Office Use Only	
Project Code	
Project Type	

FINAL REPORT 2026

Final reports must be submitted using the online application form at sagit.com.au with this Word document attached ***within two months*** after the completion of the Project Term.

PROJECT CODE	UA519
PROJECT TITLE	
Novel plant growth-promoting bacteria from Australian soil biodiversity: evaluation, understanding and application	

PROJECT DURATION *These dates **must** be the same as those stated in the Funding Agreement.*								
Project start date	**29/11/2021**							
Project end date	**28/11/2025**							
SAGIT Funding								

PRINCIPAL INVESTIGATOR *(responsible for the overall project and reporting)*		
Title:	**First Name:**	**Surname:**
Assoc. Prof.	Matthew	Denton
Organisation:	**Adelaide University**	
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ADMINISTRATION CONTACT DETAILS *(responsible for all administrative matters relating to project)*		
Title:	**First Name:**	**Surname:**
Dr	Michael	Millan
Organisation:	**Adelaide University**	
Mailing address:		
Telephone:		
Mobile:		

PROJECT REPORT: *Please provide a clear description for each of the following:*

Executive Summary (200 words maximum)

A few paragraphs covering what was discovered, written in a manner that is easily understood and relevant to SA growers. A number of key dot points should be included which can be used in SAGIT communications.

This project identified and validated plant growth-promoting bacteria (PGPB) capable of enhancing wheat performance under South Australian conditions. A total of 1,325 bacterial isolates were isolated from 71 agricultural soils, along with 34 reference strains. All 1,359 strains were screened in controlled pot trials, leading to the establishment of a core collection of 110 strains with confirmed growth-promoting traits.

Field validation was conducted at Kapunda (higher rainfall) and Waikerie (low rainfall). In large-plot trials, two strains significantly increased wheat grain yield (~30%) under harsh, low-rainfall conditions at Waikerie, while no yield benefit was observed under favourable conditions at Kapunda. This demonstrates that selected PGPB strains improve wheat resilience under environmental stress rather than increasing yield potential in optimal seasons.

Key findings:

- 1,359 bacterial strains screened; 110 core strains characterised.
- Two strains increased grain yield by ~30% under tested low rainfall conditions.
- Yield benefits were environment-specific.
- Strong potential for development of climate-resilient wheat inoculants for SA growers.

Project objectives

A concise statement of the aims of the project in outcome terms should be provided.

1. Establish a diverse germplasm collection of plant growth-promoting bacteria (PGPB) from Australian wheat soils.
2. Screen isolates for direct plant growth-promoting effects under controlled conditions.
3. Evaluate selected strains for indirect effects on wheat performance under field conditions.
4. Identify elite strains suitable for large-plot field validation and potential commercial development.

Overall Performance

A concise statement indicating the extent to which the project objectives were achieved, a list of personnel who participated in the Research Project including co-operators, and any difficulties encountered and the reasons for these difficulties.

The project successfully achieved all major objectives.

- 1,359 bacterial strains were isolated, purified, stored, and catalogued.
- A core collection of 110 strains was established through systematic pot screening and mechanistic analysis (IAA production, ACC deaminase activity, N fixation, P solubilisation, 16S rRNA identification).
- Multi-site field trials (Kapunda and Waikerie) were completed over multiple seasons.
- Two elite strains were identified that significantly improved grain yield (~30%) under harsh, low-rainfall conditions.

Personnel involved included the Principal Investigator, research staff, postgraduate students, technical staff, and collaborating partners.

Difficulties encountered:

- Dry sowing conditions (<10 mm rainfall around sowing) created highly variable establishment conditions.
- Budget constraints delayed microbiome sequencing analysis of collected samples.
- Strong environmental variation limited yield responses to harsh environments only.

Despite these challenges, the core deliverables were achieved.

KEY PERFORMANCE INDICATORS (KPI) *Please indicate whether KPIs were achieved. The KPIs **must** be the same as those stated in the Application for Funding and a brief explanation provided as to how they were achieved or why they were not achieved.*		
KPI	**Achieved**	**If not achieved, please state reason.**
Establishment of PGPB germplasm collection	Yes ☒ No ☐	
Completion of pot screening for direct PGP effects	Yes ☒ No ☐	
Field validation across contrasting environments	Yes ☒ No ☐	
Identification of PGPB mechanisms	Yes ☒ No ☐	
	Yes ☐ No ☐	
	Yes ☐ No ☐	
	Yes ☐ No ☐	
	Yes ☐ No ☐	

TECHNICAL INFORMATION (Not to exceed **three** pages)
Provide sufficient data and short clear statements of outcomes.

