach to improve the productivity and resilience of wheat farming systems. Recent examples of success are the development of earlier sowing systems in Australia (Hunt et al., 2021) and the intensification and diversification of wheat systems in the central Great Plains (Massigoge et al., 2024). A period of intense interaction between the CSIRO and KSU teams afforded by this Fulbright Scholarship would provide a unique opportunity for scientific exchange, to share research approaches used across diverse wheat-farming systems, build capacity and develop ongoing partnerships to excite and propel the careers of the next generation of transformational agronomists in Australia, the USA and beyond.

Participants

Kansas is the largest wheat-growing state in the US, and together with neighbouring states represents one of the most diverse and important wheat-growing areas in the world. The wheat farming system is dominated by monocultures of winter wheat, but there are a variety of other systems ranging from spring wheat systems in North Dakota, winter and spring wheat systems through South Dakota, Nebraska, Kansas, Colorado, Oklahoma and into Texas. In Kansas alone, the diversity of soils and climate support a wide range of systems that include predominantly hard red and hard white winter wheat in monoculture or in rotation with other crops, but also smaller areas of soft red winter wheat, spring wheat and new areas of durum wheat – with a range of end uses for the grain (predominantly bread, but also biscuit, cakes, pizza, pasta, and feed) as well as forage in dual-purpose systems (grazing and grain) and silage for a growing dairy industry.

Unsurprisingly, KSU features a world-class College of Agriculture organised in 9 departments, including the Agronomy department, that together share an interdisciplinary approach to advancing the public good through agriculture. Associate Professor in Agronomy, Romulo Lollato (PhD), the KSU host for the proposed project, is a wheat and forage extension specialist with strong extension and research programs overseeing more than 20 different research projects, many involving Master or PhD students and post-docs training in his program. Together with his KSU and interstate colleagues, a central aim of the agronomic research is to expand the adoption of more intensified and diversified wheat cropping systems by improving the capture and efficient use of resources. A recent focus of Dr Lollato's program, led by industry- and consumer-demand, has been on sustainable production and processing of winter wheat, quantifying the carbon footprint of the crop from seed to bread.

This mission aligns strongly with that of Dr Kirkegaard's Innovative Agronomy Team within the Systems Program of the Agriculture and Food Research Unit of the CSIRO, Australia's national science agency. The CSIRO team also contends with a diversity of wheat farming systems across wide gradients in rainfall and soil fertility in Australia and share the challenge to increase food production sustainably in the face of climate change and climate change policies. Dr Kirkegaard has led numerous successful national projects to improve the productivity and efficiency of farming systems, as well as several international collaborations. The expertise and common purpose of the two project participants and their organisations provides a strongly united focus within the project plan.

The exchange will build upon an existing interaction between Drs Kirkegaard and Lollato which has grown out of their roles as the former Vice Chair (Kirkegaard) and new Chair (Lollato) of the Expert Working Group (EWG) in Agronomy within the Global Wheat Initiative ([link](#)). The EWG in Agronomy was co-established by Dr Kirkegaard in 2017 and seeks to promote international exchange among agronomists targeting transformational agronomy to underpin sustainable and productive dryland farming systems of the future.

Activities

During the 6-month Scholarship, Dr Kirkegaard will be immersed into the research, extension, and teaching activities at KSU while traveling widely across the state and interstate to interact and share knowledge, experience and approaches in wheat farming systems research. This will include interactions with senior and junior scientific staff, as well as postgraduates and students working in relevant areas of agronomic research in KSU and elsewhere in USA. There are numerous areas of specific research common to the CSIRO and KSU teams and while these will provide excellent opportunities for direct interactions with staff and students, the underlying purpose is to elevate the multidisciplinary and systems-focussed approach to research and to create opportunities for ongoing partnerships and exchange. Ultimately beyond the period of the scholarship, we seek to build on existing interactions through the Global Wheat Initiative to empower a new cohort of systems agronomists in the US and Australia and connect them to wider global networks to enhance the impact of their careers.

Interactions in Dr Lollato's Team

In the preparation of this project plan, Dr's Lollato and Kirkegaard have identified several areas of specific common research interest. A few to highlight include:

- G × E × M approaches: in-season manipulation of nitrogen management, earlier sowing systems, managing varieties with different tillering habits, dual-purpose use.
- Understanding critical periods for yield determination in crops: designing agronomic systems for better provision of resources (light, water, nutrients) during that time.
- Use of long-term experimental networks: both organisations utilise long-term experiments and it is timely to consider contemporary uses for these unique research resources.
- Whole of chain sustainability metrics: consumer and industry concerns in both countries about strategies to reduce greenhouse gas emissions across the farmer-miller-baker chain.

