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FINAL REPORT 2019

PROJECT CODE	**S1218**

PROJECT TITLE
Making Science Useful to Agriculture

PROJECT DURATION

Project Start date	1 July 2018					
Project End date	31 December 2018					
SAGIT Funding Request	2019/20		2020/21	$	2021/22	$

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PROJECT REPORT

Executive Summary

Historically, technologies derived from agricultural research and development (ag R&D) have increased agricultural productivity in South Australia, Australia and worldwide. Investments in ag R&D have typically delivered benefit-cost ratios at least 10:1 and often more like 20:1. Significant increases in ag R&D are required to meet the challenges of global agriculture, including a growing demand for healthy, nutritious, affordable food while providing for farmers' income and welfare, protecting the environment in a context of scarcer land and water, and responding to climate change.

Despite this compelling case for more, we see less: in many countries, especially the high-income countries like the United States and Australia, public investment in ag R&D has stagnated or is declining in real terms. Simultaneously questions are being raised about the effectiveness and economic efficiency of the use and management of the resources in terms of the allocation of funds to the projects and programs with highest potential payoffs; the opportunity costs of the scientists' time, morale, and other resources spent in applying for and managing funds, and meeting reporting requirements; and the erosion of scientific expertise in core disciplines including crop science and ecology.

The workshop outlined the economic rationale for government involvement in supporting ag R&D, and in facilitating private ag R&D and public-private partnerships. Next, the massive impact of science and technology with emphasis on genetic improvement and agronomy was emphasized. We identified cases where oversimplification, reductionism, and occasional lack of rigour compromise returns on investment. The workshop outlined three propositions for improved focus on the allocation of ag R&D investment.

Project Objectives

The outcome of this proposal is higher return per dollar invested in research and development, and lower risk of failed investment. To achieve this outcome, national and international researchers, representatives of funding bodies, educators, science managers and policy makers meet in Adelaide from 24 to 26 November 2018 to discuss:

(a) economic criteria for the profitable investment of limited funding in R&D.
(b) scientific criteria for the profitable investment in agronomy and plant breeding.

Overall Performance

The project's objectives were fully met. Sponsored by OECD, and with SAGIT support, we held a successful meeting including 30 participants with expertise ranging from molecular biology to agricultural economics:

Julian	Alston	USA	University of California	Ag economics
Pedro	Aphalo	Finland	University of Helsinki	Plant biology
Peter	Appleford	Australia	South Australian R&D Institute	Ag Policy
Malcolm	Buckby	Australia	South Australian Grain Industry Trust	Agronomy, farming, R&D management
David	Connor	Spain	University of Melbourne	Agriculture, crop science
Mariano	Cossani	Australia	South Australian R&D Institute	Cereal physiology
Ford	Denison	USA	University of Minnesota	Ecology, evolution
Tony	Fischer	Australia	CSIRO	Agronomy, crop science
Richard	Gray	Canada	University of Saskatchewan	Ag economics
Peter	Hayman	Australia	South Australian R&D Institute	Climate science, agronomy
John	Kierkegaard	Australia	CSIRO	Farming systems
Holger	Kirchmann	Sweden	Swedish University of Agricultural Sciences	Soil chemistry, nutrition, organic agric
Martin	Kropff	Mexico	CIMMYT	R&D management, policy
Rene	Lafitte	USA	DowDupont Pioneer Research	Plant breeding
Lachlan	Lake	Australia	South Australian R&D Institute	Pulse physiology
Peter	Langridge	Australia	University of Adelaide	Genetics, biotechnology
Jill	Lenne	UK	Consultant UK	Genetic resources, tropical agriculture
Bill	Long	Australia	Ag Consulting Co	Farming
Stephen	Loss	Australia	Grains R&D Corporation	Agronomy, farming, R&D management
Allan	Mayfield	Australia	South Australian Grain Industry Trust	Agronomy, farming, policy
Ines	Minguez	Spain	Universidad Politecnica de Madrid	Irrigation, water resources
Francis	Ogbonnaya	Australia	Grains R&D Corporation	Plant breeding, R&D management
Jairo	Palta	Australia	University of Western Australia	Crop science, agronomy
John	Passioura	Australia	CSIRO	Soil and plant science
John	Porter	Denmark	University of Copenhagen	Agro-ecology, climate change
Tim	Reeves	Australia	University of Melbourne	Agriculture, R&D management
Daniel	Rodriguez	Australia	University of Queensland	Farming systems
Megan	Ryan	Australia	University of Western Australia	Soil science, microbiology
Victor	Sadras	Australia	South Australian R&D Institute	Crop ecology
Primal	Silva	Canada	Canadian Food Inspection Agency	Veterinary science, R&D policy