Stage 1: Establishment of PGPB Germplasm

Wheat (cv. Scepter) was grown in soils collected from 71 sites across the Australian soilbank under controlled-environment conditions. Roots (endosphere) and attached rhizosphere soil were sampled at three weeks after sowing. Bacterial isolates were obtained using serial dilution and selective culturing techniques.

Across 15 experimental rounds (five soils per round), a total of 1,325 putative plant growth-promoting bacterial (PGPB) isolates were recovered. In addition, 34 reference strains were included from previous collections and a commercial Bacillus-based product.

All 1,359 strains were purified, catalogued, and preserved at −80°C with duplicate backup storage. A detailed strain database was established, including source soil, isolation origin (rhizosphere/endosphere), and storage records. This collection represents a substantial microbial resource for future cereal crop research in South Australia.

Stage 2: Screening for Direct Plant Growth-Promoting Effects

All 1,359 isolates were screened in a controlled pot system using sterilised sand to eliminate background microbial interference. Wheat seeds (cv. Scepter) were inoculated individually with each strain. Five plants were grown per pot, with uninoculated controls and reference strains included in each round.

Screening was conducted in 12 rounds (approximately two weeks per round), testing 120 strains per cycle. Plants were harvested 14 days after sowing. The following parameters were measured:

- Shoot dry matter
- Root dry matter
- Seed dry matter
- Plant height

Based on statistical comparison with uninoculated controls, 110 strains were selected as a core collection (83 best-performing strains, 25 contrasting strains, and 2 reference strains).

Replicated Validation Trial

The 110 core strains were re-tested in a fully replicated pot experiment (four replicates per strain). Additional root architectural traits were measured:

- Total root length
- Root surface area
- Root-to-shoot ratio

This replicated trial confirmed consistent growth-promoting effects for a subset of strains.

Mechanistic Characterisation

To understand functional traits, the following assays were conducted:

- **Indole-3-acetic acid (IAA) production**, with and without L-tryptophan supplementation
- **ACC deaminase activity**, quantified via α-ketobutyrate production
- **Nitrogen fixation potential**
- **Phosphate solubilisation capacity** (calcium phosphate medium)
- **16S rRNA gene sequencing** for taxonomic identification

These analyses enabled linking plant growth responses with potential biochemical mechanisms and taxonomic identity. The core collection included representatives from diverse genera, including Bacillus/Peribacillus and Massilia species.

Stage 3: Field Screening Under General Farming Conditions

Field trials were conducted at:

- **Kapunda** (490 mm annual rainfall; 1.73% soil organic carbon)
- **Waikerie** (270 mm annual rainfall; 0.55% soil organic carbon)

These sites represent contrasting rainfall and soil fertility conditions typical of South Australian grain regions.

Each of the 110 strains was tested in paired inoculated and uninoculated rows, with four replicates per treatment. All sowing was conducted manually to prevent cross-contamination.

Measurements included:

- Plant height
- NDVI (measured five times from anthesis to maturity)
- Shoot biomass
- Grain yield
- Harvest index

Statistical analyses were conducted for each site independently and across environments.

Results demonstrated that yield responses were environment-dependent. Several strains showed positive responses under lower rainfall conditions, while limited responses were observed under favourable conditions.

Twelve strains were shortlisted based on combined performance across pot trials, field performance, mechanistic traits, and taxonomic identity.

Stage 4: Large-Plot Field Validation

Five elite strains (selected from Stage 3) plus one commercial comparator were evaluated in large plots (1.5 m × 10 m) at Kapunda and Waikerie.

Each site included:

- 7 treatments (6 strains + uninoculated control)
- 4 replicates
- 28 plots per site

Sowing occurred under dry conditions, with <10 mm rainfall within 10 days before and after sowing, representing realistic early-season stress conditions.

Measurements included:

- Plant height
- NDVI (six time points from tillering to maturity)
- Shoot biomass (six sampling time points)
- Grain yield
- Harvest index

Key Findings

At Waikerie (low rainfall, high temperature stress):

- Two strains (*Peribacillus frigoritolerans* strain_e086 and *Massilia* sp. strain_e068) significantly increased grain yield by approximately 30% compared with uninoculated controls.
- Yield improvements were associated with improved canopy development and biomass retention under stress conditions.

At Kapunda (higher rainfall):

- No statistically significant yield response was observed.

These results indicate that the primary benefit of selected PGPB strains is enhanced stress tolerance rather than increased yield potential under optimal conditions.

Microbiome Tracking

Bulk soil, root tissues (tillering, flowering, grain filling, maturity), and head tissues were collected for microbiome analysis to confirm colonisation and persistence of inoculated strains. DNA extraction and sequencing are planned pending funding availability.

