

KIT 1.5

Reduce the gap between actual and potential grain yield through more informed and timely decision-making on: planting time, crop/variety choice, weed management, pest and disease control, and crop nutrition



Impact Growers understand and have access to management practices that reduce the yield gap to increase profit with acceptable business risk.

Summary

- Growers and their advisers understand the opportunity to close the yield gap.
- Growers and their advisers know where, when and how to respond to factors that limit yield as part of integrated farming systems.
- New solutions to move yield targets even closer to water-limited potential are discovered, considerate of risk.

OVERVIEW

The yield gap can be defined in different ways. For the purpose of this strategy it is defined as the difference between actual crop yield, or farm yield (FY), and water-limited yield potential (PY_w) within the constraints of a given environment and germplasm. The economic benefit in bridging the gap between FY and PY_w is very large but doing so is a challenge requiring new research, development and extension (RD&E) approaches. In particular, nuances of Australian grain growers' farm management skill and ability, knowledge, motivations and attitudes to risk must be considered.

Whilst crop yield potential, calculated using simulation models, may indicate the total theoretical yield ceiling for any given environment, situation and crop variety, it generally does not represent the yield at which profit is optimised. Instead, an economically attainable yield target (AY) is a much more appropriate benchmark of performance that also better aligns to the GRDC purpose. Based on the broad assumption AY commonly equals 80 per cent of PY_w , closing the gap between average FY and AY has the potential to deliver more than \$3.8 billion of increased annual value in Australian wheat production alone.

Key Investment Target (KIT) 1.5 aims to bridge the yield gap through facilitating more informed, objective and timely decisions by grain growers, with a focus on key factors limiting their ability to profitably realise crop yield potential. These important grower decisions relate to:

- crop and varietal selection;
- time of sowing;
- control of weeds, pests and diseases; and
- appropriate crop nutrition.

The desired investment outcomes relating to this KIT strategy aim to address the yield lever of the profit equation. More specifically, the strategy is about delivering higher and more consistent realisation of the true genetic yield potential of currently available crops and varieties, cognisant of impacts on profit and risk.

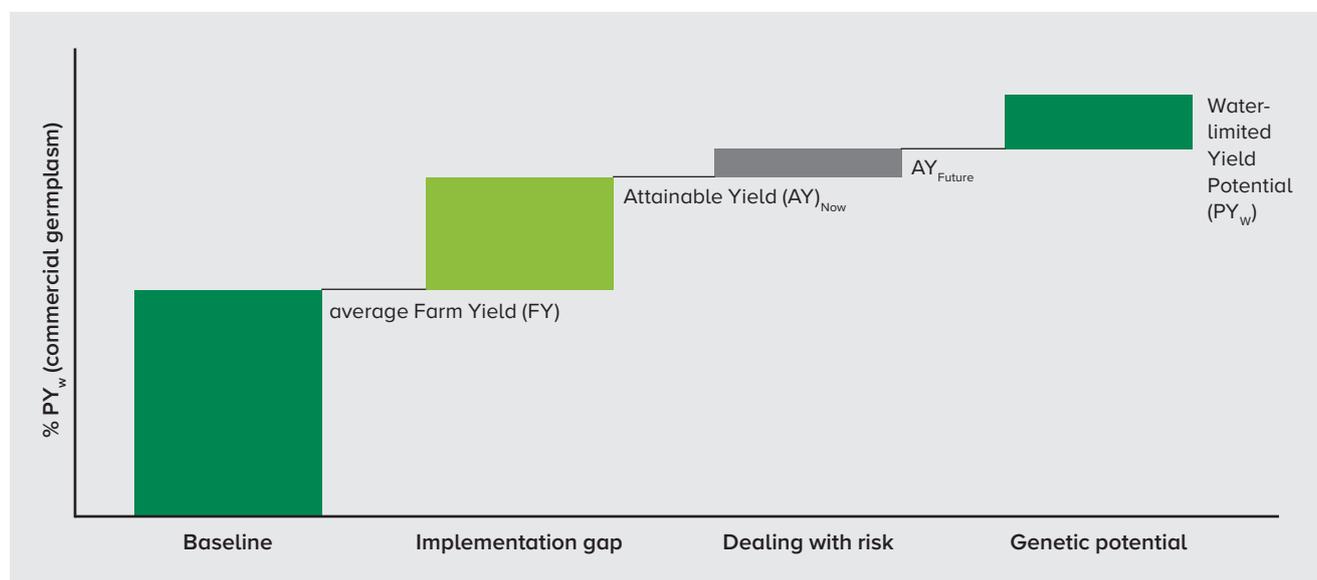
The investment strategy outlined here proposes two complementary approaches to increase FY and grain enterprise profit simultaneously. The first is to reduce the gap between FY and AY, where possible attaining AY targets with greater consistency, referred to henceforth as bridging the management-related 'implementation gap'. The second is to increase currently accepted AY targets through addressing risk and reward trade-offs frequently made by grain growers (Figure 1). It is important to note that out of scope of this strategy is the aim to increase PY_w , commonly referred to as raising the yield ceiling, this objective is instead covered in KIT 1.3.