The papers focused on agricultural R&D, and how to allocate scarce resources more effectively (Day 1). Sciences supporting plant breeding (Day 2) and agronomy (Day 3), revised achievements and areas where misconstructed science compromises returns on investment. A pattern emerged, whereby issues related to trade-offs, biological and agronomic context, reductionism and oversimplification, seem to (i) apply irrespective

of scale and discipline, from molecular to global, from crop improvement to water and nutrient management, and (ii) compromise returns on investment.

Key Performance Indicators (KPI)

KPI	*Achieved (Y/N)*
List of participants and papers for conference confirmed and finalized.	Yes , August 2018
Conference held in Adelaide	Yes, November 2018
Proceedings of conference published, and final report summarizing main findings submitted to SAGIT	Yes Conference proceedings published December 2018. Final report to SAGIT January 2019

Technical Information (Not to exceed <u>three</u> pages)
Provide sufficient data and short clear statements of outcomes.

Making science pay: economics angles on agricultural R&D

In the absence of government intervention, the private market economy underinvests in certain types of ag R&D[1]. Governments have responded to this market failure by creating intellectual property rights (IPRs) to encourage private investment, supporting producer-controlled levy funding, providing public funding for private ag R&D or conducting ag R&D in the public sector. The latter requires policies to set research priorities[1] and managing public funds for ag R&D in the context of complementing private and producer-controlled investments.

Private firms invest in ag R&D where the products of research are "excludable" and protected by IPRs. This model currently dominates hybrid and GM crop breeding, agricultural machinery and pesticides[2] where markets are concentrated allowing the technology firms to cover the fixed cost of research by pricing their product above marginal cost[3]. Where weaker IPRs exist, private firms require tax credits or other subsidies to justify investment.

Historically, governments have invested in public research goods where IPRs do not exist and the benefits flow to the society as whole. Most science-based discovery type research falls into this public good category. In many cases agricultural research is not a pure public good naturally funded by government. Often ag R&D is more of an industry collective good in the sense that the beneficiaries are producers or consumers of a particular good[4]. In this situation, commodity levies better align those who pay for ag R&D and those who benefit from it. Recognising the potential to incentivise the provision of industry goods, governments in Australia, Canada and the United States provided the legislative frameworks to create ag R&D organisations, funded by levies and controlled, at least partially, by producer representatives.

Collectively, these producer-controlled organisations invest several hundred million USD of ag R&D annually. The Australian Grains Research and Development Corporation is the largest of these organisations, with annual revenue of AU$200 M. Being neither private nor public, these organisations have catalysed new institutional relationships

to prioritise and deliver ag R&D, including private-producer-public partnerships. The producer board members, extensively involved in the decision-making, engage the scientific community, accumulate knowledge and social capital that enables the sector to identify and respond quickly to new opportunities for innovation.

The successful track record in ag R&D provides compelling evidence that science policy can be improved. Failures of markets, governments and institutions have contributed to underfunding ag R&D, and diversion of resources to both lower-value projects and programs, and distorting subsidies[5]. The remarkably high payoff from public investment in ag R&D[6,7] is direct and compelling evidence that the intervention has been too little. Governments have also failed to allocate research resources to the highest payoff areas or have invested in areas where the private sector would otherwise invest, crowding out private investment, and have often employed burdensome procedures that reduce the resources effectively available for research; the payoff could have been even higher.

Of course, it is hard to get all of these aspects of agricultural science policy right, given the time lag between initiating research and observing its impact, if any, and the inherent uncertainty about whether any research undertaking will lead to useful findings[8,9], let alone result in technologies that farmers will adopt[10]. These challenges are even greater for research that is less directly applicable, or for which the resulting knowledge is not embodied in inputs like seeds or simple management changes, including policy-oriented social science or research related to environmental externalities[11].

1 Alston, J. M., Norton, G. W. & Pardey, P. G. *Science under scarcity: principles and practice for agricultural research evaluation and priority setting.* (Cornell University Press,, 1995).

2 Fuglie, K. The growing role of the private sector in agricultural research and development world-wide. *Global Food Security-Agriculture Policy Economics and Environment* **10**, 29-38 (2016).