Summary of Technical Outcomes

- Large-scale microbial screening pipeline successfully implemented.
- Two elite strains validated in multi-year, multi-site trials.
- Yield benefit (~30%) demonstrated under harsh, low-rainfall conditions.
- Mechanistic traits characterised for core strains.
- Foundation established for commercial inoculant development targeting stress resilience in SA wheat systems.

CONCLUSIONS REACHED &/OR DISCOVERIES MADE (Not to exceed **one** page)

Please provide concise statement of any conclusions reached &/or discoveries made.

- PGPB inoculation does not increase yield potential under one tested favourable condition.
- Selected strains significantly improve wheat performance under one tested harsh, low-rainfall environment.
- Two strains demonstrated consistent yield benefits (~30%) in the tested stressful environment.
- Environment-specific inoculant strategies are required for effective adoption.

These findings support the development of climate-resilient microbial inoculants for SA grain growers.

INTELLECTUAL PROPERTY

Please provide concise statement of any intellectual property generated and potential for commercialisation.

1,325 PGPB strains including the two with demonstrated field efficacy represent potential commercial IP.
Opportunities exist for:

- Strain licensing
- Seed coating and formulation development
- Partnership with commercial inoculant companies

Further validation and formulation optimisation are required before commercialisation

APPLICATION / COMMUNICATION OF RESULTS

A concise statement describing activities undertaken to communicate the results of the project to the grains industry. This should include:

- *Main findings of the project in a dot point form suitable for use in communications to farmers;*
- *A statement of potential industry impact*
- *Publications and extension articles delivered as part of the project; and,*
- *Suggested path to market for the results including barriers to adoption.*

Note that SAGIT may directly extend information from Final reports to growers. If applicable, attach a list of published material.

Activities Undertaken to Communicate Results

Project outcomes were communicated to the grains industry through:

- Field trial site visits with collaborating partners and industry representatives.
- Presentations at grower meetings and research update events.
- Discussions with commercial partners regarding strain validation and product development pathways.

- Engagement with agronomy networks to discuss practical implications under dry-sowing systems.
- Ongoing communication with industry stakeholders regarding large-plot validation results.

Results have been presented in a format suitable for grower-focused extension, highlighting practical implications rather than laboratory mechanisms.

Main Findings (Suitable for Grower Communication)

- Over 1,300 beneficial soil bacteria were screened from Australian grain soils.
- Two elite bacterial strains increased wheat grain yield by ~30% under low-rainfall conditions.
- Yield benefits were observed in harsh environments (e.g., Waikerie-type seasons).
- No yield increase was observed in favourable, high-rainfall environments.
- The primary benefit appears to be improved stress tolerance rather than higher yield potential.
- Microbial inoculants may support wheat establishment under dry-sowing conditions.

These findings suggest microbial seed treatments could become a risk-management tool in dry seasons.

Potential Industry Impact

- Supports climate resilience in South Australian grain systems.
- Provides a potential biological tool to mitigate yield losses under drought and heat stress.
- Aligns with increasing industry interest in low-input and biologically based production systems.
- May improve return on investment in low-rainfall years where yield stability is critical.

If successfully commercialised, the technology could provide growers with a targeted inoculant option for stress-prone regions rather than a universal yield enhancer.

Publications and Extension Outputs

The publications are currently in preparation and are planned for submission by mid-2026.

Suggested Path to Market

1. **Further Multi-Site Validation**
   Expand trials across additional South Australian grain environments to confirm consistency of stress-related yield benefits.
2. **Strain Formulation Development**
   Optimise seed coating technology to ensure shelf life, survival, and compatibility with standard seed treatments.
3. **Regulatory Approval**
   Undertake necessary biosecurity and product registration steps for commercial inoculant release.
4. **Commercial Partnership**
   Partner with an established microbial inoculant company for scale-up, production, and distribution.

Barriers to Adoption

- Seasonal variability in response (benefits primarily under stress conditions).
- Grower scepticism regarding microbial products due to inconsistent past performance.

- Requirement for reliable formulation and delivery technology.
- Need for clear economic return data across multiple seasons.

Addressing these barriers will require additional field validation, robust formulation development, and clear communication of where and when the product delivers value.

POSSIBLE FUTURE WORK

Provide possible future directions for the research arising from the project including potential for further work and partnerships.

- Expanded multi-location field trials across SA environments
- Microbiome sequencing to track strain colonisation
- Testing across multiple wheat varieties
- Formulation optimisation and seed coating technologies
- Integration into climate-resilient cropping systems