Australia's National
Science Agency

Dual-purpose canola Impact Case Study

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Acronyms

BCR	Benefit Cost Ratio
CBA	Cost Benefit Analysis
CSIRO	The Commonwealth Scientific and Industrial Research Organisation
DP	Dual-purpose
DPC	Dual-purpose canola
DPW	Dual-purpose wheat
FY	Financial Year
GRDC	Grains Research and Development Corporation
ha	hectares
MLA	Meat and Livestock Australia
Nd	No date
NSW	New South Wales
NPV	Net Present Value
Pers. comm	Personal communications
PhD	Doctor of Philosophy
PV	Present Value
R&D	Research and Development
TBL	Triple Bottom Line

1 Executive Summary

1.1 The challenge

Dual purpose cereals (cereal crops grown for both grain and grazing) have been a fundamental component of Australian mixed farming operations in southern Australia in recent decades. In particular, dual-purpose wheat has been successful and widely adopted. However, the success and intensity of its use in high rainfall zones led to increasing root and leaf diseases as the strategy did not allow for a break in the continuous grass-based system of cereal and grassy pastures.

In the early 2000's, CSIRO researchers hypothesised that canola could be another dual-purpose crop option providing a break for weed and disease control while also enabling increased flexibility and profitability in farming operations. It was theorised that canola could be sown-early and grazed during winter with no cost to subsequent grain production, providing a profitable break option in mixed farming systems.

1.2 The response

CSIRO researchers with financial input from research partners, conceived, developed and successfully translated the concept of dual-purpose canola into southern Australian mixed farming enterprises. CSIRO developed robust dual-purpose canola management guidelines by applying experimental understanding to scaled up crop and whole-farm models and to commercial case studies. Commercial adoption took place within five years of the commencement of research and today the practice is an integral part of the farming system in southern New South Wales. The fast adoption is credited to the significant and consistent research-industry engagement throughout the research and development phase.

1.3 The impacts

CSIRO's dual-purpose canola management technique has been widely adopted across southern NSW and in other mixed-farming pockets of southern Australia in Victoria, Tasmania, South Australia and Western Australia. At least 150,000 hectares of canola is estimated to have been grazed in southern NSW in 2021, and up to 200,000 hectares nationally.

The strategy is profitable at the individual paddock scale because grazing either comes at no cost to grain production, or the graze-grain income exceeds that of grain-only crops. The inclusion of dual-purpose canola also provides wider system benefits to underpin weed and disease control in dual-purpose cereal crops, and for perennial pasture establishment. Ultimately, it's inclusion in the farming system mitigates risk and increases enterprise flexibility.

We estimated that the net present value of benefits (for FY2006-FY2025) of dual-purpose canola research and adoption would be approximately $1.628 billion (or a benefit cost ratio of 152) in 2020/21 dollars, at a 7 per cent discount rate and given model assumptions. This was considered a lower bound estimate of total national impact as only southern NSW adoption data and benefits were captured in the quantitative analysis.

This significant return is reflective of the fast and extensive adoption, relatively inexpensive R&D and the annual, whole of farm enterprise benefits that adoption of dual-purpose canola is expected to deliver. Sensitivity testing reveals that even at the most pessimistic lower-range parameters the results remain positive (net present value of $344 million and a benefit cost ratio of 26.5). Overall, this provides confidence that the public investment into developing and extending dual-purpose canola has delivered a positive return on investment.

This estimate of economic benefit is confined to the first-order market effects of marginal productivity improvement on-farm and does not capture other non-priced economic, environmental or social benefits. Most notably, adoption of dual-purpose canola assists to mitigate farm risk and increase farm enterprise flexibility. For example, by filling winter and autumn feed gaps when forage availability is typically low, deferring grazing of pastures allowing improved spring pasture production and allowing capture of crop value earlier in winter (through grazing) when unfavourable spring conditions eventuate later. Broadly, the introduction of dual-purpose canola has facilitated an increased level of farm diversity and flexibility that has improved business resilience.

Environmental benefits are expected through control of weeds and diseases in subsequent pastures and crops, increased groundcover and improved whole of system nutrient and water use efficiency.

Finally, it is hypothesised that there are social impacts proportional to the economic and business resilience benefits of dual-purpose canola. Improved financial resilience in farming enterprises is likely to have contributed broadly to social resilience in rural and regional communities where these farming industries are a significant economic driver. Anecdotal evidence also indicates that there are likely to be mental health benefits for farm managers associated with the improved flexibility and risk mitigation benefits offered by dual-purpose canola.

Research and development to further the reach and impact of dual-purpose canola is ongoing. Projects are underway to further refine crop and animal management, develop an industry manual and promote further adoption, breed new varieties suitable for grazing and review livestock management to capitalise on this novel feed source.

Whilst CSIRO cannot and does not claim sole attribution to the benefits earned by dual-purpose canola, this case study provides confidence that the CSIRO, research partner and industry investment has delivered considerable positive impact for the nation.

2 Purpose of the case study and audience

The purpose of this case study was to assess the retrospective and prospective benefits of CSIRO's research and development investment into dual-purpose canola. The study highlights the economic, environmental and social benefits of the research, development and extension of the dual-purpose canola farming system in Australia. The analysis provides an estimate of the benefit-cost ratio of the investment accompanied by a qualitative summary of other non-priced economic, environmental, and social benefits.

This report can be read as a stand-alone item or alongside other CSIRO Agriculture and Food evaluations to substantiate the impact and value of CSIRO's activities against funds and resources invested in this program.

CSIRO as a service provider to the Government and industry is highly focused on delivering value and impact through the scientific interventions that originate from research activities. The information is provided for accountability, communication, engagement and continuous improvement 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, the project's collaborators, CSIRO, universities and the general public.

3 Background

Dual-purpose crops

Dual-purpose cereals (cereal crops grown for both grain and grazing) have been a fundamental component of Australian mixed farming operations in southern Australia in recent decades (Kirkegaard et al. 2008). Traditionally oats, triticale and wheat have been used for dual-purpose and CSIRO has a legacy of research in this field. In particular, dual-purpose wheat proved to be a highly profitable strategy and rapidly expanded (Kirkegaard et al. 2008). However, the success and intensity of its use in high rainfall zones led to increasing root and leaf diseases and grass weed control issues as the strategy did not allow for a break in the continuous grass-based system (Kirkegaard et al. 2012).

Canola (*Brassica napus*) was first unsuccessfully investigated as another dual-purpose crop option in the 1970's (Dann et al. 1977). It was hypothesised that canola, a broadleaf break crop sown earlier than usual and grazed by livestock in the winter could then be regrown to produce grain without yield penalty. Unfortunately, a lack of suitable varieties, difficulty establishing the crop and poor recovery post grazing made it unfeasible at that time (Kirkegaard et al. 2012).

CSIRO researchers revisited the concept in the early 2000's hypothesising that it would provide a much needed break for weed and disease control in existing dual-purpose wheat systems and enable increased flexibility and profitability in mixed farming operations (Kirkegaard et al. 2008; CSIRO per comms 2021). New systems (varieties and management) would need to be developed.

CSIRO's response

CSIRO researchers, with financial input from research partners, conceived, developed and successfully translated the concept of dual-purpose canola into Australian mixed farming enterprises between 2004-2009.

CSIRO conducted experimental research, farm trials, industry consultation, simulation modelling and significant industry outreach to achieve this. This led to the release of best-bet management guidelines and a decision support tool to demonstrate the whole-of-farm benefits in different environments based on quantitative systems analysis.

Significant and consistent communication to industry was maintained through engagement with the Grains Research and Development Corporation (GRDC), state agricultural departments, Universities, private advisers and industry groups from the research out-set. This allowed the tools and knowledge developed to be refined based on industry feedback and implemented appropriately and reliably with clients.

As a result, the first on-farm commercial adoption took place in 2007, less than five years after commencement of the research. Adoption expanded rapidly and has grown year on year especially after the release of commercial winter grazing varieties in 2011. As of 2021, the estimated size of dual-purpose canola in southern NSW is *at least* 150,000 hectares, the biggest plantings to date (CSIRO per comms 2020; Delta Agribusiness per comms 2021b).

