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International Trade in Crops with New Breeding Technologies:
The Australian Perspective

Building Capacity for Small Exporters to Exploit ‘new breeding technologies'

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Department of Agriculture, Water and the Environment:

Package Assisting Small Exporters Program

Building Capacity for Small Exporters to Exploit 'new breeding technologies'

Australia is a food exporting nation

The Project

- Department of Agriculture, Water and the Environment (DAWE)
  - Package Assisting Small Exporters (PASE)
- Project: ‘Building Capacity for Small Exporters to Exploit ‘New Breeding Technologies’
- Forward looking project with the primary aim of enabling Australian grains and horticultural industries to be first-movers in applying new breeding technologies to crop improvement
- Provide information on new science/technologies, and on the policies and regulations that relate to them both in Australia and with our trading partners
- Additional aim: to help promote international harmonisation of regulations and reduce barriers to trade

PASE supporting partners

Package Assisting Small Exporters (PASE)
Learn More

Australian Seed Federation
Learn More

CBH Group
Learn More

RAYI Corporation
Learn More

Murdoch University, Perth
Learn More

Edstar Genetics Pty Ltd
Learn More

Council for Grain Grower Organisations Ltd
Learn More

The Department of Primary Industries and Regional Development, Government of Western Australia
Learn More

Green Blueprint Pty Ltd
Learn More

CropLife Australia
Learn More

Australian wheat exports (average 2016-2020)

Top 10 countries,
70-80% of exports

Country	Amount (mmt)	Value (million)
Indonesia	2.5	739
Philippines	1.5	465
Vietnam	1.3	404
Korea	1.1	361
China	1.1	346
Japan	0.9	335
Malaysia	0.7	225
India	0.7	346
Yemen	0.6	200
New Zealand	05	158
TOTAL	**14.4**	**4,600**
(Domestic use)	8	

Source: AEGIC

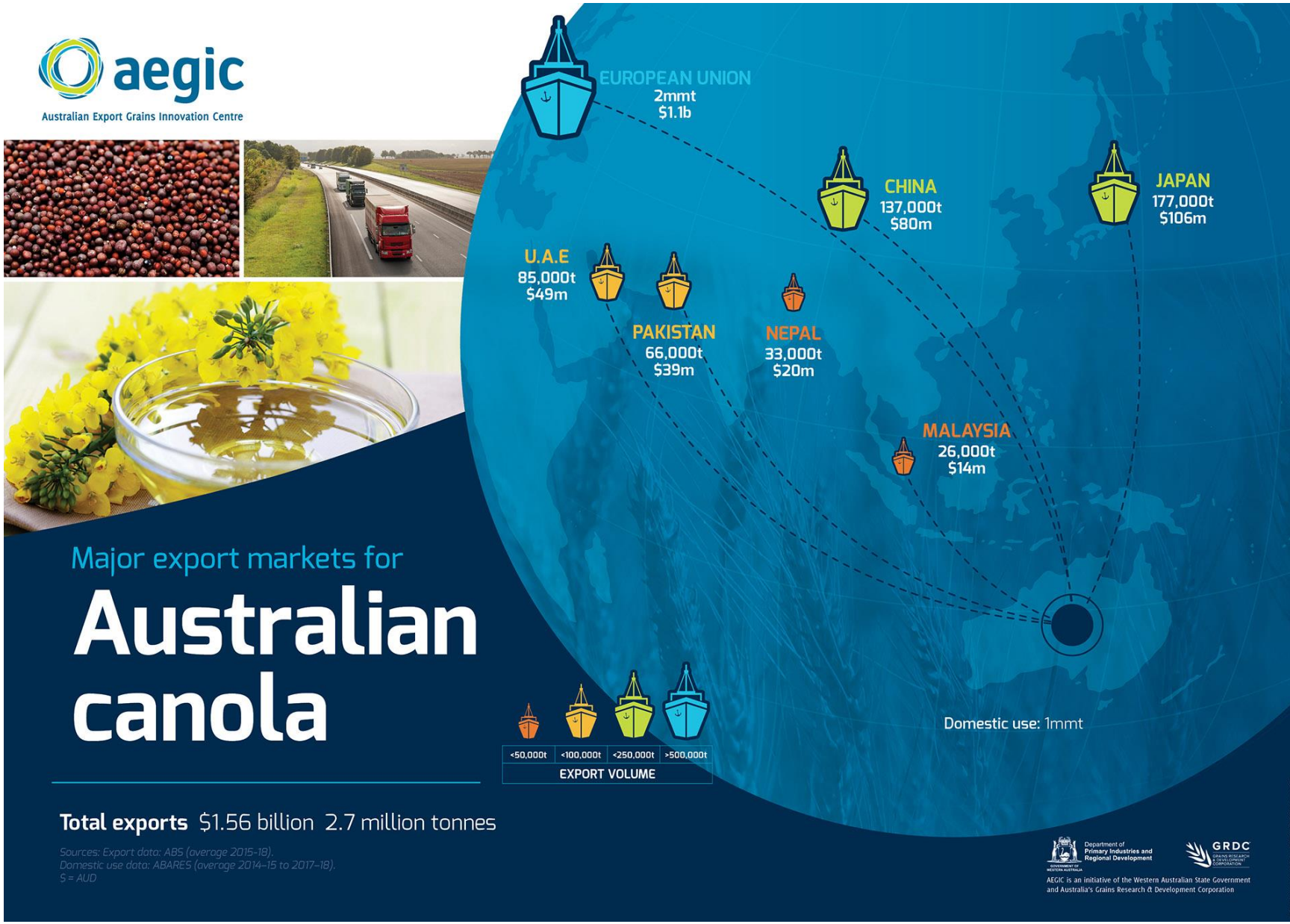
Australian barley exports (average 2016-2020)

