Appendix 3: An impact assessment of the Rice Quality and Premium-Priced Markets Cluster

Executive summary.............................................................................................................................. iii
Introduction........................................................................................................................................... 1
Objectives............................................................................................................................................... 1
Methodology .......................................................................................................................................... 2
Project details ........................................................................................................................................ 3
  Project investment .......................................................................................................................... 20
  Nominal investment ......................................................................................................................... 20
  Program management and communication/extension costs ........................................................... 21
  Real cost of investment .................................................................................................................. 21
Impacts ................................................................................................................................................. 22
  Public versus private impacts ......................................................................................................... 22
  Distribution of impacts along the supply chain .............................................................................. 22
  Impacts on other primary industries ............................................................................................... 22
  Impacts overseas ............................................................................................................................. 23
  Match with national and AgriFutures Australia priorities .............................................................. 23
  AgriFutures Australia Arenas and priorities ................................................................................... 23
  Valuation of impacts ....................................................................................................................... 24
    Counterfactual – the ‘without R&D’ scenario ................................................................................. 24
    Impacts valued .............................................................................................................................. 24
    Attribution ................................................................................................................................ 24
    Summary of assumptions ................................................................................................................ 25
    Other implied assumptions ........................................................................................................... 26
    Other impacts identified but not valued ........................................................................................ 26
Results .................................................................................................................................................. 27
  Sensitivity analyses ........................................................................................................................ 28
  Distribution analyses ....................................................................................................................... 31
  Confidence ratings .......................................................................................................................... 32
Conclusions .......................................................................................................................................... 34
Recommendations ............................................................................................................................... 35
Acknowledgments ............................................................................................................................... 35
References ............................................................................................................................................ 36
Tables

Table 1: Results from impact assessment of the Rice Quality and Premium-Priced Markets Cluster iv
Table 2: Projects in the Rice Quality and Premium-Priced Markets Cluster .................................... 2
Table 3: Project logical framework ................................................................................................... 3
Table 4: Total investment in projects attributed to Quality and Premium-Priced Markets Cluster for years ending June 2017 to June 2022 (nominal) ................................................................. 21
Table 5: Categories of impacts and potential impacts from the investment ................................... 22
Table 6: Australian Government Research Priorities ........................................................................ 23
Table 7: AgriFutures Australia Arenas and Priorities ....................................................................... 24
Table 8: Summary of base assumptions for Rice Quality and Premium-Priced Markets ................. 25
Table 9: Assumptions for new variety releases ................................................................................ 25
Table 10: Probability assumptions for new varieties ....................................................................... 26
Table 11: Investment criteria for total investment in the Rice Quality and Premium-Priced Markets Cluster (discount rate 5%) ................................................................................................... 27
Table 12: Sensitivity to discount rate (30 years) ................................................................................ 30
Table 13: Sensitivity to annual rice area (5% Discount Rate, 30 years) ............................................ 30
Table 14: Sensitivity to yield impact relative to replaced variety (5% discount rate, 30 years) ....... 30
Table 15: Sensitivity to farmgate rice price (5% discount rate, 30 years) .......................................... 30
Table 16: Sensitivity to market premium for V043 to Opus (5% discount rate, 30 years) ............... 31
Table 17: Sensitivity to attribution of benefits (5% discount rate, 30 years) ...................................... 31
Table 18: Sensitivity to probability of release (5% discount rate, 30 years) ...................................... 31
Table 19: Sensitivity to market share of new variety (5% discount rate, 30 years) ......................... 31
Table 20: Confidence in analysis of project ...................................................................................... 33

Figures

Figure 1: Flow of benefits and costs for Cluster 3 .............................................................................. 28
Figure 2: Sensitivity analysis results .................................................................................................. 29
Figure 3: BCR distribution combining multiple assumptions with ranges ...................................... 32
Executive summary

What the report is about

The purpose of this evaluation was to assess the economic, environmental, and social impacts of the investment by AgriFutures Australia and total industry investment into projects in the Rice Quality and Premium-Priced Markets Cluster in which AgriFutures Australia invested between 2016-17 and 2021-22 under the Rice Program RD&E Plan 2016-17 to 2021-22 (AgriFutures Australia, 2016).

Who is the report targeted at?

This audience for this report is AgriFutures Australia’s project and program managers and senior management, its Rice Advisory Panel and its Board, the Australian rice industry, researchers, the Commonwealth Department of Agriculture, Water and the Environment, and the Council of Rural Research & Development Corporations.

Where are the relevant industries located in Australia?

The rice industry is concentrated in the Murrumbidgee valleys of NSW and in the Murray valleys of NSW and VIC (DAWE, 2020). There are some much smaller production regions in northern NSW and northern QLD.

Background

As part of the Rice Program RD&E Plan 2016-17 to 2021-22, AgriFutures Australia invests in a number of projects that have the objective of developing new rice varieties other than medium grain rice, allowing market diversification and/or increased demand by developing new markets that potentially attract a market premium.

These projects include breeding/genetic research, supported by an extension program and the development of new methods and technology to lower the cost of evaluating breeding lines for quality. The projects relating to rice quality were aggregated into a single cluster, the Rice Quality and Premium-Priced Markets Cluster.

AgriFutures Australia faces the challenge of demonstrating the value, benefits and impacts it delivers to its stakeholders through funding RD&E in the rice industry. These stakeholders are government, the levy payers from the industry, other industry stakeholders and the broader community. To address this challenge, AgriFutures Australia requested the preparation of economic impact assessments of projects it funds under the Rice Program RD&E Plan 2016-17 to 2021-22. The impact assessment of projects that aim to improve water-use efficiency described in this report was prepared as part of the overall economic impact assessment of the plan.

Aims/objectives

The objective of this report is to conduct and describe an impact assessment of AgriFutures Australia’s investment in a cluster of projects targeted at developing new rice varieties that enable market diversification and development of new markets. This impact assessment is one of four assessments of project clusters funded under AgriFutures Australia’s Rice Program RD&E Plan 2016-17 to 2021-22. The reports on all four assessments are collated into one summary report. They will be used by the AgriFutures Rice Advisory Panel to assist in prioritising future investments in the Rice Program. Specifically, the findings quantify the benefits to industry provided by research funded by AgriFutures Australia through the rice industry RD&E levy.
Methodology

The evaluation of AgriFutures Australia’s investment in the Rice Program RD&E Plan followed the general evaluation methodology detailed in CRRDC Impact Assessment Guidelines (CRRDC, 2018). The methodology is well entrenched in the Australian primary industry research sector, including rural R&D corporations, state departments of agriculture, cooperative research centres and some universities. Subjective and objective assessments are included, with benefit-cost analysis being the main means of assessment.

AgriFutures Australia provided an initial list of 51 projects. After a review, 21 projects were excluded because they had been in the 2016 impact assessment; were projects about the Rice R&D levy; had been terminated by AgriFutures Australia before completion; or there was insufficient information for assessment. The 30 remaining projects were then grouped into four clusters:

1. Crop Yield Productivity
2. Water-Use Efficiency
3. Rice Quality and Premium-Priced Markets

An impact assessment was conducted on the nine projects included in the Rice Quality and Premium-Priced Markets Cluster. This report provides details of the assessment on this cluster.

For each project, the impact assessment methodology involved identifying and briefly describing project objectives, activities and outputs, and potential and actual outcomes and impacts. The principal economic, environmental, and social impacts were then summarised in a triple bottom line framework. The impacts were then quantified, where possible, from assumptions after discussions with AgriFutures Australia program managers, project researchers and industry experts. A benefit-cost analysis was then conducted as per CRRDC guidelines.

All past costs and benefits were expressed in 2019-20 dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2020). All benefits after 2019-20 were expressed in 2019-20 dollar terms. The base analysis used the best estimates of each variable, notwithstanding a high level of uncertainty for many estimates. All analyses ran for a period of 30 years after 2021-22.

The assumptions made for each benefit-cost analysis were conservative. For each analysis, sensitivity analyses were undertaken for several assumptions that had the greatest degree of uncertainty or for those that were seen to be key drivers of the investment criteria.

Results and key findings

The results indicate that for the base case scenario there is a forecast modest positive return on investment at year 30 for the Rice Quality and Premium Market Cluster. At a 5% discount rate, the base case scenario resulted in a benefit-cost ratio of 1.67 at year 30 and a Modified Internal Rate of Return (MIRR) at 6.1% after 30 years. Relative to the initial costs allocated to the cluster, breakeven returns do not occur until around year 15 from the final year of investment in the program.

Table 1: Results from impact assessment of the Rice Quality and Premium-Priced Markets Cluster
<table>
<thead>
<tr>
<th>Investment criteria</th>
<th>Years from last year of investment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Present value of benefits ($m)</td>
<td>0.00</td>
</tr>
<tr>
<td>Present value of costs ($m)</td>
<td>7.22</td>
</tr>
<tr>
<td>Net present value ($m)</td>
<td>-7.22</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>0.00</td>
</tr>
<tr>
<td>Internal rate of return (%)</td>
<td>N/A</td>
</tr>
<tr>
<td>Modified internal rate of return (%)</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Implications for stakeholders**

Two key drivers of the modest returns for this cluster, compared with returns estimated for Cluster 1 (Crop Yield Productivity), can be attributed to the allocation of costs between clusters for the breeding and extension programs. The proportion of costs for the breeding and extension programs assumed for this analysis was 25%. The other factor is the smaller proportions of area sown to the new varieties evaluated in this cluster (relative to the dominant variety and large planted area as in Cluster 1). The results from the sensitivity analysis support this, with the importance of total rice area planted, the proportion of market share (as a percentage of rice area) for each new variety and the discount rate being the most important variables when modelling investment outcomes.

**Recommendations**

There are two recommendations arising from undertaking the impact assessment.

1. **Rice breeding priorities should consider the likelihood of fewer varieties being grown and more ‘nil-benefit years’ for some varieties in low water allocation years.**

If the Australian rice industry is likely to have more years of constrained output when fewer rice varieties are grown in some years, then the returns on investing in smaller market share varieties (such as for some long and short grain varieties) may be lower than in the past, even with the same amount of genetic improvement (yield and/or quality). If benefits are lower under this scenario, future objectives and cost allocations for plant breeding should consider the likelihood of varieties not being grown in low water allocation years. This evaluation would also need to weigh up the lost benefits from market diversification and the impact additional quantities of medium grain rice may have on Australian rice prices.

2. **Short- and medium-term variety trial results should be summarised in milestone reports**

Future impact assessments would benefit significantly from milestone and progress reports from the breeding and agronomy research projects presenting trial results for new and existing varieties. Quantitative information can be combined with expert opinion to improve the estimate or forecast the farm-level impacts on crop yield between old and new varieties.
Introduction

In the Rice Program RD&E Plan 2016-17 to 2021-22, AgriFutures Australia invests in a number of projects that have the objective of developing new rice varieties, other than medium grain rice, for market diversification and/or higher demand by developing new markets that attract a market premium. These projects include breeding/genetic research, supported by an extension program and the development of new methods and technology to lower the cost of evaluating breeding lines for quality.