Dr Lollato currently has 6 graduate students working on these aspects of wheat farming systems, some of whom are just starting their course. The lab meets once a week (2hr block) and Dr Kirkegaard would participate in these meetings and arrange more frequent, focussed meetings on the most relevant projects. This provides an opportunity for Dr Kirkegaard to become part of the students' committee and develop opportunities for students to complete part of their PhD on visits to Australia. Dr Kirkegaard would also develop and offer a short course (1- to 2-week summer course) to graduate students focussed on his expertise, such as "*Transformational agronomy in dryland systems: A case study for Australia*", general enough to cover different areas of transformational agronomy and condensed into a series of "case studies". Dr Kirkegaard would also participate in meetings at the Kansas Wheat Innovation Center ([link](#)), a one-of-a-kind research centre built and funded by farmers through the wheat checkoff program, where Dr Lollato has direct interaction with growers and industry representatives.

Interactions with other KSU staff

We have also discussed the plan with other key staff at KSU including those at the main campus and regional field facilities and those interested to interact during the visit include:

- Professor Raj Khosla (Head of Agronomy): expertise in Precision Agriculture.
- Dr Mike Stamm (winter canola breeder): incorporating canola into wheat-based systems.
- Dr Ignacio Ciampitti (cropping systems): corn, soybeans, sorghum and canola agronomy.
- Dr Colby Moorberg (soil specialist): focused on effective function of crop root systems.
- Dr Chuck Rice (soil microbiology): soil health, regenerative agriculture, long-term studies.
- Dr Vara Prasad (crop eco-physiologist): focused on heat stress / critical period.
- Dr Lucas Haag (cropping systems agronomist): semi-arid systems, based on Colby (NW KS).
- Dr John Holman (cropping systems agronomist): forages and cover crops in semi-arid systems, based on Garden City (SW KS).
- Dr Augustine Obour (soil fertility specialist): focused on soil health and fertility based on Hays (eastern portion of NW KS).

These faculty also have regular team meeting schedules, and Dr Kirkegaard would welcome the chance to join and contribute to any relevant meetings during the scholarship period.

Interactions beyond Kansas

In addition to interactions within KSU, Dr Kirkegaard will also organise a range of interstate visits especially covering the historical cross section of the Great Plains-subhumid Prairie continuum, starting with the dry western plains from the Texas Panhandle to Eastern Colorado/Eastern Montana, Western Kansas/Nebraska/Oklahoma/Wyoming and North Dakota. He would also make targeted visits to the southern and central part of the dry Plains which is underlain by the Great Plains Aquifer,

to look at irrigated agriculture from the Texas High Plains north to Western KS, NE, East to central NE, and Eastern Colorado to visit regions that sit atop plentiful water, and those cursed atop the shallow bays and shoals. Dr Lollato has collaborators across this region (Texas Tech in Lubbock, Oklahoma State University in Stillwater, Colorado State University in Fort Collins) and would help identify and organize these targeted visits. Some of these visits could form part of Dr Lollato's existing research interactions, and some may be organized separately.

For Distinguished Chairs there is a recommendation that a speaking tour to other US institutions be arranged, which Dr Kirkegaard would enthusiastically embrace. While these would primarily focus on the same theme of incremental transformation in dryland wheat production systems, they would also include contrasting higher yielding grain farming systems unique to the US to explore the utility of similar research approaches in those systems. Initial thoughts for visits outside the immediate reach of Kansas include the Pacific Northwest (Washington and Idaho State Universities); UC-Davis in California; University of Nebraska-Lincoln (Patricio Grassini and team), and Iowa State University in Ames (Mike Castellano and Dan Olk).

During his stay in the US, Dr Kirkegaard would also seek to travel to Washington DC and to New York to experience more of the broader political, scientific, cultural and social history of the US from both agricultural and non-agricultural perspectives. Visits to important national scientific and historical institutions would be of significant interest, including the National Academy of Science and The Smithsonian Institute. While in Washington DC, Dr Kirkegaard would plan to visit with the Australian Embassy to interact with diplomats and report on the outcomes of the scholarship.