(Latest data not available)

Country	Amount (mt)	Value (million)
China	3,900	1,100,00
Japan	817	241
Thailand	250	78
Saudi Arabia	215	49
UAE	122	32
Vietnam	120	41
Kuwait	103	24
Qatar	44	14
Taiwan	38	11
Korea	29	8
Total	**5,700**	**1,600**
Domestic use	3,200	

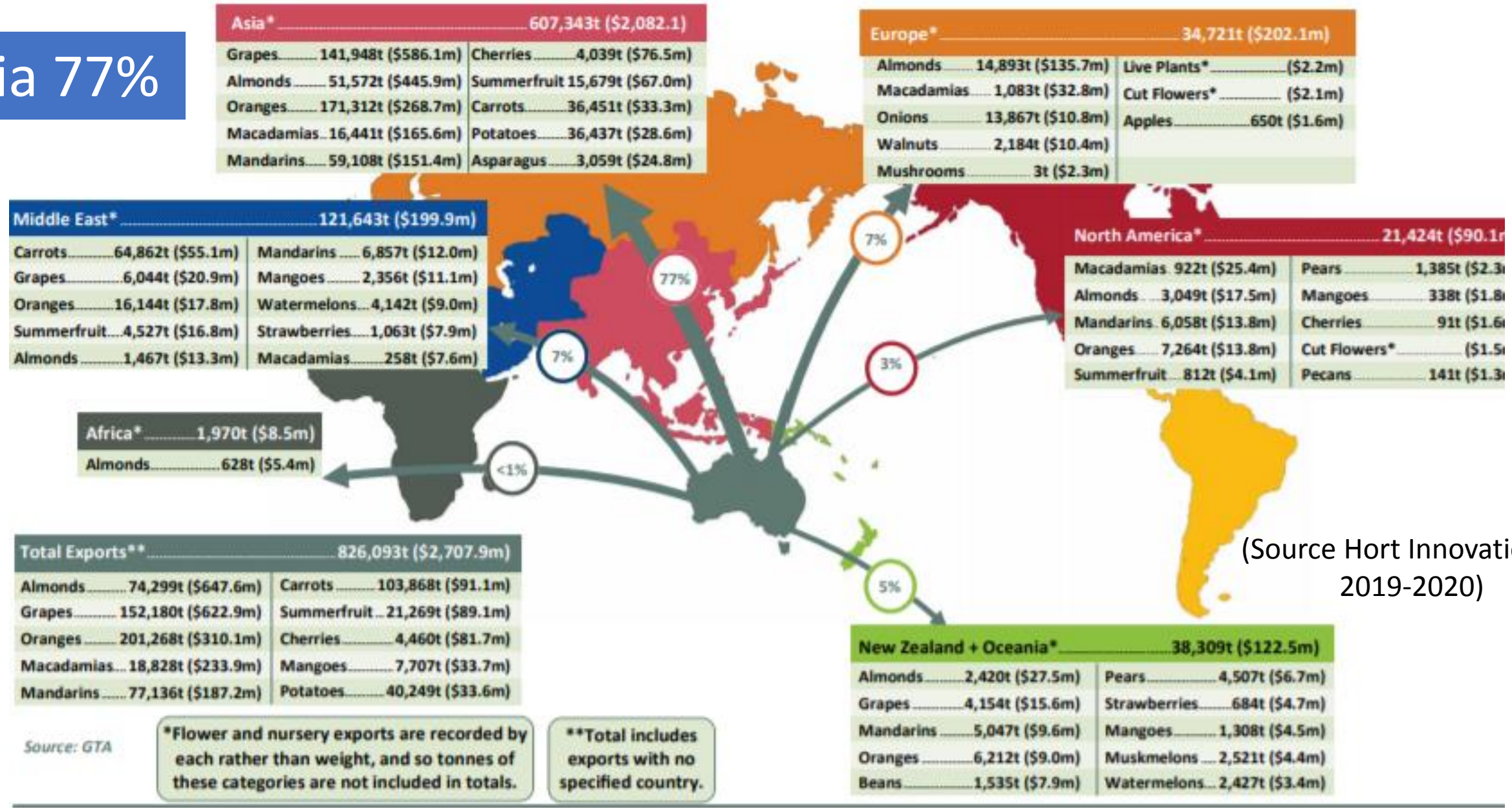
Canola exports

Includes GM canola



Australian fruit and vegetable exports

Asia 77%



(Source Hort Innovation 2019-2020)