Dual-purpose canola has become a highly profitable component of southern mixed farming systems in Australia. The enterprise is profitable at an individual paddock scale because grazing either comes at no cost to grain production, or the graze-grain income exceeds that of grain-only crops. The inclusion of dual-purpose canola has also been shown to provide wider system benefits to underpin weed and disease control in dual-purpose cereal crops, and for perennial pasture establishment. High biomass production of canola in the traditional autumn feed gap promotes rapid weight gain in livestock for earlier selling and/or trading opportunities, and its timing complements dual-purpose cereals grazed in sequence to extend the winter spelling of pasture (Kirkegaard et al, 2021).

Of note, in 2021 a mixed farming business in New South Wales claimed an Australian record harvest of 7.16 tonnes per hectare of canola and cited the dual-purpose cropping technique with the achievement (CSIRO, 2021).

CSIRO remains a scientific leader in this field of research as evidenced by the dominance of academic publications and citations on the topic. Research continues in partnership with GRDC, Meat and Livestock Australia (MLA) and State Government agricultural departments to refine approaches to crop and animal management, continue extension and adoption and develop an industry manual on dual-purpose crops. Recently, CSIRO has successfully secured co-investment from a private canola breeding company to investigate the potential of breeding new grazing canola varieties.

An impact pathway is used to identify the causal relationship of a project from the inputs through to impacts. Section 4 illustrates the impact pathway for the CSIRO and partners R&D investment into dual-purpose canola.

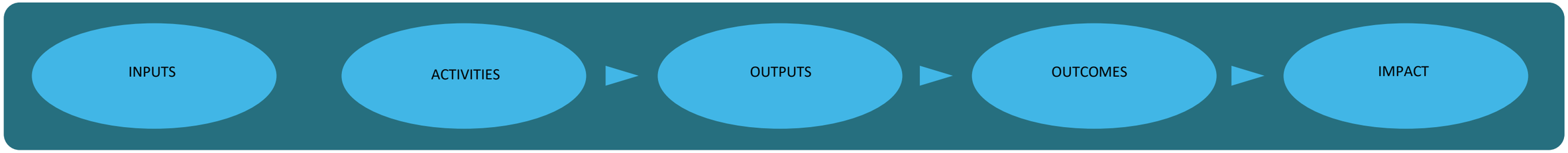
Key Stakeholders

- CSIRO (Plant Industry, Agriculture and Food)
- The Grains Research and Development Corporation (GRDC)
- Meat and Livestock Australia (MLA)
- NSW Government Department of Primary Industries (NSW DPI)
- Victorian Government Department of Primary Industries (VIC DPI)
- Western Australian Government Department of Agriculture (DAFWA)
- Various private agronomic consultants, grower groups and individual producers

Figure 1 Sheep grazing canola near Cowra in southern NSW

Source: CSIRO

4 Impact pathway



Funding

- CSIRO (financial and in-kind)
- External investment by:
  - Grains Research and Development Corporations (GRDC)
  - Meat and Livestock Australia (MLA)
  - State Government Agriculture Departments (NSW DPI, VIC DPI, DAFWA)
  - Charles Sturt University (CSU)

Research Capabilities

- Background knowledge and expertise animal nutrition, crop physiology, plant pathology agronomy, grazing management, soil science and resource management
- Access to infrastructure and resources to execute projects (e.g. on-site and off-site facilities including CSIRO Ginninderra Experiment Station)

Research and Development

- Research to maximise the productivity and profitability outcomes from the dual purpose systems
- Quantification of system benefits
- Farm experiments
- Simulation modelling to extrapolate findings across environments
- Small plot experimental work and larger scale on-farm trials
- Ongoing research to refine approaches with crop and animal management

Translation and communication

- Significant and consistent communication to industry through the media and other channels
- Ongoing engagement with private advisers
- Presentations of research findings at local and international conferences, industry and farmer events

New research knowledge and management strategies of dual-purpose canola farming

Best-bet management guidelines for dual-purpose canola

Systems analysis demonstrating whole-farm benefits of dual-purpose canola across Australia

Development of the 'Grazing Crop Lock-up Calculator'

External Network:

Working and productive networks and relationships between CSIRO, State Government agricultural departments, Research Development Corporations, private agronomic advisers, commercial canola seed companies and grower groups

Awards

- 2008 CSE G&G1 Award for cross-Divisional collaboration
- 2008 GRDC Seed of Light John Kirkegaard (DP Canola)
- 2011 CPI Chiefs Award for Excellence in Teamwork

Training

- 2 x PhDs
- 1 x Postdoctoral Fellow

Publications

- Numerous academic and industry publications

Uptake and adoption

- Widespread adoption of dual-purpose canola by farming enterprises across the southern states of Australia since 2008
- Indirect contribution to the importation and commercial release of canola varieties suited to grazing
- Influenced international research trials and investigation into the application of dual-purpose canola
- Influenced private investment into breeding of specific varieties for dual purpose use in Australia

Sustained co-operative relationships between CSIRO and:

- private advisers
- canola breeding companies
- grower groups
- state agricultural departments
- industry research development organisations

CSIRO is a science leader in dual-purpose canola internationally, authoring most of the research on this topic in the scientific literature

ECONOMIC IMPACT

- Improved productivity, profitability and management flexibility for mixed farming businesses in medium-high rainfall cropping regions
  - Increased grazing days and stocking rates without consequence to grain yield
  - Increased canola yields possible
  - Increased subsequent wheat yield
  - Reduced supplementary feeding requirements
  - Increased value obtained from spared pasture
- Mitigation of farm risk
  - Filling feed gap through valuable feed source during autumn/winter periods when forage availability typically low
  - Deferring grazing of pastures during winter period allows improved spring/summer pasture production and opportunities to control weeds
  - In dry conditions, allows capture of value of grazing crops in winter despite unfavorable spring conditions with no grain income

ENVIRONMENTAL IMPACT

- Rotational break crop providing weed and disease control in subsequent wheat crops and legume-based pastures
- Increased year-round ground cover leading to greater biomass production and greater carbon inputs into the farming system
- Increased water and nutrient efficiency due to increased ground cover reducing evaporative losses and deep roots using water and nutrients in the subsoil

SOCIAL IMPACT

- Contribution to more resilient rural communities due to improved financial rand risk resilience of farming enterprises
- Improved mental health amongst farm managers

2004-2010

2010 – 2021+

Figure 2 Impact Pathway for CSIRO's Dual-purpose canola research and development

5 Impact Evaluation

5.1 Inputs

CSIRO's inputs

- CSIRO Funding: $2.18 million (nominal, undiscounted); For more details see Table 1
- Background knowledge and expertise in animal nutrition, crop physiology, plant pathology agronomy, grazing management, soil science and resource management
- Access to infrastructure and resources to execute projects (e.g. on-site and off-site facilities, CSIRO Ginninderra Experiment Station, APSIM models)
- Expertise of crop and pasture agronomists, plant pathologists, grazing animal scientists, crop physiologists, simulation modellers and systems analysts as well as PhD students and postdoctoral fellows

Partner inputs

- External R&D Funding: $5.20 million (nominal, undiscounted); For more details see Table 1
- CSIRO received financial investment to develop dual-purpose canola from the Grains Research and Development Corporation, Meat and Livestock Australia and from the Western Australian, Victorian and New South Wales state agricultural departments. A contribution was also received from Charles Sturt University for the funding of a PhD student
- Informal in-kind advice from industry stakeholders during the research and development phase e.g. farmers, advisers and breeding companies. While critical, the financial magnitude of these in-kind costs is believed to be relatively small in comparison and is not quantified in this analysis (CSIRO per comms, 2021).

It is estimated that $7.39 million (nominal, undiscounted) was invested into the R&D of dual-purpose canola by CSIRO and partners between FY2004 and FY2020. This is equivalent to $10.75 million when adjusted for inflation and discounted at a real discount rate of 7% (base year FY2020) as per the CSIRO Impact Evaluation guidelines.