The breeding/genetic projects related to this cluster aim to maintain or improve quality attributes for short and long grain rice varieties while addressing key constraints in lifting crop yields, such as better cold tolerance. Projects related to the breeding program also include research into potentially new niche varietal classes such as coloured rice. Projects related to developing new methods and technology to lower the cost of evaluating breeding lines for quality parameters are also included in this cluster. Such technology improvements in testing grain quality can benefit the industry by enabling new selection for quality selection characteristics previously unmeasurable and/or replacing existing methods to reduce costs (either through lower input costs or greater annual throughput of breeding lines).

AgriFutures Australia faces the challenge of demonstrating the value, benefits and impacts it delivers to its stakeholders through funding RD&E in the rice industry. These stakeholders are government, industry levy payers, other industry stakeholders and the broader community. To address this challenge, AgriFutures Australia requested the preparation of economic impact assessments of projects it funds under the Rice Program RD&E Plan 2016-17 to 2021-22. The impact assessment described in this report was prepared as part of the overall economic impact assessment of the plan. A notable feature of the Rice Program RD&E Plan is a strong, longstanding partnership between AgriFutures Australia, the NSW DPI and SunRice.

The projects relating to rice quality were aggregated into a single cluster, the Rice Quality and Premium-Priced Markets Cluster. This cluster was evaluated for the triple bottom line impacts (economic, environmental and social) of the investment.

Objectives

The objective of this report was to conduct and report on an impact assessment of investment by AgriFutures Australia and the industry in projects between 2016-17 and 2021-22 in the Rice Quality and Premium-Priced Markets Cluster in the Rice Program RD&E Plan 2016-17 to 2021-22.
Methodology

The Rice Quality and Premium-Priced Markets Cluster was determined by the review team and agreed with the AgriFutures Australia management. Nine projects were included in the cluster, as listed in Table 2. Three projects (PRJ-009296, PRJ-010696 and PRJ-009950) were also included as part of Clusters 1 and 2.

Table 2: Projects in the Rice Quality and Premium-Priced Markets Cluster

<table>
<thead>
<tr>
<th>Program objective</th>
<th>Project number</th>
<th>Project name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice breeding – varieties and quality improvement</td>
<td>PRJ-009805</td>
<td>Next-generation healthy rice</td>
</tr>
<tr>
<td></td>
<td>PRJ-009950</td>
<td>Australian Rice Partnership 2 (25% of costs)</td>
</tr>
<tr>
<td>Extension, sustainability and human capital</td>
<td>PRJ-009296</td>
<td>Rice extension coordination</td>
</tr>
<tr>
<td></td>
<td>PRJ-010696</td>
<td>Extension for improved efficiency (25% of costs)</td>
</tr>
<tr>
<td>Rice breeding – varieties and quality improvement</td>
<td>PRJ-011503</td>
<td>Exploring the health beneficial properties of rice bran</td>
</tr>
<tr>
<td>Rice breeding – varieties and quality improvement</td>
<td>PRJ-011504</td>
<td>The therapeutic properties of coloured rice-derived polyphenols</td>
</tr>
<tr>
<td></td>
<td>PRJ-011505</td>
<td>The impact of farm practices on rice grain quality in south-eastern Australia</td>
</tr>
<tr>
<td>Rice breeding – varieties and quality improvement</td>
<td>PRJ-011506</td>
<td>Effect of environment on cereal phenolic composition and its chemopreventive potential</td>
</tr>
<tr>
<td>Rice breeding – varieties and quality improvement</td>
<td>PRJ-011507</td>
<td>Factors affecting the starch digestibility of rice</td>
</tr>
</tbody>
</table>

The evaluation of AgriFutures Australia’s investment in projects included the Rice Quality and Premium-Priced Markets Cluster followed the general evaluation methodology detailed in the *CRRDC Impact Assessment Guidelines* (CRRDC, 2018). The methodology is well entrenched in the Australian primary industry research sector, including rural R&D Corporations, state departments of agriculture, cooperative research centres and some universities. Subjective and objective assessments are included in the methodology, with benefit-cost analysis being the main means of assessment.

The methodology for this impact assessment involved identifying and briefly describing project objectives, activities and outputs, and potential and actual outcomes and impacts for each project in this cluster. The principal economic, environmental, and social impacts were then summarised in a triple bottom line framework.

Some, but not all, of the identified impacts were then valued in monetary terms. A shortage of necessary evidence and data prevented some impacts from being valued. The impacts valued are deemed to represent some of the main benefits, but by no means the only benefits, of the project.
Project details

The main breeding program objectives related to rice quality and premium-priced markets included the development of rice varieties with different characteristics to the main medium grain variety grown in Australia, currently Reiziq. In the current Rice RD&E program time period, there were some objectives to develop new short and long grain varieties to replace older long grain varieties Langi and Doongara, and the main short grain variety grown in Australia, Opus. All three varieties were released over 20 years ago. Projects related to the breeding program also included foundational research into potentially new niche varietal classes such as coloured rice. One specific project related to the development of a new method as a proxy for indicating the glycemic rating for rice, which enables cheaper and faster screening of breeding lines for low-GI traits.

The nine projects included in the Rice Quality and Premium-Priced Markets Cluster are described in a logical framework (Table 3).

Table 3: Project logical framework

<table>
<thead>
<tr>
<th>Project number and title</th>
<th>PRJ-009805 Next-Generation Healthy Rice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation/University</td>
<td>Charles Sturt University</td>
</tr>
<tr>
<td>Chief investigator</td>
<td>Prof. Christopher Blanchard</td>
</tr>
<tr>
<td>Start date</td>
<td>15/06/2015</td>
</tr>
<tr>
<td>End date</td>
<td>15/05/2018</td>
</tr>
</tbody>
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Objectives

1. Develop a cost-effective and consistent in vitro GI method to select advanced breeding lines for low-GI potential for implementation by the Rice Quality component of the Australian Rice Partnership II Project.
2. Due to challenges with importing porcine pancreatin into Australia, there is also a need to develop an alternative digestive method to replace this enzyme with another accessible option.
3. Fast-track development of potential low-GI rice varieties by assessing up to 120 advanced breeding lines each year for the duration of this project.
4. Assist with delivering advanced rice-breeding lines with low GI in the Australian Rice Partnership II Project.

Activities

- The glycemic index of potential breeding lines was created and analysed.
- A cost-effective method for screening potential low-GI breeding lines while maintaining desired consumer sensory preferences was fast-tracked and developed.

Outputs

- Initial investigations determined that existing methodologies, including the commercially available automated GI estimation instrument, were not suitable for screening rice-breeding lines. Modifications were made to published methodologies to develop a rice-specific technique that was able to rank genotypes based on their digestibility.
- Commercial rice genotypes with diverse GI values were successfully differentiated using the in vitro protocol. The proportion of starch hydrolysed at 60 minutes (SH-60) during the in vitro digestion assay was used to rank the digestibility of the samples. Further investigations of nine rice genotypes indicated that the assay can successfully differentiate genotypes with a wide range of GI values. The technique was then used to evaluate the genetic basis of digestibility by screening a diverse panel of rice varieties.
- Training with NSW DPI technical staff enabled deployment of the method in the Australian rice breeding program. This training – hands-on workshops at CSU’s National Life Sciences Hub – resulted in further enhancement to the method based on NSW DPI staff feedback.

Outcomes

The new technique has the capacity to screen many genotypes for their digestion behaviour. Validated by screening 200+ diverse genotypes, the method is an in vitro technique that mimics simple starch digestion as
a way of predicting GI values. While the method does not provide a GI value, it is accurate enough to rank
rice genotypes as either high, medium or low digestibility.

<table>
<thead>
<tr>
<th>Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>The glycaemic index is a nutritional measure of carbohydrate-containing foods, quantifying their potential to raise post-prandial blood glucose levels. As such, GI testing requires human participants, which is expensive, time consuming and highly impractical for most applications. The present study demonstrated that the use of a rapid, in vitro assay for ranking digestibility of rice overcomes the financial and time limitations of in vivo testing. The measurement of SH-60 or SH-20 using the in vitro digestibility assay offers a practical, high-throughput tool for rice breeding programs to screen for new low-GI varieties that can then be validated by a more detailed analysis, if required.</td>
</tr>
</tbody>
</table>

The assay developed here appears to provide a useful and practical approach to screening genotypes for their digestibility properties. NSW DPI staff have been trained in the technique so it is ready to be used in the Australian rice breeding program. However, before this is done, a clear assessment of the style of low-GI rice is needed. In the past, amylose levels have been used as a proxy for selecting for low-GI rice. However, high amylose levels result in firm cooking rice, which is not always desired. The assay developed here is independent of amylose, hence, the development of low-GI rice with low amylose levels is now possible. |

Having the ability to rapidly screen the digestibility of rice breeding lines will hasten development of high-quality rice varieties with lower digestibility. Demand for food with enhanced health properties is increasing and high-quality rice with a low GI is in high demand. This high demand will translate to a more valuable product that will ultimately increase the profitability of rice production in Australia.
PRJ-009950
Australian Rice Partnership 2 (cost part only)

Organisation: NSW DPI
Chief investigator: Deb Slinger
Start date: 15/06/2015
End date: 20/07/2021

Objectives

The Australian Rice Partnership II project has six Variety objectives and nine Supporting objectives. Delivery of these objectives requires integrated research from five distinct components: rice breeding; rice yield stability; rice quality; molecular breeding; and a component covering the activities of Rice Research Australia Pty Ltd (RRAPL). All components contribute to the Variety objectives; individual or combinations of components contribute to the Supporting objectives.

The objectives relevant to the Rice Quality and Premium-Priced Markets Cluster:

**Objective 2. Calrose-style medium grain**
By 2020, at least one advanced breeding line of a softer cooking medium grain with Calrose-type grain dimensions, with quality close to a short grain for processing and food service purposes.

**Objective 3. Soft-cooking long grain**
By 2020, at least one advanced breeding line of a soft-cooking long grain variety. This breeding line will be softer cooking than Langi, probably closer to the superseded variety Pelde. This breeding line will have low chalk and long, slender grains.

**Objective 4. Jasmine-style fragrant long grain**
By 2020, at least one advanced breeding line with superior agronomic performance and quality equivalent to the recently released fragrant long grain variety Topaz.

**Objective 5. Short grain Koshihikari-style variety**
By 2020, at least one advanced breeding line suitable for a high-quality short grain variety with the sweet, softer cooking quality attributes of Koshihikari.

**Objective 6. Rice breeding material for functional and healthy rice varieties**
By 2020, develop improved breeding material that could be developed into advanced breeding lines for rice varieties with the following characteristics:
- Low glycaemic index (GI) – equivalent to or lower GI than Doongara, either in a medium grain or long grain quality package.
- Coloured pericarp – black and red rice in either a medium grain or long grain.
- Long grain glutinous rice.
- Fragrant Basmati-style rice with long slender grains that elongate when cooked.

**Objective 10. Molecular breeding**
By 2020, the rice breeding program will implement whole genome profiling, and screen for published molecular markers through a contracted service provider.

