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# An Economic Analysis of GRDC's Investment in Barley Breeding

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# Impact Assessment: An Economic Analysis of the GRDC Investment in Barley Breeding

# Summary

This report evaluates the impacts from 22 new barley varieties released over the period from 2002 to 2008. The new varieties were the main outputs from 12 completed or ongoing projects in all states that span varying durations between 2001 and 2011. Investment by GRDC in the projects being funded over the period of the releases from 2002 to 2008 totalled $25.5 million.

To correctly account for the continuous nature of a breeding cycle of the order of a decade, the analysis included an estimate of contributions from investments prior to 2002 and excluded contributions up to 2008 towards future outputs beyond 2008. The analysis is therefore only of the additional investments that can be readily attributed to achieving the outputs over the period 2002 to 2008.

The benefits from new varieties were estimated from data on current and forecast production by the time the varieties are expected to reach about their maximum adoption in 2013. The production data and yield estimates from National Variety Trial data were used to estimate increased production attributable to the new varieties. The cumulative national yield increase was estimated at 0.75 per cent annually over the period to 2013. Further benefits out to the twenty five year period of analysis were assumed constant. The assumption recognised that the varieties being evaluated would be displaced eventually. However the benefits are maintained because they provide the basis for further gains.

The evaluation using the best available estimates of benefits suggested the total investment by GRDC in barley breeding is giving high returns. The benefit cost ratio taking into account investments over the breeding cycle is of the order of eight to one.

The rapid increase in production from varieties released early in the period of evaluation was the main feature of the evaluation. A recent outstanding new variety Hindmarsh appears to be widely adapted and is expected to contribute about one fifth of the national crop by 2013. The investment appears profitable because adoption of new varieties has been rapid to date, and is sufficient to ensure the investment is already close to profitable. The only qualification to that conclusion is the yield estimates are based on NVT data. There was little evidence to support the extent to which trial data on per cent yield increases is transferable to farm level.

The investment was evaluated against a base of what could have been expected to eventuate if GRDC had not invested. When GRDC made the decision to invest in 2002, the likelihood of alternative private sector arrangements evolving would have been minimal. Since then varieties with End Point Royalties are an increasing proportion of the crop. A sensitivity analysis showed that the profitability of future GRDC investments will be determined by updated assumptions on new breeding arrangements and how successful they are likely to be.

The breeding program was rationalised to a three-node model in 2006. The results of this evaluation are more indicative of a successful pre-rationalisation model. They therefore provide a challenging benchmark for the new model.

# 1 Introduction

This report evaluates the impact of investments by GRDC in twelve GRDC projects in barley breeding. The projects have varying duration spanning parts of the period from 2002 to 2011. Investment in the twelve projects from 2002 to 2008 totalled $25.5m. Outputs up to mid-2008 are included in the evaluation.

Barley is grown for malt for brewing and as a feedgrain. Grain meeting malting specifications can attract a price premium. Although most barley grown is from a malting variety potentially suitable for beer production, the major end use has been for livestock feed. At the beginning of the period of analysis there were projects in each of the six states. They were producing a range of varieties with varying levels of adaptation to mainly regional environments. There were national and regional anomalies and gaps in meeting the market. For example breeding programs were geared to the domestic malt market based on flat beer demand. Export malt was an important market in Western Australia but there were deficiencies in varieties tailored to that market. In South Australia feed barley varieties were more important than the distance from the major eastern Australian feedgrain markets appeared to warrant. In contrast in the north the industry remained malting-focussed as demand shifted rapidly to feed grains (Hafi and Connell 2003) and production declined as drought frequency increased. Wheat is the major feedgrain but not a preference for some end users. For eastern Australia the feedgrain export trade dominated by wheat is increasingly a residual one. In 2002 the portfolio of barley varieties clearly had some outmoded suitabilities for likely end uses in rapidly evolving domestic and export markets. The industry including its components needed to adjust.

A major rationalisation of breeding activities began in 2006 when Barley Breeding Australia (BBA) formally commenced operations (BBA Advisory Board 2007). BBA followed the earlier formation of the industry body, Barley Australia to increase coordination activities of malsters and marketers. The BBA national plan for breeding improved varieties to benefit the barley industry uses a node in each GRDC region to replace the previous state-based system. The plan was based on an earlier study by Fellowes (2005). Barley Australia has a key role to control national varietal accreditation. The plan also incorporated measures to strengthen links with the major GRDC research effort in pre-breeding.

