Early sowing of canola in Eastern Australia

Research Impact Evaluation

June 2020

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1 Executive Summary

Background

Canola is Australia's third-largest broadacre crop by area. On average, the nation produces around 3.6 M tonnes at a farm-gate value of $3.0 B. More than two million tonnes of canola grain is exported every year worth billions of dollars to the industry. Canola is grown for its break-crop benefits as well as for profitability.

Canola requires more management, monitoring and inputs than cereal crops. Yield, quality and consistency of production have been key factors affecting the production of this high return, high-cost crop. Although traditionally grown in the higher rainfall areas, there is an effort to expand production in the medium and low rainfall zones.

The challenge

Climate and availability of water greatly affect canola production and hence poor seasonal conditions are the main deterrent to farmer's interest in growing canola. One agronomic option to reduce such risks is to sow the crop at an earlier stage in the season and ensure it flowers in the optimum time to reduce frost, heat and drought stress. However, there has been a lack of robust guidelines and underlying agronomic knowledge of canola physiology, relative to other winter cereal crops (example: drivers of flowering time, the value of hybrids, N management) to help growers who wish to adopt earlier sowing systems.

The response

CSIRO in collaboration with key partners GRDC and NSWDPI played a significant role in the development of early sowing programs for canola in Eastern Australia (scope of work). The main aim of this work has been to address the critical need to reduce the business risk associated with growing canola thereby enabling farmers to capture economic benefits from early sown crops. Through this work, the team:

- established agronomic guidelines for early sowing of canola
- defined constraints to achieving greater water use efficiency
- developed tactical management packages for canola in risky environments

The impact

The recommended practices from the early sowing of canola work have been progressively adopted by the canola industry resulting in higher yields, lower risks and other economic, social and environmental benefits (see Table 1 below). With changes induced by climate change encouraging a shift towards earlier sowing, these recommended practices are likely to become "new normal" for the canola industry in the coming years.

The cost benefit analysis (CBA) for this study focuses on the yield benefits emerging from the shift in sowing date. However there will likely be additional benefits that emerge from adopting early sowing in conjunction with a) variety choice b) matching variety with optimum sowing date c) nitrogen (N) management; these have not been accounted for in this assessment due to lack of information such as corresponding costs. The economic assessment is partially based on findings from an independent report *"Optimised canola profitability research report"* (published Jan 2020). The adoption rates for the current assessment are assumed as 10% for FY2018 (base year) with an increment of 5%-10% until FY2027, reaching 60% by FY2026/FY2027. These estimates are lower than the reference report (assumes 100% adoption) as well as GRDC data that reports current level of adoption at ~ 45%. This has been done to keep the analysis conservative[1]. CSIRO's benefits are assessed at attribution rate of 13% (cost share basis; See Section 5). During independent consultation GRDC assessed CSIRO's attribution at 50%. To address this variability sensitivity analysis has been conducted (See Table 9). The benefits of the project are estimated as:

- Overall net present value (without/ with deadweight loss; FY2020$ @ 7% discount rate) of $125-122 million for Australia, with $16.5-16.1 million attributable to CSIRO for the assessment period of FY2018-FY2027 (@13% attribution)
- benefit-cost ratio (without/with deadweight loss) of 9.2 – 7.6 for the program

[1] The corresponding costs for each of the yield benefit measures are not known and have therefore not been included in the cost-benefit analysis. To offset any overestimation of benefits, the assumed adoption rates have been set conservatively in the current analysis.

Prospective future benefits include uptake of the work for the development of slow-maturing cultivars and their management. Although scope of the work was Eastern Australia, the project had significant spill over into the Western Australia (WA) as it identified optimum flowering times and the critical period. Both of these were published and utilised by WA researchers and agronomists.

Table 1: Impact assessment of Early sowing of canola in Eastern Australia: Key summary items

<table>
<tr><td>Timeline</td><td>Costs</td><td colspan="2">FY2014- FY2019</td><td>Benefits</td><td>Ex-post: FY2018 to FY2020
Ex-ante: FY2021 to FY2027</td></tr>
<tr><td>Financial Investment (FY2014-FY2019; in FY2020$ @ 7% discount rate)</td><td>WDWL</td><td colspan="2">Overall: $ 18.3 million
CSIRO: $ 2.4 million</td><td>WODWL</td><td>Overall: $ 15.3 million
CSIRO: $ 2.02 million</td></tr>
<tr><td>CSIRO’s key challenge of focus addressed</td><td colspan="5">Food security and quality</td></tr>
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<tr><td colspan="2">Economic</td><td colspan="2">Environmental</td><td>Social</td></tr>
<tr><td colspan="2">- National Economic performance
- Management of risk and uncertainty
- New markets and products (genetic varieties
- Canola growing practices - shift in industry practice
- Trade and competitiveness</td><td colspan="2">- Lower maintenance requirements through weed and disease control
- High water and nutrient use efficiency of the cereal-based system
- Lower environmental footprint of canola production</td><td>- Health and wellbeing
- Access to resources, services and opportunities
- Canola industry resilience</td></tr>
<tr><td>Business Unit(s)</td><td colspan="5">CSIRO Agriculture & Food</td></tr>
<tr><td>Underpinning Background Research</td><td colspan="5">Dual-purpose cropping work and other canola disease and agronomy work conducted by CSIRO before 2012</td></tr>
<tr><td>Confidence Rating in assessment</td><td colspan="5">Low-Medium
List of recommendations have been included that provide a snapshot of data to be collected to support a robust analysis, should the team decide to conduct a refresh of this impact assessment in 3-5 years.</td></tr>
<tr><td>Sources to corroborate Impact</td><td colspan="5">GRDC, NSWDPI, CSU</td></tr>
<tr><td>Further Information</td><td colspan="5">Research Case-Study: John Kirkegaard
Impact Evaluation: Anne-Maree Dowd, Harmeet Kaur</td></tr>
</table>

This case study uses the evaluation framework outlined in the CSIRO Impact Evaluation Guide. The results of applying that framework to the Early sowing of canola project are summarised in Figure

Glossary

AGT	Australian Grain Technologies
APSIM	Agricultural Production Systems sIMulator
BCR	Benefit-cost ratio
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CBA	Cost-benefit assessment
CSU	Charles Stuart University
DPIRD	Department of Primary Industries and Regional Development
DPI	Department of Primary Industries
GRDC	Grains Research and Development Corporation
FY	Financial Year
LRZ	Low rainfall zones
Mgmt	Management
M/mil	Million
MRZ	Medium rainfall zones
NCAI	National Canola Agronomy Initiative
NPV	Net present value
NSW	New South Wales
OPTT	Open pollinated
PV	Present Value
ROI	Return on Investment Ratio
SA	South Australia
SARDI	South Australian Research and Development Institute
WA	Western Australia
WUE	Water use efficiency
Notes • All $$ in AUD, unless mentioned otherwise	

2 Purpose of case study and audience

CSIRO in collaboration with key partners GRDC and NSWDPI led the scientific development of early sowing practices for canola in Eastern Australia to support the grains industry. The purpose of this case study was to assess impacts of this research program for the nation, estimate part of those benefits attributable to CSIRO and understand the payoff from this research work with respect to (wrt) funding invested.

With food security and quality being one of the 6 major challenges, that CSIRO is focused on, the study highlights the spectrum of economic, environmental and social benefits arising for a range of stakeholders from this work at the macro (government at three levels/ public), meso (CSIRO and similar organizations like GRDC) and micro levels (farmers/ researchers/ social scientists).

The analysis provides an estimate of the benefit-cost ratio and the direct, indirect and potential future benefits of the research work. The case study also discusses the key limitations and provides a list of recommendations to catalyse adoption of outputs from this work and facilitate more robust monitoring & evaluation in future assessments.

This report can be read as a stand-alone or alongside other CSIRO Agriculture and Food evaluations to substantiate the impact and value of CSIRO's work against funds and resources invested in this program. CSIRO as a service provider to the Government and Industry is highly focussed on delivering value and impact through the scientific interventions that originate from research activities. The information is provided for accountability, communication, engagement, continuous improvement, and future application purposes. The study is also intended to serve as a tool to underpin strategic investment decision making. The intended audience includes Business Unit Review Panels, federal, state, and local governments, GRDC, canola grower groups, CSIRO, universities and the general public.

3 Background

Canola is Australia's third-largest broadacre crop by area. On average, the nation produces around 3.6 M tonnes at a farm-gate value of $3.0 B. More than two million tonnes of canola grain is exported every year worth billions of dollars to the industry.

Canola is grown for its break-crop benefits as well as for profitability. Western Australia is the largest producer for Australian canola (30-50% depending on season), followed by New South Wales, Victoria and South Australia. Although traditionally grown in the higher rainfall areas (HRZ), canola is rapidly expanding throughout the drier parts of medium (MRZ) and low rainfall zones (LRZ).

Canola requires more management, monitoring and inputs than cereal crops. Yield, quality and consistency of production have been key factors affecting the production of this high return, high-cost crop. Although traditionally grown in the higher rainfall areas, there is an effort to expand production in the medium and low rainfall zones.