Table 1 Estimated R&D investment (nominal, undiscounted) into Dual-purpose Canola R&D

Year	CSIRO	GRDC	PhD project (CSU)	MLA	DAFWA	DPIVIC	NSWDPI
FY2004/5	$ 50,000	$ -	$ -	$ -	$ -	$ -	$ -
FY2005/6	$ 75,000	$ -	$ -	$ -	$ -	$ -	$ -
FY2006/7	$ 370,531	$ 150,000	$ 30,000	$ -	$ -	$ -	$ -
FY2007/8	$ 283,690	$ 150,000	$ 30,000	$ -	$ -	$ -	$ -
FY2008/9	$ 299,544	$ 175,000	$ 30,000	$ -	$ -	$ -	$ -
FY2009/10	$ 109,027	$ 128,316	$ 30,000	$ -	$ -	$ -	$ -
FY2010/11	$ 141,569	$ 174,108	$ -	$ -	$ -	$ -	$ -
FY2011/12	$ 137,128	$ 347,575	$ -	$ 22,007	$ -	$ -	$ -
FY2012/13	$ 111,213	$ -	$ -	$ 119,283	$ 332,258	$ 91,574	$ -
FY2013/14	$ 114,980	$ 200,000	$ -	$ 120,541	$ 360,856	$ 91,574	$ -
FY2014/15	$ 151,742	$ 198,789	$ -	$ 124,056	$ 379,906	$ 91,574	$ -
FY2015/16	$ 40,185	$ -	$ -	$ 46,727	$ -	$ -	$ -
FY2016/17	$ 27,460	$ -	$ -	$ 30,460	$ -	$ -	$ -
FY2017/18	$ 80,124	$ 132,296	$ -	-	$ -	$ -	$ 306,457
FY2018/19	$ 48,038	$ 132,296	$ -	-	$ -	$ -	$ 306,457
FY2019/20	$ 65,191	$ 132,296	$ -	-	$ -	$ -	$ 306,457
FY2020/21	$ 80,348	$ 132,296	$ -	-	$ -	$ -	$ 306,457
TOTAL	**$ 2,185,770**	**$ 2,052,972**	**$ 120,000**	**$ 463,074**	**$ 1,073,020**	**$ 274,722**	**$ 1,225,828**

SOURCE: CSIRO

5.2 Activities

Research and Development

- Research to maximise the productivity and profitability outcomes from the individual canola and cereal components of dual-purpose systems
- Quantifying the system benefits arising from integrating both options on a mixed farm
- Farm experiments to quantify benefits
- Experimentation and simulation modelling to extrapolate these findings across environments nationally
- Small-plot experimental work, larger scale on-farm trials and development of case studies involving growers and consultants
- Refinement of the dual-purpose concept and development of credible evidence of the multiple benefits of the technology in conjunction with feedback from on-farm experiences
- Further international testing of concept
- Ongoing research with GRDC and MLA to refine approaches to crop and animal management and adoption of dual-purpose canola

Translation and communication

The successful translation of dual-purpose canola from research into real-world outcomes is undisputable. According to one private consultant:

'[Dual-purpose canola] has been a major change in our part of the world right across the board. It provides a phenomenal amount of profit and wealth for growers and is an integral part of the system now…]'

- Delta Agribusiness per comms (2021a)

The CSIRO research team was able to achieve this fast and widespread adoption in southern NSW and nationally by:

1. ***Having insight and understanding of what drives farmers and their decisions around cropping and grazing practice***

By having a multidisciplinary science team (including agronomy, plant physiology and pathology, soil science, animal nutrition, crop simulation and systems analysis, economics and risk assessment) CSIRO was able to ensure that every aspect of the research was covered. This, combined with forging enduring and productive two-way relationships with industry, meant that they were able to develop a thorough understanding of the needs of their end-users and adapt the research agenda as required given the breadth of capability available.

2. ***Instigating thorough industry collaboration from the outset of the research***

From the outset, the research team engaged with growers, private advisers and canola breeders to thoroughly investigate all facets of grazing canola to ensure that there were no research gaps. There was considerable trust developed between the CSIRO team and industry during this process allowing early testing and uptake (CSIRO per comms, 2021).

Embedding growers, advisers, and breeders in research projects from the beginning ensured that the research outcomes were relevant and adoptable (Kirkegaard, 2021). This approach of open and active engagement with all industry collaborators has been commended by industry stakeholders and credited with the early and widespread successful adoption (Condon, 2021).

The ongoing engagement allowed incorporation of feedback and facilitated ongoing refinement and improvement of the research outputs. The two-way relationship between the research team and industry allowed them to try new concepts, share ideas and fully explore the concept (Ibid, 2021).

For example, as farmers increasingly grazed their canola, advisers were challenged to provide advice on when to stop grazing to maximise grain yield. The research team responded by implementing experiments and modelling analysis to address these questions. Eventually this resulted in a decision support tool that evaluated the current grazing value compared to the impact on final grain yield.

3. ***Successive research projects allowing continuity and consistent communication to industry***

The CSIRO research team undertook significant and consistent communication to industry through a wide variety of media. On average, two communication activities per week during the research phase and the research team estimate approximately 4000 farm businesses per year were influenced through this (CSIRO, per comms 2021). The team were also frequently invited to present the research findings and recommendations at the GRDC and various farmer events, fields days, presentations and conferences throughout the R&D phase (CSIRO per comms, 2021).

Funding across four successive research projects (over 10+ years) with the GRDC enabled this consistent communication with potential end-users. Consistent communication over this length of

time provided confidence to adopters and local advisers who were then willing to take the concept forward themselves.

4. Demonstrating and quantifying the concept as part of the whole farming system

The research process included demonstrating the concept in numerous farming system trials in collaboration with the NSW Department of Primary Industries and GRDC (Condon, 2021) and attempting to quantify its value at the farm scale. This allowed an understanding of the impact of the technique on the entire farming system to be understood and communicated to potential adopters (Kirkegaard, 2021).

National adoption

Adoption outside of southern NSW was first prompted through a nationally focused research project where local research nodes were set up in the high rainfall areas of Western Australia, South Australia, Victoria and Northern NSW between 2010-2012. By taking six years of previous research and adapting it to local conditions, adoption commenced nationally. More recently, local dual-purpose canola research with Meat and Livestock Australia has taken place in Victoria.

While climatic, soil and livestock factors inevitably constrain the area of potential adoption nationally, reduced proximity to dual-purpose canola research activity (since the active research program concluded) has likely led to a plateauing of adoption outside of southern NSW (CSIRO, per comms 2021). While the area is slowly expanding, the current CSIRO co-investment with a canola breeding company to expand variety suitability is expected to promote further national adoption in the near future.

International engagements

- A number of collaborative international engagements took place with international peers during the course of research including with the Agriculture and Agri-food Canada, University of Copenhagen, Marie Coque (BioGemma, France) and the University of Goettingen.
- CSIRO researchers attended numerous international meetings including but not limited to:
    - The European Society of Agronomy meeting, Hungary, August 2014 “Have your canola and eat it too!”
    - The American-Argentine Animal Production Conference, Buenos Aires “Improving eco-efficiency and reducing risk through crop-livestock integration” –21 October 2014.
    - INTA Invited Lecture, Balcarce, Argentina “Opportunities for agriculture-livestock integration” –27 October 2014

5.3 Outputs

Best-bet management guidelines for dual-purpose canola

CSIRO developed evidence-based agronomic and grazing management guidelines and decision tools. Guidelines provide robust, region-specific recommendations for varietal selection and management to maximise productivity, resource-use efficiency and minimise environmental and business risk.

Systems analysis demonstrating whole-farm benefits of dual-purpose canola

The team quantified the benefits and risks of dual-purpose canola at a range of sites across Australia through simulations using experimental and case study data at the paddock, farm and enterprise scales.