Over a decade ago barley improvement programs began to take advantage of a range of new technologies such as molecular markers, double haploid production, and NIR quality evaluation to increase efficiency in selecting new varieties. Molecular markers for example can indicate presence of genes that help confer disease resistance or improved malting quality. Selection in the laboratory can now be done more quickly and more cheaply.

On Australian grain farms, barley has traditionally been the second most important grain crop after wheat. Barley is grown in all states including in northern Tasmania. South Australia and increasingly Western Australia are the major producers. From a farmer perspective, barley can have a range of advantages; for example it has the reputation of being a tough crop more tolerant of a poor season or a poor paddock. Barley varieties offer increased choices and the opportunities to better manage some of the likely risks from frost, diseases or moisture stress. The chance of attracting a premium for malting quality is another factor advantageous to farmers growing barley in some less risky environments. However, malsters prefer uniform quality and that objective can conflict with an objective of breeding varieties adaptable to a wide range of sites, seasons and end uses.

Table 1 summarises the four major markets for Australian barley. Australia is a significant exporter accounting for around a quarter of world trade in some years. The data are based on an average season. There were two years in the past decade when, as a result of widespread drought, production was less than half that of the previous year and higher proportions went to domestic users.

**Table 1 Barley production by destination and end use (% of total)**

| Market | Malting Barley | Feed Barley | Total |
|---|---|---|---|
| Domestic | 13 | 30 | 43 |
| Export | 25 | 32 | 57 |
| Total | 38 | 62 | 100 |

Source: www.barleyaustralia.com.au (based on an average production of about 6.6 Mt. over 2005/06 to 2007/08.)

Some key features of the Australian barley industry are:

- The domestic market for livestock feed has traditionally been a residual market for malting barley varieties that do not meet malting specifications.
- Domestic demand for varieties more tailored to feedgrain markets has been rapidly increasing.
- The northern breeding program has recently shifted priority from breeding targeted at malting requirements to breeding more for the feedgrain market.
- The feedgrain market is not yet sophisticated in terms of quality.
- The export markets for malting barley are expanding particularly in Asia.
- It is notable that the average Australian malting selection rate is the highest of the world's exporting nations with around 38 per cent of our national crop selected as malt (www.barleyaustralia.com.au ).
- Markets for malt are diverse in terms of quality.
- Some Asian markets have different brewing processes compared with those for Australian beers - they require different malting varieties, and
- Export malt includes about one-third in grain equivalent terms of barley exported as malt.

This report identifies outcomes to estimate impacts from barley breeding from an economic, social and environmental perspective. The outputs of the research projects in the form of improved barley varieties lead to specific outcomes via various pathways to adoption. The economic evaluation was based on the actual performance of varieties released over the period from 2002 to 2008 and on estimates of their future performance. A cost benefit framework is utilised that takes into account the breeding cycle. Base case, optimistic, and pessimistic scenarios are proposed to take account of uncertainties, particularly what might have eventuated had GRDC not invested in barley breeding. The analysis takes into account the long term nature of the breeding cycle, of the order of a decade from when crosses are made to the release of a new variety. The conclusions and lessons learnt from the cost benefit analysis are then developed.

## 2 Project Investment

The projects contribute to the general GRDC objective for Output Group1 – Varieties of '*Providing growers with access to new superior varieties by actively developing world-leading, cost-efficient breeding programs in Australia'.*

The GRDC investment includes twelve projects covering barley breeding activities in six states. The projects are listed in Table 2. The complete duration of the projects is included. However this evaluation includes only outputs that were released or in train for release by 30 June 2008. To account for the continuous nature of the breeding cycle of the order of a decade, the analysis included an estimate of attributions from investments prior to 2002 and excluded attributions up to 2008 towards future outputs beyond 2008. Details of how investment costs were attributed to outputs will be presented in Section 7.