3.1 Current challenges

Canola yield is a function of soil moisture and nutrient content, seasonal temperatures, establishment date and cultivar development rate. Since climate and availability of water greatly affect canola production, poor seasonal conditions are the main deterrent to farmer's interest in growing canola. One agronomic option to reduce such risks is to sow the crop at an earlier stage in the season. However, there has been a lack of robust guidelines and underlying agronomic knowledge of canola physiology, relative to other winter cereal crops (example: drivers of flowering time, the value of hybrids, N management) to help grower who wish to adopt earlier sowing. Some of the key challenges are listed below:

Key Challenges

- High input prices (owing to inherently lower water use efficiency, higher nitrogen requirement and extra machinery costs), variable rainfall and delay in sowing. This continues to impede the profitability of canola from being optimised especially in the non-traditional growing areas
- Significant gaps in the underlying agronomic knowledge of canola physiology, relative to other winter cereal crops (example: drivers of flowering time, critical yield-determining periods, the value of hybrids, N management).
- Need for determination of the level of investment appropriate on a regional scale and the tactical agronomic management to reduce the overall risk of early-sown canola while increasing profitability.

CSIRO's Response

CSIRO in collaboration with key partners GRDC and NSWDPI played a significant role in the development of early sowing practices for canola in Eastern Australia. The main aim of this work has been to address the critical need of reducing the business risk associated with growing canola and enabling farmers to capture economic benefits from the early sown crop. Through this work, the team:

- established agronomic guidelines for early sowing of canola
- defined constraints to achieving greater water use efficiency
- developed tactical management packages for canola in risky environments

With the global climate change accelerating the issue of reduced rainfall, varying rainfall patterns, drought and increasing temperatures, the Australian canola industry is seeking solutions to maintain the profitability of farmer bottom-line and meet market demands.

3.2 Objectives of investment in the program

CSIRO has played a key role in the development of early sowing programs for canola to support the Australian canola industry. The principal goals of investment in this research program work have been to increase profitability and reduce production risk for canola growers. Some of the key factors that make the recommended practices effective and help achieve the intended objectives from this program of work, include:

- Provide understanding and assist with uptake of early sowing practices to:
    a) enable deeper root growth
    b) increase paddock and farm yield potential
    c) improve utilization of water
    d) capitalise on soil moisture opportunities
    e) reduces evaporative and transpiration water losses
    f) creates a longer growing season
    g) cut-down overall production risk

- Establishing a better understanding of the drivers of development, flowering time and the critical period for grain yield development
- Deliver tactical agronomy advice for
    a) robust, high-yielding early sowing systems
    b) reduced production risk in low rainfall areas, and
    c) improved harvest management

4 Impact Pathway

INPUTS ► ACTIVITIES ► OUTPUTS ► OUTCOMES ► IMPACT

INPUTS

- Background knowledge and expertise in sowing programs and canola optimal development and flowering times
- CSIRO Business Unit funding and in-kind support
- External financial Investment by Grains Research &Development Corporation, DPI and CSU
- Access to high calibre, multidisciplinary CSIRO capability and APSIM Canola Model
- Access to infrastructure and resources to execute projects (example: on-site and off-site facilities, computer resources etc)
- CSIRO's brand recognition, strategic position and existing relationships that enables enabling liaison with different players (grower groups, consultants, collaborators etc) for successful execution and implementation of this project.
- Strategic position and expertise of organizations like GRDC, DPI and CSU to raise awareness, organize national workshops and provide necessary support to propel farmer training, uptake and implementation.

ACTIVITIES

- Ideation: defining, characterising and explaining logic and conceptual models that underpin RD&I
- POC activities, incl but not limited to:
  - Pre-experimental modelling
  - Field experiments and demonstration experiments
  - Updating of APSIM canola model parameters
  - Validation against agronomy experiments
- Uptake and Innovation support
  - Establishment of National Canola Agronomy Initiative
  - Planning and implementation for major practice changes by key stakeholders
  - Development of workshop and roadshow resources, reports
  - Interviews, training programs
- Engagement
  - F2F interviews with growers and advisors (incl but not limited to field days, Industry meetings, GRDC Updates, Conferences)
  - Roadshows, presentations at field days, workshops, industry meetings; industry consultation process
  - Major and minor regional engagement activities
  - Engaging with allied industries like breeders for underpinning their RD&I activities

OUTPUTS

- Development of early sowing practices for canola
- Novel approaches to early sowing programs for canola
  - new knowledge
  - validated models
  - decision frameworks
  - specialised agronomy advice
- Risk mitigation programs
- Implementation support
- Innovation support
  - Industry articles
  - Scientific writing course
  - Canola flowering APP
  - Impact survey
  - Key learnings document from regional engagements
  - E-booklets, datasets, case studies
  - Publications
  - Farmer and industry survey data
  - New knowledge for allied industries
- Engagement
- Awards

OUTCOMES

- Systems change in canola industry driven by uptake of new information (esp medium and low rainfall zones) for informed investment decision making.
- Farmer uptake and adoption of new practices to attain higher yields and lower risk associated with canola farming.
- The benefits of the new knowledge go beyond the farmers to include project proponents, State and local governments, land holders, interest groups and the general public (See Outcomes section for more details).
- Validation of APSIM's capacity for improved agronomy management.
- Commencement of two new projects on two new GRDC projects on canola phenology and establishment
- Uptake of best information and science for informed decision making and risk mitigation. Providing a common information base for governments, landowners, the community, industry and investors.
- Building a pipeline where returns from this scientific investment can be scaled through training and collaboration.
- Stakeholder engagement through new partnerships and participation in field days, industry meetings, impact surveys etc

IMPACT

ECONOMIC IMPACT

- National economic performance
  - The wider economic benefit at the national level through increased productivity and canola growers and advisors)
  - Increased potential flow through to increased government taxation and royalty revenues
- Management of risk and uncertainty
- New markets and products (cultivars)
- Canola growing programs – shift in industry practice
- Trade and competitiveness

ENVIRONMENTAL IMPACT

- Lower maintenance requirements through weed and disease control
- High water and nutrient use efficiency of the cereal-based system
- Lower environmental footprint of canola production

SOCIAL IMPACT

- Farmer health and wellbeing
- Access to resources, services and opportunities
- Canola industry resilience

Fig 1: Impact Pathway for Early sowing of canola project

Impact Evaluation

New agronomic guidelines, improved WUE practices and tactical management packages developed by CSIRO in collaboration with GRDC and NSWDPI have attained significant traction within Eastern Australia canola industry. The new knowledge has boosted the canola industry's confidence especially in the higher risk MRZ and LRZs. The team performed a range of activities (See Fig 2) for developing early sowing practices and propelling their uptake by Australian canola farmers.

The significant industry impact from this project can be attributed to several aspects of the project design and conduct from its inception to its conclusion, which include:

(1) Careful review and analysis with industry stakeholders to identify the key strategies to target for greatest impact of canola productivity and risk namely (1) earlier sowing systems; (2) reduced risk in low rainfall areas; (3) improved harvest advice. By focussing on these strategic outcome areas, which resonated with growers and consultants from the outset, the outcomes for research were clear and adoptable.

(2) Regional spread of the R, D & E activities focussed on 9 key regions across eastern Australia, and the research and advice arising was tailored to each region, increasing relevance and ease of adoption.

(3) Research activities to identify new knowledge (e.g. optimum flowering dates, critical growth periods, drivers of plant development) (Module 1) were closely linked to regional tactical agronomic experiments and demonstrations so that new strategies could be tested and validated (Module 2 and 3). Simulation modelling was a key tool in extrapolating experimental results beyond the sites and years of the experiments to provide more confidence in the advice.

(4) The project capitalised on the widespread and pre-existing networks of farmers and consultants of the key researchers to rapidly and effectively disseminate the most recent advice at field days, industry meetings, consultant groups, radio and social media. An average of at least 2 communication events per week were achieved for the entire 5-year period by the project team representing an enormous and targeted effort in industry delivery.

(5) A final series of "8 Industry Roadshows" and online E-booklet for each region summarising the major outcomes of the work was widely distributed to the industry. Feedback from the attendees who covered an estimated 70% of the canola growing area in eastern Australia provided insights into the major practice changes resulting from the project.

The adoption of interventions by the canola industry is resulting in spectrum of economic, social and environmental benefits (see Table 3 below). The economic assessment presented in this section focuses on the canola yield benefits emerging from the uptake of new knowledge. It also discusses the key information from each stage of the impact pathway that lead to the realization of the claimed benefits.

The early sowing research for canola was active from FY2014 - FY2019. Due to the awareness and implementation support provided by CSIRO and other key players, the grain growers started uptake and adoption of new practices starting FY2017. To keep the analysis conservative the benefits are assessed from FY2018 to FY2027 (Expost: FY2018 to FY2020; Ex-ante: FY2021 to FY2027). In the coming 5-7 years, it is expected that the recommended practices would become the 'new normal' for the canola industry.

The following sections provide further details on each section of the impact pathway (Fig 1).