Development of the 'Grazing Crop Lock-up Calculator'

An excel-based tool was developed to predict the impact of grazing timing, lock-up date and residual biomass on the likely yield penalty.

New research knowledge and management strategies

Novel management strategies were developed to increase the area, productivity and resilience of mixed farming systems and included:

- the dual-purpose canola concept
- mineral supplementation of grazed crops for increased animal production, and
- whole-farm synergies arising from the integration of dual-purpose canola and cereals within a mixed farming system.

Awards

- 2008 CSE G&G1 Award for cross-Divisional collaboration
- 2008 GRDC Seed of Light John Kirkegaard
- 2011 CPI Chiefs Award for Excellence in Teamwork

Key Publications

List of key publications can be found in Appendix B.

Key communications

- Landline program, Australian Broadcasting Corporation (2011)
- Significant rural media and grower communications
- Numerous GRDC Updates
- Numerous farmer field days and grower presentations
- GRDC funded national workshop of Dual-purpose cropping from which a special issue of Crop and Pasture Science was published (2015, Volume 66).

PhD and Postdoctoral Fellow training

Two PhD's and one postdoctoral fellow were trained during the course of the research increasing Australian research capacity.

- Dr Matthew Harrison (PhD - Australian National University) The Physiology of Crop recovery
- Dr Jeff McCormick (PhD – Charles Sturt University) Growth, development and yield of dual-purpose canola (*Brassica napus*) in the medium rainfall zone of South East Australia.

- Dr Susie Sprague (Post-doctoral fellow)) Impact of grazing on Blackleg (*Leptosphaeria maculans*)

5.4 Outcomes

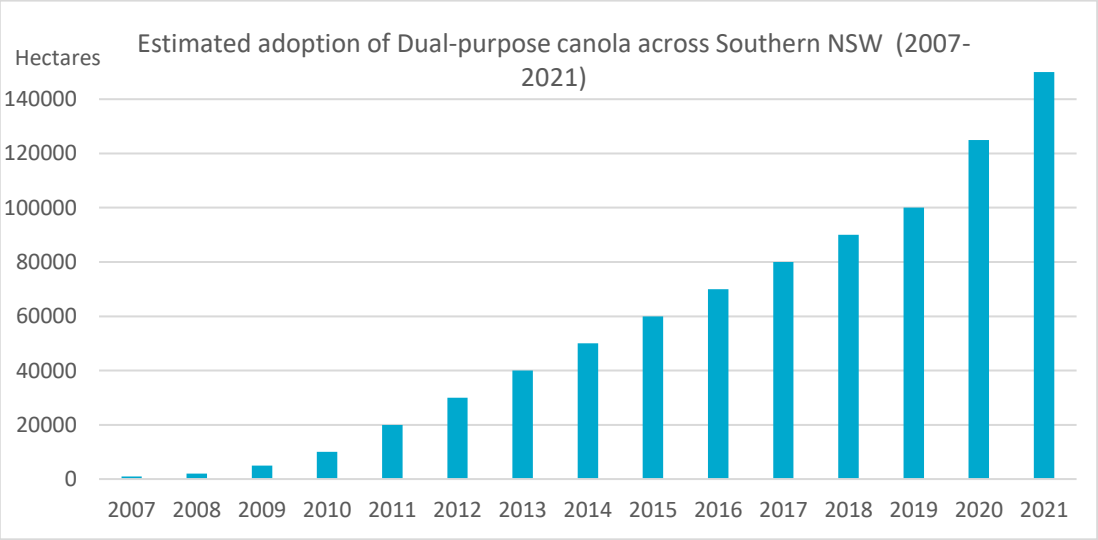
Uptake and adoption

Commercial adoption of dual-purpose canola first commenced in 2007 on farms near Galong, New South Wales. By 2015 the area had continued to steadily increase, with some canola grazing in all southern states across medium and high rainfall zones (CSIRO, per comms 2021). While the main area of adoption remains across southern NSW, it has also been adopted in other regions in southern Australia in Victoria, Western Australia, South Australia and Tasmania.

As of 2021, it is reported that dual-purpose canola has become standard practice and an integral part of the mixed farming system (in southern NSW) and in the past 5 years has been reaching into areas that have not traditionally been used for cropping (Delta Agribusiness per comms, 2021b). Private advisers report that the area of adoption has been growing year on year and 2021 is the biggest plantings ever seen (Ibid, 2021). There is believed to be scope for further adoption into the future, however, this will be constrained in lower rainfall regions with higher heat and stress risk areas until more suitable varieties become available for grazing canola in these environments (Delta Agribusiness, per comms 2021a).

Adoption estimates herein are for southern NSW only based on surveys of private consultants, seed sales from canola seed companies and informed CSIRO researcher estimates for the intervening years. Adoption is particularly difficult to estimate as farmers sometimes retain seed to re-seed, potentially leading to significant underestimates of the actual areas planted.

It is estimated that *at least* 150,000 hectares have been grazed in southern NSW in 2021 (CSIRO per comms, 2021; Delta Agribusiness and Elders consultant survey, 2021). Other pockets of adoption in all southern states have occurred. In 2021, there is a further 50,000 hectares comprised of approximately: 32,000 hectares in Victoria, 12,000 in South Australia, 4,000 in Tasmania and 2,000 in Western Australia bringing total current national adoption to approximately 200,000 hectares (Ibid, 2021).



SOURCE: CSIRO per coms (2021), Delta Agribusiness and Elders survey (2021)

International trials and adoption

Throughout the course of the research, CSIRO researchers have engaged with research peers internationally and trials have taken place in the USA, China, France, Argentina, Canada and New Zealand further broadening and refining the concept. Recently, CSIRO researchers have received feedback from peers in the United Kingdom that have been inspired to investigate applications of dual-purpose canola and its principles in their local context (CSIRO per comms, 2021).

Sustained co-operative relationships

Throughout the research, CSIRO has developed and maintained productive working relationships with research and development organisations, private consultants, and canola seed companies.

Private advisers interviewed in the course of this case study noted *'…There has been a great working relationship with John and his team at CSIRO…they involved us very early and the collaboration was very strong'* and *'John and team have a very strong relationship with a lot of clients and are highly respected and regarded' (*Delta Agribusiness per comms, 2021a and b).

Demonstration of these sustainable relationships and trust in CSIRO to deliver in this field is also evidenced by the repeat investments by GRDC in CSIRO dual-purpose canola research over multiple investment cycles since 2004. More recently, there has been co-investment with CSIRO by a canola seed company to pursue breeding development of a new canola variety specifically developed for grazing, further evidencing ongoing co-operative and collaborative partnerships in this field of research. GRDC have also funded a literature review and development of a technical annual to further increase adoption of successful DP canola systems.

Contribution to the development and release of new commercial varieties in Australia

The research stimulated investment from breeding companies to release canola varieties specifically for grain and graze purposes, the first of which were released in 2011 with new varieties and more companies releasing lines (mostly imported directly from Europe) since then. This was necessary given that winter canola varieties typically grown in Europe are better suited for grazing opportunities in the high rainfall zones of Australia.

Royalties

There are no royalities earned by CSIRO for dual-purpose canola.

Science/research leader

The CSIRO team has led the scientific enquiry of dual-purpose canola internationally authoring almost all of the research on this topic in the scientific literature. 24 journal articles have been published on the topic and cited over 360 times (CSIRO, per comms 2021). Scientific research leadership is demonstrated through several invitations to present on the topic at international conferences and at over 30 industry supported forums throughout the years (Ibid, 2021).