**Objective 11. Quality Evaluation Program (QEP)**
By 2020, the quality team will develop new improved methodologies for quality assessment for chalkiness, whole grain millout, amylase content, and texture evaluation.

**Objective 12. Pure seed production and satellite site variety trial management**
Rice Research Australia Pty Ltd will produce pure seed short rows, long rows, and nucleus seed lots, along with 1-2 tonnes of breeders’ seed, and conduct district and satellite site field trials annually under a service agreement with NSW DPI.
**Objective 13. New science for existing varieties**
The breeding and quality programs will provide supply chain support on variety-specific issues, in particular where new science is needed to understand the performance or properties of a rice variety annually, as requested by industry stakeholders through management committee meetings.

**Activities**
- A collaborative agreement was formed between NSW DPI, Rice Research Australia Pty Ltd (RRAPL, the SunRice-owned subsidiary) in June 2015, and extended until June 2021.
- The agreement established a seven-year program (called the Australian Rice Partnership 2) of which the nine objectives listed above are part.
- The program is overseen by a project management committee drawn from the three funding groups.
- Breeding objectives were established to address marketing and farm productivity issues in line with project objectives, including the objectives to improve crop yield productivity.
- Planting, husbandry, harvest and collection of data from experimental field trials (Rice Breeding and Molecular Breeding).
- Grain quality data collected on selected field trial samples (Rice Quality), under an array of managed environment conditions (e.g. nitrogen).
- Researched screening methods for selecting healthy rice germplasm.
- Researched the agronomic characteristics of short-season varieties.
- Researched screening methods for selecting cold-tolerant rice germplasm.
- Conduct screening nurseries to screen for cold-tolerant rice germplasm.
- Researched the blast resistance races present in Australia.
- Evaluated breeding lines for performance and grain quality in field trials in Northern Australia at sites provided by SunRice in QLD.
- Planting and tissue sampling of single plants in the glasshouse and as part of the pure seed program, and the generation of genotyping reports.
- Planting, husbandry, harvest and cleaning of pure seed scheme seed lots.
- Planting, husbandry, harvest and provision of collected data for experimental field trials.
- Researched variety-specific agronomic characteristics or performance.
- Understanding research contributions or outcomes relevant to the breeding program from each ancillary project.
- At least one staff member attended a conference with relevance to international rice research activities.
- Presented results at annual rice industry field days.
- Improved testing methods and equipment for rice grain quality testing.

**Outputs**
- Annual milestone reports provide updates on progress.
- Presentations to annual rice field days.
- From 2016 to 2020, at least 10 journal articles published, 26 conference papers and presentations, 48 technical papers, and four extension articles.
- A review of the Australian Rice Partnership was conducted in 2019 by Linscombe and Lambrides (2019)

The specific outputs of the ARP against each of the relevant objectives for the Rice Breeding Quality Premium-Priced Markets Cluster:

**Objective 2. Calrose-style medium grain**
District trial data for Viand indicated reasonable yield potential, although early-sown replicated trials indicated some tendency for lodging.

**Objective 3. Soft-cooking long grain**
A large partially replicated trial was conducted to identify the most promising long grain breeding lines from a large amount of untested germplasm developed by the previous long grain breeder. A total of 690 unique entries were tested in small plots (i.e. 5 m² plots). Most were tested with only one replicate to evaluate as many entries as possible, with about 15% replicated entries.
Objective 4. Jasmine-style fragrant long grain
Specific efforts are continuing of cold tolerance into fragrant long-grain elite germplasm, prioritising the testing of new breeding lines with cold-tolerant parentage.

Objective 5. Short grain Koshihikari-style variety
Two recent promising lines (YRA18=V043 and YRJ18=V035) continue to be evaluated and data collected from district trials (S4).

Objective 6. Rice breeding material for functional and healthy rice varieties
Various varieties continue to be evaluated and data collected, including detailed grain quality tests. Data from three low-GI lines are collected and benchmarked against Doongara in district trials (S4). Three lines in the coloured pericarp objective are being trialed with data collected at the S3 stage – fully replicated trials across multiple sowing dates.

Objective 10. Molecular breeding
DArT genotyping was minimal this year due to the deliberate action to save resources and carry forward the dedicated marker genotyping funds for the next season. The main focus was on further validation of the KASP system. To date, >100 KASP markers have been tested from the available markers on the IRRI ‘menu’ comprising over 200 trait-based markers.

Objective 11. Quality Evaluation Program (QEP)
Physical quality assessment of 2020 samples started in May. The team will start wet chemistry evaluation from October.

Objective 12. Pure seed production and satellite site variety trial management
All pure seed varieties were grown in 2020 cropping year. Doongara was the only variety grown using nucleus seed. Uraraka (YRK5) was again grown, but is unlikely to be grown commercially again; decided again to not keep the breeders seed. Along with the commercial varieties, several newer varieties were included in the seed multiplication process, adding significantly to the workload at RRAPL (these included three bold medium grains similar to Reiziq: V037, V038 and V071). The reduced crop planting across the Riverina resulted in only four district trials being sown on grower’s farms as part of RRAPL’s CY2020 commitments. All trials at RRAPL were drill sown this year into fresh fallow paddocks at the appropriate sowing times. For the trials at RRAPL, agronomic data was collected, including sowing dates, fertiliser and chemical applications, water depths, flowering dates and harvest data.

Objective 13. New science for existing varieties
Collaboration with the Yanco rice agronomy team led by Brian Dunn continues to thoroughly test the latest advanced breeding lines to evaluate agronomic performance and grain quality. A trial related to the storage quality of Australian paddy is undergoing.

Outcomes
Specific outcomes of the ARP against each of the relevant objectives for this cluster:

Objective 2. Calrose-style medium grain
This variety class is becoming obsolete due to outsourcing from overseas producers, such as Vietnam. New options are provided by shorter duration medium grain varieties, such as Viand, for the organic/biodynamic growers who have historically used Amaroo. District trial data for Viand indicated reasonable yield potential, although early-sown replicated trials indicated some tendency for lodging.

Milestone 3. Soft-cooking long grain
The most promising line from district trials was YRD16-V025, which showed superior yield compared to Langi. However, the quality of this line may not match the profile for soft cooking, and further quality evaluation is needed for confirmation.

Milestone 4. Jasmine-style fragrant long grain
Specific efforts are continuing to cold tolerance into fragrant long-grain elite germplasm, prioritising the testing of new breeding lines with cold-tolerant parentage. The advanced new breeding line YRI14-V042 appears to be the most promising line compared to Topaz in terms of yield and agronomic performance. However, this line needs full physical and wet chemistry evaluation to determine whether it is superior in quality to Topaz.

**Milestone 5. Short grain Koshihikari-style variety**

Lines YRA18=V043 and YRJ18=V035 are higher yielding than Koshi, but comparable in yield to Opus.

**Milestone 6. Rice breeding material for functional and healthy rice varieties**

**Low GI**

Several selections from YRL127 (long grain) generally were higher yielding than Doongara. These lines require advanced stage quality testing. The advanced medium grain line YDP14=V44 is a low-GI entry (GI = 49) with optimal yields under early sowing. Other derivatives of this line (‘Lot 2’ source) have been ruled out after having a low-GI status, but they were higher yielding. Another low-GI medium grain YUA16=V030, which also recorded a low-GI rating from the University of Sydney in a recent screen (GI=50), has demonstrated higher yield potential under salty conditions, or higher plant density (6-inch spacing), suggesting more agronomic research is needed if commercialisation of these largely indica-like varieties is to be considered.

**Coloured pericarp**

Three coloured advanced breeding lines continue to show promise for this niche varietal class for which no current varieties exist: ReiziqYunlu29 (coloured bold MG); 2M205ML (coloured SG); and 2DoonML (coloured LG).

Based on differences in sowing date in replicated trials, the line ReiziqYunlu29 may require timely or early sowing to achieve yields comparable to Reiziq. The line 2M205ML (coloured SG) has comparable yields to Koshi. The 2DoonML is a coloured long grain line that has yields comparable to or much higher than Doongara, and appears to have cold tolerance.

Summary of advanced lines in variety pipeline for quality characteristics

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Variety class</th>
<th>Benchmark and release year</th>
<th>5-year market share (% area planted)</th>
<th>New lines</th>
<th>Most recent testing</th>
<th>Seed production status</th>
<th>Agronomy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3</strong></td>
<td>Soft-cooking long grain</td>
<td>Langi (1994)</td>
<td>4.7%</td>
<td>YRA18=V025 YRD16-V028</td>
<td>District trials</td>
<td>Long rows Long rows</td>
<td></td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>Soft-cooking long grain</td>
<td>Langi (1994)</td>
<td>4.7%</td>
<td>MSC16n=08-12 ‡</td>
<td>District trials (North)</td>
<td>Breeders Seed 2 seasons</td>
<td></td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>Jasmine-style fragrant long grain</td>
<td>Topaz (2014)</td>
<td>6.6%</td>
<td>YRI14-V042 S3</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>Jasmine-style fragrant long grain</td>
<td>Topaz (2014)</td>
<td>6.6%</td>
<td>YRD16-V025 S3</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>Jasmine-style fragrant long grain</td>
<td>Topaz (2014)</td>
<td>6.6%</td>
<td>YRF217 ‡ MSC16n=13-10 ‡</td>
<td>District trials (North)</td>
<td>Breeders seed 4 seasons</td>
<td></td>
</tr>
<tr>
<td><strong>5</strong></td>
<td>Short grain</td>
<td>Opus (1999), Koshihikari, Urara</td>
<td>Opus 7.6%, Koshikihari 1.8%, Urara (YRK5) 1.2%</td>
<td>YRA18=V043</td>
<td>District Trials</td>
<td>Long rows</td>
<td></td>
</tr>
</tbody>
</table>
Objective 10. Molecular breeding
A set of 40 KASP markers has been identified as being discriminatory for Australian varieties and elite lines. These markers (or a selected smaller subset of 20-30 markers) will be extremely useful for quick, routine, cost-effective QC genotyping in the breeding and pure seed programs.
The emphasis of validation activities was on critical grain quality traits. Although only preliminary, the results are extremely promising. New KASP markers for these traits appear to be highly predictive. Eight KASP markers for three traits cost < $10/sample, and data is usually delivered within 2 weeks, providing efficient tools for routine molecular breeding.
A single fragrance marker (snpOS00022) appears to be completely reliable for detection of the BADH gene, which is the main gene controlling fragrance. It is effectively a diagnostic or ‘perfect’ marker.
Amylose content is arguably the most critical trait determining rice quality. The Waxy gene is the most important major gene controlling this trait. A set of 5 KASP markers within the Waxy gene were used to compare allelic haplotypes (i.e. combinations of several individual markers) for amylose content. Literature in international journals indicates that 3 SNP markers located within the Waxy gene (5’ intron, exon 6, exon 10) explain > 93% of the variation for amylose. In our testing, these haplotypes explain over 70% of phenotypic variance for this trait, excluding glutinous varieties. Haplotype F warrants further investigation because it consists of a heterogeneous group of waxy alleles.