Project inputs

The dual-purpose cropping work that underpinned this work commenced in 2004. Dual-purpose cropping is when a long season crop is sown early and then grazed by livestock while still vegetative. After grazing, the crop is left to reach maturity and the grain is harvested. Dual-purpose cropping provides two income streams from the same crop and has been shown to be highly profitable in mixed farming systems.

CSIRO's dual-purpose cropping work provided the foundation blocks for the early sowing research; however, the program under review only focussed on non-grazed canola. Hence any investment into dual-purpose cropping work has not been included in this analysis

CSIRO

- Background knowledge and expertise in farming systems, sowing practices, canola development required to obtain optimal flowering times
- Access to high calibre, multidisciplinary CSIRO capability
- APSIM canola model, central to a lot of the work in this research
- Access to infrastructure and resources to execute projects (example: on-site and off-site facilities, computer resources etc)
- CSIRO's brand recognition, strategic position and existing relationships that enabled liaison with different players (grower groups, consultants, collaborators etc) for successful execution and implementation of this project.

Partners: Grains Research and Development Corporation (GRDC), NSW Department of Primary Industries (DPI), Charles Stuart University (CSU)

- External financial Investment, with GRDC being the main partner and co-investor
- Strategic position and expertise of GRDC, DPI and CSU to raise awareness, organize national workshops and provide the necessary support to training, awareness and uptake for growers and consultants.

Investments

- The details for cash and in-kind support associated with all the work conducted by CSIRO and partners in the period of FY2014 to FY2019 for executing this project are included Table 2 below:

Table 2: Early sowing of canola project costs

Contributor / type of support	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019
CSIRO (R-06594-01; PV in $$, AUD)	149,000	321,000	311,800	321,700	270,500	111,730
GRDC (in $$, AUD)	1,110,154	1,250,057	1,242,937	1,233,019	1,137,751	373,493
DPI (in $$, AUD)	503,700	520,000	537,400	554,700	573,200	156,514
CSU (in $$, AUD)	60,000	80,000	80,000	80,000	60,000	
Total investment (real, in AUD)	2,007,266	2,350,412	2,319,554	2,298,741	2,102,817	650,312
Total CSIRO Investment (PV in mil AUD, FY2020$ @ Real Discount Rate 7%)	**2.02**					
Total CSIRO Investment (PV in mil AUD, FY2020$ @ Real Discount Rate 7%) incl deadweight loss	**2.43**					
Overall Investment (PV in mil AUD, FY2020$ @ Real Discount Rate 7%)	**15.3**					
Overall Program Investment (PV in mil AUD, FY2020$ @ Real Discount Rate 7%) incl deadweight loss	**18.3**					

*Since the projects under the umbrella of early sowing work are mainly funded by the Australian and state governments, the cost of the funds used for the research program should reflect on the rest of the economy. If it is assumed that funding for this work has been obtained through income taxation, there will have been negative effects on the private sector in the form of deadweight loss. It has been argued by several authors that research costs should be increased by about 20% to reflect the deadweight loss of income tax-based funding, although many Australian cost-benefit studies omit it.

Activities

CSIRO has played a key role in driving the revolution of early sowing for Australian canola farmers. There are several activities that underpin the establishment of these novel approaches as solutions for effective farm management and higher crop yields with the changing environmental conditions. CSIRO has been working with key partners - GRDC and NSWDPI, universities, grain growers, consultants, and other key stakeholders in the industry to enable this shift. A snapshot of the key scientific activities performed under the program umbrella are included in Fig 2 below:

Engagement

- F2F interviews with growers and advisors (incl but not limited to field days, Industry meetings, GRDC Updates, Conferences)
- Roadshows, presentations at field days, workshops, industry meetings; industry consultation process
- Major and minor regional engagement activities
- Engaging with allied industries like breeders for underpinning their RD&I activities

Uptake and Innovation support

- Establishment of NCAI
- Planning and implementation for major practice changes by key stakeholders
- Development of workshop and roadshow resources
- Interviews, training programs

Proof of concept

- Field and demonstration experiments
- Implementation support
- Updating of APSIM canola model parameters
- Validation against agronomy experiments

Ideation

- Experiments and simulation studies
- Data analysis
- Area specific insights wrt canola production

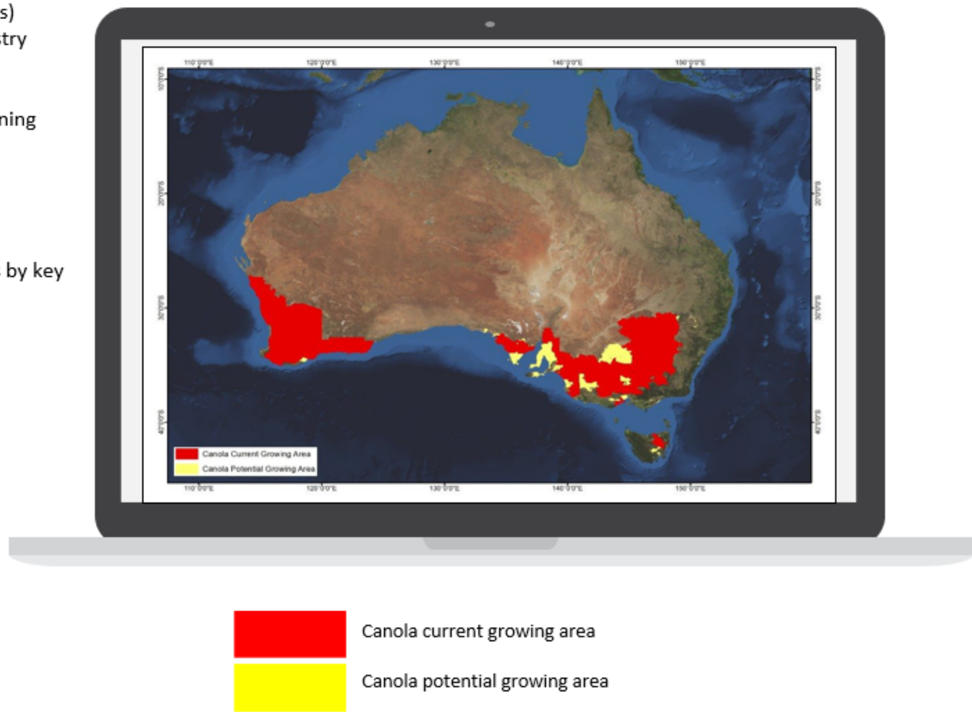


Fig 2: Components in Early sowing of canola project. Current and potential canola producing areas in Australia

For details of communication activities: 2014-2020 – See Appendix A

Outputs

New Knowledge

01

Novel approaches to early sowing practices for canola

- Robust information from field experimentation and simulation modelling that helped refine, validate and promote best-practice management techniques when early sowing canola.
- Validated model(s) and input decision support interfaces (example: Yield Prophet) for growers and advisers for improved agronomy management practices.
- Development and implementation of an annual field-based tactical agronomy research program to provide practical decision frameworks to optimise canola profitability across specified low and medium rainfall zone regions
- Improved physiological understanding of yield and oil formation in canola, and how they are affected by genotype, environment, and management (G x E x M).
- Tactical agronomy advice for (1) robust, high-yielding early sowing systems (2) reduced production risk in low rainfall areas, and (3) improved harvest management.

02

Identification and mitigation of risks

- Understanding of higher yield and lower-risk benefits provided by canola early sowing practices (example: modelling studies have shown that the risks of dry sowing are outweighed by the benefits)
- Learnings from profit-risk assessment of key sites within each region to explore the impact of tactical agronomy decisions on the yield gains that drive profitability in each region

03

Implementation Support

- Necessary support programs to implement the canola early sowing practices unlocking the potential for generating higher yield gains and adapting to the shift.
- CSIRO led a national agronomy project to provide crop science, soil and climate modelling support to other projects and facilitate sharing of information and experience across cropping systems for benefit of everyone involved.