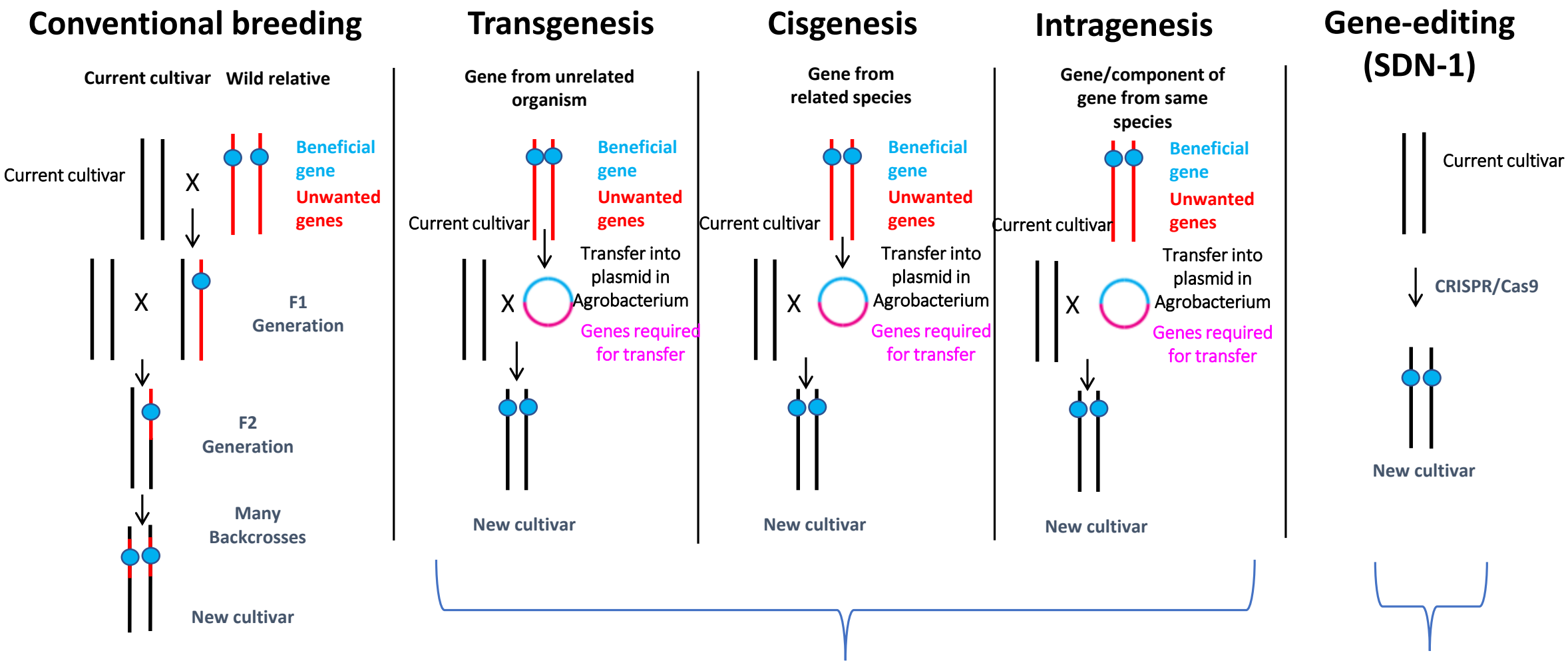
But, Australia is an ancient and weathered continent

Challenges to crop production

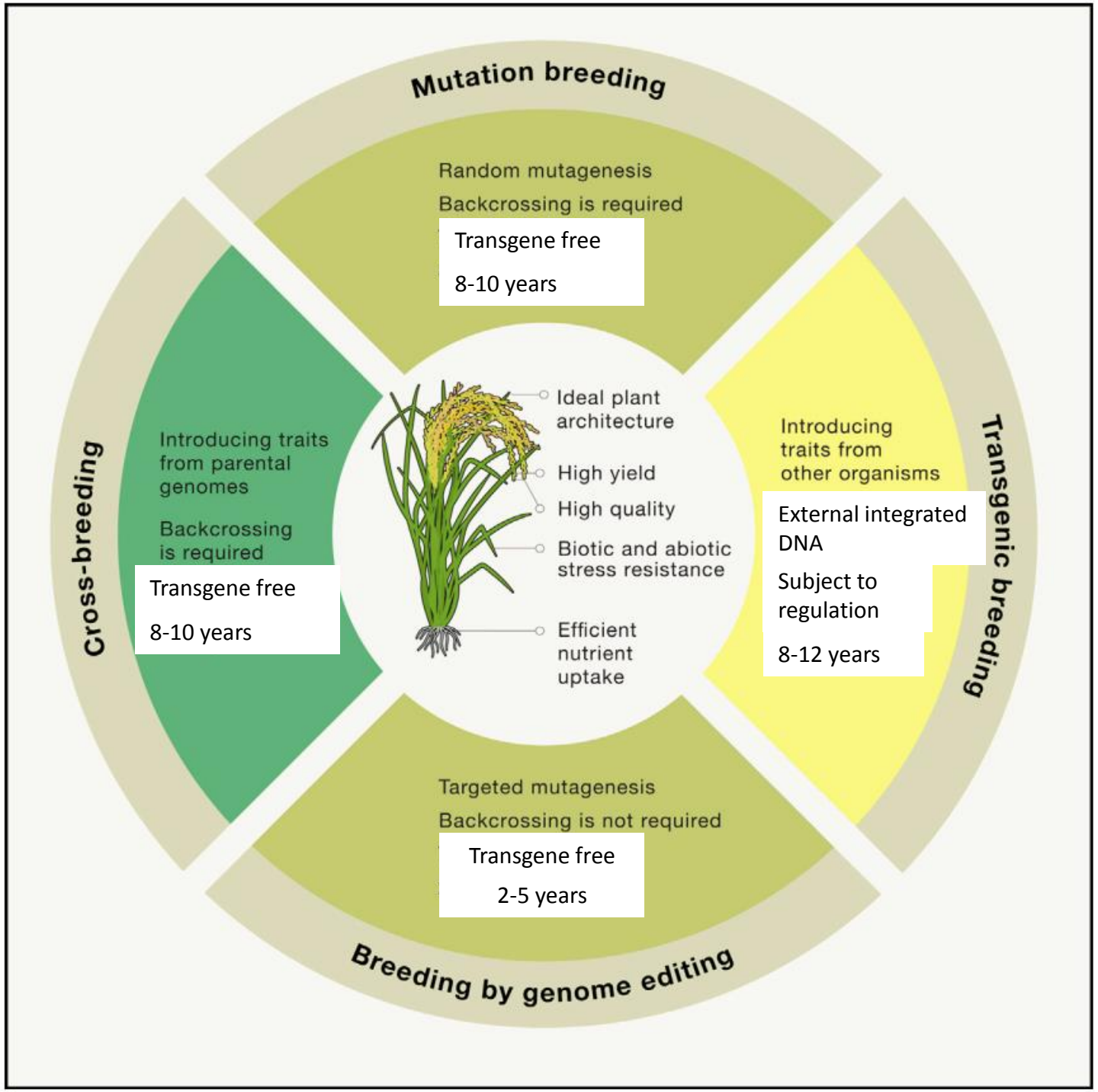
- Often water limited
- Soils often nutrient poor
- Drought and heat stress
- Prevention of incursions of new pests and diseases