Whilst the strategy is aligned to Objective 1 of the GRDC 2018-23 RD&E Plan, to *improve yield and yield stability*, consideration of impact on grower profitability remains critical. Hence, the aspirational outcome sought from this strategy must take into account associated changes in production cost as well as any impact on business risk. The strategy must similarly be considered in the enduring context of the whole farm system, moving beyond the target of higher yield in a single paddock



in a single season towards optimisation of yield across rotations and seasons.

Figure 1: Conceptual illustration of the two approaches proposed to bridge the yield gap through implementing the known (the ‘implementation gap’) and increasing current economically attainable yield targets, by dealing with risk and reward trade-offs. FY denotes average farm yield, AY denotes the yield at which profit is optimised, now or in the future, and PY_w denotes the water-limited potential yield for a given environment and crop variety.



Grain grower farm management skill and ability in decision-making and effective implementation are recognised as key enablers in realising the economic opportunity associated with bridging the yield gap. The significant opportunity to increase total crop production across the Australian grains industry through more consistent realisation of AY across more farm businesses has long been recognised. Transformational change, however, will come only as a result of greater investment focus on addressing motivational, attitudinal and other grower decision making related factors.

The aspirational impact, investment scope and target outcomes of future investment for KIT 1.5 are summarised in the KIT 1.5 strategy summary document. The strategy considers business decisions, systems decisions and tactical crop management decisions under three areas of scope, being:

- Understanding of the yield gap opportunity;
- Effectively implementing to bridge the yield gap; and
- New goals and solutions.

In summary, it is intended that investments within the scope of KIT 1.5 will assist growers in the refinement, integration and effective implementation of management practices necessary to overcome priority yield-limiting factors. The management practices identified will also need to take into account any likely implications on the entire farming system, business profit and risk. New investment in this area should embed existing knowledge in a whole of systems approach to effect adoption, and support and inform complex system decisions for a target environment, ensuring relevance to individual cropping enterprises.

The strategy will ensure:

- Growers and their advisers understand the opportunity to close the yield gap;
- Growers and their advisers know where, when and how to respond to factors that limit yield as part of integrated farming systems;
- New solutions to help growers move yield targets even closer to water-limited potential are discovered and are considerate of business risk.



FUTURE RD&E FOCUS

Future investments in RD&E aligned to KIT 1.5 will seek to deliver the following aspirational impact: *Growers understand and have access to management practices that reduce the yield gap to increase profit with acceptable business risk.*

This aspirational goal has been constructed in an enduring whole of farm systems context and aims to move beyond the 'yield in a single season or paddock' approach to consider 'cumulative yield across paddocks, farms and seasons'. Whilst future investment aligned to KIT 1.5 will primarily focus on lifting crop productivity, whole-of-farm grain enterprise profit per millimetre of water must remain a key measure of performance. Future investments will need to take into account the likely variance in business costs and exposure to risk associated with different management practices.

SCOPE – Understanding of the yield gap opportunity

The size of the yield gap is quantified and the constraints to closing the gap are identified

Future investments will aim to quantify the size of the yield gap opportunity, identify yield-limiting factors and confirm yield targets locally to shift from awareness of the opportunity to an intent to change.

In order to realise an opportunity, it must first be well understood. Hence, quantification of crop yield potential and yield-limiting factors across environments and crops is critical in realising opportunities to bridge the yield gap. Whilst current crop simulation models and previous GRDC investments go some way to address this, Australian growers frequently question the relevance and accuracy of such yield predictions. Growers also can have limited awareness or knowledge of local AY targets, yield constraints and the magnitude of the impact of each constraint individually or as a whole. An improved understanding of these factors is integral to addressing the motivational and attitudinal issues that must be overcome if grain growers are to shift from awareness of the opportunity to an intent to change.

Investment Outcome 1.5.1 – Growers and their advisers understand the scope of the yield gap opportunity and the associated constraints.