Innovation Support

04

- Industry articles reporting regionally relevant outcomes from the project.
- Scientific writing course
- A canola flowering APP prototype for ongoing development
- Insights from impact survey conducted by Stephen Wentworth from *"Feeding the Future"*
- Key learnings from major and minor regional engagement activities that include (but not limited to) package of new recommendations, individual site/node reports, as well as to inform participants of constraints or opportunities to canola production

04	- E-Booklets • “20 tips for profitable canola”- entails experimental data and recommendations relevant for four selected regions of research focus • "10 tips for early-sown canola"- entails learnings from tactical agronomy experiments The booklets also include numerous links to more detailed information found in various publications including GRDC updates & conference papers available online. - Datasets. example: data on optimum flowering and sowing dates for a range of varieties at 79 sites throughout Australia was completed for dissemination at the Roadshows - Case Study: Condobolin whole-farm Canola financial analysis– See App C - Case Study: Summary of experimental canola work at the CSU Rhizolysimeter and NSW-DPI Wagga Wagga - Relevant scientific outcomes have been published in scientific journals (16), conference proceedings (26), E-booklets, (5) GRDC Update papers (45), Departmental and Grower Group Annual Reports and various industry and media articles (35) as well as on social media - New information and support for allied industries example: breeders **Publications** - Book Chapter: Kirkegaard et al., (2020) Canola. (In: V Sadras and D Calderini Eds.) Crop Physiology: Applications for the production of starch, sugar, protein and oil. Academic Press, 3rd Edition (in press). - Lilley et al., (2019) Defining optimal sowing and flowering periods for canola in Australia. Field Crops Research 235, 118-128. - Meier et al., (2020) Management practices that maximise gross margins in Australian canola (Brassica napus L.). Field Crops Research (in press). - Whish et al., (2020) Vernalisation in Australian spring canola explains variable flowering responses. Field Crops Research (in press). - Pitt et al., (2020) Trouble without the curve: A generalized non-linear vernalization response function for winter canola (Brassica napus L.). (Complete draft) - Goward et al., (2020) Simulation confirms canola with slow-developing phenology allows for sowing as early as mid-March in south-eastern Australia (Complete draft) - NSW DPI Winter Crop Variety Sowing Guide. Major changes made to sowing date recommendations (from OCP findings), incorporating recommendations based on phenology (distributed to 1000’s of Advisors and Farmers)
05	**Engagement** - Engagement with Grain growers, agribusiness, researchers, breeders - A total of 189 field days, field walks and industry meetings were run by the Project team.
06	**Awards** - NSWDPI Rohan Brill Young Agronomist of the Year Award - CSIRO John Kirkegaard GRDC Recognising and Rewarding Research Excellence Award 2018

Outcomes

	Uptake
01	Industry-wide change in practices of growing canola driven by the uptake of new information (esp MRZ and LRZ) for informed investment decision making.
02	Uptake of new information by canola farmers (especially from medium and low rainfall regions) for easier adaptation of canola varieties while enabling higher overall yield, profits and management decisions.
03	The benefits of the new knowledge systems, implementation and management solutions go beyond the farmers to include project proponents, State and local governments, landholders, interest groups and the general public. The major practice changes as a consequence of this work include: - Adoption of phenology information and sowing date to target optimum start of flowering dates (including use of the canola flowering app) and management choices - More attention to crop maturity assessments, measuring seed colour change across the whole plant and likely windrow slightly later - Improved focus on nitrogen management to increase growth during the critical period, including fertiliser management and growing canola after legumes - Rotation of canola blackleg groups and avoid early flowering to reduce disease risk - Utilization of soil moisture as a trigger for canola management decisions, example: sowing hybrids earlier when deep water is available - Uptake of relevant information pertaining to tactical agronomy-based issues - Uptake of new knowledge to improve prediction and management of risk for selected canola harvest operations and quality outcomes in dry finishes and marginal growing regions by breeders, pre-breeders, growers and advisers
04	- Validation of APSIM's capacity for improved agronomy management. - Future Work: Stimulated at least two new GRDC projects on canola phenology and establishment, and investment to pursue work in biomass allocation and physiology space.
	Training & Consultancy
05	**Information Sessions** - Uptake of scientific advice on the likelihood of direct, indirect and cumulative impacts of scientific intervention - Improved farmer understanding, awareness and confidence through sharing of quantitative, semi-quantitative and qualitative results from modelling, demonstration experiments and farmer survey data - Formation of National Canola Agronomy Initiative (NCAI) to share the most up-to-date information with key stakeholders on strategies to improve canola productivity and profitability - Engagement with CSIRO and NSWDPI organised workshops attended by 472 people; including commercial

	agronomists, consultants, farmers, students, researchers and industry/company representatives that catalysed uptake of this work.
Decision Making	
06	- Uptake of best information and science for informed decision making and risk mitigation in the canola industry. Providing a common information base for governments, landowners, the community, industry & investors.
Stakeholder Engagement	
07	- New partnerships and joint-projects between research organisations and regional grower groups. - Awareness and impact surveys • 1st: Feedback from evaluation sheets completed by the 472 advisors and growers who attended the 8 regional "roadshows" in September-October 2019 and who collectively managed/consulted to 710,000 ha (65%) of the canola grown in the project area. • 2nd: Findings from the impact survey conducted by Stephen Wentworth, Feeding the Future. He interviewed 90 agricultural advisers (who consulted to 700,000 ha of canola in eastern Australia). 84% of them were aware of the OCP project and 68% of those who were aware had made practice change as a result of the project.

Testimonials

Francis Ogbonnaya, Manager (GRDC)	*"John led the Optimised Canola Profitability project which GRDC/CSIRO/NSWDPI co-invested in. By all accounts, John's (CSIRO) scientific leadership and management of the project resulted in significant Australian canola growers' benefit; which without doubt increased profitability from the practice changes implemented by growers' and advisers. The estimated value to the Industry was $74Mil pa from $1.2Mill of investment. The most significant influence was in matching variety with optimum sowing date. Resultantly, Australian canola breeders are now strong advocates for better understanding of the phenology in their near release lines. Some of the flow on effects include the need for an investment in the understanding and development of genetic tools to increase the precision and accuracy of predicting canola phenology."*

Impacts

Table 3: Summary of project impacts using CSIRO triple bottom line (TBL) benefit classification approach

Type	Category	Indicator	Description
Economic	National economic performance	- increased yield - higher farmer profitability - better managed canola farming systems - higher government taxation and royalty revenues	Better yields enabled by scientific interventions that benefit farmers bottomline and enable more efficient use of resources. Higher yield (see Table 6) from crops grown in rotation with canola which converts to higher tax income for the government
	Management of risk and uncertainty	- decreased risk in canola production - higher farmer confidence	Scientific interventions provide improved risk management and better-informed decision making
	New markets and products (genetic varieties)	- new cultivars in the market tailored for early sowing of canola	Development of better slow or fast cultivars by breeders specific to Australia's needs
	Canola growing practices - shift in industry practice	- changes in canola growing practices and decision making	Scientific advice and insights for grain growers and consultants to shift new normal for the canola industry
	Trade and competitiveness	- Higher canola export revenue	Higher canola yields, with potential for higher Australian canola exports
Environmental	Lower maintenance requirements through weed and disease control induced by canola growing	- ↓ fertiliser, pesticide and herbicide use - Improved use of resources, machinery and labour - ↑Water and nutrient use efficiency (WUE) - Improved efficiency in the management of larger farms	Devising best practices based upon scientific findings and farmer experiences for overall better returns on farming investments. Higher outputs (yields etc) from the same level of resource investments in canola production
	High water and nutrient use efficiency of the cereal-based system		
	Lower environmental footprint of canola production		
Social	Health and wellbeing	- higher farmer income - improved community wellbeing	Better yield & efficient management practices leading to higher overall incomes for farmers. Impact survey indicated that ~70% of advisors had changed practices as a result of this research as suggested by impact survey
	Access to resources, services and opportunities		
	Canola industry resilience	- higher farmer confidence - reduced stress	Better risk management practices that lower threats of climate change and reduce farmer stress caused by environmental variabilities

5 Clarifying the impacts

The work has improved underlying knowledge of canola physiology and agronomy to support the objectives of increasing profits and reducing risks in canola production. There has been a significant need to bolster this understanding especially with the expansion of canola production into new (medium-low rainfall) areas and the introduction of new technologies including vigorous hybrid varieties. With global climate change expected to exacerbate and accelerate the occurrence of drought, the scientific community foresees widespread adoption of this work by the canola growers, thereby catalysing the impacts from this work with the potential of the recommended practices becoming a new normal for the industry in the coming years.

It is important to note that the adoption of early sowing practices and application of new management solutions represents “wide-ranging” changes and requires several interdisciplinary players to actualize benefits. Key stakeholders that have played a cardinal role in driving this shift in farmer practices in response to changing environmental and commercial circumstances include funders, R&D organizations, industry (grower groups and consultants), breeders and government.

Key challenges associated with quantifying benefits generated through this work, assessing CSIRO’s attribution, and gauging the anticipated impacts yet to occur, include:

a) The program of research and engagement covered in this case study is trying to address an industry-wide change. The work is not producing a single, tangible product or technology for which we can quantify commercial adoption and sales. Instead, it is producing new knowledge tailored to address the needs of the changing farming system in a focused and coordinated way. Evaluating the benefits emerging from this change requires measuring a number of variables for the entire region in scope for this study (i.e. Eastern Australia). This is inherently hard to do with limitations associated with budget, time and data.

b) Canola yield is highly dependent upon the rainfall. Much of eastern Australia was in a serious drought in 2018 and 2019, while 2020 and 2021 have been record wet years. Hence the yield trends have been driven by climate in those years. In 2018 and 2019 many Canola crops without early and timely sowing were reported to have failed. In the wet years of 2020 and 2021, the early sowing packages probably were not as important because the late rain meant that later sown crops still did okay. So it is not possible to use the actual farmer yield trends over 4 years to quantify/ claim or project impact, even though it is clear that the early sowing packages were valuable in those years.

c) Although the sowing dates are measurable, with >1.1 million hectares of land being used for canola production in Eastern Australia[2], the extent of adoption of new knowledge (by farmers) enabled by this project is by nature hard to measure. Some of the grain growers have already been aware of and practising early sowing of canola to varying extents even without this work. Although their overall % is very low, there is no benchmark data available to highlight in this assessment.