Milestone 11. Quality Evaluation Program (QEP)
QSorger calibration
A brief comparison of the advantages of the QSorter compared to the SeedCount is shown below.

<table>
<thead>
<tr>
<th>Particulars</th>
<th>SeedCount</th>
<th>Q-Sorter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of samples/day</td>
<td>70-80</td>
<td>100-120</td>
</tr>
<tr>
<td>Accuracy prediction (Grain Length)</td>
<td>90%</td>
<td>More than 95%</td>
</tr>
<tr>
<td>Accuracy prediction (Grain Width)</td>
<td>85-90%</td>
<td>More than 95%</td>
</tr>
<tr>
<td>Accuracy prediction (Grain Thickness)</td>
<td>70-80%</td>
<td>More than 90%</td>
</tr>
<tr>
<td>Accuracy of prediction (chalk classification)</td>
<td>50%</td>
<td>More than 85%</td>
</tr>
<tr>
<td>Prediction of colour</td>
<td>No</td>
<td>Yes (saves 1-2 minutes/sample)</td>
</tr>
<tr>
<td>Prediction of single kernel weight</td>
<td>No</td>
<td>Yes (added quality trait)</td>
</tr>
<tr>
<td>Future development</td>
<td>No</td>
<td>Possible for fissure detection and NIR</td>
</tr>
</tbody>
</table>

Improvement on Texture Analyser
The QEP team uses a texture analyser (TVT) to determine hardness, adhesiveness, stringiness, and stickiness of rice gel. However, due to the lifting of sample cans during probe retraction of TVT, the results were not
A long-term and more reliable solution was sought for this problem. After consultation with inhouse engineers, the best possible design was selected and fabricated. The tests performed from this design showed that the equipment performed well.

Paddycheck evaluation

The Paddycheck system under development can evaluate milling quality, physical dimension and chalk in paddy form. This equipment uses a small quantity of paddy for testing that could be suitable for many breeding trials for which only a small quantity of seed is available.

Objective 12. Pure seed production and satellite site variety trial management

Pure Seed inventory for existing and promising varieties maintained/expanded.

For the trials at RRAPL, agronomic data collected included sowing dates, fertiliser and chemical applications, water depths, flowering dates and harvest data made available to breeders. A 300 g sample of grain was retained from all plots harvested and dried down and sent to NSW DPI for quality analysis.

Objective 13. New science for existing varieties

Program in progress.

Impacts

Impacts relating to the objectives related to the Rice Quality and Premium-Priced Markets Cluster include:

**Calrose-style medium grain**

A continual trend away from this varietal class has been due to the uptake of Viand.

**Soft-cooking long grain**

In district trials, the advanced line YRD16-V025 demonstrated yield advantages over Langi. However, the grain quality of this line needs to be rigorously evaluated for soft-cooking characteristics.

**Jasmine-style fragrant long grain**

In district trials, the most promising advanced line YRI14-V042 demonstrated yield advantages over Topaz. However, the grain quality needs to be rigorously evaluated.

**Short grain Koshihikari-style variety**

Compared to Uraraka (YRK5), two recent new lines (YRA18=V43 and YRJ18=V35) are promising but did not show marked increases in yield compared to Opus.

**Functional and healthy rice**

- Low GI
  - YRL127 is a low-GI long grain line with higher yield potential than Doongara
  - YDP14=V044 continues to show promise as a low-GI medium grain with a yield potential that is high in optimal conditions
- Coloured
  - ReiziqYunlu29 is a potential coloured bold medium grain
  - 2M205ML is a coloured short grain line with comparable/superior yield advantage to Koshi
  - 2DoonML is a coloured long grain with soft-cooking characteristics; its yield potential is higher than its cold-sensitive parent Doongara.

**Molecular breeding**

- The KASP platform continues to show great promise for routine implementation of MAS.
- Further validation of this method was performed with an emphasis on trait screening for key grain quality traits and for application as a tool for rapid DNA fingerprinting.

**Quality evaluation program (QEP)**

- Just under 5,000 samples have been evaluated for physical quality traits.
The top R&D priority was to optimise the QSorter, which is now fully operational and provides great potential to increase sample throughput this season.

| Project number and title | PRJ-011503  
Exploring the health beneficial properties of rice bran |
|-------------------------|---------------------------------------------------|
| **Project information** | Organisation: Charles Sturt University  
Chief investigators: Nancy Saji/Prof. Christopher Blanchard  
Start date: 12/10/2018  
End date: 30/4/2019 |
| **Objectives** | Sub-Project 1: Effect of stabilisation treatments on the phenolic content and antioxidant activity of rice bran extracts  
Sub-Project 2: Effect of stabilised rice bran extracts in modulating endothelial function and inflammatory responses in vitro  
Sub-Project 3: Effect of stabilised rice bran extracts on platelet activation associated thrombogenesis ex vivo |
| **Activities** | Sub-Project 1: Freshly milled, non-stabilised rice bran was sourced directly from SunRice. The rice bran samples were defatted, and the phenolic compounds were extracted, dried and reconstituted in methanol. The extracts were analysed using ultra high-performance liquid chromatography with diode array detection and liquid chromatography followed by quadrupole time-of-flight mass spectrometry. Benchtop assays were used to determine total phenolic content, antioxidant potential and radical scavenging activity of each sample.  
Sub-Project 2: Human umbilical vein endothelial cells (HUVEC) under induced oxidative stress were used. Before extract application, a cytotoxicity assay was performed on HUVECs using stabilised rice bran extracts at varying concentrations to determine HUVEC viability at different concentrations. Gene expression analysis assessed the transcriptional regulation of selected molecular biomarkers in the presence of stabilised rice bran extract. The expression of genes involved in the regulation of antioxidant and anti-inflammatory pathways was evaluated against a housekeeping reference gene using quantitative real-time polymerase chain reaction.  
Sub-Project 3: Whole blood was collected from healthy (BMI 18.5-24.9) participants. Different concentrations of rice bran extracts were added. An antibody mixture containing the platelet activation antibodies was added and platelet activation was induced via addition of adenosine diphosphate. The red blood cells were lysed and the cell suspension was fixed using a lysing solution. The samples were analysed using a flow cytometer. |
| **Outputs** | Sub-Project 1: Data was collected and analysed on total phenolic content, antioxidant potential and radical scavenging activity of each sample.  
Sub-Project 2: Data was collected and analysed on gene expression.  
Sub-Project 3: Cytometer results were collected and analysed. |
| Outcomes | Sub-Project 1: Results show significant differences in the total phenolic content, radical scavenging activity and antioxidant activity between the different stabilisation treatments compared to the non-stabilised RB.  
Sub-Project 2: Phenolic extracts derived from stabilised rice bran have resulted in regulation of several genes associated with antioxidant and anti-inflammatory pathways in HUVECs induced with oxidative stress conditions. This signifies protection against endothelial dysfunction via amelioration of reactive oxygen species that cause oxidative stress and inflammation, thus providing a potential cardio-protective outcome.  
Sub-Project 3: The results from this study did not show any significant conformational changes to platelet activation after treatment with different concentrations of rice bran extracts. |
| Impacts | The results show that rice bran-derived phenolic compounds have antioxidant and anti-inflammatory potential. Other studies that were initially proposed in the application are yet to be completed. This includes in vitro starch digestibility assay and human clinical trial on the effect of rice bran on risk factors associated with CVD in Type II diabetic patients. Therefore, affirmative conclusions cannot be made yet. Completion of this project is expected in July 2020. |
Project number and title | PRJ-009296 Rice Extension Coordination
---|---

**Project information**

- **Organisation:** Ricegrowers’ Association of Australia
- **Chief investigator:** Travis Tobin
- **Start date:** 16/06/2014
- **End date:** 15/02/2018

**Objectives**

- To provide effective coordination between relevant public and private sector rice industry providers including NSW DPI officers and researchers; NSW Local Land Services (LLS) officers; commercial agronomists; SunRice and Rice Research Australia Pty Ltd (RRAPL); other researchers; RGA and the Environmental Champions Program (ECP); and other relevant commodity industries and growers.
- To create a collaborative public and private sector network that uses available expertise to deliver the broadest, most cost-effective extension system possible.
- To provide effective and timely dissemination of key R&D information for rice-based farming systems that is easy for growers to understand and apply on-farm.
- To help growers increase their uptake of technological advancements and BMP that improve farm business profitability and sustainability.
- To improve the uptake of rice industry BMP and the adoption of new technologies, and increase growers’ knowledge of the farming system and the benefits of managing farms as a system.

**Activities**

- Establish a stable and recognisable industry-supported extension team.
- Establish an industry cadetship program to train and develop emerging industry advisors, maintain industry technical expertise, and ensure succession is in place.
- Establish a central website to structure, store and share rice R&D information.
- Incorporate the Environmental Champions Program (ECP).
- Produce extension publications and communication tools covering R&D outcomes, BMP and updated ECP content.
- Distribute relevant R&D findings, agronomic advice, NRM information and BMP guidelines to growers and other relevant parties through print, electronic communication, verbal and face-to-face interaction.
- Conduct grower meetings and rice field days at key times throughout the rice season.
- Provide support for evolving grower groups.

**Outputs**

- 4,410 people attended 117 Rice Extension events over the life of the project.
- 1,238 people attended 13 whole-of-industry events.
- 1,505 attended 41 local events across the Murray Valley region.
- 610 attended 23 local events in Coleambally.
- 1,057 attended 40 local events in the MIA.
- Rice Extension Client Database developed covering all sectors of the industry. About 79% of all SunRice growers subscribed to the Rice Extension Client Database by providing their contact details at Rice Extension events.
- Six Innovators events were held for young growers, new agronomists and new industry service providers.
- Two Women in Rice events specifically designed for females with important roles on rice farms and in businesses serving rice growers.
- The @riceextension Twitter account has 897 followers, which has grown from zero when the Twitter profile was started in December 2016. Sent 1,633 tweets, uploaded 436 photos and videos, and receive regular likes and retweets. The Rice Extension Facebook page followed 543 people and is linked to the Twitter feeds.
- Rice Extension Newsletter is emailed to 1,600 subscribers monthly. Open rate is typically 35-45%, which is much higher than the industry average open rate of 19.4% because the articles are designed to be targeted, topical and informative.
• An analytics function was added to the new Rice Extension website in December 2017 [https://riceextension.org.au/](https://riceextension.org.au/). All traffic from newsletters, emails and event invites now goes to the website.
• Rice Extension PI Predictor web app has had high usage rates since its release in 2016 and again this season. From 8 December 2017 to 8 Jan 2018, there were 1266 crops entered for a prediction of when panicle initiation (PI) would occur.
• RiceScenario was released in 2015. Training workshops were held in RiceScenario and general business management.

Outcomes

• Continued event attendance shows attendees trust the quality of information and understand the learnings.
• Rice Extension publication titles are all available on the Rice Extension website.
• Feedback from the Rice Industry Field Day and collected through surveys indicates satisfaction with the quality of information presented at this field day. Growers indicated they were going to make changes on their farms as a result of attending the day: try the new short-season variety, delayed permanent water (DPW) and assess management practices with an eye on costs and water use.
• A large extension effort promoted the results of NSW DPI research that found drill-sowing uses less water than aerial and dry broadcast sowing methods. The adoption of drill sowing as a water-saving technology increased over the period of the Rice Extension project.