5.5 Impacts

Table 2 Summary of project impacts using CSIRO triple bottom line (TBL) benefit classification approach

Type	Category	Indicator	Description
Economic	Productivity and efficiency	Improved farm productivity and profitability	Improved productivity, profitability and management flexibility for farming businesses in medium-high rainfall cropping regions due to: • Increased grazing days and stocking rates without consequence to grain yield • Increased canola yields possible • Reduces supplementary feeding requirements • Increased value obtained from spared pasture • Providing capacity to pay for lime on acid soil • Increased subsequent cereal yields
	Management of risk and uncertainty	Reduced farm risk	Mitigation of mixed farm risk due to: • Filling feed gap as a valuable feed source during winter periods when forage availability (and therefore stocking rates) typically low • Deferred grazing of pastures during winter period allows improved spring/summer pasture production and opportunities to control weeds • In dry conditions, allowing capture of value of grazing crops in winter despite unfavourable spring conditions with no grain income
Environmental	Land quality	Improved landscape function	Rotational break crop providing weed and disease control in subsequent wheat crops and legume-based pastures Increased year-round ground cover leading to greater biomass production and greater carbon inputs into the farming system Increased water and nutrient efficiency due to increased ground cover reducing evaporative losses and deep roots using water and nutrients in the subsoil
Social	Resilience	Sustained rural communities	Indirect benefit of improved resilience in rural communities due to improved profitability and reduced risk exposure of farm enterprises in dual-purpose canola areas.
	Health and wellbeing	Improved mental health	Indirect benefit of improved mental health and resilience amongst farm managers due to increased business flexibility, profitability, and mitigated risk.

6 Economic modelling

Cost Benefit Analysis (CBA)

This section details the method of calculating the benefit cost ratio (BCR) in this analysis.

The formula for calculating a benefit cost ratio is defined as economic benefits (Present Value) divided by the research, adaptive development and extension costs (Present Value).

$Benefit\ Cost\ Ratio = PV(B_t)/\ PV(C_t)$

Where

$PV(B_t)$ *is the present value of the benefits at time t*

$PV(C_t)$ *is the present value of the costs at time t*

The benefits calculated in the analysis are the net benefits from the program, that is, the difference between the 'with' and 'without program' scenarios. Costs and benefits have been recalculated in order for them to be expressed in a dollar value at a common point in time, namely in 2020/21 AUD dollars, using the Consumer Price Index. Present value calculations of costs and benefits have also been harmonised so that they have a common base year (2020/21) across the program. A real discount rate of 7 per cent has been assumed in these present value recalculations[1].

The costs considered in the cost-benefit analyses include the costs incurred by CSIRO and its research partners to produce the research outputs. Additional in-kind contribution is believed to be small in comparison, and was not estimated.

The economic assessment for this study focuses on the adoption of dual-purpose canola by farming enterprises in southern Australia. This section provides an estimate of the realised and potential future impacts through an incremental profit farm level approach capturing the first round effects.

Given that the incremental farm level approach does not account for second order market effects, the potential effects of a supply shift on the market are discussed in the sensitivity analysis (Section 7). This is not part of the CBA but helps provide context and consideration for the broader impact on industry as a result of the assumed productivity benefits on individual farms.

Usage and adoption costs

Where data is available usage and adoption costs borne by end-users should be included. There are expected to be little to no on-farm adaptation costs associated with adopting dual-purpose canola for those who already have a cropping enterprise. However, this will depend on the nature of the existing enterprise adopting canola (CSIRO, per comms 2021). A 25% discount on the incremental benefits expected for livestock pasture-only enterprises is applied to discount for unaccounted adaptation costs of these enterprises adding cropping to their farm enterprise (e.g. additional equipment, machinery, infrastructure). This is expected to be a high estimate, keeping the analysis conservative (CSIRO, per comms 2021).

[1] *As per CSIRO (2020) Impact Evaluation Guide p. 13*

The research has also prompted private investment by Australian canola seed companies to import and release new grazing-suited canola varieties. It is assumed in this analysis that the price of the seed sold (within the incremental farm profit gross margin calculations) is equivalent to the marginal cost of selling the seed. That is, equivalent to the costs incurred by canola seed companies to release the grazing suitable varieties. This means that the additional cost incurred by local canola seed companies to import grazing suitable varieties is covered in the price paid for seed by the producers adopting dual-purpose canola.

Perspective and stakeholders

For most CSIRO impact case studies the scope of benefits quantification is national. In this instance, the adoption has mostly taken place by farming enterprises in southern NSW. As the CBA needs to be conducted from Australia's perspective, it includes economic costs and benefits arising from CSIRO as well as other potential stakeholders of this project. Given the direct benefits accrue to southern Australian farm enterprises in areas currently suitable for dual-purpose canola and this is the only adoption data available, the distribution of benefits in this analysis is skewed towards these stakeholders.

CBA cases

Cost benefit analysis has been conducted for the period FY2004 to FY2025 and estimates the first-round effects of CSIRO's dual-purpose canola management technique on the Australian economy and community. This analysis determines:

- A base case (status quo) i.e. a benchmark to compare counterfactual scenario representing the possible outcome in the absence of the introduction of dual-purpose canola, and
- The project case that estimates incremental farm level profit benefits from adoption of dual-purpose canola.

Base Case (counterfactual) – without dual-purpose canola scenario

The counterfactual represents a situation where CSIRO and partners did not engage in the research, development and extension of dual-purpose canola in 2004. As a result, the pre-existing farming enterprise structures are assumed to have continued in lieu of the available option of incorporating dual-purpose canola (e.g. pasture only livestock enterprise or mixed farming with no crop grazing).

Following the initial lack of success with dual-purpose canola in the 1970's, no-one pursued its development until CSIRO re-conceived the idea and successfully developed it in the mid 2000's. To date, CSIRO remains the global leader in the research.

One industry stakeholder corroborates that the development of dual-purpose canola was likely to be, at least, significantly delayed in the absence of CSIRO:

> *'It's still not used anywhere elsewhere in the world, so it's reasonable to expect that it wouldn't have happened in a hurry but may have been possible and worked out eventually by someone else.'*
>
> - Delta Agribusiness per comms (2021a)

Therefore, we cannot assume that there would have been no development of the practice at all in the absence of the CSIRO program. Given that it is possible others may have produced similar research outputs but on a delayed timeframe and/or on a smaller scale we include a 50% discount on the incremental profit gain attributable to dual-purpose canola from 2014 onwards (i.e. 10 years delayed development).

This accounts for a non-zero gain in the counterfactual scenario. This 50% discount in benefits is arbitrary but accounts for the significant role CSIRO has played and still plays dominantly in this field. This is tested at 0% and 80% in sensitivity testing.

Project case – with dual-purpose canola scenario

The individual value of grazed canola at the paddock level is significant and often the most profitable enterprise on a mixed farm. According to Kirkegaard et al. (2020b) whole-farm benefits can accrue to produce returns of up to $1000 per hectare of crop above those of grain-only crops in higher rainfall zones of southern NSW.

However, dual-purpose canola benefits both the livestock and crop enterprise and has wider system benefits for farm profitability such as increasing subsequent pasture availability (Ibid, 2020b). When whole farm profit is considered, incremental farm profit per hectare depends on a number of factors including what existing enterprise is being replaced, where it is being implemented geographically, how well the management practice is implemented and the relative profitability of grain and forage.

Motivations to adopt are varied and change over time depending on prevailing circumstances such as buoyant lamb prices or shifts in weather patterns to more reliable late rain (Delta Agribusiness per comms, 2021). According to a private adviser, existing mixed farm enterprises are likely to have been the majority of adopters choosing to add grazing to their existing crops in the early days but more recently there has been a shift towards traditionally livestock pasture-only enterprises adopting dual-purpose canola (Ibid, 2021).

As such, in the project case the incorporation of dual-purpose canola into farming enterprises is divided into three 'regions of impact' based on the informed advice of CSIRO researchers and private advisers. These three regions (See **Error! Reference source not found.**) broadly model low, medium and high farm profit impacts expected to accrue due to the addition of grazed canola to the farming enterprise. Assumptions are made broadly about average farm sizes and proportion of dual-purpose canola to total farm size in each of these regions based on stakeholder advice. Assumptions about each regions adoption as a proportion of total hectares over time is made based on advice from informed stakeholders (CSIRO per comms, 2021; Delta Agribusiness per comms 2021b).