   In addition to the unavailability of benchmark data, the analysis is also heavily based upon assumptions due to ongoing and multi-phase nature of this work. None of the active organizations in this space is actively measuring the adoption rate over the years to assess impact. It is impractical to engage with all the farmers and get data on the extent to which they have adopted the new practices at their farms. Due to such factors, the estimated benefits are bound to be based on assumptions (within the scope of the study).

[2] https://www.agriculture.gov.au/sites/default/files/documents/austcroprrt20191203_v1.0.0.pdf

d) The overall quantified benefits are highly dependent upon many external factors (example: canola varieties, rainfall, rainfall pattern, temperature etc). For instance increases in yield did not always result in a correlating increase in overall grower profits. This is due to outside influences such as the price of seed in changing from open-pollinated (OPTT) to a hybrid or vice versa. These factors can make quantification of benefits from early sowing practices difficult.

e) The footprint of implementation of new practices by farmers and deriving tangible benefits is being driven by a number of other key players (example: GRDC, DPI, CSU etc) thereby making it hard to accurately estimate CSIRO's attribution for the purpose of this assessment.

Counterfactual

As mentioned above, CSIRO is working with key partner GRDC with the goal of driving this shift in the canola industry. A part of the change would have happened even without CSIRO's participation, but the rate of this change and overall impact would have been measurably slower and lower. CSIRO played a critical role in providing central science and implementation support for this work that enabled the realization of "real-world" benefits. Author's discussion with GRDC validates and underlines these claims.

Had CSIRO not been involved, there would be a lag of at least 5-10 years in realising the benefits from this work. This is an arbitrary yet conservative assumption supported by the findings from "Optimised canola profitability research report", published Jan 2020 (this is a restricted document; for more details See Appendix A)

CSIRO's unique value-addition can be attributed to:

- CSIRO has a talented team of multi-disciplinary professionals enabling easy access to varied expertise. To execute this work successfully seasoned professionals with capabilities in crop physiology, agronomy and crop modelling analysis worked together
- CSIRO's collaboration with GRDC, DPI, CSU and strategic positioning enabled engagement with key stakeholders to achieve the intended objectives of this program

Assessment of CSIRO's attribution

The focus of this CBA is to estimate the broader benefits generated from early sowing work for canola conducted by CSIRO in collaboration with its partners, especially GRDC and to estimate the part of the net benefits attributable specifically to CSIRO.

Overall realised benefits for any farmland are a result of a combination of:

1) Earlier sowing systems
2) Reducing risk in LRZ
3) Harvest management

CSIRO worked in collaboration with key partners GRDC to achieve the ultimate objectives of early sowing of canola program. DPI and CSU played a key role in driving the uptake of this work. Since CSIRO and all key-players were necessary for the success of this work, it is considered appropriate to allocate the benefits on the basis of the share of total program costs. Table 2 shows that CSIRO's share of total expenditure on this program was approximately 13%. Based on the above, this case study will attribute total impacts as follows:

- CSIRO – 13%
- Other collaborators – 85%

Although the attribution for CBA is based on financial contributions; in real-world the actual benefits emerging from any work are dependent upon a broad array of factors over and above financial share. Hence the author contacted GRDC to gauge their assessment of CSIRO's attribution. GRDC stated that CSIRO acted as scientific lead and intellect to drive the success of this project and quoted CSIRO's attribution as a minimum of 50%. To address this variability sensitivity analysis has been conducted (Table 9) which assesses overall benefits at CSIRO's attribution of 10%, 13%, 20%, 50%. See Sensitivity Analysis (Section 7) for more details.

6 Evaluating the impacts

6.1 Evaluation Method

The study conducts this impact evaluation using a mixed-methods approach (i.e. identifying market and non-market benefits, using both quantitative and qualitative data), to provide an assessment. A cost-benefit analysis was conducted for the period FY2014 to FY2027 (Costs: FY2014 – FY2019; Benefits: FY2018- FY2027) for the assessment of this work to Australia. <u>Since this work was conducted only in Eastern Australia, only benefits associated with those regions are quantified for this analysis.</u>

Use of CBA enables comparison of impacts arising from CSIRO activities against the associated costs. The method provides a monetary measure of the current value for the program of work conducted (net present value) as well as calculating the effects on possible future benefits and costs (Benefit Cost Ratio (BCR) or Return on Investment Ratio (ROI)). The CBA was conducted from an Australian perspective and only measures economic costs and benefits arising from and attributable to CSIRO's scientific interventions in Eastern Australia.

6.2 Modelling Approach

To estimate the benefits of this work <u>attributable to CSIRO</u>, the following project case was used to model the estimated range of benefits as shown in Table 4 below:

Table 4: Modelling approach for estimating CSIRO's costs and benefits for Early sowing of canola project

Parameter	Estimation
CSIRO costs associated with Early sowing of canola project	All program costs, as provided in Table 2
Benefits attributable to CSIRO with the adoption of early sowing (for any year) *This estimates the <u>additional</u> canola produced through the adoption of scientific intervention compared to normal sowing (base case)*	Total Area under canola production (million hectares) in Eastern Australia (ha)* Adoption of early sowing for canola practices by Australian growers in FY (of interest; in %) * Base Canola Yield (t/ha) Σ Yield benefits emerging from the adoption of early sowing ONLY (%) * Price / ton of canola (in FY of interest - $/t) * CSIRO's Attribution

Project background data and assumptions

a) This work was conducted in <u>Eastern Australia</u>. Although there are flow-on benefits with the uptake and adoption of this work in Western Australia as well, benefits associated only with eastern Australia will be quantified for the purpose of this assessment.

b) There would have been a lag of at least 5-10 years with the uptake of this intervention if CSIRO had not been engaged in this work.

c) The farmers incur no additional costs with the adoption of the outputs from Early sowing project.

Farmer information sessions and training programs will involve opportunity costs of time to the farmers. Similarly, the use of new cultivars, fertilizers etc will incur additional costs. Lack of precise information precludes the inclusion of these costs. For purposes of this assessment, it is assumed that there are no additional costs associated with the adoption of new interventions.

d) Overall area under canola production as well as base yield stay flat for the evaluation period i.e. FY2018-FY2027.

e) The real discount rate for the CBA is 7% per annum, based on CSIRO's Impact Evaluation Guide Feb 2020.

The focus of this analysis is to estimate the broader net benefit from the investment in the work for Eastern Australia, calculate the part of those benefits attributable to CSIRO and understand the payoff from this research work with respect to funding invested. It is, therefore, necessary to tease out CSIRO's costs and benefits—requiring a disaggregation of the positive externalities back to either CSIRO or other contributors. See the steps in Table 5 below:

Table 5: Benefits assessment process

Step 1: Impacts measured: Benefits generated through the adoption of early sowing of canola practices (example: generating yield gains) for Australia.	Table 6
Step 2: Supporting data: Approach and data (incl references and assumptions) used for benefits assessment	Table 7
Step 3: CBA calculation and results	Table 8

6.3 Quantification of benefits

6.3.1 Snapshot of benefits

Table 6: Benefits from Early sowing of canola project

	Deliverable	Reported Benefits*	Adoption* (basis: Australia)	Yield Increase* (%)
1) Earlier sowing systems	- variety and sowing date advice - agronomic packages for success with sowing in early to mid-April rather than in late April - improved agronomic advice - risk mitigation: E.g. new knowledge for the industry that major yield penalties occurred when fast-maturing varieties were sown too early	- average yield benefits of around 0.4 t/ha (often up to 1 t/ha) for an average yield of 2 t/ha[3] - ↑ $Overall profit by $60-100/ha	Sowing date (early sowing practices): 38%	8%
			Variety choice (early sowing practices): 35%	1.2%
			Matching variety with optimum sowing date (early sowing practices): 25%	6.2%
			Nitrogen (N) Management (early sowing practices): 25%	9.8%
2) Reducing risk in LRZ	- solutions to reduce risk of canola production to maintain profit rather than pursuing higher yield - demonstration of growing canola in the cropping sequence - set of rules on sowing opportunistically for successful establishment increased profit and reduced risk - the yield advantage of a hybrid variety needed to be in excess of 20% to be a viable option - simple changes to N management for both higher profit and risk, despite an increase in nitrogen inputs in most season types	- Improved choice of technology –Hybrid v OP TT (Biomass Production)	23%	8.4%
3)Harvest management	- new knowledge that windrowing should occur when 60-80% of seed sampled from the middle third of branches and the main stem has changed colour (previous: 40-60% changed colour)	- Yield (↑up to 55%), oil (↑of up to 8%) and economic benefit: $34/ha	50%	5.8%
*Benefits, Adoption rates and yield increase benefits as reported by "Optimised canola profitability research report", published Jan 2020 (restricted document, please refer to Appendix A for further details)				

[3] https://grdc.com.au/20-tips-for-profitable-canola-central-and-southern-nsw?utm_source=website&utm_medium=short_url&utm_term=North&utm_content=20%20tips%20for%20profitable%20canola%20-%20central%20&%20southern%20nsw , page 15

6.3.2 Time Period

CSIRO’s work on early sowing started in 2012. However, the dual-purpose cropping work that heavily underpinned early sowing work started before 2004. For the purpose of CBA, we account for costs associated with the work in the period of FY2014- FY2019. The benefits are assessed from FY2018 to FY2027 (Expost: FY2018 to FY2020; Ex-ante: FY2021 to FY2027).

