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Submission to the

Independent review of the South Australian moratorium on the cultivation of genetically modified food crops

APPLIED

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Key message:

These advanced precision gene editing technologies have the potential to improve drought and disease resistance, decrease the use of fertilisers, herbicides and pesticides, and increase nutritional profiles.

Preamble

The Australian Academy of Technology and Engineering (the Academy) welcome the opportunity to participate in the South Australian (SA) Government's review of the moratorium on the cultivation of genetically-modified (GM) food crops.

The Academy is an independent think tank that comprises the leaders in the fields of technology and engineering, who gain Fellowship to the Academy in a highly competitive process. The Academy advocates for a future in which technological sciences, engineering and innovation contribute significantly to Australia's social, economic and environmental wellbeing. The Academy is empowered in its mission by some 800 Fellows drawn from industry, academia, research institutes and government, who represent the brightest and the best in technological sciences and engineering in Australia. The Academy provides robust, independent and trusted evidence-based advice on technological issues of national importance. The Academy fosters national and international collaboration and encourages technology transfer for economic, social and environmental benefit.

The focus of this submission reflects our expertise and considerable experience in science, research, technology and its translation to innovative agricultural practices. As such, we only address the question on potential innovations likely to be available for commercial adoption by 2025.

The Australian economy faces unprecedented disruption due to emerging technologies and global trends. This disruption will impact jobs at every level in the economy and will occur at exponential pace. Failure to be prepared will risk a decline in many aspects of our Australian way of life and society. With 0.3 per cent of the global population, Australia cannot expect to produce more than 3 to 5 per cent of the world's technology. However, we need to adopt all of the world's emerging technologies relevant to Australia's needs.

We need to identify and advocate best-practice technology adoption/utilisation and technology invention.

There is a need to assess the readiness of Australian agribusiness, including within South Australia, to be able to develop, adapt and adopt new technologies over the next decade. As such, there needs to be a very clear awareness of global trends in technology and its potential disruption, if the industry is to maintain its global competitiveness.

Issue: are there potential innovations likely to be available for commercial adoption by South Australia's agricultural industries prior to 2025 that would justify a reconsideration of the moratorium on grounds of economic benefit to the state?

The Academy notes that the development of biotechnology and molecular biology such as gene sequencing, have had wide application to regulate/control plant traits. Gene technologies based on DNA molecular markers, transgenic technology and gene expression technology have been widely used in agricultural production in the last twenty years and have been shown to improve agricultural yields and quality, reduce environmental impacts of modern farming practices, reduce losses caused by various biotic and abiotic stresses promoting the broader utilisation of germplasm resources, to improve breeding efficiencies and strengthen the regulation of plant growth.

These modern gene technologies in global agricultural production today already have a history of wide use and a growing importance in achieving the sustainable development of agricultural products and continuation of the SA moratorium is depriving SA farmers of benefits being achieved by farmers in other Australian States.

These modern gene technologies in global agricultural production today already have a wide use and a growing importance in achieving the sustainable development of agricultural products.

The Academy notes the emergence of a range of new gene editing technologies with agricultural application, such as enhancements in food quality, removal of allergens, increases in resistance to pathogens, enhanced yield and reduced environmental impact.

The Australian Academy of Technology and Engineering is an independent thinktank that helps Australians understand and use technology to solve complex problems. We bring together Australia's leading experts in technology, engineering and science to provide impartial, practical and evidence-based advice on how to achieve sustainable solutions and advance prosperity. We are one of Australia's four national Learned Academies, with almost 900 Fellows from industry, government and research organisations, as well as academia. **Applied.org.au**

These advanced precision gene editing technologies allows the high precision addition, detection or replacement of gene segments or fragments. This enables the introduction of desired genetic variants (or suppression of undesirable ones) and has the potential to improve drought and disease resistance, decrease the use of fertilisers, herbicides and pesticides, and increase nutritional profiles.

Agricultural products produced by gene editing techniques that are analogous to natural mutagenesis (chemical or radiation) and/or conventional selection of natural crop variants are currently appearing in global markets.

Extensive genetic variations have been introduced by a range of previously available conventional breeding techniques that have historically been accepted without a need for regulation, and while the Office of the Gene Technology Regulator (OGTR) has recommended that some forms of simple gene editing should not be regulated as genetically modified this is unlikely to be in place quickly so gene edited crops that will be available soon internationally will still be regulated as GM and not be able to be grown or used in SA if the moratorium continues again depriving SA farmers and consumers of the benefits that they will undoubtedly bring.