→ Need to apply the best science and technology to improve yields and quality, including gene-editing

CONVENTIONAL AND NEW BREEDING TECHNOLOGIES



A comparison of breeding technologies



Gao, Genome engineering for crop improvement and future agriculture, Cell (2021), https://doi.org/10.1016/j.cell.2021.01.005

Gene-editing technologies

- Zinc finger nucleases (ZFNs)
- Transcription activator-like effector nucleases (TALENS)
- Clustered regularly interspaced short palindromic repeat (CRISPR/Cas9)

These systems are based on the production and repair of double stranded breaks (DSBs) *via*

- non homologous end joining (NHEJ)
- homology-directed repair (HDR)

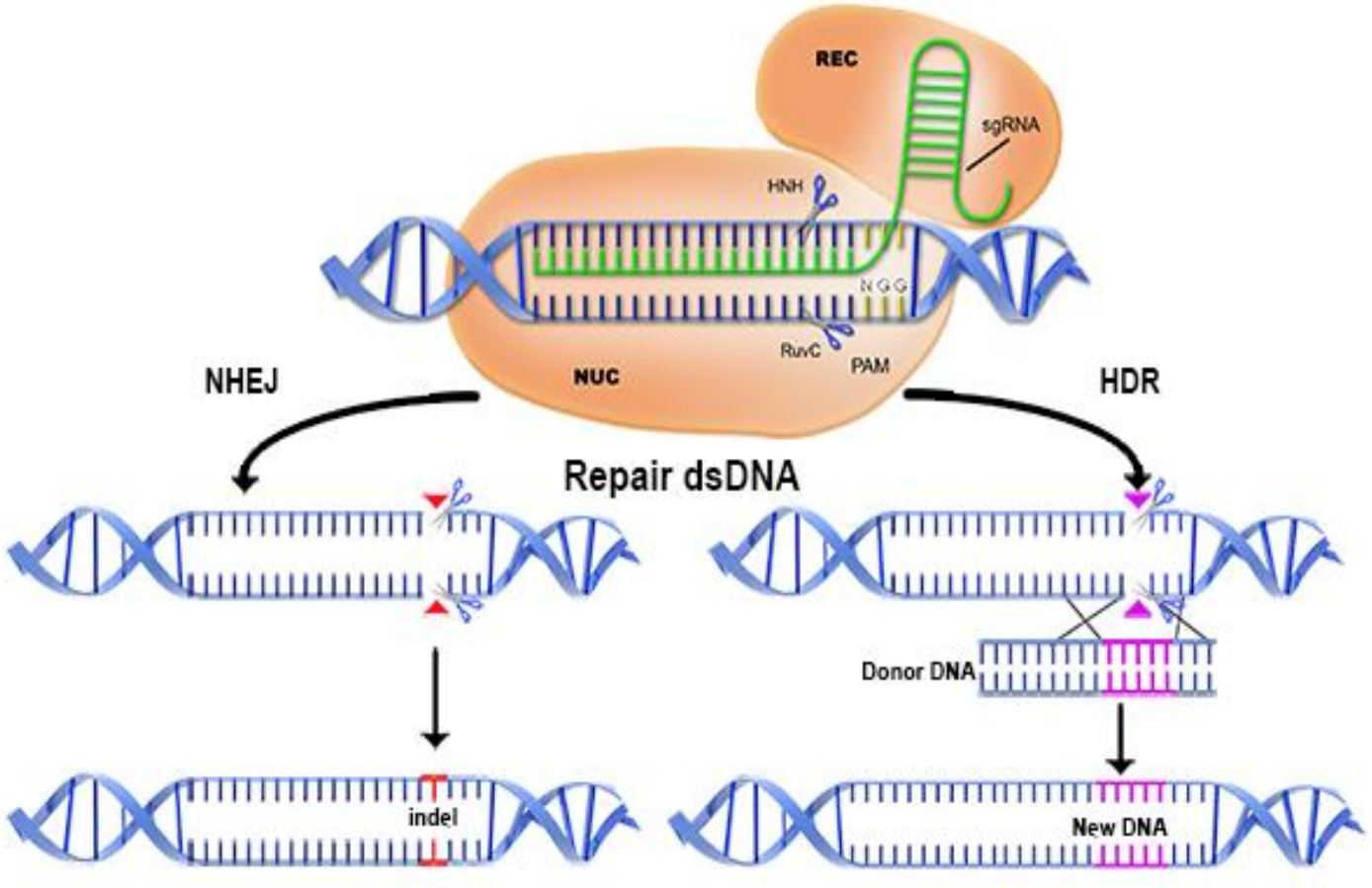
CRISPR-Cas9

CRISPR-Cas9 targeted double-strand DNA break

SDN-1 – non-homologous end joining (NHEJ) - natural repair mechanism, small nucleotide deletions, additions or substitutions

SDN-2 – in the presence of an oligonucleotide template with ends homologous to each side of the double-stranded break, homologous end joining (HEJ or HDR) can occur, such that one or more bases can be included in the repaired sequence

SDN-3 – as for SDN-2, but with a longer DNA insert, for example up to a full gene expression cassette