In any program, there are lags between the research and development and the realisation of benefits after adoption by the agronomy industry. Early sowing practices of canola started seeing early uptake interests starting 2017). Due to the changing climatic conditions and expansion of canola production in low-medium rainfall areas, there is a high likelihood of the recommended practices being in a new normal for the industry in the coming years. By nature, the rate of adoption in subsequent years would be higher. On that basis, the benefits are measured from FY2018 onwards.

A conservative approach is adopted where it is assumed that benefits are measured to FY2027. This is consistent with our prior assumption that in the counterfactual scenario the development and adoption of the work would be delayed by at least 5 - 10 years in the absence of CSIRO in this space.

6.3.3 Cost Benefit Analysis Data

Table 7: Adoption estimates for measuring impact of Early sowing of canola project in Eastern Australia

<table>
<tr><th colspan="10">Parameter Description</th><th>Reference/ Comments/ Assumptions (also refer to Table 4)</th></tr>
<tr><td colspan="9">1. Background Data for Benefits Estimation:
Total Area under canola production in Eastern Australia (million hectares):</td><td>1</td><td>https://www.agriculture.gov.au/sites/default/files/documents/austcroprrt20191203_v1.0.0.pdf
This work was conducted in Eastern Australia ONLY. However there are some spill over benefits through adoption in Western Australia which. These have not been accounted for in this analysis.</td></tr>
<tr><td colspan="9">2. Average canola yield in Eastern Australia (tonnes / ha)</td><td>1.4</td><td>Kirkegaard, J., Lilley, J. and Morrison, M., 2016. Drivers of trends in Australian canola productivity and future prospects. Crop and Pasture Science, 67(4), p.i.</td></tr>
<tr><td colspan="10">3. Canola prices (AUD/tonne)</td><td rowspan="3">Canola prices for FY2018-FY2022 are based on ABARES data. For FY2023-FY2027 the canola price for each year is calculated as an average of last 3 years.</td></tr>
<tr><td>FY2018</td><td>FY2019</td><td>FY2020</td><td>FY2021</td><td>FY2022</td><td>FY2023</td><td>FY2024</td><td>FY2025</td><td>FY2026</td><td>FY2027</td></tr>
<tr><td>539</td><td>574</td><td>620</td><td>594</td><td>598</td><td>604</td><td>599</td><td>600</td><td>601</td><td>600</td></tr>
<tr><td colspan="10">4. Reported yield benefit from uptake and adoption of outputs from Early sowing project (%)</td><td rowspan="3">As assessed in “Optimised canola profitability research report”, published Jan 2020 (this is a restricted document; See Appendix A for more details)</td></tr>
<tr><td colspan="2">Sowing date</td><td>Variety choice</td><td colspan="3">Matching variety with optimum sowing date</td><td colspan="2">Nitrogen (N) Mgmt</td><td colspan="2"></td></tr>
<tr><td colspan="2">8</td><td>1.2</td><td colspan="3">6.2</td><td colspan="2">9.8</td><td colspan="2"></td></tr>
<tr><td colspan="10">5. Estimated yield benefits for the purpose of this CBA</td><td rowspan="3">The canola yield as reported in ABARES data could not be used for assessment as it was for entire nation and not just eastern Australia. Due to significant impact of rains the yield benefit from adoption of Early Sowing practices can look very different over the years. See Section 5 # (b)
Yield gains for FY2018 - FY2027 are conservatively assumed based on inputs of CSIRO R&D team (suggest that the yield benefits due to early sowing Canola practices are ~10%) and supported by</td></tr>
<tr><td>FY2018</td><td>FY2019</td><td>FY2020</td><td>FY2021</td><td>FY2022</td><td>FY2023</td><td>FY2024</td><td>FY2025</td><td>FY2026</td><td>FY2027</td></tr>
<tr><td>8.00%</td><td>8.00%</td><td>2.00%</td><td>2.00%</td><td>6.00%</td><td>6.00%</td><td>6.00%</td><td>6.00%</td><td>6.00%</td><td>6.00%</td></tr>
</table>

	referenced papers and Optimised canola profitability research report, published Jan 2020.[4,5,6] It is reported that any farmer adopting the recommended early sowing practices will obtain yield benefits from not just sowing date but also from a) variety choice b) Matching variety with optimum sowing date and c) Nitrogen (N) Mgmt as stated in the point #4. Hence, the overall yield would be the sum of each of the stated yield benefits. However, the corresponding attribution of early sowing practices towards generating yield benefits and the costs for each of these measures are not known and have therefore not been included in the cost-benefit analysis. Consequently, the net benefits are likely an underestimate.
6. Annual adoption of early sowing practices by canola growers in Eastern Australia for the period of FY2018 to FY2020 (%) **Ex-post Adoption rates (%)** **FY2018**: 10% **FY2019**: 15% **FY2020**: 20%	Based on "Optimised canola profitability research report", published Jan 2020 (this is a restricted document; See Appendix A for more details) GRDC reports that the likely adoption currently is ~45% as this is a relatively simple practice change to make. Lower adoption rates have been used for the current analysis to keep the assessment conservative. With global climate change expected to exacerbate and accelerate the occurrence of drought and the expansion of canola production in new areas (low-medium rainfall), the key stakeholders in the ecosystem foresee much higher adoption rates in the coming years as well with potential of these recommended practices becoming a new normal for the canola industry.
7. Annual adoption of early sowing practices by canola growers in Eastern Australia for the period of FY2021 to FY2027 (%) **Ex-Ante Adoption rates (%)** **FY2021**: 30% **FY2022**: 40% **FY2023**: 45% **FY2024**: 50% **FY2025**: 55% **FY2026-2027**: 60%	

6.3.4 Cost Benefit Analysis (CBA) Results

The following section presents the results of the CBA, comparing the performance of options using the two-key metrics:

• BCR/ ROI: The ratio of the present value (PV) of economic benefits to PV of economic costs over the evaluation period

• NPV: The PV of economic benefits delivered by the Early sowing of canola project less the PV of the costs incurred.

The CBA measures the benefit to Australia through this work. To keep the analysis conservative, this assessment accounts deadweight loss of government taxation.

The results of the CBA are summarised in Table 8 and based on costs and benefit items using a real discount rate of 7%. The results are based on data and methodology outlined in Section 6.2 -6.3.3.

[4] https://grdc.com.au/20-tips-for-profitable-canola-central-and-southern-nsw?utm_source=website&utm_medium=short_url&utm_term=North&utm_content=20%20tips%20for%20profitable%20canola%20-%20central%20&%20southern%20nsw , page 15 suggests 10% - 25% yield increase with application of early sowing practices for canola yield levels between 1.5 - 4 t/ha.

[5] https://www.sciencedirect.com/science/article/abs/pii/S0378429019321847 , suggests that in the low rainfall zone, where yields are often only 1-2 t/ha, hybrid varieties are more risky due to the higher seed costs, but can be profitable if they have 20% higher yield than current varieties. However earlier sowing with right variety phenology and higher N rates (or after a legume) were profitable

[6] https://bioone.org/journals/crop-and-pasture-science/volume-71/issue-9/CP20226/Agronomic-management-combining-early-sowing-on-establishment-opportunities-cultivar- options/10.1071/CP20226.short

Benefits FY2018 to FY2027

Table 8: CBA Results (See Table 4 for approach and assumptions): Impacts of Early sowing of canola project in Eastern Australia

Parameter Description	Benefits Estimated		Reference
Inputs for assessment of benefits from Early sowing of canola project (any year)	Total area under canola production (million hectares) in Eastern Australia[7]		See Table 7 above (1) The overall canola planted area has been assumed to remain the same for CBA analysis period[8]
	Average canola yield in Eastern Australia (tonnes / ha)		See Table 7 above (2)
	Adoption estimates (in %) of early sowing practices for canola production by Australian growers in FY of interest		See Table 7 above (6) and (7)
	Yield benefit attributed to the adoption of early sowing practices ONLY (t/ha)		See Table 7 above (5)
	Price / tonne of canola ($AUD/tonne)		See Table 7 above (3)
	CSIRO's attribution	13%	See Section 5 GRDC states CSIRO attribution as 50%. To keep analysis conservative the author conducts CBA based on cost share. Sensitivity analysis captures benefits on the basis of GRDC's assessment of 50%.
	Adoption costs for farmers		Nil See Table 4 above
Ex-Post benefits associated with the adoption of outputs from Early sowing of canola project: FY2018- FY2020 (overall, for Australia, PV in mil 2020 $$; ex-post)	21		$\sum_{n=FY2018}^{FY2020}$ (Canola Area*Adoption rate *Average canola yield * Σ yield benefits[9]*Canola price) See Table 7 above (6)
Ex-ante benefits associated with outputs from Early sowing of canola project: FY2021 to FY2027 (overall for Australia, PV in mil FY2020$; ex-ante)	119		$\sum_{n=FY2021}^{FY2027}$ (Canola Area*Adoption rate* *Average canola yield * Σ yield benefits*Canola price), See Table 7 above (7)

[7] This work was conducted in Eastern Australia ONLY. There are some flow-on benefits to Western Australia, but that has not been accounted for in this CBA

[8] In reality, with the expansion in low-medium rainfall areas, overall canola production land will be expected to grow in coming years. This will imply greater production costs (seed, fertilizer etc) for farmers and potentially greater benefits from adoption of early sowing practices.