<table>
<thead>
<tr>
<th></th>
<th>2017-18</th>
<th>2016-17</th>
<th>2015-16</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIA</td>
<td>CIA</td>
<td>WMV</td>
</tr>
<tr>
<td>Aerial</td>
<td>5.9</td>
<td>12.8</td>
<td>60.9</td>
</tr>
<tr>
<td>Drill</td>
<td>42.8</td>
<td>58.6</td>
<td>30.4</td>
</tr>
<tr>
<td>Dry Broadcast</td>
<td>51.0</td>
<td>25.3</td>
<td>8.2</td>
</tr>
</tbody>
</table>

• The Rice Extension project promoted changes to the recommended sowing windows for some varieties as a result of outcomes from the Rice Variety and Agronomy Project conducted by Brian Dunn. Less than 20% of crops were planted earlier than the new 2017 recommended planting window.
• Growers have fully subscribed to the available seed and production requirements of the two new shorter season varieties, with a planting window one month later than conventional varieties. The varieties have better cold tolerance to withstand cool conditions during the reproductive phase, are high yielding and save water.

Impacts

• Growers are better informed.
• Rice R&D outcomes are being adopted.
Objectives

The principle objective is the uptake of rice industry best management practices and the adoption of new technologies. Effective and timely dissemination of key R&D information for rice-based farming systems will improve the adoption of new research findings and increase grower productivity.

Three of the five specific objectives are relevant to the Crop Productivity Cluster:

1. Effective coordination between relevant public and private sector rice industry, including NSW DPI, SunRice, Rice Research Australia Pty Ltd (RRAPL), RGA ECP, NSW Local Land Services (LLS), private and retail researchers and agronomists, and other relevant commodity industries, government and growers. The effective coordination will:
   - Avoid duplication of RD&E effort and identify opportunities for working together, pooling resources, sharing RD&E Information within the rice industry and with other related industries, such as dryland grains and other irrigated crops
   - Provide a linkage for information to flow between growers and researchers to identify emerging issues for rice-based farming systems and to better target research investment
   - Distribute best practice management information to growers as cost effectively as possible.

2. Increase uptake of innovations, technological advancements and best management practices:
   - Short term: growers are attending more events to share knowledge and skills and learning more through targeted publications and digital communications.
   - Medium term: they are taking action, adopting practices and making changes on their own farms.
   - Long term: improvements in water-use efficiency, farm business profitability and environmental sustainability of rice farming systems will improve the condition of the whole industry.

4. Better alignment of AgriFutures Rice Program Advisory Panel-funded programs with grower needs. Real outcomes from R&D programs will result in real uptake and benefit on-farm.

Activities

- Annual Operating Plans and Communication Plans developed each year.
- Monthly Newsletter to growers (October, November, December, January, February, March and April).
- Rice Extension website developed and maintained.
- Press releases and radio advertising each year on key events.
- Rice Extension Newsletter covering key topics such as drill sowing vs aerial and dry broadcast sowing, pests (notably armyworms), water depth management and cold weather management, stubble burning, new rice varieties, use of NIR and imaging for nitrogen topdressing, drill sowing, herbicide use, DPW.
- Rice Extension publications, such as the NSW DPI Rice Weed Pocket Guide.
- Agronomists Newsletter.
- Field days and walks for growers (covering topics such as BMP for drill-sown rice, water management, use of groundwater).
- Field days for agronomists.
- Agronomists Technical Updates.
- Milestone reports, including interim and annual.
- Biannual meetings of the Rice Extension Steering Group.
- Some alterations due to Covid-19 virus, including introduction of podcasts and webinars to the communication strategy, as well as more social media engagement (Twitter, WhatsApp).
Outputs

- More unique visitors to the Rice Extension website, with a 32% increase year on year in 2019-20.
  - 38% increase in number of website visits and a 15% year-on-year increase in page views
  - 7,892 page views for the 12 months to 31 March 2020
- Face-to-face engagements from 1 October to 30 March 2020 numbered 1,086 compared to 880 in C19, a 23% increase. There were 18 events held in 26 locations in C20.
- Sowing methods to save water were essential in C20, including drill sowing and delaying permanent water on drill-sown crops.
- Milestone reports produced every six months.
- More social media engagement (Twitter).

<table>
<thead>
<tr>
<th>Twitter</th>
<th>No. of Tweets</th>
<th>Link Clicks</th>
<th>Retweets</th>
<th>Likes</th>
<th>Replies</th>
</tr>
</thead>
<tbody>
<tr>
<td>C18 Season</td>
<td>112</td>
<td>337</td>
<td>325</td>
<td>859</td>
<td>41</td>
</tr>
<tr>
<td>C19 Season</td>
<td>51</td>
<td>304</td>
<td>149</td>
<td>421</td>
<td>18</td>
</tr>
<tr>
<td>C20 Season</td>
<td>128</td>
<td>445</td>
<td>340</td>
<td>1017</td>
<td>34</td>
</tr>
</tbody>
</table>

Outcomes

The following are conclusions from the Evaluation of the Rice Extension program:

- There have been considerable improvements in various rice agronomic practices, such as drill sowing, but attribution to RE is tenuous given there is no explicit program logic.
- The AOP, M&E and communication plans are almost entirely output-focused, rather than outcome- or impact-focused.

Outcomes reported in the annual progress report for the project:

- Increase in the number of events in C20, notably more face-to-face engagement with stakeholders. This engagement covered 18 events at 26 locations. It is due to having three staff members (not all FTE) and a slight increase in grower numbers, from 67 in C19 to 80 in C20.
- The activities from Rice Extension resulted in a record percentage of drill-sown crops in C20. The biggest shift this season was in the MIA (where the preferred method of sowing had been dry broadcast), with 84% of the crop drill-sown. This was also the first season that 100% of crops in the EMV have been drill-sown (Source: Rice Extension Milestone Report 6; 25 April 2020).

<table>
<thead>
<tr>
<th>Sowing method</th>
<th>MIA</th>
<th>C18</th>
<th>C19</th>
<th>C20</th>
<th>CIA</th>
<th>C18</th>
<th>C19</th>
<th>C20</th>
<th>WMV</th>
<th>C18</th>
<th>C19</th>
<th>C20</th>
<th>EMV</th>
<th>C18</th>
<th>C19</th>
<th>C20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerial</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Drill</td>
<td>43</td>
<td>50</td>
<td>64</td>
<td>59</td>
<td>100</td>
<td>100</td>
<td>30</td>
<td>70</td>
<td>82</td>
<td>45</td>
<td>64</td>
<td>100</td>
<td>45</td>
<td>64</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Dry Broadcast</td>
<td>51</td>
<td>48</td>
<td>15</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Impacts

- Earlier adoption of on-farm R&D than would otherwise have happened (e.g. drill sowing)
- Faster adoption of on-farm R&D than would otherwise have happened (e.g. drill sowing)
- Higher crop yield due to earlier and faster adoption of agronomy R&D
- Lower production cost due to adoption of on-farm R&D/Best Management Practices

Project number and title

PRJ-011504
The Therapeutic Properties of Coloured Rice-derived Polyphenols in Alleviating Obesity-related Oxidative Stress and Inflammation

Project information

Organisation: Charles Sturt University
Chief investigators: Esther Callcott/Chris Blanchard
Start date: 12/10/2018
End date: 30/04/2019

Objectives

1. After coloured rice consumption, what polyphenols and metabolites become bioavailable in obese and healthy populations?
2. Does coloured rice consumption improve antioxidant and anti-inflammatory status in obese and healthy populations?

3. Compare (if any) differences between healthy and obese populations in antioxidant and anti-inflammatory status and polyphenol/metabolite bioavailability.