Some examples of these technologies are listed in the Table below.

TECHNOLOGY	
Disabled Cas9 enzymes (dCas9)	Disabled Cas9 enzymes (dCas9) bind to DNA using their specific guide RNAs but do not cut the DNA. These disabled enzymes can then be used with other proteins such as transcription factors to up or down regulate other genes containing the specific target sequence or they can be fused to DNA modifying enzymes that can convert one DNA base into another (called base editing). This generates potential new uses for the gene editing machinery in both plants and animals beyond the initial application of making double stranded breaks and repairing them with or without a DNA repair template.[1]
Cas9 ribonucleoproteins	There are a number of systems for the delivery of Cas9 ribonucleoproteins (RNPs) into cells, including transient (viral) delivery systems or systems involving in vitro assembly of RNPs and injection into cells.[2] This gene editing system does not require the initial production of a transgenic cell or organism and does not integrate any novel DNA into the final host.[3] Genome outcomes are similar to existing methods involving transgenics, with a higher specificity due to the rapid turnover of the RNP complex relative to that produced in a transgenic organism.
RNAi technology	RNA interference (RNAi), also known as gene silencing, is a way of reducing or switching off the activity of genes. RNAi gene silencing technology is enabling researchers around the world to protect plants and animals from diseases, and to develop new plant varieties with beneficial attributes.[4] The technology holds much promise as a therapeutic agent to control disease and prevent infection in plant and animal cells. It can be integrated into the organisms' genome or applied exogenously as synthetic RNAs.
Oligo-directed mutagenesis, SDN-1, SDN-2 and SDN-3	The technology /techniques are analogous to natural mutagenesis, i.e. oligo-directed mutagenesis (ODM), site directed nuclease 1, 2 and 3 (SDN-1, SDN-2, SDN-3).
Plasmid vector techniques	A vector, like the plasmids of Agrobacterium tumefaciens may be used to introduce the gene or genes of interest stably into the plant DNA. The resulting cells are then screened to identify those that have successfully expressed the new trait for agricultural production. Many of the commercially released GM crop plants currently grown in Australia were generated through this process.
Particle bombardment techniques	The DNA to be introduced into plant cells is coated onto tiny particles, which are then physically "shot" into the plant cells. Some DNA is incorporated into the DNA of the target plant. This method has often been used to produce GM cereals such as maize.

1. Thakore P.I. et al. Editing the Epigenome: Technologies for Programmable Transcriptional Modulation and Epigenetic Regulation. Nature Methods, 2016, 13(2):127-137. Doi:10.1038/nmeth. 3733.

2. Sojung, K., at al. Highly efficient RNA-guided genome editing in human cells via delivery of purified Cas9 ribonucleoproteins. Genome Research, 2014, 24(6):1012-1019. Doi:10.1101/gr.171322.113

3. Zong, Y. at al. Precise base editing in rice, wheat and maize with a Cas9-cytidine deaminase fusion. Nat. Biotechnol. 2017, 35:438-440. Dol:10.1038/nbt.3811.

4. See, for example, Brodersen, P. and Voinnet, O. The Diversity of RNA silencing pathways in plants. Trends Genet., 2006, 22(5):269-280.

New and emerging gene technologies will provide Australia a renewed opportunity to participate in global biotechnology, especially as these technologies are more precise and have fewer off-target effects.

While gene technology improvements are not a panacea for all the challenges that the agribusiness sector faces, the adoption of available and emerging gene technologies present many potential benefits. The Australian agribusiness sector must continue to adopt new gene technologies to remain globally, competitive and maintain its comparative advantage (gained from many years of embracing and adopting science and technology innovation.

Concluding remarks

Genetic modification and editing technologies hold exceptional promise in their application to the agriculture sector. Given their rapid development and a potential for extensive economic and environmental benefit, it is important that the SA agribusiness sector is able to access these innovations.

The South Australian agricultural sector will need to embrace new and emerging gene technology to ensure it can remain globally competitive and maximise its profitability.

The current moratorium denies the SA agribusiness sector access to new and emerging technology that can enhance profitability, increase resilience and provide a safe, reliable and affordable food supply, and environmental sustainability.

The Academy would be pleased to provide further information to expand on these views and Fellows of the Academia are available to assist the Review as required.