[9] Σ yield benefits = Adding yield benefits from (Sowing date ONLY). Not including early sowing practice attributable benefits from Variety choice, Matching variety with optimum sowing date, Nitrogen (N) Mgmt, Choice of technology, Harvest Mgmt), See Table 7 (5)

Overall project benefits (for Australia, PV in mil FY2020$)	140	
Overall project costs without deadweight loss (for Australia, PV in mil FY2020$)	15.7	Table 2
Overall project costs with deadweight loss (for Australia, PV in mil FY2020$)	18.3	Table 2
Overall project BCR/ ROI without deadweight loss	9.2	
Overall project BCR/ ROI with deadweight loss	7.6	
Overall project NPV without deadweight loss (PV in mil FY2020$)	125	
Overall project NPV with deadweight loss (PV in mil FY2020$)	122	
Total benefits attributed to CSIRO's work - FY2018 to FY2027 (based on 13% attribution for analysis period; PV in mil FY2020$)	19	Overall (Ex-post + Ex-ante benefits) *0.13
Total CSIRO costs without deadweight loss (PV in mil FY2020$; See Table 2)	2.02	Table 2
Total CSIRO costs with deadweight loss (PV in mil FY2020$; See Table 2)	2.43	Table 2
CSIRO BCR/ROI without deadweight loss	9.2	
CSIRO BCR/ROI with deadweight loss	7.6	
CSIRO NPV without deadweight loss (PV in mil FY2020$)	16.5	
CSIRO NPV with deadweight loss (PV in mil FY2020$)	16.11	

The BCR/ ROI for CSIRO's role in this work varies from 9.2-7.6 (with or without deadweight loss).
The NPV for CSIRO's role in this work varies from 16.5-16.1 (PV in mil FY2020$ without or with deadweight loss)

In light of the underlying assumptions, the estimated potential benefits delivered by the Early sowing of canola research are expected to far exceed the total costs of the research, from the perspectives of the program as a whole.

6.3.5 Externalities, spill overs and economic flow-on effect on non-users

The scope of early sowing work for canola was eastern Australia. However, there is the uptake of this work in WA as well, which is adding to the overall benefits generated by this project. The work helped identifying optimum flowering times and the critical period in the region, both of which were published and utilised by WA researchers and agronomists. In addition, the canola production area has been assumed to remain the same for the analysis period. In reality, with the expansion in low-medium rainfall areas, canola production area will be expected to grow in coming years; which in return has the potential to generate greater benefits out of this work.

The canola work and the underlying knowledge generated by this project has provided a framework for similar interventions in the production of legumes. GRDC is driving this work and CSIRO is the lead agency. The project has also stimulated at least two new GRDC projects on canola phenology and establishment, and the third investment on biomass allocation and physiology was considered following a workshop organised by the project team in Canberra in 2019 to guide future research. Furthermore, this work has provided insights to conduct advanced investigations in this space and establish success strategies for dry sowing of canola, a special case of early sowing.

Overall the work has generated invaluable insights and new knowledge for breeding and agri-chemical companies to help with shaping their research activities and for informed decision making.

7 Sensitivity Analysis

The CBA is necessarily based on a series of assumptions which implies that there is a degree of uncertainty around the results. Sensitivity testing has been undertaken to clarify which assumption can materially change the results and has been undertaken on the key parameters that include:

- **Real discount rate**: Analysis in Section 6 is based on 7%. Sensitivity test results are provided for 4% and 10%
- **Changes in adoption rate**: As suggested earlier, with global climate change expected to exacerbate and accelerate the occurrence of drought, the scientific community foresees greater adoption of this work by the Australian canola growers in the coming years. To test the sensitivity against adoption rates, the analysis is run with rate of ± 10%/annum vs base case for the assessment period.
- **Change in yield gain:** The overall benefits delivered through the adoption of early sowing practices depend upon the yield benefits. These can be highly variable due to its dependence upon factors such as rainfall, terrain etc. Sensitivity analysis is conducted using change in yield benefit of ±2% against the base case.
- **Changes in CSIRO's attribution**: As stated earlier, the benefits generated from this work are a result of efforts by a number of key players in the ecosystem. The analysis in Section 6 is based upon CSIRO's attribution of 13%. Sensitivity test results are provided for <u>10% (lower) and 20% (higher) and GRDC's stated CSIRO attribution of 50%.</u>

The results of the sensitivity analysis are provided in Table 9.

Table 9: Sensitivity Test results

Variable (Overall)	**BCR/ROI** Without-With deadweight	**NPV** Without - With deadweight (PV in mil FY2020$)
Discount Rate		
No change (7%)/ Base Case	9.2-7.6	125-122
4%	11.4-9.5	142-139
10%	7.4-6.2	110-107
Adoption Rate		
No Change/ Base Case	9.2-7.6	125-122

Incremental increase of +10% vs base case over period of FY2018 to FY2027	11.8-9.8	164-161
Incremental decrease of -10% vs base case over period of FY2018 to FY2027	6.6-5.5	85-82
Incremental Yield Benefit (+-2%)		
No Change/ Base Case	9.2-7.6	125-122
Incremental increase of +2% vs base case over period of FY2018 to FY2027	12.5-10.4	175-172
Incremental decrease of -2% vs base case over period of FY2018 to FY2027	5.8-4.9	74-71
Variable (CSIRO)	**CSIRO BCR/ROI** Without - With deadweight	**CSIRO NPV** Without - With deadweight (PV in mil $$, 2020 $$)
CSIRO Case: Attribution		
No change (13%)/ Base Case	9.2-7.6	16.5-16.1
10%	6.9-5.8	12-11.6
20%	13.8-11.5	26-25.5
50%	34.6-28.8	68-67.5

Note: Real Discount rate of 7 per cent per annum, based on CSIRO. Feb 2020, 'Impact Evaluation Guide', p. 13. *SOURCE: CSIRO*

It is important to note that the overall benefits of any research work depend critically on the adoption profile and actual achievement of the economic, social and environmental benefits. The sensitivity analysis reported in Table 9 shows that change in CSIRO attribution will have a significant effect on CSIRO's BCR/ ROI and NPV. The incremental increase in yield benefit will have the most significant effect on the overall NPV.

8 Limitations of assessment & Recommendations

Limitations of assessment

Kindly also refer to Section 5 Clarifying the impacts

1. This evaluation uses a mixed methodology to evaluate the research impact arising from the Early sowing of canola project. It combines quantitative and qualitative methods to illustrate the nature of the economic, environmental, and social impacts of this work. In cases where the impacts can be assessed in monetary terms, a CBA is used as a primary tool for evaluation. As a methodology for impact assessment, CBA relies on the use of assumptions and judgments made by the author in conjunction with the research team. This relates primarily to the economic indicators for impact contribution, attribution, and the counterfactual. These limitations should be considered when interpreting the results presented in this case study.
2. The author makes significantly conservative estimates for this analysis and this may substantially underestimate benefits generated by CSIRO's contributions (refer to Section 7; attribution). Some other examples include, the overall area under canola production is assumed to be constant for the analysis period. Similarly, the increase in sales of hybrid seeds has not been considered. Both these factors would be expected to increase over the years, driven by greater adoption of this work.
   Due to the high magnitude of variation produced by even a small variation in adoption or attribution rates (see Table 9) which is further intensified by the absence of reliable benchmarking data; the analysis was consciously kept conservative. The main intent of this analysis is to demonstrate the growing significance of this work especially with the uncertainties posed by climate change and provide a snapshot of the potential of

the return generated from the investment for accountability, communication, engagement, continuous improvement and future application purposes.

3. Given the scope and budget for the analysis, we acknowledge that there are some limitations with regards to the evidence base of impacts.
4. The benefits are assessed over a 5-year period for Eastern Australia. However, with the changing environment and canola industry conditions, the real adoption of this work has potential to transform “new normal” for the industry with far-reaching benefits being realised Australia wide for the canola producers. Hence the overall benefits from this work have likely been underestimated.

Recommendations

1. This project, unlike many others specifically and successfully included two activities funded by GRDC to assess its impact as part of the project. Both activities surveyed growers and/or consultants responsible for the management of, or advice to, ~ 70% of the canola area in eastern Australia at the end of the project. The survey asked about practice change arising from the project. To the project leader’s knowledge, this is rare, although GRDC has done *Post Hoc* CBAs of other projects.

   Capturing pertinent pre and post data as business as usual activities to benchmark, monitor and measure impact can significantly help with effective impact management while strengthening impact capacity for the benefit of all stakeholders. The practice would also help recognize any caveats to assist with improved implementation and continuous improvement of the work thereby improving the likelihood of catalysing overall impacts. In the absence of this information, any measured impacts post completion of the project are at best, a guesstimate.