3 Fulton, M. The economics of intellectual property rights: Discussion. *American Journal of Agricultural Economics* **79**, 1592-1594 (1997).

4 Gray, R. in *Improving Agricultural Knowledge and Innovation Systems* (OECD Conference Proceedings. Paris: OECD Publishing, 2010).

5 Searchinger, T. *et al.* Creating a sustainable food future. A menu of solutions to feed nearly 10 billion people by 2050. *World Resources Institute,* https://www.wri.org/publication/creating-sustainable-food-future (2018).

6 Alston, J. M., Pardey, P. G., James, J. S. & Andersen, M. A. A review of research on the economics of agricultural R&D. *Annual Review of Resource Economics* **1**, 537-565.

7 Hurley, T. M., Rao, X. & Pardey, P. G. Re-examining the reported rates of return to food and agricultural research and development. *American Journal of Agricultural Economics* **96**, 1492-1504 (2014).

8 Osmond, C. B. Quintessential inefficiencies of plant bioenergetics: Tales of two cultures. *Aust. J. Plant Physiol.* **22**, 123-129 (1995).

9 Kauffman, S. A. *Reinventing the Sacred: A New View of Science, Reason, and Religion* (Basic Books, 2008).

10 Kuehne, G. *et al.* Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy. *Agric. Syst.* **156**, 115-125 (2017).
11 Pannell, D. J. *et al.* Policy-oriented environmental research: What is it worth? *Environmental Science & Policy* **86**, 64-71 (2018).

Conclusions Reached &/or Discoveries Made

There is an urgent need to increase resources for ag R&D, and to halt the concerning erosion in core scientific expertise. The workshop advanced three high-level propositions to refine the allocation of ag R&D resources:

- **Multiple perspectives would reduce the likelihood of misconstructed science**, and improve the return on R&D investment. In 1786, Auguste Broussonet, the secretary of the Société Royale d'Agriculture, called for multiple perspectives; the list of research styles including multi-, inter- and trans-disciplinarity continues to grow; but our record of achievement is mixed. We propose that specific training to work in a multidisciplinary setting would be helpful. Demographics of scientific careers and academic reward systems need attention; there is concerning erosion in core disciplines including crop science and ecology. The tension between co-operation and competition that obstructs multiple perspectives needs to be managed.

- **Explicit pathways to agronomic applications and reality checks would increase the likelihood of real-world impact**. Explicit consideration of trade-offs, biological and agronomic context, scaling and system boundaries are important. Proposals have to articulate how outputs from ag R&D, e.g. a new practice or a new phenotype, would fit in current or alternative cropping systems. Engaging with end-users including agronomists, farmers and breeders would provide reality checks. The realities of risks associated with climate and markets, labour supply, logistics, ease of implementation, personal circumstances, motivation and many other factors influence the capacity of growers to adopt innovations. Science that proceeds without connection to that context, no matter its quality, is unlikely to lead to significant impact.

- **Rigour in claims of utility is important for both funding bodies and scientific journals;** it could be improved by an expanded definition of peer to assess not only the quality of science, but also the claims of relevance. Scientific journals might unintentionally contribute to a loop where poorly justified claims of agronomic relevance could reinforce misguided investment. Analogous to the rigour in the protocol for drug development, claims of agronomic utility must be supported by comprehensive, agronomically sound field trials where new phenotypes or practices are tested in a large sample of target environments. The benchmark for a new phenotype must be the best available variety or hybrid, rather than a comparison between wild-type and alternative. We advocate for funding bodies (and journals) to augment their evaluation panels, where necessary, with people who can effectively judge claims of utility. To do so would have a double benefit. It would select proposals with much better chances of practical success. And, if seen as a dichotomous process, it would free up other scientists across all levels of

biological organisation to ask questions that are more penetrating of the materials that interest them – for deepening understanding at every level remains essential.

Intellectual Property

NA

Application / Communication of Results

- The power-point presentations and papers of the workshop are published on-line https://msua.aweb.net.au/
- SAGIT contribution was acknowledged with banners during the workshop, in the website, and in the published proceedings.
- Alistair Lawson (AgCommunicators) covered the event, and wrote an article to be published in GroundCover.
- Photos of the event are available that can be used in future promotional material: https://msua.aweb.net.au/

POSSIBLE FUTURE WORK

A GRDC-sponsored follow-up workshop, with a narrower focus on Australian agriculture, is envisaged for 2019.

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