Given less certainty about adoption and benefits outside of southern NSW, the quantitative analysis only estimates impact based on data for southern NSW. While benefits in other southern states is expected to broadly replicate that seen in southern NSW (CSIRO, per comms 2021,) there is insufficient precision in the estimates to include in the analysis at this time. As such, the analysis remains conservative, and the results are expected to be a lower-bound estimate for total national impact.

Time period and Costs

Table 3 CBA Analysis – Timeline and Costs Table

Timeline	Costs: FY2004 to FY2020 Benefits: Ex-post: FY2007 to FY2020 Ex-ante: FY2021 to FY2025
Costs	It is estimated that CSIRO and partners invested $7.39 million (nominal, undiscounted) or $10.75 million (real, discounted) financially towards the total R&D FY2004 and FY2020.

The analysis involves a component of *ex-post* analysis (relating to the costs and benefits in the period FY2004 to FY2020) and a component of *ex-ante* analysis forecasting the benefits flowing from the research activities over the period FY2021 to FY2025.

No benefits beyond FY2025 have been estimated. Private advisers have advised CSIRO that the area of adoption is steadily increasing though will be limited in the future by the need for earlier maturing varieties and seed availability (Delta Agribusiness per comms, 2021a). Thus, the adoption forecast herein is capped at five years. This is arbitrary but necessary given the increasing uncertainty associated with forecasts into the future.

It should be noted that benefits may continue to accrue post 2025 but this is beyond the scope of the analysis. No R&D costs beyond FY2020 (present day) are captured in this analysis.

Attribution

CSIRO conceived the research concept and was the primary organisation responsible for the research and development associated with dual-purpose canola. This research was funded largely by CSIRO, GRDC and MLA and with contributions from Universities and state agricultural departments. Given CSIRO's central and crucial role in the R&D and translation of dual-purpose canola, we allocate 70% of the research benefits to CSIRO. This is tested in sensitivity testing. This has been corroborated with key stakeholders who stated:

> '*…Absolutely it's true that a very high proportion of the benefits should be considered CSIRO's.'* - Delta Agribusiness per comms (2021a)

The remaining 30% of benefits is shared between the funding research collaborators, canola seed companies bringing more suitable grazing canola varieties to the market and private advisers and their clients involved in the successful translation of the research outputs.

Quantifying Benefits – Incremental farm profit

Incremental farm level profits are estimated through marginal farm gross margin per hectare afforded by adopting dual-purpose canola in the farming system. As described above, these are broad estimates for three on-farm 'impact regions' depending on a number of variables. These low, medium and high impact region assumptions are described in Table 4. Broader benefit model assumptions are listed in Table 5.

Table 4 Estimated average whole farm profitability impact across southern NSW

Impact magnitude	Typical area	Enterprise use	Average dual-purpose canola area per farm (ha per year)	Average farm size (ha)	Increase in farm profit (per farm ha)
High farm profit impact	Tablelands (e.g. Goulburn, Yass, Oberon, Crookwell, Holbrook)	Grazing crops (winter wheat and canola) introduced into grazing-only enterprises to replace pasture. Stock trading Diversify business.	100	1000	$200-400
Medium farm profit impact	Slopes (e.g. Cowra, Canowindra, Young, Harden, Junee, Wagga, Henty)	Used on mixed farms to replace grazing oats or grain-only canola – winter and spring canola. Increases winter stocking rates. Used for trading and breeding enterprises.	100	2000	$100-200
Low farm profit impact	Plains (e.g. Dunedoo, Forbes, Temora, Lockhart)	Used opportunistically for grazing opportunities of existing spring canola. Some planned graze-only winter crops.	50	3000	$50

SOURCE: CSIRO per comms (2021); Elders and Delta agribusiness consultants survey (2021); Kirkegaard et al (2020b); McGrath (Nd, unpublished manuscript); Kirkegaard, J. et al (Nd)

Dual-purpose canola has been demonstrated to increase farm profit on the Tablelands, Slopes and Plains of southern NSW. However, CSIRO researchers note that higher whole-farm profit relies on attention to detail with crop and livestock management. Establishing the right crop early and correct lock-up time are key to increase profit and reduce risk (Kirkegaard et al., 2020b). This analysis uses the lower bound marginal increases in profit per hectare provided in Table 4, noting that this model assumes optimal implementation of the dual-purpose grazing approach.

Lower bound estimates are further discounted by 10% in all regions for potential unaccounted for non-cash labour costs due to increased complexity of this management technique. CSIRO researchers acknowledge potential marginal increases in management complexity though expect these to be small for the majority of producers. In most cases, any increase in management complexity is at most expected to be some additional monitoring of animal health (CSIRO per comms, 2021).

Finally, the marginal profit increase estimate for the Tablelands (high profit region) is discounted by a further 25% to account for potentially unaccounted for up-front capital or other adaptation costs incurred by enterprises introducing cropping in previously livestock only enterprises. This is arbitrary but necessary given uncertainty in these potential additional costs. Additional adaptation costs are not modelled for enterprises that already comprise a cropping component in their business.

Table 5 Benefits assessment model assumptions

Model assumptions		
Description	**Main assumption**	**Source**
Discount rate	7%	CSIRO Impact Evaluation Guidelines (2020)
Incremental improvement in whole-of-farm profit per hectare (low/medium/high impact regions)	$50/$100/$200/ha	See Table 4
Estimated proportion of total farm hectares sown with DP Canola (low/medium/high impact regions)	2%/5%/10%	See Table 4
Estimated proportion of total DP crop in each 'impact region' (low/medium/high)	Various	CSIRO per comms (2021)
Moderation of incremental benefits to account for non-zero benefits in counterfactual scenario	50% after 10 years (i.e. 2014 onwards)	Author estimation
Moderation of incremental benefits for additional non-cash labour due to increased management complexity	10%	Author estimation
Moderation of incremental benefits for farm enterprise adaptation costs (Tablelands)	25%	Author estimation
CSIRO attribution to benefits	70%	Author assumption
Benefits timeframe	Ex-post: FY2007 - FY2020 Ex-ante forecast: FY2021 - FY2025	Author assumption based on informed stakeholder advice

Scaling up of dual-purpose canola hectares to total farm hectares is based on an assumed fixed proportion of dual-purpose canola to total farm hectares for each region. See Table 4. For example, for every 100 hectares of dual-purpose canola planted in the 'high farm profit' region 1000 farm hectares are expected to benefit (i.e. 10% of property is assumed to be planted to dual-purpose canola).

The assumptions made here are conservative and the lower bound estimates are used in all instances. However, the results should be viewed with care due to data limitations, the use of representative farm assumptions, best estimates of adoption and anecdotal advice. The analysis provides an informed estimate only of the realised and potential net on-farm first round benefits of the adoption of dual-purpose canola. Sensitivity testing is conducted on all key parameters.

7 Results

As stated above, the economic benefits captured in this analysis are the estimated aggregated incremental farm level profits of adopting dual-purpose canola. The adoption data and impact data available and included in this model represents southern NSW only, where the majority of adoption has taken place. Therefore, this estimate is considered a lower bound estimate of total national impact.

On this basis, the Net Present Value (NPV) and benefit cost ratio (BCR) are presented in Table 6. However, this should be interpreted in the context of the parameter range testing and second-order market effects (not captured in an incremental farm profit level approach) discussed in the sensitivity analysis. **The whole of program result is a NPV of $1628 million (2020/21 AUD) with a BCR of 152.**

Table 6 Dual-purpose canola case-study CBA results. Basis: all investment costs (all $ in million, 2020/21 AUD)

Scenario	PV costs	PV benefits	NPV	BCR
Improved farm level profits due to adoption of dual-purpose canola	10.7	1,639	1,628	152

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

To estimate the return on CSIRO's contribution to dual-purpose canola, it is assumed that 70% of benefits are attributable to CSIRO. On this basis, the NPV and BCR for CSIRO is calculated as NPV $1027 million (2020/21 AUD) with a benefit-cost ratio of 289.