   Understandably, the availability and willingness of growers and consultants to engage in such an activity prior to its commencement, and even the development of relevant questions, when the research issues and outcomes are uncertain and immature, is questionable. However, earlier engagement of “survey/impact specialists” might be helpful to address some of these concerns. The specialists can refine the methods and techniques as the project evolves to serve the intended objectives. In most cases, this can add to overall project costs and it may seem prudent not to spend limited research funds; however, these practices can potentially generate significantly higher returns in the form of catalysed impacts, boosting stakeholder confidence and continuous improvement.

   Many organizations are progressively adopting these practices globally to foster a culture of integrated approach towards generating wider and stronger impacts.

2. Future work that includes monitoring and measurement of annual area under canola production and hybrid seed sales would help assess the impact of this work in reducing overall risk sentiment and driving canola production within Australia.

3. Unlike other countries there is little standardised or comprehensive data available on the management practices used by Australian farmers, and surveys to do so are often flawed. Remote sensing and other technologies could be helpful in future to answer some of these questions (e.g. satellite images to detect sowing, flowering and windrowing times) and the power of this would be large sample size and veracity (what actually happened rather than what the grower said happened). This highlights an opportunity area for CSIRO to champion the development of these techniques through its Digital Agriculture activities and potentially use projects like this one to road test strategies and monitor practice change.

Appendix A) Reference Documents

i) Optimised canola profitability research report

Available upon request

ii) Early sowing canola – communication activities

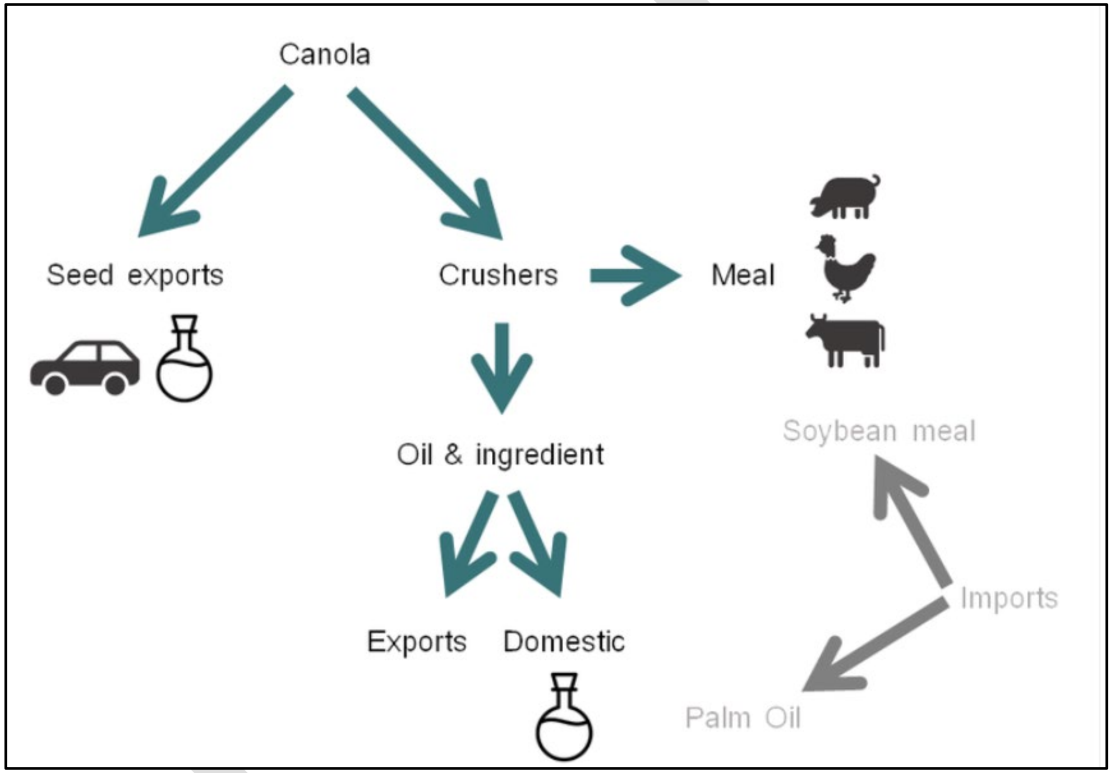
Communication Activities details.pdf

Appendix B) Key factors driving Early Sowing practices[10]

Uncertainties				
Cropping break date	Time to flowering	Probability and timing of frost	Aggregate Rainfall – April to Aug (incl – to flowering)	Rainfall, winds and temperature at the finish of growing season
Logistical considerations				
Effective work rate of the seeder	Effective hours/day seeding can be scheduled and maintained	Interruptions to the seeding process	availability of and willingness to use contractors	Burden of weed
Other Factors				
Yield response	Extent of effective weed control	Prior soil moisture in the area dry seeded	survival of prematurely germinated wheat seed	Season's rainfall, for at least part of the growing season

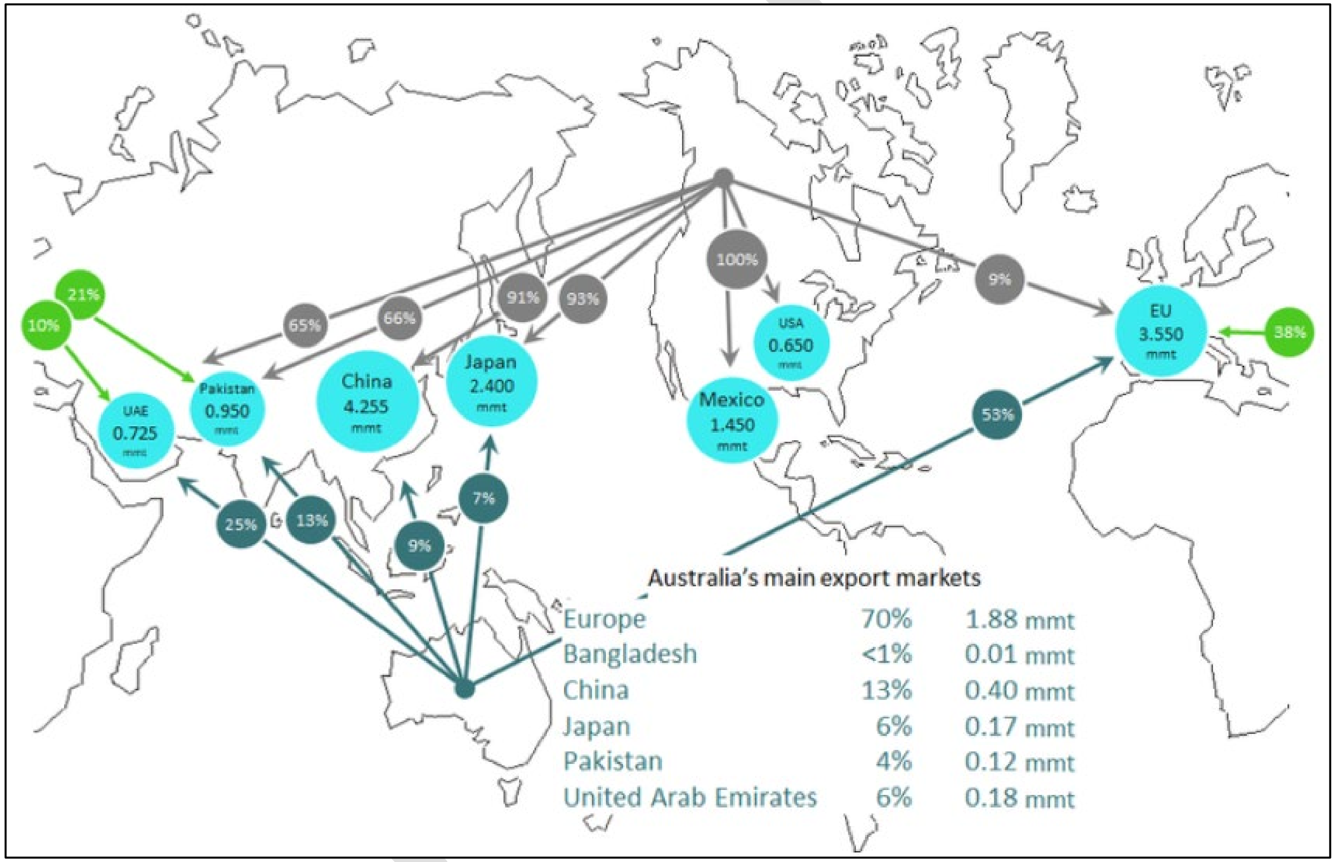
[10] Decisions under uncertainity: Seeding wheat befire the break. **David M Gray,** Department of Agriculture & Food WA, Katanning

Appendix C) Canola Uses[11]



[11] https://www.graincentral.com/cropping/oilseeds/dont-think-twice-its-all-right-australias-canola-exports/

Appendix D) Market share of Canola Exporters[12]



[12] https://www.graincentral.com/cropping/oilseeds/dont-think-twice-its-all-right-australias-canola-exports/