In order to have the ability to quantify the occurrence and size of the yield gap and the associated economic opportunity, to create grower belief and confidence in the opportunity and to drive grower intent to change, there is a need to ensure yield targets for all major crops are accurate and of local relevance. Whilst there has been significant historic investment in modelling PY_w in crops such as wheat, barley, sorghum and canola, the ability of crop simulation models such as the Agricultural Production Systems SIMulator (APSIM) to accurately predict yield potential in other major pulse and summer grain crops remains an important gap. In addition, current simulated yield estimates do not fully consider major soil constraints, the impact of frost and heat stress, or the many potential biotic stresses (eg. weeds, pests and disease) commonly affecting yield. Growers therefore frequently lack confidence in current yield targets and how they are calculated. In addition, sound and detailed data on current FY by crop and environment - including local variance from the mean across paddocks, farms, seasons and enterprises - is sparse and a significant barrier to determining the size of the gap.

The identification of common yield-limiting factors by crop and environment has been the focus of significant previous research effort in Australia. For example, relevant outcomes have been delivered through GRDC investment in Yield Gap Australia (CSA00042) and the National Paddock Survey (BWD00025). However, the complexity of the interactions between yield-limiting factors and the management factors to overcome them necessitates local confirmation and interpretation to determine appropriate responses for each situation.

Future investments by GRDC will aim to:

- improve the confidence and accuracy of yield targets across major crops and scenarios to quantify the yield gap opportunity;
- further validate yield-limiting factors at sub-regional level in order to better understand the proportionate impact of constraints identified on yield and profit and to inform the most appropriate response by growers.



Investment Outcome 1.5.2 – Growers and their advisers are motivated to take action to close the yield gap.

Locally relevant data, knowledge and awareness regarding yield targets and specific yield constraints are deemed critical in creating grower and adviser 'reasons to believe'. The aim is to understand how to compel receptive growers to strive to realise the profitable opportunities for yield improvement identified and to address any existing misconceptions or motivational barriers to change. GRDC will invest in identifying and quantifying the size of the opportunity, raising awareness of the opportunity, and ensuring local relevance amongst growers and advisers. GRDC will not, however, invest beyond this to attempt to change deeply held attitudes of those unwilling to change. Greater awareness of opportunities to increase yield and an improved understanding of the yield limiting factors that should be addressed locally will assist growers and advisers in identifying profit opportunities, create belief and drive the intent to respond.

SCOPE – Effectively implementing to bridge the yield gap

The options for responding to known yield constraints are identified, prioritised and integrated.

Assuming yield targets and yield constraining factors are well understood, growers and their advisers need to know where, when and how to respond in order to bridge the yield gap. This area of investment is at the core of the KIT 1.5 strategy and recognises the importance of timely and effective implementation of management practices that are required to realise immediate yield and profit opportunities. This enhanced knowledge and ability will support the practice changes required to address the 'implementation gap', allowing the identification, prioritisation and integration of options specific to environment and farming system.

Future GRDC investments will aim to: determine the order and type of response to known yield-limiting factors; assist in the integration and refinement of different practices, tools and technologies; and share and validate current best practice to facilitate local adoption, considerate of whole farm systems and farm business implications.

New investments in this area should consider the key influencers of practice change on-farm, moving beyond engagement to encourage direct participation and involvement. The primary pathway to market for knowledge generated from new investment in this area will be via agribusiness and private sector advisory support and hence investments should explore and leverage opportunities for collaboration with these parties where appropriate.

Investment Outcome 1.5.3 – Growers and their advisers understand the options to address identified yield constraints and how to integrate into their system.

Whilst significant investment has been and continues to be made in addressing the individual profitability challenges of Australian growers, previous investment has largely focused on addressing a single constraint or opportunity to grower profitability through targeted but often discrete research outputs. In practice, decision making on-farm frequently requires a more holistic, whole of systems approach that includes consideration of how to best implement a range of management tactics to address numerous yield-limiting factors, considerate of operational complexity, perceived benefits, cost and business risk.

Future investments in this area will assist growers in the integration and effective implementation of management responses to priority yield-limiting factors, considerate of systems and financial implications at farm scale. Existing knowledge may be refined and embedded into a whole of systems approach, to enhance adoption and inform and support timely decision-making regarding practices expected to bridge the yield gap. GRDC will invest to assist growers to address known yield-limiting factors through the identification, prioritisation and integration of management approaches that contribute towards the following outcomes:

- Growers are planting the most appropriate crop types, at appropriate frequency and/or sequence for their environment, soils, land class and system, considerate of soil water and seasonal outlook;
- Growers are making informed varietal choices, sowing an appropriate variety at the appropriate time for their environment, soils, system and season, considerate of the impact of frost, water and heat stresses;
- Growers are ensuring crops have adequate nutrition to attain yield and quality targets, through informed decisions on product, rate, timing and application method, with a focus on nitrogen and other yield-limiting nutrients when appropriate;



- Growers are integrating and implementing appropriate practices, tools and technologies in a timely manner at farm scale to ensure weeds are not driving systems decisions, affecting flexibility or limiting yield;
- Growers are integrating and implementing appropriate practices, tools and technologies in a timely manner at farm scale to minimise the yield impact of pests and diseases.