Potential activities to build enduring partnerships

Based on Dr Kirkegaard's demonstrated capacity to build and nurture effective ongoing international partnerships with international institutions, several activities could be initiated during the scholarship. These include:

- Serving as outside advisory in larger research grants could lead to the development of joint projects between KSU and CSIRO.
- Creating symposia at relevant US agronomy, crop science and soil science society meetings focussed on the theme of the Global Wheat Initiative Expert Working Group in Agronomy.
- Exchange visits for mutual research of scientists, postdoctoral fellows and graduate students in Australia under CSIRO funding or other sources.
- Organizing a Special Issue in an appropriate refereed journal (e.g. Field Crops Research) with invited papers on topics identified during the visit.
- Developing a CSIRO-KSU Linkage Grant initiative as has been developed with INRAE, Rothamsted Research, and UC Davis for scientific exchange visits.

References

Kirkegaard JA (2019) Incremental transformation: success from farming system synergy. *Outlook in Agriculture*, 48, 105-112. <https://doi.org/10.1177/0030727019851813>

Hunt JR, **Kirkegaard JA**, *et al.* (2021). Exploiting genotype × management interactions to increase rainfed crop production: a case study from south-eastern Australia. *Journal of Experimental Botany*, 72, 5189-5207. <https://doi.org/10.1093/jxb/erab250>

Massigoe I (**Lollato RP**), *et al.*, (2024). Exploring alternative crop rotations to continuous winter wheat for agricultural intensification in the US central Great Plains. *Agricultural Systems*, 216, 10389. <https://doi.org/10.1016/j.agsy.2024.103879>

A Timeline of Activities

Late March-Early April:

- Arrive in the USA, possible cultural visits to key centres prior to taking up the scholarship.
- Arrival in Manhattan, Kansas and settling in with orientation at KSU.
- Possibly participate in the Great Plains Soil Fertility Conference ([link](#)), which is focused on semi-arid systems, is biennial and will be held in early 2026.

April/May:

- Settle into regular meetings with students and staff of Dr Lollato's group as well as other on-campus faculty of interest.
- Visit Dr Lollato's agronomic research trials at 12 climatically diverse locations across Kansas.
- Agronomic activities during this time with which Dr Kirkegaard may be involved include termination of winter cereal cover crops, planting of summer crops, fungicide application to winter wheat, late season agronomic measurements (anthesis biomass/N uptake, drone flying, canopy cover photos, height, etc.) in winter wheat and canola.
- Relevant inter and intra-state visits and discussions.

May/June:

- Participate in the Wheat Quality Tour ([link](#)), where stakeholders from different sectors of the wheat industry (production, elevators, milling, baking, bankers, journalists, traders, etc.) travel around Kansas on field and cultural visits to landmarks.
- Visit the Mennonite Heritage and Agricultural Museum in Goessel, Kansas ([link](#)), to experience cultural aspects of the beginning of wheat cultivation in the Great Plains over 150 years ago.
- Join and present at extension wheat plot tours across the state. These are field days demonstrating different technologies in collaboration with county- and district-agricultural agents, providing cultural opportunity to interact with producers and industry stakeholders.
- Join early season summer crop agronomy activities in the field.
- Canola harvest and discussions with canola scientists in Kansas and Oklahoma.
- Relevant inter and intra-state visits and discussions.
- 1st phase of speaking tour.

June/July:

- Harvest of field experiments involving wheat and discussions of results.
- Meetings with scientists and students to discuss outcomes of experiments.
- Submit joint abstract based on the scholarship to the American Society of Agronomy international meetings (1-4 Nov. 2026 in Portland), to be presented by Dr Lollato.
- Deliver short course "*Transformational agronomy in dryland systems in Australia*" as a 3-credit special course for Agronomy graduate students at KSU.
- Participate in many summer crop agronomy activities.

August

- Participate in regional pre-plant wheat industry meetings and stakeholder interactions.
- Many agronomic activities in the field involving summer crops.
- Join the Nitrogen Use Efficiency workshop ([link](#)), which rotates from institution to institution and is usually held in August.
- Provide input to new field experiments being established in Dr Lollato's program.

September

- Participate in early wheat planting for forage and late season summer crop activities (corn harvest).
- Leave Kansas to undertake 2nd phase of speaking tour to relevant US institutions.
- Return to Australia.