**Table 2: Barley improvement projects funded by GRDC 2002-2011**

| Title | Project Code | Duration |
|---|---|---|
| Barley Improvement and Quality Program for South Eastern Australia | DAN00055 | 1/7/2003 to 30/6/2006 |
| Barley Breeding Australia – NSWDPI | DAN00101 | 1/7/2006 to 30/6/2011 |
| Barley Improvement for the GRDC Northern Region | DAQ00038 | 1/7/2002 to 30/6/2005 |
| Barley Breeding Australia - Northern Node | DAQ00110 | 1/7/2006 to 30/6/2011 |
| Barley Improvement and Industry Development – VIDA | DAV00025 | 1/7/2002 to 30/6/2005 |
| National Barley Enhancement Program coordinator | DAV00079 | 1/7/2006 to 30/6/2008 |
| Barley cultivar development DPI Horsham | DAV00080 | 1/7/2006 to 30/6/2009 |
| Barley Improvement and Industry Development for the Western Region | DAW00045 | 1/7/2002 to 30/6/2005 |
| Barley Improvement and Industry Development for the Western Region | DAW00119 | 01/07/2005 to 30/6/2006 |
| Barley Breeding Australia : Western Region | DAW00151 | 17/2006 to 30/6/2011 |
| Barley Improvement and industry development | UA00032 | Phase 1:1/7/2002 to 30/6/2006<br>Phase 2: 1/7/2006 to |

| | | |
|---|---|---|
| | | 30/6/2011 |
| Australia China Collaboration on Barley Genetic Resources and Development of New Barley Varieties for High Rainfall Areas | UT8 | 1/7/2001 to 30/6/2007 |

Source: GRDC Project Proposals

The investments listed in this section are all for the seven year period from 2001/02 to 2007/08 although some projects extend to 2011. It should be noted that the approach adopted of attributing outputs over a period to the relevant investments in the prior breeding cycle still results in total costs equivalent to seven years of investment if the rate of investment is constant.

The investments in the projects for the period from 2001/02 to 2007/08 are listed by projects in Table 3.

**Table 3: Project Expenditure over the seven years to 30 June 2008 ($)**

| Project | Project Expenditure (years to 30 June) | | |
|---|---|---|---|
| | Host Organisations | GRDC | Total |
| DAN00055 | 2,024,762 | 657,364 | 2,682,126 |
| DAN00101 | 449,030 | 339,456 | 788,486 |
| DAQ00038 | 5,808,650 | 3,804,161 | 9,612,811 |
| DAQ00110 | 2,754,100 | 2,679,541 | 5,433,641 |
| DAV00025 | 1,345,586 | 1,900,366 | 3,245,952 |
| DAV00079 | 26,354 | 92,541 | 118,895 |
| DAV00080 | 542,954 | 766,812 | 1,309,766 |
| DAW00045 | 9,167,035 | 3,666,814 | 12,833,849 |
| DAW00119 | 3,803,106 | 1,356,838 | 5,159,944 |
| DAW00151 | 6,175,404 | 2,667,430 | 8,842,834 |
| UA00032 | 9,719,790 | 6,384,335 | 16,104,125 |
| UT8 | 749,164 | 1,204,510 | 1,953,674 |
| Total | 42,565,935 | 25,520,168 | 68,086,103 |

Source: GRDC Project Proposals.

Overall for the twelve projects funded over the seven year period GRDC has contributed 37.5 per cent of resources in nominal terms with the remaining support provided by the host organisations. Total investment came to $68.1million with the GRDC contribution amounting to approximately $25.5 million.

Estimates of the funding by year in nominal dollar terms and by source for the projects as listed in Table 3 are shown in Table 4.

**Table 4: Annual expenditure for the projects, 2001/02 to 2007/08**

| Year to 30 June | Host Organisations | GRDC | Total |
|---|---|---|---|
| 2002 | 156,000 | 193,358 | 349,358 |
| 2003 | 6,901,545 | 4,124,542 | 11,026,087 |
| 2004 | 6,376,122 | 3,412,185 | 9,788,307 |
| 2005 | 6,782,085 | 3,870,694 | 10,652,779 |
| 2006 | 7,255,535 | 4,539,534 | 11,795,069 |
| 2007 | 7,372,187 | 4,501,721 | 11,873,908 |
| 2008 | 7,722,461 | 4,878,134 | 12,600,595 |
| Total | 42,565,935 | 25,520,168 | 68,086,103 |

Source: GRDC Project Proposals.

As shown in Table 4, the expenditure in 2001/02 was minor compared to other years. The Tasmanian project, UT8 was the only project that started in 2001/02. Given the desirability of including a full portfolio of breeding projects from all States, it was necessary to start the period of analysis in 2001/02. But as previously discussed, the investment analysis will not be biased by the atypical expenditure in 2001/02 because it is based on the total GRDC expenditure over the breeding cycle that can be attributed to outputs from 2002 to 2008.