Although many growers are achieving AY targets in some paddocks and in some seasons, whole-of-farm productivity may be further improved overall through more consistent achievement of yield targets across paddocks, farms and seasons. GRDC will also consider new investments targeted at identifying opportunities to deliver greater consistency in AY across paddocks, farms and seasons, ensuring the benefits and risk of solutions identified are quantified and represent a compelling value proposition.

Investment Outcome 1.5.4 – Growers make informed and objective business and management decisions to prioritise potential responses and effectively implement.

The skill and ability of grain growers to make objective and sound decisions and effectively implement are considered critical enablers in achieving the targeted impact of this strategy. This capacity and ability is a potentially transformational opportunity for the Australian grains industry. Improved timeliness of operations, more systemised patterns of work and generally improved decision making by growers all represent potentially low-cost opportunities for farm businesses to close the implementation yield gap and in turn promote significant increases in profitability.

GRDC will consider targeted and strategic investment in this area and will be highly considerate of existing related activity by the private sector and others. Opportunities to collaborate with other Rural Research & Development Corporations (RDCs) or private or public sector organisations in potential cross-sectoral RD&E opportunities may be explored. Future investment will focus on the development of grower skills and abilities that support effective implementation and timely and objective decision making, considerate of complexity of farm operations, risk, seasonality and unexpected events, and of course the impact on farm profit.

GRDC's future investment in this area will focus primarily on, but not be limited to, opportunities to contribute toward the following outcomes:

- Growers are making timely and objective decisions to capture opportunities to close the yield gap whilst considering impacts on farm profit and risk and reward trade-offs;
- Growers are implementing required farm operations consistently, effectively and on-time, in a way that deals with complexity of operations, seasonality and unexpected events;
- Growers have the ability and skill, knowledge and tools, and appropriately qualified and skilled advisory support, to inform complex systems decisions that will close the yield gap.

Given the importance of grower decision making skills and abilities as key enablers of this strategy, opportunities to leverage investment across the following GRDC strategies or frameworks should be considered:

- The GRDC Capacity and Ability Framework;
- KIT 5.3 Support growers to acquire business management skills;
- KIT 5.2 Understand grain grower decision making and the drivers for adoption of new technology;
- KIT 3.2 Generate more informed, accurate and timely input for decision making (e.g. sensor/monitoring technology or decision support models).

SCOPE – New goals and solutions

New, best practice is discovered and developed to move yield targets even closer to water-limited yield potential.

Whilst the previous investment scope aims to address the implementation gap, this scope area aims to push current AY targets even higher through the discovery, development and on-farm implementation of innovative new knowledge, tools, technologies and practices. With a focus on grower profitability and an intent to push the boundaries, investment in this area will largely deal with the risk and reward trade-offs commonly made by growers to increase profit with acceptable business risk.



Future investment by GRDC in this area will aim to discover and develop new best practices to address current risk and reward trade-offs made by grain growers to continue to move AY closer to PY_w .

Out of scope of this strategy will be any investment specifically targeted at raising the PY_w of current crops. This is specifically addressed through other relevant GRDC KIT strategies, including KIT 1.3: Change fundamental plant architecture, physiology and/or biochemistry to maximise water-limited yield potential in wheat, barley, canola and sorghum.

Investment Outcome 1.5.5 – New solutions that address current risk and reward trade-offs to further reduce the gap between attainable yield and water-limited yield potential with acceptable business risk are discovered and benefits quantified.

GRDC will consider new investments aimed at increasing present attainable yield targets (AY_{Now}) above currently accepted benchmarks (frequently assumed to be 80% of water-limited yield potential) primarily by addressing issues relating to farm business risk. Such investment will build upon existing best practice, identifying risk and reward trade-offs and other factors presently limiting growers' ability or willingness to strive to further increase yields of current crop varieties. New investments will need to identify, develop and quantify the value of new knowledge, tools, technologies or practices that address risk-related factors and deliver compelling reasons for grain growers to set even higher attainable yield targets (AY_{Future}).

Investment Outcome 1.5.6 – Growers and their advisers implement new knowledge, tools, technologies or practices into whole-of-farm systems to set new attainable yield benchmarks.

GRDC will consider new investment opportunities that build knowledge, increase awareness and/or address the barriers to adoption of new solutions (discovered through Outcome 1.5.5) to help growers achieve future economically attainable yield targets (AY_{Future}). This will include, but will not be limited to, activities that enable the integration and effective implementation of new knowledge, tools, technologies or practices into existing farming systems.