<table>
<thead>
<tr>
<th>Activities</th>
<th>For a dietary intervention trial, 21 healthy sedentary obese (BMI&gt;30) and 21 healthy (BMI 18.5-24.9) volunteers with equal gender distribution for both groups were recruited.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outputs</td>
<td>Full blood count and biochemistry pathology was conducted on every participant’s baseline sample. Each sample also had antioxidant status and biomarkers for inflammation (e.g. pro-inflammatory cytokines) and lipid peroxidation (malondialdehyde) analysed. Polyphenol bioavailability was measured using ultra-high-performance liquid chromatography (UHLPC) with potential polyphenol metabolites identified using liquid chromatography quadrupole time-of-flight mass spectrometry (LC-QToF-MS).</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Results thus far have shown one hour after purple rice consumption significantly increases antioxidant status in obese populations. In healthy populations, increase in antioxidant status occurs at 30 minutes after purple rice consumption, and remains elevated until the final four-hour sample point. Yunlu29 (red rice) significantly increased antioxidant status 30 minutes after rice consumption in both healthy and obese populations and then reduced to baseline levels at the remaining time points. Brown rice (Reiziq) had no effect on increasing antioxidant status in either population.</td>
</tr>
<tr>
<td>Impacts</td>
<td>The outcomes of this research can be used to educate health-conscious consumers that coloured rice, when consumed, may serve as a functional food to meet their culinary and nutritional needs. This research will benefit the Australian rice industry as increases in demand for a ‘therapeutic rice’ will enhance Australia’s competitiveness in the global rice market, providing higher profitable returns to the Australian rice industry.</td>
</tr>
</tbody>
</table>
| Project number and title | PRJ-011505  
The impact of farm practices on rice grain quality in south-eastern Australia |
|-------------------------|--------------------------------------------------|
| Project information     | Organisation: Charles Sturt University  
Chief investigators: Shiwangni Rao/Chris Blanchard  
Start date: 12/10/2018  
End date: 30/04/2019 |
| Objectives              | To determine the impact of crop management practices on the grain quality of rice grown in Australia's southern rice-growing region.  
To further this investigation, the specific objectives were to:  
- Investigate the effect of nitrogen rate and timing on grain quality parameters  
- Determine the impact of water-saving techniques on rice grain quality  
- Examine the effect of plant density on grain quality parameters. |
| Activities              | Multiple experiments grown over several locations in 2016-19 using different pre-PW and PI N rates applied to multiple varieties were analysed for grain quality. This strategy involves a base N application applied pre-permanent water (PW) and the second application following panicle initiation (PI). |
| Outputs                 | Data was collected and analysed by variety for quality differences – whole grain yield (WGY) – by different N treatments. |
| Outcomes                | Results showed increasing the rate of N applied pre-PW significantly increased WGY in all tested varieties; however, the effect of splitting the same total N rate into two applications on WGY was variety-specific.  
For Viand and Opus, plants with N applied at PI had a lower WGY compared to the same total N rate applied in a single pre-PW dose. For YRK5, plants with N applied at PI had a higher WGY compared to the same total pre-PW N rate, while there was no difference in all other tested varieties.  
Analysis of economic return revealed the highest return did not always match the highest WGY. Analysis of grain quality under various sowing and N rates during 2017-18 revealed changes in plant architecture as a result of different density significantly affected grain weight, and milling quality and the response differed between varieties. Decreasing sowing rate increased the number of grains per panicle, reduced grain dimensions, the thousand-grain weight (TGW), and slightly increased WGY in Viand.  
In YRK5, decreased sowing rate increased TGW and reduced WGY in one season. These results demonstrate a reduction in plant density due to poor establishment, environmental or bird damage does not affect crop yield or grain quality. |
| Impacts                 | Results revealed above 120 kg N/ha, WGY was higher in both water-saving methods (DPW and DPW+PFF) than in plants grown with conventional irrigation methods (aerial and drill). DPW reduced grain filling duration while prolonging the grain ripening phase due to a slower infield grain drying, which had a positive effect on WGY.  
DPW reduces water usage and costs, increases nitrogen-use efficiency, has no adverse impact to crop yield, and improves WGY, and ultimately grower profit per ML. |
| Project number and title | PRJ-011506  
Effect of environment on cereal phenolic composition and its chemopreventive potential |
|--------------------------|------------------------------------------------------------------------------------------------|
| Project information      | Organisation: Charles Sturt University  
Chief investigators: Rachel Wood/Chris Blanchard  
Start date: 12/10/2018  
End date: 30/04/2019 |
| Objectives               | The research project aimed to characterise rice varieties with a focus on phenolic compounds with significant antioxidant activity. The project explored potential impact of cultivation location on rice phenolic compounds and its antioxidant activity. |
| Activities               | • Wholegrain pigment and non-pigment rice were investigated in this study. The pigmented varieties included red pericarp, Yunlu29, Black Gora, Lijiangheguie and Purple pericarp variety purple. The non-pigmented varieties included Reiziq, Sherpa, Langi and Topaz.  
• Extracts were analysed for total phenolic content, anthocyanin content, proanthocyanidin and antioxidant activity.  
• Investigations were also conducted on colorectal cancer cells to examine the anti-cancer potential of rice phenolic compounds. |
| Outputs                  | • Data collected and analysed from samples from two locations were examined for phenolic compounds. Extracts of rice phenolic compound were also examined for their potential to induce natural cell death (apoptosis) in cancerous colon cells. |
| Outcomes                 | • Varietal characterisation of wholegrain rice exhibited pigmented varieties to have significantly higher phenolic content and antioxidant activity. This was attributed to the anthocyanin and proanthocyanidin phenolic compounds present only in pigmented rice. The anthocyanins that were found in purple rice included cyanidin 3-glucoside and peonidin 3-glucoside. Proanthocyanidins were found in both red and purple rice varieties, which included compounds such as procyanidin, derivatives of catechin and epicatechin. Proanthocyanidins dominated the phenolic and antioxidant profile of red rice varieties. The cultivation location was also observed to have a significant impact on rice phenolic compounds.  
• The investigation revealed rice varieties with higher phenolic content and antioxidant activity to also have superior ability in inhibition of colorectal cancer cell proliferation. Hence, pigmented rice varieties such as Yunlu29, Black Gora, Lijiangheguie and Purple, were observed to have high levels of cytotoxic potency on SW480 cells. |
| Impacts                  | • The research shows the impact cultivation location can have on cereal phenolic composition. Potential exists for market segmentation by growing varieties of interest in different locations, and for the industry to select for varietal lines that produce higher amounts of specific compounds, such as purple rice varieties with higher levels of anthocyanins or red rice with higher proanthocyanidin levels. |
## Project investment

### Nominal investment

The total investment for the projects included in the Rice Quality and Premium-Priced Markets Cluster is provided (Table 4) by funding source and for each project. This shows the total investment, not the attributed investment to the cluster. AgriFutures provided funding of 36% over the evaluation period for all projects combined, with research organisations and industry providing an additional 31% and 33% of funding, respectively.

Of the projects listed in Table 4, four (PRJ-009950, PRJ-010696, PRJ-009296 and PRJ-009805) are only partly attributed to the Rice Quality and Premium-Priced Markets cluster. For PRJ-009950, PRJ-010696 and PRJ-009296, costs are allocated proportionally across other clusters based on estimated contribution to project sub-objectives and extension activities. For PRJ-009805, which involves the development of cheaper and faster testing for low-GI rice, costs are proportioned as a capital investment on the assumption the technology will be available for future breeding cycles and also as no economic benefits were attributed.
Total costs attributed to the Rice Quality and Premium-Priced Markets Cluster over the six-year period are $6,606,121 (nominal) including management costs (management cost multiplier). This compares with the total investment in the nine projects of $26.3 million (including the management cost), as shown in Table 4. Of the attributed amount, the Australian Rice Partnership 2 project is the largest cost, and represents 80% of total attributed costs for the cluster.

**Table 4: Total investment in projects attributed to Quality and Premium-Priced Markets Cluster for years ending June 2017 to June 2022 (nominal)**

<table>
<thead>
<tr>
<th>Project</th>
<th>AgriFutures Australia</th>
<th>Research organisation</th>
<th>Industry</th>
<th>Other</th>
<th>Total</th>
<th>Proportioned to Quality Cluster (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRJ-009805</td>
<td>$260,000</td>
<td>$100,000</td>
<td>$100,000</td>
<td>$0</td>
<td>$460,000</td>
<td>25%</td>
</tr>
<tr>
<td>PRJ-009950</td>
<td>$5,926,340</td>
<td>$7,387,174</td>
<td>$7,677,088</td>
<td>$0</td>
<td>$20,990,602</td>
<td>25%</td>
</tr>
<tr>
<td>PRJ-010696</td>
<td>$1,661,655</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$1,661,655</td>
<td>25%</td>
</tr>
<tr>
<td>PRJ-009296</td>
<td>$750,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$750,000</td>
<td>25%</td>
</tr>
<tr>
<td>PRJ-011503</td>
<td>$8,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$8,000</td>
<td>25%</td>
</tr>
<tr>
<td>PRJ-011504</td>
<td>$8,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$8,000</td>
<td>100%</td>
</tr>
<tr>
<td>PRJ-011505</td>
<td>$8,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$8,000</td>
<td>100%</td>
</tr>
<tr>
<td>PRJ-011506</td>
<td>$8,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$8,000</td>
<td>100%</td>
</tr>
<tr>
<td>PRJ-011507</td>
<td>$8,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$8,000</td>
<td>100%</td>
</tr>
<tr>
<td>Management Cost&lt;sup&gt;b&lt;/sup&gt;</td>
<td>$863,800</td>
<td>$748,717</td>
<td>$777,709</td>
<td>$0</td>
<td>$2,390,226</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$9,501,795</strong></td>
<td><strong>$8,235,891</strong></td>
<td><strong>$8,554,797</strong></td>
<td><strong>$0</strong></td>
<td><strong>$26,292,483</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: AgriFutures Australia (2020)
<sup>b</sup> Based on the management cost multiplier explained in the next section.

**Program management and communication/extension costs**

The cost of managing the project may vary with the source of funds. Estimates were added to the total project costs (Table 4) via a management cost multiplier. The multiplier for AgriFutures Australia was assessed at 1.10. The same multiplier was used for all other organisations that invested in the projects.

The multipliers accommodate allocation of indirect RD&E expenditure (management and administrative resources) across individual projects, ensuring that the full costs of RD&E funding are included as per CRRDC Guidelines (CRRDC, 2018). The use of multipliers is an accountability item only.

**Real cost of investment**

For the purposes of the investment analysis, the investment costs of all parties were expressed in 2019-20 dollar terms using the Implicit GDP Deflator index (ABS, 2020).
**Impacts**

A summary of the types of impacts and potential impacts associated with the outcomes of the project is shown in Table 5.

**Table 5: Categories of impacts and potential impacts from the investment**

<table>
<thead>
<tr>
<th>Economic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Better short and long rice varieties with higher yields, primarily from better cold tolerance.</td>
</tr>
<tr>
<td>2. Less production risk for short and long grain rice varieties from better cold tolerance.</td>
</tr>
<tr>
<td>3. Rice varieties with improved grain quality characteristics, resulting in more demand.</td>
</tr>
<tr>
<td>4. Greater market diversification of Australian rice production through the development of short, medium and long grain rice with unique quality attributes.</td>
</tr>
<tr>
<td>5. Lower input costs for the breeding program, including shorter development (selection) times for the release of low-GI rice varieties.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Contribution to regional and local employment, in growing and processing rice.</td>
</tr>
<tr>
<td>2. Increased scientific capacity in the rice industry.</td>
</tr>
<tr>
<td>3. Better community welfare flowing from higher rice farm productivity and profitability.</td>
</tr>
</tbody>
</table>

**Public versus private impacts**

The principal potential impacts would accrue to the private sector, predominantly rice growers and SunRice. The local and Australian community will gain social benefits from maintenance of jobs in the growing and processing industries, and higher profitability and productivity in the rice industry.

**Distribution of impacts along the supply chain**

The economic benefits from the project will accrue to rice growers, SunRice (as processors and marketers) and to the customers of Australian rice in the domestic and export markets. The environmental and social benefits from the project will go to participants in the rice industry, to the local, regional and Australian communities, and to the communities of the export markets.

The actual distribution of economic benefits among the supply chain sectors (growers, SunRice and customers in the domestic and export markets) will depend on the relative own-price elasticities of supply and demand\(^1\), as well as the input substitution elasticities at processing. The distribution of benefits arising from the investment in RD&E in the rice industry is detailed in the main report for the impact assessment of the four project clusters.

**Impacts on other primary industries**

There may be some positive impacts to other primary industries, notably other field crop industries, that could benefit from some of the new methods and technology in testing for grain quality arising

---\(^1\) The elasticity of supply and of demand is a key variable used in economics. It measures the responsiveness of supply or demand to a change in price. An elasticity of less than 1 means that the quantity of supply or demand reacts proportionately less to a 1% change in price, while an elasticity of greater than 1 means the quantity of supply or demand reacts proportionately more to a 1% change in price.
from the projects. As well, there may be spillover benefits in the form of scientific research capacity, with scientists moving between industries.

**Impacts overseas**

Some international impacts would arise from the improved efficiency and productivity in the Australian rice industry in terms of competition for other rice-growing countries and benefits to overseas consumers of Australian rice. Benefits from the improved scientific knowledge and techniques arising from the R&D investments in the Rice Industry RD&E program is conveyed in papers at international conferences and in scientific literature.

**Match with national and AgriFutures Australia priorities**

The Australian Government’s Science and Research Priorities and Rural Research, Development and Extension (RD&E) priorities are reproduced in Table 6. The investment in the Rice Program RD&E Plan 2016-17 to 2021-22 and projects in the Rice Quality and Premium Markets Cluster contributes to Rural RD&E Priorities 1, 3 and 4. It also contributes to the Science and Research Priority 1.