# 3 Project Outputs

The projects include some funded under the previous model of breeding activity in six states and the more recent projects as a part of the new national approach based on three nodes. The recent projects include projects in Victoria and New South Wales that contribute breeding material to the nodes as their main output. This evaluation is of outputs achieved from mid 2001 to mid 2008.

Outputs from the projects are:

- technologies — new barley varieties with improved agronomic performance, with improved quality to meet requirements of domestic and export markets for feed and malting barley, together with information products to accelerate uptake by farmers and by industry, and
- research capacity —breeding stock including advanced breeding lines as a basis for future varieties, and a better integrated national program drawing on a wider range of scientific knowledge and understanding, and increasing the skills of researchers, farmers and industry.

The new barley varieties have been extensively trialed and compared with existing varieties over a range of sites and seasons before they are released. Information packages on crop management and quality attributes on the new varieties are also an output to guide extension and industry development. Prior to release varieties are further assessed for their suitability for the malting and brewing industries.  Some varieties are released initially as feed varieties pending finalisation of testing and accreditation as either a feed or malting variety.  Malt accreditation is specified for a target market, either export or domestic brewing.

This evaluation of readily quantifiable benefits concentrates on the technological outputs leading more directly to farmer outcomes.  The benefits in terms of capacity building are not quantified in this analysis.  They would be partly reflected in the increase to 2008 in the potential value of the breeding programs additional to the value at the start of the projects in 2001/02.

The principal technological outputs from the investment made over the seven year period to 2008 are listed in Table 5.

**Table 5: Outputs achieved by the projects from 2002-2008**

| **Project Code, Title and Duration** | **Outputs ( including *varieties* released 2002-2008)** |
|---|---|
| DAN00055 Barley Improvement and Quality Program for South Eastern Australia | • Malting quality advanced lines progressed up to commercial malting stage.<br>• *Urambie, Cowabie, Tulla, Binalong ( with QDPI).* |
| DAN00101 Barley Breeding Australia – NSWDPI | • Genotypes scored for each of the three nodes for barley scald.<br>• Multienvironment evaluation of crossbreds. |
| DAQ00038 Barley Improvement for the GRDC Northern Region | • Superior barley varieties and advanced breeding lines combining improved yield, feed and/or malting quality, multiple disease resistances and stability of production.<br>• Extension to support decision making and market development.<br>• *Grout, Mackay.* |
| DAQ00110 Barley Breeding Australia - Northern Node | • New barley varieties, advanced breeding lines and germplasm with improved quality attributes, and targeted to feed and malt markets.<br>• *NRB03470.* |
| DAV00025 Barley Improvement and Industry Development – VIDA | • Development of germplasm with superior agronomic performance and malting quality.<br>• Extension of improved management practice for malting barley.<br>• *SloopVIC, Fitzroy, Buloke, Hindmarsh* |
| DAV00079 National Barley Enhancement Program coordinator | • A review of BBA barley breeding and national germplasm enhancement activities.<br>• Coordination of germplasm and information flow between germplasm enhancement research groups and BBA barley breeding nodes. |
| DAV00080 Barley cultivar | • Provision of fixed breeding lines, with sufficient |

| | |
|---|---|
| development DPI Horsham | phenotypic description, to warrant inclusion in the BBA breeding node S3 trials.<br>• Provision of an information resource to the barley industry in southeastern Australia, |
| DAW00045 Barley Improvement and Industry Development for the Western Region | • Elite lines with improved malting and agronomic qualities submitted for evaluation.<br>• Extension of management advice.<br>• *Baudin, Hamelin*. |
| DAW00119 Barley Improvement and Industry Development for the Western Region | • Malting barley lines nominated from Stage 2.2 to proceed to wide scale testing.<br>• An agronomic research and extension program on the performance of barley growing in Western Australia and extension of this information to growers and industry.<br>• *Vlamingh.* |
| DAW00151 Barley Breeding Australia : Western Region | • Barley varieties, advanced breeding lines and germplasm exhibiting improved agronomic performance, disease resistance, and abiotic stress tolerance and grain quality attributes, and targeted to malt and feed markets.<br>• *Roe, Lockyer, Hannan* |
| UA00032 Barley Improvement and industry development | • Malting barley varieties with high yield, improved disease resistance, malting quality and improved tolerance to abiotic stress.<br>• Characterisation of breeders' lines, parents and introductions and new varieties for malting and brewing quality.<br>• *SloopSA, Flagship, Fleet, Commander* |
| UT8 Australia China Collaboration on Barley Genetic Resources and Development of New Barley Varieties for High Rainfall Areas | • One new line superior to Franklin and Gairdner for spring sowing in Tasmania,<br>• 100 varieties introduced from China for use in Australian breeding programs, including for waterlogging and acid soil situations,<br>• *Vertess* |

Source: GRDC Project Proposals.