Table 7 CSIRO only Dual-purpose canola case-study CBA results. Basis: CSIRO investment costs (all $ in million, 2020/21 AUD)

Scenario	PV costs	PV benefits	NPV	BCR
Improved farm level profits due to adoption of dual-purpose canola	3.5	1031	1027	289

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

The results indicate that the CSIRO and research partner investment into dual-purpose canola research has had and will have considerable net positive impact. While only considering first round effects (see next section) and making broad assumptions about farm characteristics and adoption, the results provide confidence that the public investment in developing and extending dual-purpose canola across 2004-2020 has been wise. The significantly positive result is in part due to the relatively inexpensive cost of this R&D, the fast and significant adoption since 2007 and the recurring annual and farm system wide benefits that are modelled to accrue across the whole farm.

Sensitivity Analysis

Sensitivity analysis has been conducted to account for inherent uncertainty in model assumptions and to gauge the effect of a deviation in the parameters presumed for the analysis. The CBA is necessarily based on a series of assumptions which implies that there is a degree of uncertainty around the results. To address the above issues, sensitivity analysis (see Table 8) is performed on each key parameter. Sensitivity testing is performed on whole program costs and benefits, one parameter at a time.

Table 8 Sensitivity testing results (each parameter range tested individually; all others held equal; all $ in million, 2020/21 AUD)

Parameter		Low	Assumption (Model)	High
Discount rate		**5%**	**7%**	10%
	NPV	1564	1628	1753
	BCR	170	152	130
Whole of farm incremental profit gain/ha (low/medium/high profit regions)		**$25/$50/$100/ha**	**$50/$100/$200/ha**	**$100/$150/$300/ha**
	NPV	808	1628	2291
	BCR	76	152	214
Non-zero counterfactual benefits gain		**0%**	**50%**	**80%**
	NPV	**3359**	**1628**	**589**
	BCR	**313**	**152**	**55**

Testing from the lowest to highest ranges on key all parameters maintained positive NPV and BCR in all cases. When all parameters listed in Table 4 are set to the most pessimistic estimates, the result is a more modest but positive net present value of $344 million and a benefit cost ratio of 26.5.

The above results are performed with both the ex-post (FY2006-FY2020) and ex-ante (forecasted FY2021 to FY2025) components of the analysis. Given that forecasting adoption has a high degree of uncertainty, the results are tested with the removal of all forecasted adoption. The result (all other assumptions held constant) is a benefit cost ratio of 99 and net present value of $1054 million. This is equivalent to saying that the adoption of dual-purpose canola is estimated to have already delivered $1054 million in first round, economic benefits in present value terms as of 2021, given model assumptions.

Second round economic effects of improved productivity on farm

The incremental farm profit approach utilised in this analysis only accounts for the first-round effects of a productivity increase, that is the value of an increase in livestock and crop productivity per hectare calculated on fixed prices and areas. However, in the medium to longer term, widespread adoption of a profitable new technology will result in expansion in the aggregate supply, with consequent impacts on prices and volumes at all other stages of the value chain. The aggregate benefits of these price and quantity changes in the value chain are measured by changes to producer and consumer surplus.

Thus, the CBA analysis in this case study does not illustrate how the gross benefits from the increase in livestock or grain industry productivity are distributed across the various stakeholders nor how overall producer or consumer surplus change may change as it flows through the market.

The net benefits calculated in the analysis should be interpreted as a ballpark approximation of present value benefit, representing aggregated on-farm profits only. Any discussion of national benefits should be considered in the context of potential flow-on and distributional affects across the value chain.

8 Non-quantified impacts

8.1 Non-priced economic impacts

The preceding economic analysis has captured the economic benefits of dual-purpose canola that can be estimated through an incremental gain in farm profit per hectare. For example, increased grazing days and stocking rates without compromising canola yield and reductions in supplementary feeding costs increased pasture values. However, there are wider economic system benefits that are difficult to capture in a farm profit per hectare calculation. Most notably, the value of farm risk mitigation and increased farm enterprise flexibility.

Mitigation of mixed farm risk due to the adoption of dual-purpose canola can occur through:

- Filling the feed gap through valuable feed source during autumn/winter periods when forage availability (and therefore stocking rates) are typically low
- Deferring grazing of pastures during winter period allows improved spring/summer pasture production and opportunities to control weeds
- In dry conditions, allowing capture of value of grazing crops in winter despite possible unfavourable spring conditions with no grain income
- Provide opportunities for disease prevention in the livestock enterprise through shifts to earlier lambing afforded by filling the winter gap (CSIRO per comms, 2021).

The addition of dual-purpose canola to the repertoire of farming practices increases farm enterprise flexibility (also reducing risk) and increases business resilience. According to Delta Agribusiness (per comms, 2021b), the dual-purpose crop gives producers increased options year to year such as whether to harvest, put to hay or graze out the crop in tougher years depending on the prevailing conditions. Overall, researchers have observed an incremental transformation in mixed farm enterprises in southern Australia attributable to the availability of the dual-purpose canola management option.

> *"Farms that a decade ago produced only wool, now produce a range of cereals, oilseeds, hay and silage as well as cattle or sheep enterprises for meat and wool and have a level of diversity and flexibility that has improved business resilience".*
>
> Kirkegaard et al. (Nd)

This is corroborated by personal communication with Delta Agribusiness advisers who report observing traditional grazing land converting into highly profitably mixed-cropping land in areas that are not traditionally used for cropping (Delta Agribusiness per comms, 2021b). While these farm risk mitigation and flexibility benefits are not captured in this impact assessment quantitatively their value should not be overlooked.

8.2 Environmental impacts

There are a number of environmental benefits of incorporating dual-purpose canola into the farming system including the improved control of weeds and diseases in subsequent pastures and

crops (reducing reliance on agri-chemicals), increased duration of groundcover and improved whole of system nutrient and water use efficiency.

As canola is a broadleaf crop it does not host the diseases of wheat and allows easier control of grass weeds that cannot be controlled in cereals or pastures. For example, experiments on the forage production and grain yield of wheat following canola were both increased by 1 t/ha compared to wheat following wheat and growers have confirmed that without the canola rotation crop included in the system the dual-purpose cereals would become unprofitable to grow due to weed and disease problems (Kirkegaard, 2012b).

As dual-purpose crops are sown earlier then grain only crops, the rooting depth and the uptake of water from depth is much greater in dual-purpose crops. CSIRO researchers have measured roots of dual purpose crops growing up to one metre deeper than those of later-sown grain-only crops and this has been associated with 30-50mm more water uptake from the subsoil which reduces the risk of deep drainage in high rainfall areas (Kirkegaard et. al. 2020a).

Also due to the earlier sowing of dual-purpose crops, the bare soil after summer is covered much earlier in the season which reduces the loss of water directly from the soil by evaporation and reduces erosion risk. Overall the season length of dual-purpose crops is longer meaning that the soil surface is covered for a longer proportion of the year, which also translates to higher biomass production and greater carbon input into the farming system compared to grain-only crops (CSIRO per comms, 2021). The combination of improved earlier soil cover to reduce evaporative losses, and the deeper roots capturing water and nitrogen from the subsoil means that the water and nitrogen use efficiency of dual-purpose crops across the season can be improved.

8.3 Social impacts

It is hypothesised that there are social impacts proportional to the economic benefits that the adoption of dual-purpose canola has delivered. Improved financial resilience in farming enterprises is likely to have contributed broadly to social resilience in rural and regional communities where these farming industries are a significant economic driver. According to a CSIRO project report, the adoption of the practice has not only increased economic stimulus in mixed farming communities but also allowed for increased optimism among younger farmers for improved viability of existing farm enterprises and enthusiasm for dynamic mixed systems involving increased cropping (Kirkegaard, 2012b)

Anecdotal evidence based on CSIRO research engagement with adopters of dual-purpose canola has also indicated that there are likely to be mental health benefits associated with the increased business resilience and flexibility afforded by the approach. Producers have commented that the guaranteed filling of the autumn feed gap provides significant relief knowing that there will be enough feed in autumn (CSIRO per comms, 2021). As previously noted, dual-purpose canola has become a highly profitable and integral part of the farming system across southern NSW and the less tangible social impacts of this increased business resilience should be acknowledged.