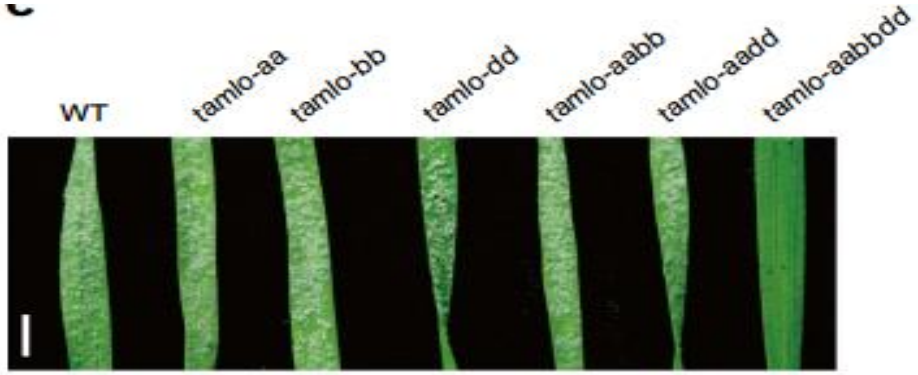
(Source: http://www.labgene.ch/img/cms/AATI/crispr-dual-editing-method.png).

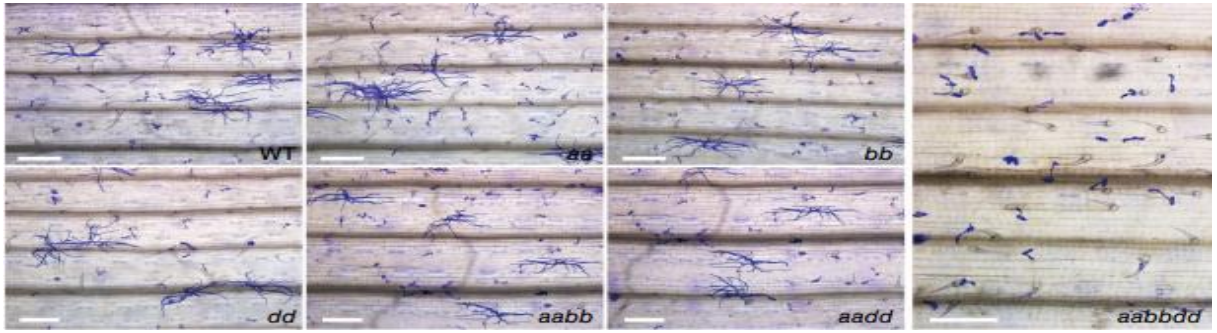
Other types of gene editing

- Sequence deletion/insertion (SDN-1) or replacement
- DNA free editing – Cas9 plus guide RNA (RNPs)
- Base substitution
- Prime editing
- Gene segment deletion
- Gene expression changes
- Epigenetic changes

The power SDN-1 gene editing for crop improvement

- *Gene-editing of all six MLO alleles in hexaploid bread wheat confers heritable, broad-spectrum resistance to powdery mildew (TaMLO-A1)(Wang et al, 2016, Nature Biotech)*