**Table 6: Australian Government Research Priorities**

<table>
<thead>
<tr>
<th>Australian Government</th>
<th>Rural RD&amp;E Priorities (est. 2015)</th>
<th>Science and Research Priorities (est. 2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Advanced technology</td>
<td>1. Food</td>
</tr>
<tr>
<td>2.</td>
<td>Biosecurity</td>
<td>2. Soil and Water</td>
</tr>
<tr>
<td>3.</td>
<td>Soil, water and managing natural resources</td>
<td>3. Transport</td>
</tr>
<tr>
<td>4.</td>
<td>Adoption of R&amp;D</td>
<td>4. Cybersecurity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Resources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7. Advanced Manufacturing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8. Environmental Change</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9. Health</td>
</tr>
</tbody>
</table>

Sources: Commonwealth of Australia (2016) and Office of the Chief Scientist (2015)

**AgriFutures Australia Arenas and priorities**

AgriFutures Australia’s Four Arenas and Priorities for each are presented in Table 7. The Rice RD&E program (and the projects included in this cluster) address the priorities in Arena 1 and the three priorities in Arena 3.
### Table 7: AgriFutures Australia Arenas and Priorities

<table>
<thead>
<tr>
<th>Arenas</th>
<th>Priorities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. People and leadership</td>
<td>• Attracting capable people into careers in agriculture</td>
</tr>
<tr>
<td></td>
<td>• Building the capability of future rural leaders</td>
</tr>
<tr>
<td>2. National challenges and opportunities</td>
<td>• Informing debate on issues of importance to rural industries</td>
</tr>
<tr>
<td></td>
<td>• Adapting new technologies for use across rural industries</td>
</tr>
<tr>
<td></td>
<td>• Working collaboratively on issues common across rural sectors</td>
</tr>
<tr>
<td>3. Growing profitability</td>
<td>• Engaging industry participants in determining RD&amp;E priorities</td>
</tr>
<tr>
<td></td>
<td>• Investing in innovation that assists levied industries to be more</td>
</tr>
<tr>
<td></td>
<td>profitable</td>
</tr>
<tr>
<td></td>
<td>• Delivering outcomes to maximise industry uptake and adoption</td>
</tr>
<tr>
<td>4. Emerging industries</td>
<td>• Supporting the early-stage establishment of high-potential</td>
</tr>
<tr>
<td></td>
<td>rural industries</td>
</tr>
</tbody>
</table>

Source: AgriFutures Australia Strategic Plan (2018)

The objectives of the Rice Program RD&E Plan 2016-17 to 2021-22 are as follows:

1. Cross-sectorial research required to achieve the Dry Rice 1.5 t/ML water-use efficiency target by 2030.
2. Rice breeding – varieties and quality improvement
3. Farm productivity – crop inputs, crop protection and the farming system
4. Extension, sustainability and human capital.

The projects included in this cluster address objectives 2 and 4.

### Valuation of impacts

#### Counterfactual – the ‘without R&D’ scenario

Without the investment by AgriFutures Australia and its partner organisations in the projects in the Rice Quality and Premium-Priced Markets Cluster, it is assumed that the existing rice varieties will continue to be grown at similar proportions as the last five years. Implicit in this assumption is SunRice’s maintenance of price differentials by variety.

#### Impacts valued

The evaluation approach consists of a mix of ex post and ex ante economic analysis of the benefits arising from the nine projects in this cluster. The main benefits valued relate to the likely release of three new varieties to replace existing short and long grain rice varieties. As a result, these benefits are forecasts, and closest to the definition of ex project using CRRDC Guidelines (CRRDC, 2018). The main benefits valued were impacts associated with better cold tolerance increasing crop yields in certain years. Potential changes in price premiums between varieties were assumed for only one variety – V043. The assumptions related to the impacts are shown in Table 9.

#### Attribution

The attribution of the investment in the nine projects included in the Rice Quality and Premium-Priced Markets Cluster was based on the proportion of investment made over six years, assuming a full breeding program cycle is longer, and forecast benefits with a new variety release are contingent on both current and previous investments as part of the RD&E plan.
Summary of assumptions

Assumptions were needed for the impact assessment. Table 8 shows the base assumptions, while Table 9 shows the assumptions associated with individual variety releases.

The assumptions are based on objective data, where available, and subjective assessment from rice industry expert opinion, notably Chris Quirk (pers comm, October 2020), Laurie Lewin (pers comm, October 2020) and Peter Snell (pers comm, October 2020). Given the reliance on expert opinion about impacts achieved by the new varieties, these assumptions are tested using scenario analysis.

Table 8: Summary of base assumptions for Rice Quality and Premium-Priced Markets

<table>
<thead>
<tr>
<th>Variable</th>
<th>Assumption</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual rice production ('000 tonnes) 5-year average: 2014-15 to 2018-19</td>
<td>489.1 (+/- 315)</td>
<td>ABS (2020c)</td>
</tr>
<tr>
<td>Average annual rice area for NSW ('000 ha) 5-year average: 2014-15 to 2018-19</td>
<td>48.6 (+/- 30.0)</td>
<td>ABS (2020c) and ABARES (2020a)</td>
</tr>
<tr>
<td>Average farmgate rice price ($/tonne)</td>
<td>$485 (+/- 160)</td>
<td>SunRice</td>
</tr>
<tr>
<td>Management cost multiplier</td>
<td>1.10</td>
<td>AgriFutures Australia cost</td>
</tr>
</tbody>
</table>

Table 9: Assumptions for new variety releases

<table>
<thead>
<tr>
<th>Variety</th>
<th>First year grown</th>
<th>Variety replaced</th>
<th>Maximum area (% total rice area: 5-year average)</th>
<th>Time to peak adoption (years)</th>
<th>Yield impact (compared with old variety being replaced)</th>
<th>Other impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Langi</td>
<td>5% (2-8%)</td>
<td>5</td>
<td>+1.5 t/ha (+0.5-3.0)</td>
<td>Low to moderate severity cold years (5 years in 10)</td>
</tr>
<tr>
<td>V028</td>
<td>2024</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7.5% market premium to Opus (5%-10%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Opus</td>
<td>8% (4-12%)</td>
<td>5</td>
<td>+2.0 t/ha (+1.5-3.0)</td>
<td>Low to moderate severity cold years (5 years in 10)</td>
</tr>
<tr>
<td>V043</td>
<td>2024</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7.5% market premium to Opus (5%-10%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Doongara</td>
<td>2% (1-3%)</td>
<td>5</td>
<td>+2.0 t/ha (+1.5-3.0)</td>
<td>Low to moderate severity cold years (5 years in 10)</td>
</tr>
<tr>
<td>YRL127</td>
<td>2024</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7.5% market premium to Opus (5%-10%)</td>
</tr>
</tbody>
</table>
Table 10: Probability assumptions for new varieties

<table>
<thead>
<tr>
<th>Variety</th>
<th>Probability of release</th>
<th>Probability of impact</th>
<th>Attribution to investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>V028 (YRD16)</td>
<td>70% (50-90%)</td>
<td>90%</td>
<td>40% (30-50%)</td>
</tr>
<tr>
<td>V043 (YRA18)</td>
<td>70% (50-90%)</td>
<td>90%</td>
<td>40% (30-50%)</td>
</tr>
<tr>
<td>YRL127</td>
<td>70% (50-90%)</td>
<td>90%</td>
<td>40% (30-50%)</td>
</tr>
</tbody>
</table>

Other implied assumptions

Average seasonal conditions are assumed. There are significant swings in total production between years, depending on seasonal conditions and availability of water. This variability is illustrated by the ranges for the rice area planted, the annual rice production, the volume of water applied, and the area of rice watered. This variability is addressed in the sensitivity analysis of the net benefits.

Other implied assumptions are:

- The cost of seed for the new variety is the same as existing varieties for growers.
- No correlations are modelled between the variables.

Other impacts identified but not valued

The impacts identified but not valued include:

- Potential varieties developed for Northern Australia may be released in the future that have been partly funded under the ARP2 project.
- Potential future benefits through the development of a new testing and faster/lower cost screening for low-GI rice breeding lines.
Results

All past costs and benefits were expressed in 2019-20 dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2020). All benefits after 2019-20 were expressed in 2019-20 dollar terms using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the MIRR. The base analysis used the best estimates of each variable, notwithstanding a high level of uncertainty for many estimates. All analyses ran for a period of 30 years after the last year of investment (2021-22).

The results indicate that for the base case scenario there is a forecast modest positive return on investment at year 30 for the Rice Quality and Premium-Priced Markets Cluster. At a 5% discount rate, the base case scenario resulted in a BCR of 1.67 at year 30, and a MIRR at 6.1% after 30 years. Relative to the initial costs allocated to the cluster, breakeven returns do not occur until around year 15 from the final year of investment in the program (Table 11).

The two key drivers of the modest returns for this cluster compared with the more significant returns seen for Cluster 1 can be attributed to:

- The allocation of costs for the breeding and extension programs between clusters. This cluster includes an evaluation of new varieties related to breeding objectives for different rice qualities/unique attributes for long and short grain. Historically, short and long grain varieties have represented 15-30% of Australian rice production. The proportion of costs for the breeding and extension programs assumed for this analysis was 25%, with most of the remaining amount allocated to Cluster 1.
- The smaller proportions of area sown to new varieties evaluated in this cluster other than the dominant variety Reiziq. For example, YRL127, if commercialised, is targeted to replace Doongara, which only twice in the last decade has had an area planted above 500 ha.

<table>
<thead>
<tr>
<th>Investment criteria</th>
<th>Years from last year of investment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Present value of benefits ($m)</td>
<td>$0.00</td>
</tr>
<tr>
<td>Present value of costs ($m)</td>
<td>$7.22</td>
</tr>
<tr>
<td>Net present value ($m)</td>
<td>-$7.22</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>0.00</td>
</tr>
<tr>
<td>Internal rate of return (%)</td>
<td>N/A</td>
</tr>
<tr>
<td>Modified internal rate of return (%)</td>
<td>N/A</td>
</tr>
</tbody>
</table>

The annual cash flows of undiscounted benefits and costs for the investment are shown in Figure 1.
Sensitivity analyses

The results above are from using the assumptions listed in Table 9, but some variables are ex ante and unknowable. To illustrate how different assumptions can influence final investment performance, a sensitivity analysis was conducted. In a sensitivity analysis, variables are adjusted one at a time (while all other variables remain the same and are set on the base case or central assumptions). This analysis was done on the following variables in the model:

- Discount rate
- Annual rice area
- Improvement in crop yield
- Farmgate price for rice
- Price premium for V043
- Attribution of benefits to the new crop varieties
- Probability of release (commercialisation) of new crop varieties
- Final market share (% of total rice area).

Figure 2 provides a summary of the range in BCR using the range of assumptions (low, high) relative to the base case. The results by other investment criteria are reported in Table 12 to Table 19. All sensitivity analyses on the total investment used only a 5% discount rate (except Table 12) with benefits taken over the 30-year period.
The results from the sensitivity analysis show that the most important factors are total rice area planted, the proportion of market share (as a percentage of rice area) for each new variety, and the discount rate.