9 Future R&D

Dual-purpose canola research and development is ongoing at CSIRO in collaboration with a number of research partners. Initiatives currently underway that may deliver further impact include:

- Ongoing research with GRDC and MLA to refine approaches to crop and animal management and adoption
- A project funded by GRDC to review the area of dual-purpose crops and to develop an industry manual on best bet management of dual-purpose crops
- Co-investment from a breeding company to investigate breeding a specific dual-purpose canola variety for the first time and to review animal health issues for grazing canola
- A project to investigate digital approaches to estimate and track the adopted area of dual-purpose canola by identifying part of the landscape that are green in February-April and yellow in September-October.

CSIRO researchers identify that there are a number of outstanding research questions to answer such as the relationship between animal health and canola grazing and nitrogen management in the dual-purpose system (CSIRO, per comms 2021).

10 Limitations

This impact case study has limitations due to broad estimates and assumptions required to characterise adoption rates and the nature of adoption of dual-purpose canola across the Australian landscape, and the use of broad proxy measures and calculated assumptions were required to estimate farm profits. However, these were informed by expert advice both internal and external to CSIRO and the academic and grey literature. Qualitative summaries of benefits are based on the available existing literature, interviews with informed key stakeholders and CSIRO researcher advice. Thus, the case study provides an informed estimate and picture of the realised and prospective impacts of dual-purpose canola R&D only and results should be interpreted within the context of the data available and assumptions made.

11 Confidence Rating

Data that underpins the CBA is based on estimates of adoption and general estimates for low, medium and high whole-of-farm profit impacts based on the best available information including experimental data, simulation and farm case studies. The analysis is performed using CSIRO internal information, advice from external organisations, literature and calculated assumptions thereby making the results informed approximations only. In all instances, lower-bound estimates and conservative assumptions have been used. Due to scope, time and informational availability constraints, further refinement of these estimates is not viable.

The author determines the confidence rating of the quantitative component of the assessment as medium.

Appendix A References

Condon, T (2021) Letter of support - *The Sir Ian McLennan "Impact from Science and Engineering Medal"* on 22/07/2021

CSIRO (2021) *Record-breaking canola crop credited to science from CSIRO* News Release 24/02/2021 Available at < https://www.csiro.au/en/News/News-releases/2021/Record-breaking-canola-crop-credited-to-science-from-CSIRO>

CSIRO per comms (2021) Dr. J Kirkegaard on 20/05/2021; 17/06/2021; 1/07/2021;11/08/2021

CSIRO, Nd, *DP Canola CSIRO impact medal case 2019_revised_JL*

CSIRO (2020) Impact Evaluation Guidelines < https://www.csiro.au/~/media/About/Files/Our-impact-framework/CSIROImpactEvaluationGuide_WEB.pdf>

Dann PR, Axelsen A, Edwards CBH (1977) *The grain yield of winter-grazed crops. Australian Journal of Experimental Agriculture and Animal Husbandry* 17, 452–461

Delta Agribusiness per comms (2021a) – Phone call T. Condon on 28/05/2021

Delta Agribusiness per comms (2021b) – Phone call J. Cheetham on 01/06/2021

Kirkegaard JA., et al. (2008). *Dual-purpose canola – a new opportunity in mixed farming systems.* Australian Journal Agricultural Research 59, 291-302

Kirkegaard JA., et al. (2012a). *Refining crop and livestock management for dual-purpose spring canola (Brassica napus).* Crop and Pasture Science 63, 429-443

Kirkegaard JA., (2012b) Final Report to GRDC project CSP00132: *Optimising the integration of dual-purpose crops in the high rainfall zone*

Kirkegaard, JA., (2015) Final report to GRDC project CSP00160: *Refining variety and management recommendations to improve productivity and resource efficiency of dual-purpose crops in Australia*

Kirkegaard, JA., et al. (2020a) The physiological adaptation and future prospects for canola (oilseed rape) in global farming systems. In: (Eds V. Sadras and D. Calderini) *Crop Physiology: Case histories of major crops* (3rd Edition Academic Press)

Kirkegaard, J., Sprague, S., Bell, L., Swan, T. Sandral, G. (2020b) *Dual-purpose crops – direct and indirect contributions to profit*. – GRDC Update paper,

Kirkegaard, J., Sprague, S., Lilley, J., Swan, T., Bell, L., Cheetham, J. (2021) Transformational impacts of dual-purpose canola in mixed farming systems. Australian Agronomy Conference (accepted manuscript in press).

McGrath, S.R., Behrendt R., Friend, M.A. and Moore, A.D. (2021) *Utilising dual-purpose crops effectively to increase profit and manage risk in meat production systems* Animal Production Science *(in press*)

Appendix B Key Publications

Bell LW., Harrison MT., Kirkegaard JA (2015) *Foreward: Dual-purpose cropping -capitalising on potential grain crop grazing to enhance mixed-farming profitability*. Crop and Pasture Science, 66, i-iv.

Bell LW., et al. *Integrating canola and wheat into high-rainfall livestock systems in south-east Australia*. *3. An extrapolation to whole-farm grazing potential and productivity.* (2015) Crop and Pasture Science 66, 390-398

Dove H., Kirkegaard JA (2014) *Using dual-purpose crops in sheep-grazing systems: a review.* Journal of the Science of Food and Agriculture 94, 1276-1283

Dove H, Kirkegaard JA, Kelman WM, Sprague SJ, McDonald SE, Graham JM (2015) *Integrating dual-purpose wheat and canola into high-rainfall livestock systems in south-eastern Australia*. 2. Pasture and livestock production. Crop & Pasture Science 66, 377–389.

Kirkegaard JA, Sprague SJ, Dove II, Kelman WM, Marcroft SJ, Lieschke A, Howe GN and JG Graham (2008) *Dual-purpose canola – a new opportunity in mixed farming systems*. Australian Journal of Agricultural Research 59, 291-302

Kirkegaard JA., Sprague S., Dove H., Potter T., Marcroft S., Kelman W., Lilley J (2010) *Adaptation of winter canola (Brassica napus) for grain and dual-purpose use in Australia's high rainfall zone*. Australian Agronomy Conference.

Kirkegaard JA, Sprague SJ, Lilley JM, McCormick J, Virgona JM, Morrison MJ (2011) *Physiological response of canola to defoliation in diverse environments*. Field Crops Research 125, 61-68

Kirkegaard JA et. al. (2015) *Forage canola –using spring-sown winter canola for summer and autumn forage prior to grain harvest in the high rainfall zone of southern Australia*. Crop and Pasture Science 66, 275-286.

Kirkegaard JA et. al. (2015) *Effect of grazing or defoliation on the root growth of field-grown wheat (Triticum aestivum) and canola (Brassica napus*). Crop and Pasture Science 66, 249-259

Lilley JM., et. al. (2015) *Grain yield and grazing potential of canola across Australia's high rainfall zone: a simulation modelling analysis.* Crop and Pasture Science 66, 349-364

McCormick JI., Virgona JM., Kirkegaard JA (2013) *Regrowth of spring canola (Brassica napus) after defoliation.* Plant and Soil 372, 655-668

Seymour M., et. al. *Effect of timing and height of cutting on the grain yield of barley, wheat, oats and canola in Western Australia.* Crop and Pasture Science 66, 287-300.

Sprague SK., Kirkegaard JA., Marcroft SJ., Graham JM (2010) *Defoliation of Brassica napus increases severity of blackleg caused by Leptosphaeria macularis: implications for dual-purpose cropping.* Annals of Applied Biology 157, 71-80

Sprague SJ., Kirkegaard JA., et. al. (2014) *Crop and livestock production for dual-purpose winter canola (Brassica napus) in the high-rainfall zone of south-eastern Australia.* Field Crops Research 156, 30-39.

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1300 363 400
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csiro.au

For further information

CSIRO Performance and Evaluation
Dr. Anne-Maree Dowd
+61 7 3327 4468
anne-maree.dowd@csiro.au