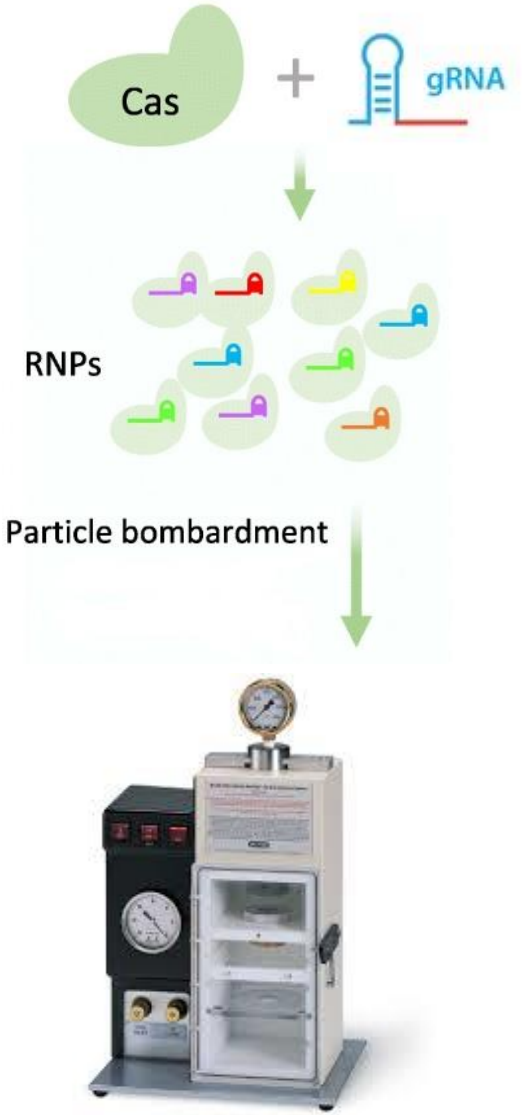


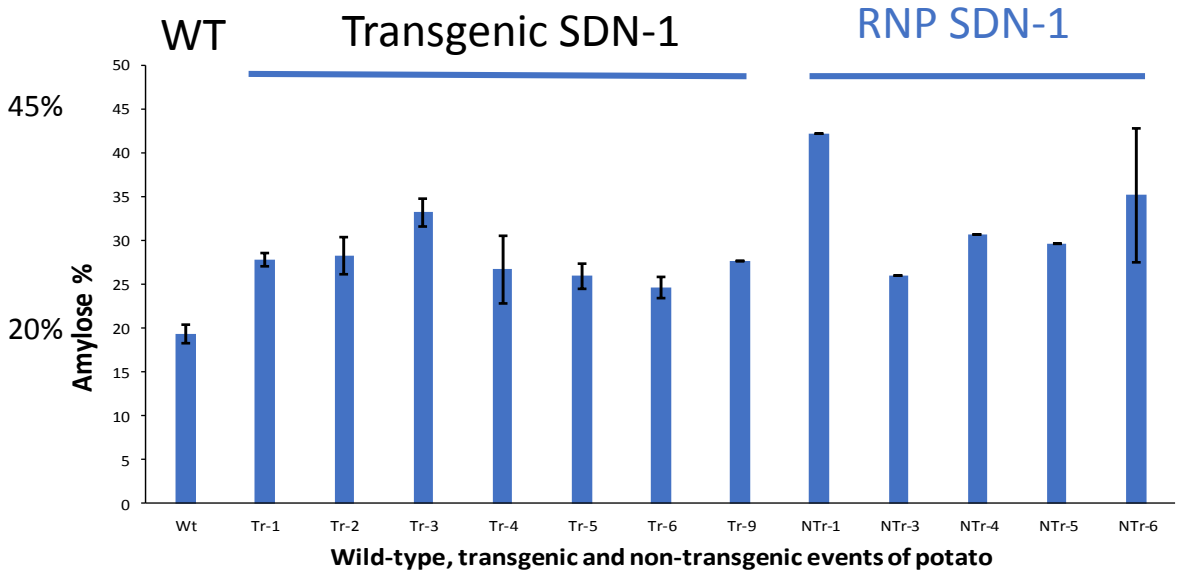


- *Gene-Edited Triple-Recessive Mutation Alters Seed Dormancy in Wheat* (Abe at al Cell Reports 2019).

Left – pre-harvest sprouting, Right – edited to prevent pre-harvest sprouting (heads equally treated with water). Pre-harvest sprouting reduces grain quality and value.

Gene-edited potatoes without external DNA to improve the dietary quality – Sadia Iqbal





- GE targeting starch branching enzymes
- Amylose–resistant starch increased from 20% to 43% in RNP edited lines
- Slower glucose release helps reduce Type II diabetes, improves bowel health

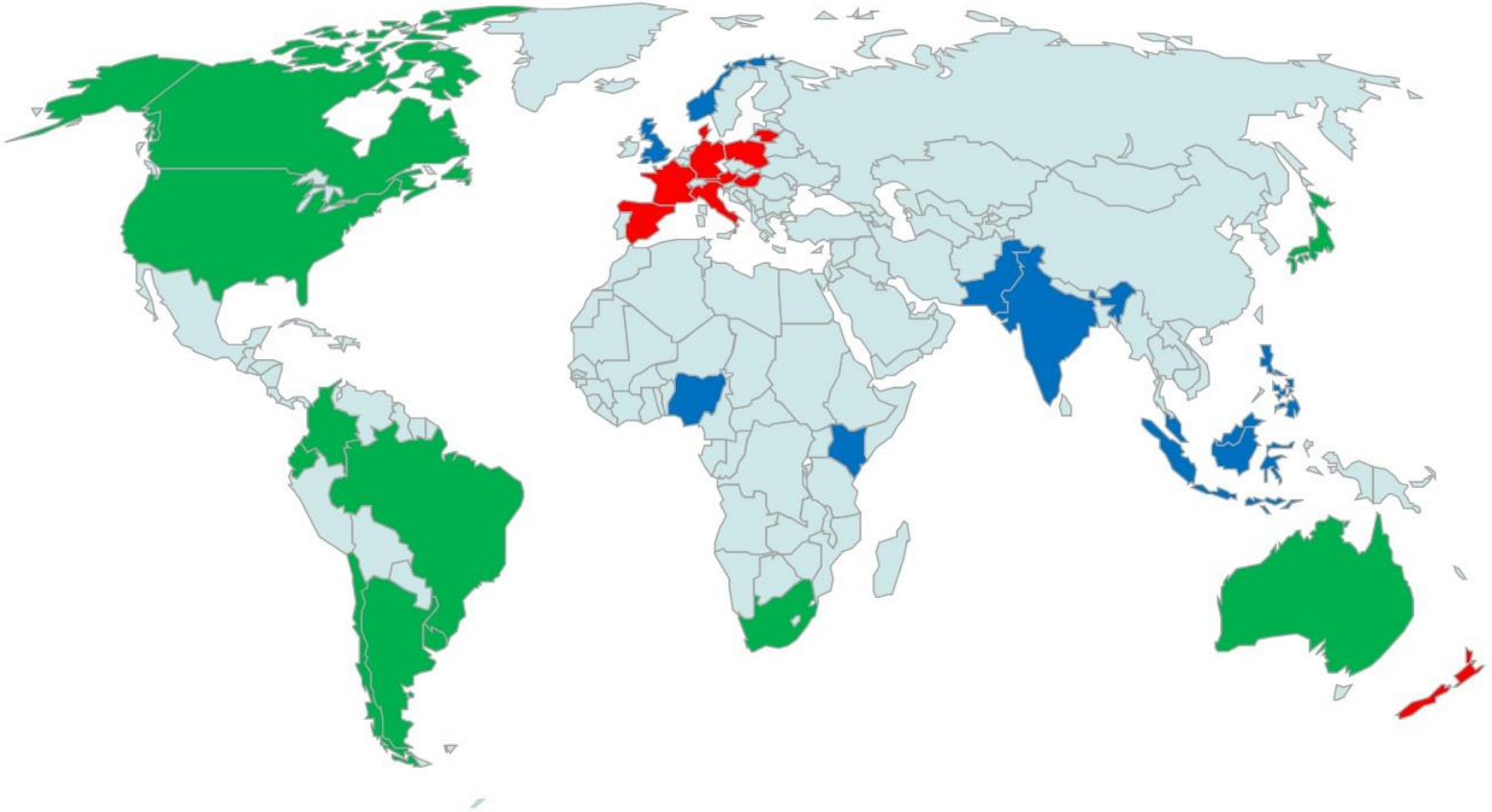
Living organisms vs food products (Australia)

