On-farm applications of advanced bioengineering

Preliminary opportunity identification and assessment

Executive summary | July 2022

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Foreword

In August 2021, CSIRO released the *A National Synthetic Biology Roadmap*, which found that under a high growth, high market share scenario, synthetic biology could unlock up to $27 billion in annual revenue and 44,000 new jobs for Australia by 2040. It also identified food and agriculture as one of the largest emerging markets for synthetic biology applications.

Advanced bioengineering (also referred to as synthetic biology) is the design and production of novel, functional biological products through the application of engineering principles and genetic technologies. While high level information outlining potential use cases for bioengineering solutions in agriculture exists, there is little guidance on who, how and what is practically needed to achieve on-farm impact and deliver on those opportunities identified.

This research explores the most impactful bioengineering opportunities that exist to overcome challenges with pests and disease, waste and crop loss, as well as take advantage of opportunities with new crops, reduced/alternative inputs, new production systems and markets for Australian agriculture, in addition to potential areas for development and adoption.

Consideration was given to who is currently doing work in this space, both domestically and internationally, as well as commercial bioengineering and other technology applications currently available to the agriculture sector, or that could be repurposed for agricultural use.

The report provides guidance on the current "state of play" of bioengineering in Australian agriculture and informs government, industry and AgriFutures Australia on research and commercialisation opportunities to engage in advanced bioengineering, including the breadth and depth of opportunities, the likely impact and the necessary steps to delivery.

This report has been produced under AgriFutures Australia's National Challenges and Opportunities Arena which focuses on thought provoking and horizon-scanning research to inform debate and policy on issues of importance across rural industries.

It is an addition to AgriFutures Australia's diverse range of over 2000 research publications, most of which are available for viewing, free downloading or purchasing online at: www.agrifutures.com.au

Michael Beer
General Manager, Business Development
AgriFutures Australia

Executive summary

This report provides a preliminary assessment of eight on-farm applications of advanced bioengineering techniques that could benefit Australia's agriculture, aquaculture and forestry industries over the next 10 years. Advanced bioengineering (also referred to as synthetic biology) is the design and production of novel, functional biological products through the application of engineering principles and genetic technologies. The intent of the report is to help AgriFutures Australia and their producer stakeholders better understand the potential benefits that advanced bioengineering can offer and facilitate discussions around the most valuable applications of this technology area for Australia's agriculture industries.

Advanced bioengineering can help address key agricultural and environmental challenges

Advanced bioengineering solutions can harness the power of biological processes to improve agricultural productivity, detect and control pest and disease threats, reduce traditional agrochemical use, remediate land and water, and improve animal welfare. These solutions can support the agricultural sector's ambition to boost farm-gate output to $100 billion by 2030.[1]

For technology developers, the successful commercialisation of advanced bioengineering solutions for Australia's food and agriculture sector could unlock up to $19.2 billion in annual revenue and 31,200 new jobs for Australia by 2040.[2]

Australia has bioengineering research strengths, but deeper industry collaboration will be necessary to bridge the commercialisation gap

Australia has a strong and growing advanced bioengineering research community;[3] however, awareness of and engagement with these emerging solutions is low amongst agricultural producers. Ensuring end-users are engaged in co-design and demonstration of bioengineering opportunities will be critical to the successful commercialisation and adoption of these emerging solutions.

1 DAWE (2021) Delivering Ag2030, May 2021. Department of Agriculture, Water and the Environment, Canberra. https://www.awe.gov.au/sites/default/files/documents/ag-2030.pdf

2 CSIRO Futures (2021) A National Synthetic Biology Roadmap: Identifying commercial and economic opportunities for Australia. CSIRO, Canberra.

3 Australia ranks 9th globally for research impact for synthetic biology (led by the University of Queensland), and 13th internationally for patent numbers. Critical Technologies Policy Coordination Office (2021) Synthetic biology. <https://www.pmc.gov.au/sites/default/files/publications/ctpco-tech-cards-synthetic-biology-aust_0.pdf>.

Findings of the preliminary analysis

Eight opportunities were assessed (see Table 1) after a scoping exercise (see Appendix A). Assessment included a consideration of current technical and commercial maturity, key challenges to reaching commercial maturity, and the primary benefits over existing products.

While the majority of opportunities have an existing commercially available product, there is often only one or two globally, and they have a relatively small market share compared to more traditional, competing approaches. Coupled with the breadth of each of these opportunity areas, this highlights that there are product development opportunities for Australian businesses across all eight fields. There is also variation between different applications in each opportunity. As such, assessments for individual technologies or businesses may not match with the overall opportunity assessment below.

Producers, technology developers and other potential investors will weight the framework criteria differently, and so prioritise different opportunities for further investment (see Next steps). Making informed investment decisions will require conducting deeper analysis on prioritised opportunities and specific applications within them. This could include economic analysis into the size of the opportunity, defining R&D activities to further mature these applications, and identifying implementation considerations.

Table 1: Summary of preliminary opportunity analysis

		MATURITY		CHALLENGE						PRIMARY BENEFIT			
	OPPORTUNITY	Commercial availability	Maximum TRL	Technical	Plug and play	Effectiveness	Cost	Public attitude	Regulation	Yield	Product quality	Cost saving	Environment, human health and animal welfare
1	Engineered biosensors for product quality		9										
2	Engineered biosensors for animal and crop health		9										
3	Biomanufactured animal feed		9										
4	Biomanufactured agricultural chemicals		9										
5	Engineered bioremediation solutions		9										
6	Engineered biological agricultural treatments		9										
7	Engineered biosensors for environmental conditions		6										
8	On-farm bioenergy solutions		5										

Commercial availability rating

- Commercial scale-up (CRI 3) feasible in 5 years or less
- Commercial scale-up (CRI 3) feasible in 5-10 years

Challenge rating

- Potentially significant challenge that could delay commercialisation of some applications in this opportunity
- Not expected to be a significant challenge that delays commercialisation of applications in this opportunity

Benefit rating

- Expected to be a primary benefit compared to conventional solutions
- Not expected to be a primary benefit compared to conventional solutions

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For further information

CSIRO Futures
Greg Williams
Associate Director
+61 3 9545 2138
greg.williams@csiro.au
csiro.au/futures

AgriFutures Australia
Building 007, Tooma Way
Charles Sturt University
Locked Bag 588
Wagga Wagga NSW 2650
+61 2 6923 6900
info@agrifutures.com.au
www.agrifutures.com.au

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