# 4 Benefits

## *4.1 Economic*

The major benefit is the extra profitability accruing to grain farmers from increased productivity of grain production. As shown in the previous section the investment has led to outputs in the form of 22 improved varieties and information on their management to foster widespread adoption. The major impact on productivity arises from higher yields from newer varieties compared with the varieties they displace.

There are in addition other benefits, for example from improved disease resistance and from improvements in quality leading to more efficient malting and brewing. The program in the GRDC Northern Region has changed its priority from breeding malting varieties to breeding feed varieties to meet increasing demand. Benefits from changes in quality have not been evaluated.

Barley has an important role in value adding. The major domestic market is as a feed grain for intensive livestock feeding. In some regions much of the grain is consumed on-farm or in the region. The domestic malting and brewing industries are now more closely integrated as part of a supply chain with the barley breeding programs to ensure barley produced meets their specifications.

Barley is an important crop agronomically in its role of a hardy crop often more tolerant of drought, frost, and disease. In rotations barley has a key role as a break crop in areas of southern Australia where Cereal Cyst Nematode (CCN) is a problem. A CCN benefit is included in the analysis. Barley is a crop that has adapted to a wide range of environments and is likely to have an important role in adaptations by the grain industry to climate change.

### *4.2 Social*

Barley is a significant and traditional part of the local economy in many Australian communities. By improving yields and maintaining industry competitiveness, the investment leads to higher incomes, regional stability and thus improving social welfare. These benefits have not been evaluated.

### *4.3 Environmental*

Although there is no significant environmental outcome identified or quantified from these projects, there is a general environmental management benefit in maintaining barley as a key contributor in rotations that underpin sustainable farming systems. Barley has a reputation as a highly adaptable crop. Compared with wheat, it is often more resistant to disease and it can be planted later.

Barley can be used as a break crop to control disease in rotations. Barley can give farmers more options for maintaining an effective conservation cropping system with increased ground cover. A further environmental benefit can arise from a reduced nitrogen fertiliser requirement. To avoid high protein levels, barley grown for malting generally needs less nitrogen than wheat.

## 5 National and Rural Research and Development Priorities

The major benefits from the project are the increases in productivity of grain production. There are in addition contributions to capacity building through a better integrated and more national research program. Improved productivity is a high priority for Rural Research and Development as shown in Table 6.

**Table 6: National and Rural Research and Development Priorities**

| National Research Priorities | Rural Research and Development Priorities |
|---|---|
| 1. An Environmentally Sustainable Australia<br>2. Promoting and Maintaining Good Health<br>3. Frontier Technologies for Building and Transforming Australian Industries<br>4. Safeguarding Australia | 1. Productivity and Adding Value<br>2. Supply Chain and Markets<br>3. Natural Resource Management<br>4. Climate Variability and Climate change<br>5. Biosecurity<br>6. Supporting the Rural Research and Development Priorities |

The projects contribute to some extent to each Rural Research priority, but mainly to the productivity priority.

**Productivity and Adding Value**
The projects improve the profitability of the grains industry, particularly by providing higher yielding varieties more suited to market needs. The improved varieties therefore maintain the competitiveness of value adding industries dependent on barley. These include the domestic malting and brewing industries, and feedgrains for livestock. In addition Australia is a leading exporter of barley for brewing and livestock feeding. Increasing incomes in Asia have resulted in rapidly expanding markets for beer and for meat.

**Supply Chain and Markets**
The projects have been more effectively integrated with the major industries dependent on barley. They have improved the flow of information through the supply chain. Intellectual property rights have been developed through EPR and increased the scope for value creation and private sector involvement. Accreditation for malting barley varieties and improved links with intensive livestock industries will help ensure more effective market signals and more effective competition. The new national arrangements will assist in the development of a better understanding of markets and of consumer requirements.