- **GM Living organisms** (GMOs or LMOs) - regulated in Australia by the *Gene Technology Act 2000* and administered by the Office of the Gene Technology Regulator (OGTR) – SDN-1 de-regulated in Australia
- **Food Products** are regulated in Australia - governed by *the Australia New Zealand Food Standards Code* and administered by Food Standards Australia New Zealand (FSANZ)

  - Food derived using new breeding techniques under review, public comment mid 2021

  - FSANZ will consider applications for commercial GE food products

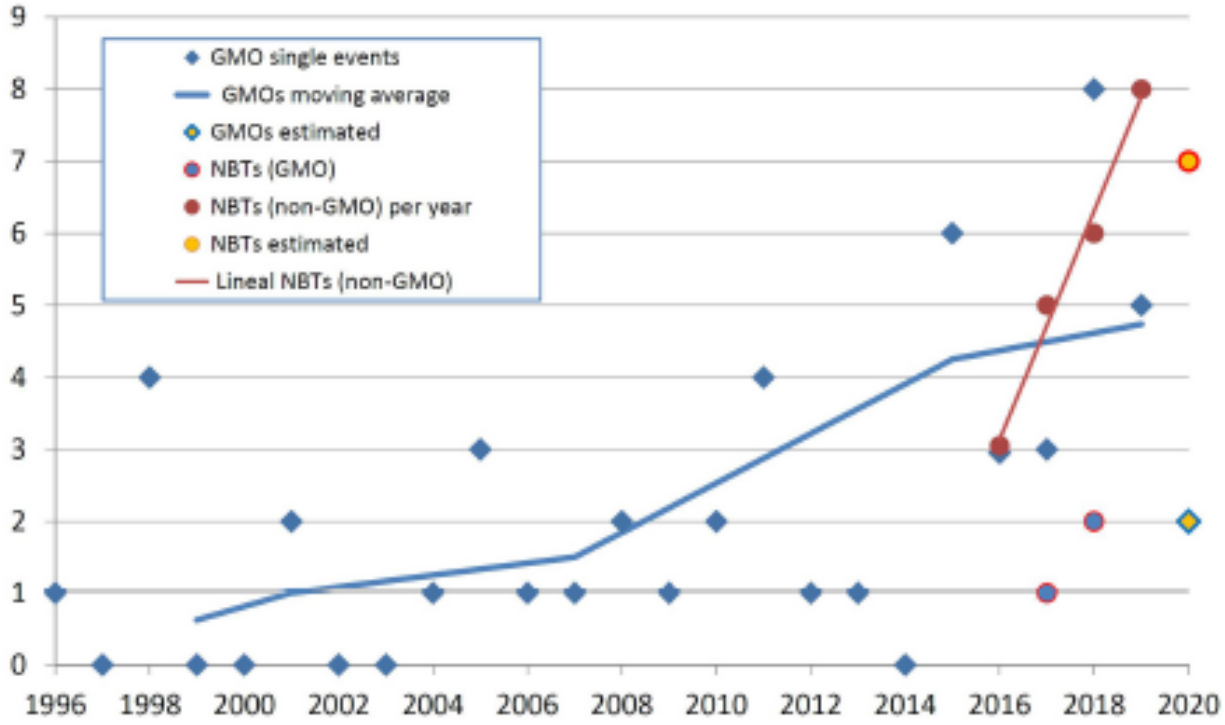
Current status of regulation of GE crops



- GE SDN-1 crops deregulated
- Ongoing discussion with recommendation to deregulate GE SDN-1 crops (progressing)
- GE crops regulated

GE regulations – Argentina, a case study

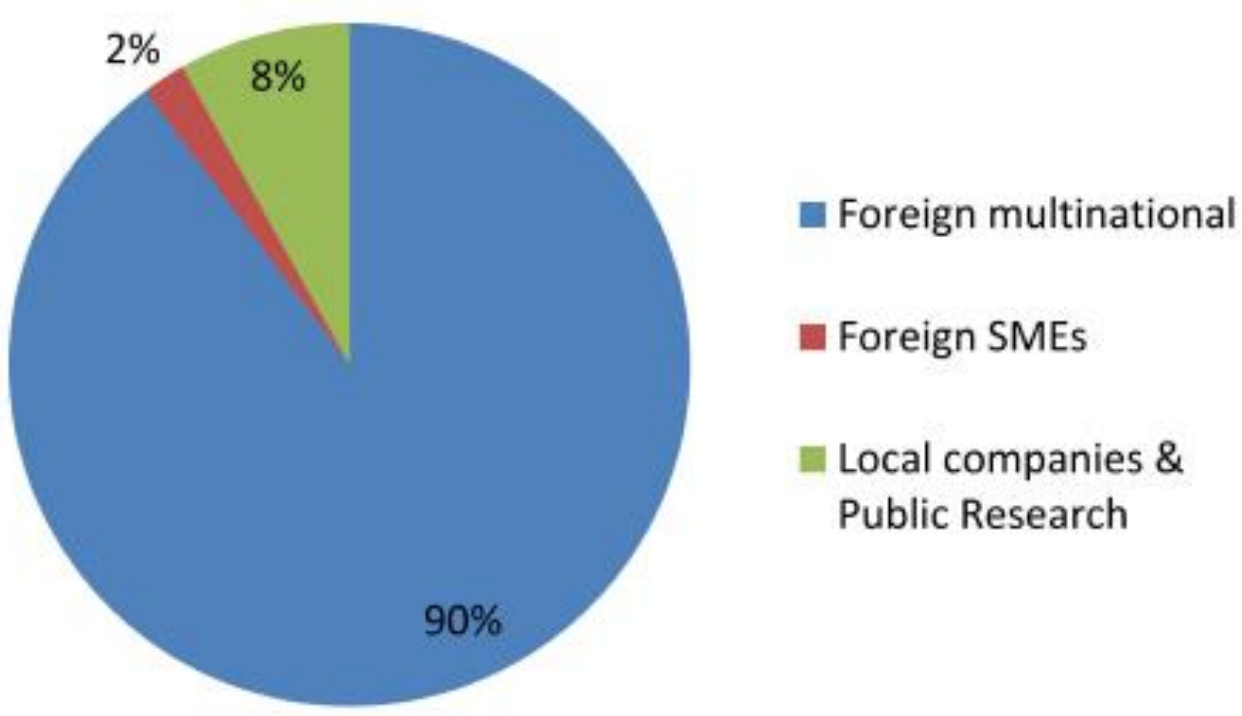
- Five years experience
- GE products: much faster development from bench to market than GMOs