Rice area relates to the importance of the size of the future rice industry. A smaller industry or area planted produces less output from which benefits can be obtained. However, it also has particular relevance for breeding objectives and returns related to this cluster if the future industry is restricted more often in the number of varieties grown or targeted in a season. When rice planted area is constrained by low water availability and high water costs, a corresponding reduction in the area planted to lower market share varieties can make it uneconomical to segment and market small quantities of segment rice varieties. In such years, seed might not be released for lower market share varieties, resulting in nil output, in years when zero benefits are achieved from new varieties. If the industry has more frequent times when not all rice varieties are grown in some years, and excluded varieties tend to be the smaller market share varieties similar to this cluster, then investment returns for breeding objectives related to short and long grain varieties could be lower than anticipated.

The ranges (lower and upper) for yield impact and farmgate price both show a similar degree of variability in influencing the investment outcome, with a BCR range of 1.1.

The probability of release for each variety (range 50% to 90%, base case 70%) results in a BCR modestly above breakeven. If there is a high certainty that all three varieties are likely to be released (90% probability), then the BCR rises to above 2 with all other variables unchanged.

A price premium for new variety V043 was assumed relative to the old variety being replaced (Opus) due to improvements in eating quality and market branding opportunities (closer to Koshihikari quality). For the range of premiums defined (minimum 5%, maximum 10%), this assumption had the least impact on investment returns (Figure 2).
Table 12: Sensitivity to discount rate (30 years)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Discount rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2% Base (5%) 8%</td>
</tr>
<tr>
<td>Present value of benefits ($m)</td>
<td>18.05 12.07 8.55</td>
</tr>
<tr>
<td>Present value of costs ($m)</td>
<td>6.99 7.22 7.46</td>
</tr>
<tr>
<td>Net present value ($m)</td>
<td>11.05 4.85 1.09</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>2.58 1.67 1.15</td>
</tr>
<tr>
<td>MIRR (%)</td>
<td>4.5% 6.1% 7.7%</td>
</tr>
</tbody>
</table>

Table 13: Sensitivity to annual rice area (5% Discount Rate, 30 years)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Annual NSW rice area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pessimistic Base Optimistic</td>
</tr>
<tr>
<td>Present value of benefits ($m)</td>
<td>4.61 12.07 19.53</td>
</tr>
<tr>
<td>Present value of costs ($m)</td>
<td>7.22 7.22 7.22</td>
</tr>
<tr>
<td>Net present value ($m)</td>
<td>-2.61 4.85 12.30</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>0.64 1.67 2.70</td>
</tr>
<tr>
<td>MIRR (%)</td>
<td>3.3% 6.1% 7.5%</td>
</tr>
</tbody>
</table>

Table 14: Sensitivity to yield impact relative to replaced variety (5% discount rate, 30 years)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Yield impact from changes to cold sensitivity (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low Base High</td>
</tr>
<tr>
<td>Present value of benefits ($m)</td>
<td>6.82 12.07 15.63</td>
</tr>
<tr>
<td>Present value of costs ($m)</td>
<td>7.22 7.22 7.22</td>
</tr>
<tr>
<td>Net present value ($m)</td>
<td>-0.40 4.85 8.41</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>0.94 1.67 2.16</td>
</tr>
<tr>
<td>MIRR (%)</td>
<td>4.4% 6.1% 6.8%</td>
</tr>
</tbody>
</table>

Table 15: Sensitivity to farmgate rice price (5% discount rate, 30 years)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Rice price ($/tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low Base High</td>
</tr>
<tr>
<td>Present value of benefits ($m)</td>
<td>7.85 12.07 16.30</td>
</tr>
<tr>
<td>Present value of costs ($m)</td>
<td>7.22 7.22 7.22</td>
</tr>
<tr>
<td>Net present value ($m)</td>
<td>0.62 4.85 9.07</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>1.09 1.67 2.26</td>
</tr>
<tr>
<td>MIRR (%)</td>
<td>4.8% 6.1% 7.0%</td>
</tr>
</tbody>
</table>
Table 16: Sensitivity to market premium for V043 to Opus (5% discount rate, 30 years)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Premium to Opus (% of price)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Present value of benefits ($m)</td>
<td>10.50</td>
</tr>
<tr>
<td>Present value of costs ($m)</td>
<td>7.22</td>
</tr>
<tr>
<td>Net present value ($m)</td>
<td>3.28</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>1.45</td>
</tr>
<tr>
<td>MIRR (%)</td>
<td>5.7%</td>
</tr>
</tbody>
</table>

Table 17: Sensitivity to attribution of benefits (5% discount rate, 30 years)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Attribution (% of total benefits)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Present value of benefits ($m)</td>
<td>9.05</td>
</tr>
<tr>
<td>Present value of costs ($m)</td>
<td>7.22</td>
</tr>
<tr>
<td>Net present value ($m)</td>
<td>1.83</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>1.25</td>
</tr>
<tr>
<td>MIRR (%)</td>
<td>5.2%</td>
</tr>
</tbody>
</table>

Table 18: Sensitivity to probability of release (5% discount rate, 30 years)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>% probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Present value of benefits ($m)</td>
<td>8.62</td>
</tr>
<tr>
<td>Present value of costs ($m)</td>
<td>7.22</td>
</tr>
<tr>
<td>Net present value ($m)</td>
<td>1.40</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>1.19</td>
</tr>
<tr>
<td>MIRR (%)</td>
<td>5.1%</td>
</tr>
</tbody>
</table>

Table 19: Sensitivity to market share of new variety (5% discount rate, 30 years)

<table>
<thead>
<tr>
<th>Criterion</th>
<th>% of total rice area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Present value of benefits ($m)</td>
<td>5.80</td>
</tr>
<tr>
<td>Present value of costs ($m)</td>
<td>7.22</td>
</tr>
<tr>
<td>Net present value ($m)</td>
<td>-1.42</td>
</tr>
<tr>
<td>Benefit-cost ratio</td>
<td>0.80</td>
</tr>
<tr>
<td>MIRR (%)</td>
<td>3.9%</td>
</tr>
</tbody>
</table>

Distribution analyses

A natural extension of sensitivity analysis is to use stochastic modelling to incorporate multiple assumptions and the uncertainty associated with each input (ranges). The results are based on input distributions for key assumptions set using three-point estimates for each variable. No correlations are modelled in the stochastic simulation, implying all variables are independent of each other.
Results (Figure 3) indicate that on a 30-year evaluation period (orange) at a 5% discount rate, there is an 81% chance the program will generate a positive return (i.e. BCR >1), and a 54% probability the outcomes fall between a BCR of 1 and 2. However, with a 10-year timeframe, the likelihood of negative return (i.e. BCR < 1 ) rises to 87%, and only a 13% chance that the BCR is between 1 and 2.

**Figure 3: BCR distribution combining multiple assumptions with ranges**

Confidence ratings

As noted previously, the investment analysis results are highly dependent on the assumptions made, almost all of which are uncertain. Two factors warrant recognition.

The first factor is the coverage of benefits. Where there are multiple types of benefits, it is often not possible to quantify all the benefits that may be linked to the investment.

The second factor involves uncertainty about the assumptions made, including the linkage between the research and the assumed outcomes and impacts.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 20). The rating categories used are high, medium, and low, where:

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>A good coverage of benefits or reasonable confidence in the assumptions made</td>
</tr>
<tr>
<td>Medium</td>
<td>Only a reasonable coverage of benefits or some uncertainties in assumptions made</td>
</tr>
<tr>
<td>Low</td>
<td>A poor coverage of benefits or many uncertainties in assumptions made</td>
</tr>
</tbody>
</table>
Table 20: Confidence in analysis of project

<table>
<thead>
<tr>
<th>Coverage of benefits</th>
<th>Confidence in assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium to High</td>
<td>Low to Medium</td>
</tr>
</tbody>
</table>

The coverage of economic benefits is rated medium to high, with the main benefits of either higher yields and/or changes to quality increasing demand from a new variety forecast. Part of the funding for the breeding program has been used to improve varieties for Northern Australia, but were not evaluated because in a typical season Northern Australian production represents around 1% of Australia’s rice area.

The confidence in assumptions was rated low to medium because the varieties are still at least three years away from commercialisation and release, and are subject to new information from evaluation in cold tolerance, agronomy, and rice quality for each variety evaluated.
Conclusions

The evaluation approach consists of a mix of ex post and ex ante economic analysis of the benefits arising from the nine projects in this cluster. The main benefits that were valued related to the likely release of three new varieties to replace existing short and long grain rice varieties forecast for release in the 2023-24 rice growing season. As a result, these benefits are forecasts and closest to the definition of ex project, using CRRDC Guidelines (CRRDC, 2018). The main benefits valued were impacts associated with better cold tolerance increasing crop yields in certain years. Potential changes in price premiums between varieties were assumed for only one variety – V043.

The results indicate that for the base case scenario there is a forecast modest positive return on investment at year 30 for this cluster. At a 5% discount rate, the base case scenario resulted in a BCR of 1.67 at year 30 and a MIRR at 6.1% after 30 years. Relative to initial costs allocated to the cluster, breakeven returns do not occur until about year 15 from the final year of investment in the program.

Two key drivers of the modest returns for this cluster, compared with the larger returns estimated for Cluster 1, can be attributed to the allocation of costs between clusters for the breeding and extension programs. The proportion of costs for the breeding and extension programs assumed for this analysis was 25%. The other factor is the smaller proportions of area sown to the new varieties evaluated in this cluster (relative to the dominant variety and large planted area, as in Cluster 1). The results from the sensitivity analysis support this, with the importance of total rice area planted, the proportion of market share (as a percentage of rice area) for each new variety, and the discount rate the most important variables when modelling investment outcomes.
Recommendations

There are two recommendations arising from undertaking the impact assessment:

1. **Rice breeding priorities should consider the likelihood of fewer varieties being grown and more ‘nil-benefit years’ for some varieties in low water allocation years.**

   If the Australian rice industry is likely to have more years of constrained output when fewer rice varieties are grown in some years, then the returns on investing in smaller market share varieties (such as for some long and short grain varieties) may be lower than in the past, even with the same amount of genetic improvement (yield and/or quality). When rice planted area is constrained by low water availability and high water costs, a corresponding reduction in the area planted to lower market share varieties can make it uneconomical to segment and market small quantities of rice varieties. In such years, seed might not be released for lower market share varieties, resulting in nil output and more years when zero benefits are achieved from newer, smaller planted-area varieties. If future benefits are lower under such a scenario, future objectives and cost allocations for plant breeding should consider the likelihood of varieties not being grown in low water allocation years. This evaluation would also need to weigh up the lost benefits from market diversification and the impact additional quantities of medium grain rice may have on Australian rice prices in higher water allocation and lower water price years.

2. **Short- and medium-term variety trial results should be summarised in milestone reports**

   Future impact assessments would benefit significantly from milestone and progress reports from the breeding and research projects presenting trial results for new and existing varieties. Quantitative information combined with expert opinion provides a better estimate or forecast on the farm-level impacts on crop yield between old and new varieties.

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Impact assessment of investment in the AgriFutures Rice Program – Appendix 3

by Chris Wilcox and Paul Deane
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