**Natural Resource Management**
Improved barley varieties will continue to have an important role in more sustainable farming systems. Advantages can include maintaining a role for barley as a more resilient crop less dependent on fertiliser, and with more flexibility to help farmers maintain ground cover and reduce erosion.

**Climate Variability and Climate Change**
Barley is a highly adaptable crop. Improved barley varieties will continue to have an important role in cropping systems that need to cope with increased climate stresses.

**Biosecurity**
Increased production of barley will reduce the occasional dependence of the feedgrain industry on imports of grain with associated risks from pests and diseases.

By contributing to the Rural Research priorities above the projects are satisfying the National Research Priorities particularly **Frontier Technologies for Building and Transforming Australian Industries.**

The assessment of the percentage contributions to the five Rural Research Priorities are:
1: 70
2: 15
3: 5
4: 5
5: 5

# 6 Pathways to Adoption

The rate of adoption of the new varieties is dependent on the quality of information communicated to growers and to end users. The projects included components giving priority to industry development activities better integrated with variety breeding and field and laboratory testing. In 2005 GRDC developed the National Variety Trials (NVT) as an improved system for comparative crop variety testing based on standardised trials. The system complements the breeding system by further testing of a limited number of lines close to commercial release. Growers can readily access results relevant to their region and assess yields compared with widely grown reference varieties (http://www.nvtonline.com.au/home.htm ). In Western Australia analysis of the options includes comprehensive comparisons of yield and quality in each region (Paynter et al 2008). The likelihood of achieving a malt premium is presented based on the main factors influencing key quality measures such as screenings (a measure of grain size or plumpness).

In addition to comparative yields there are other agronomic and disease factors that influence farmer choices of new varieties. For example, the South Australian guide (Wheeler 2008) lists ratings for each variety for eight disease and nine agronomic factors. Growers also need to consider the status of a variety from the end user perspective. Barley Australia was set up in 2005 as a peak industry body with functions including accreditation of new varieties for malting or feedgrain end uses ( Barley Australia 2008). When a grower has considered the range of information on a new variety, a trial area might be planted by the grower. However availability of seed can be a constraint while seed stocks build up.

Given the influence of the above factors, adoption of new varieties by displacing well established traditional varieties may only increase gradually over many years. Some of the recently predominant barley varieties were released over twenty years ago. A GRDC survey in 2006 showed that only 41 per cent of barley growers had grown new barley varieties in the past five years. This was no change from 2005 and well below the levels for wheat of over 70 per cent (GRDC 2007).

However, as the next section will show there has been a rapid increase in the number of releases and rate of adoption of superior barley varieties in the last few years. Barley industry development officers funded by GRDC have a key role to communicate information on varieties most suited to the wide range of environments. Their role in minimising what growers perceive as the risk in growing new varieties has become more important. The emphasis on more rapid release and commercialisation has increased. Shortened testing times put greater emphasis on better communication and on the role of industry development activities. An increasing proportion of the crop is subject to End Point Royalties (EPR) and this will tend to increase the more aggressive marketing of new varieties.

# 7 Measuring Benefits

As discussed in Section 4 no major social or environmental benefits were identified or evaluated. The only economic benefits identified that can be readily quantified are those relating to improved productivity from increased yields.

**Barley prospects**

The benefits are assumed to consist of the increased profits from the higher yielding varieties grown by farmers. The analysis also needs to take into account any expansion in the area sown to barley. In the longer term, profitability relative to alternative uses of the resources involved will be a key factor. Barley has traditionally been often grown in rotations with other crops and pastures on mixed or more specialised grain farms. The likelihood of a premium for barley that meets malting specifications is often a key factor influencing a farmer's choice of crop. In southern Australia and in Western Australia malting barley is often more competitive with wheat. In parts of northern and eastern Australia wheat premiums have traditionally been more likely than barley premiums. That may be changing. As fertility declines on some soils that don't have a sustainable rotation, wheat is becoming more dependent on fertiliser inputs. However increasing costs and more variable seasons have made fertiliser decisions more risky.