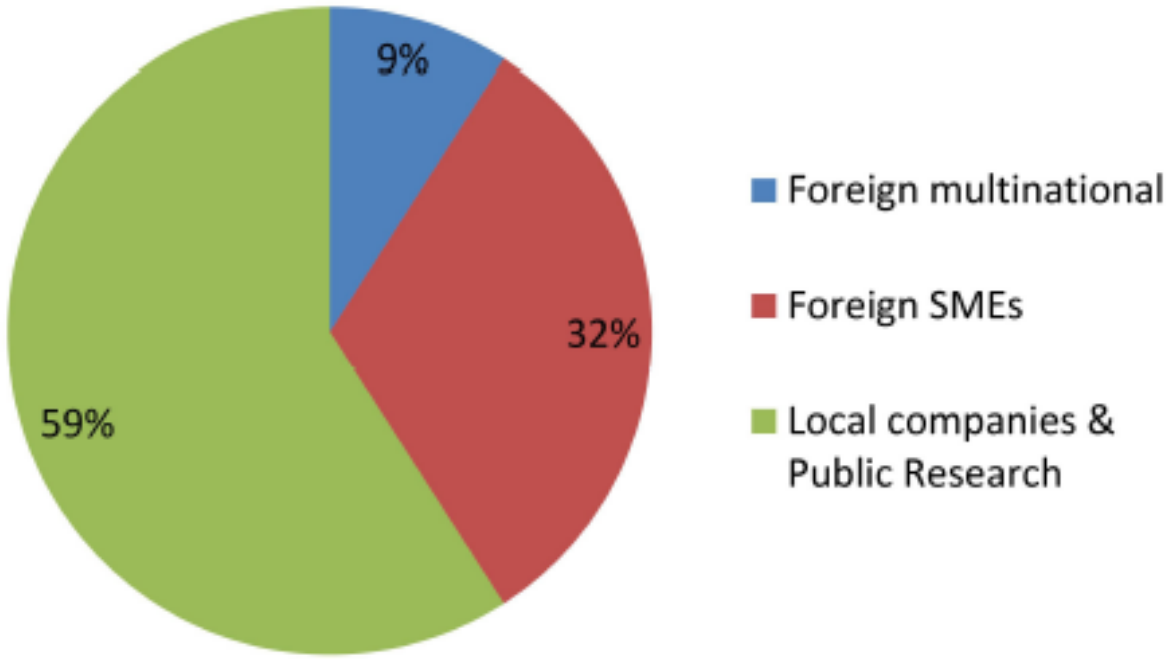
Whelan et al (2020). Gene editing regulation and innovation economics. Frontiers in Bioengineering and Biotechnology, doi: 10.3389/fbioe.2020.00303

Developer profiles: GM vs GE products

GMO products deregulated (20 years)



Gene-edited products deregulated (5 years)



- Mainly public institutions, public research and SMEs
- More diversified traits and plant species

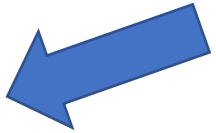
Whelan et al (2020). Gene editing regulation and innovation economics. Frontiers in Bioengineering and Biotechnology, doi: 10.3389/fbioe.2020.00303

Path-to-market, SDN-1 products (Australia, SE Asia)

SDN-1 RNP products

SDN-1 products from transgenic selected lines captured by GM trigger

Null segregants of SDN-1 products



Treat as ‘conventially’ bred products

The future

- FSANZ to accept SDN-1 gene-edited food (no external DNA) as non-GM
- No additional tier of regulations for gene-edited crops/products
  i.e. same treatment for SDN-1 crops/food as conventional breeding
- Public acceptance of GE crops/foods
- Use the term ‘gene-editing’ rather than ‘genome-editing’
- Counter EU influence on GE legislation
- Provide industry and government with updates and quality briefings
- Promote harmonisation of international regulations for GE crops/produce

Quote from a recent ISAAA webinar

- *'Paradoxically, the main challenge facing genome editing is not scientific, but political'*
- *'It defies logic why introducing one single mutation in a specific genomic locus with extreme precision using Cas effectors is subject to strict regulations in some countries, while introducing thousands of simultaneous mutations in a completely uncontrolled manner by chemical/physical random mutagenesis methods is not regulated'*

Jose Botella UQ, Brisbane, Australia (Zhan et al 2021, Genome editing for plant research and crop improvement, J Integrative Plant Biol https://doi.org/10.1111/jipb.13063)

Quote from a recent ISAAA webinar

- *'Feeding the world is not a scientific problem – it's a regulatory problem'*

- Professor Jim Whelan, LaTrobe University, Melbourne, Australia

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Thank you

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