**Table 7 Trends in yield and production of barley in relation to wheat, Australia 1979 to 2008**

| Period | Barley Yield Advantage (% increase on wheat) | Barley production (% of wheat) |
|---|---|---|
| 1979-1993 | 2.4 | 26.6 |
| 1994-2008 | 4.7 | 33.1 |

Source: Calculated from ABARE (2006 and 2008) commodity statistics (based on Australian Bureau of Statistics and other sources)

As shown in Table 7 barley production has increased from about one quarter of the level of wheat to about one-third over the last few decades. The trends may be influenced by varying rates of expansion of wheat and barley in different regions. Wheat had been the crop of choice in more marginal areas of eastern Australia. The table also shows an increasing yield advantage of barley compared with wheat. In contrast Stephens (2003) in a national analysis to 1996 showed barley yield trends were generally lower than wheat, attributable to less fertiliser applied to malting barley. In the Stephens analysis, barley trends had similar regional patterns to wheat. However, barley trends were better than wheat in southern Victoria and southern Western Australia where barley better handles waterlogging and frosts. Those problems have probably decreased.

Recent increased drought incidence may also be a factor influencing the yield trends. To test that, the yield data used in Table 7 were partitioned using the Southern Oscillation Index as a drought indicator. All major grain industry droughts have been El Niño events. Low values of the SOI are an indicator of El Niño. Barley yields in the low SOI years were 5.4 per cent higher than wheat. In high SOI years the barley advantage was only 1.9 per cent.

The above analysis incorporates underlying trends in demand and supply of barley. Future trends are more problematic. However barley markets for example as inputs for production of beer and beef could be more likely to respond to rising incomes than the market for wheat products. The cursory analysis therefore supports a continuing favourable outlook for barley production given the favourable recent trends comparing barley demand, yields and production with wheat.

**Adoption/ Disadoption Patterns**

Adoption patterns for a new barley variety can be expected to be generally similar to those for wheat. For NSW wheat receivals data analysed by Brennan and Bialowas (2001) a peak rate of adoption was reached after an average of five years followed by a decline to zero over 17 years. Typical annual Shire yield increases were only of the order of one or two per cent. Only a part of the increase was attributed to breeding. An obvious feature of adoption patterns is the eventual displacement of a variety by a superior variety. In that case, the level of adoption and the benefits being achieved provide the ongoing base against which a new variety can be evaluated. The benefits achieved by the variety displaced continue to be attributed to the original investment.

The argument is also made by Brennan and Bialowas (2001) that benefits will decline because for example varieties become less resistant to evolving diseases. But often that and other factors will apply to both new and old varieties so that the difference in yield may be more or less constant. Another factor suggesting less yield decline in the case of barley is the evident longevity of some barley varieties over the last century.

**Benefits from Barley Breeding**

The new varieties have been bred to incorporate a wide range of improved agronomic and quality attributes. Benefits resulting from the quality attributes are more difficult to quantify than the yield changes. But quality advantages will impact directly in the analysis by influencing adoption rates, and thus increasing benefits via price driving adoption. The two key factors to be accounted for in determining benefits are the increased profits from new varieties and the extent to which they displace other varieties on barley production areas or make them more competitive with other crops, for example wheat. Yield increases can also be manifest in subsequent crops in a rotation. For example a new variety resistant to CCN can increase the yield of a subsequent wheat crop. An estimate of CCN benefits in the GRDC Southern Region will be included in this analysis.

Quality has always been a priority for malting barley. In the USA, Wilson (1984) showed that lower protein levels and increasing grain plumpness were the key quality attributes forming higher barley prices. Barley of malting quality may attract a premium. More is grown than is malted. This analysis assumes no change in the proportion of the total crop attracting a premium for malting quality. Recent emphasis on feedgrain quality particularly in the GRDC Northern Region has been prompted by the rapid expansion in demand by livestock industries and by an increasing need to import feedgrain during major droughts. Many of the new varieties have improved quality particularly key processing attributes such as grain plumpness. On export malt markets, quality improvements will have an important role perhaps more in maintaining competitiveness than achieving premiums.

Leaders of the research projects provided details on current and likely future adoption of new varieties and on likely yield increases. The NVT data set is extensive. For barley, over 900 entries are listed of mean yields for varieties tested in regions and zones covering the main barley producing areas. Barley breeders using NVT experience and knowledge of current and likely adoption of the new varieties provided estimates of varying detail at State or GRDC Region level for this evaluation. The estimates were provided for 2007/08 corresponding to the end of the period of investment, and for 2012/13 as an indication of the likely adoption at about the time the varieties could be expected to achieve near to their maximum levels. The contributions by 2012/13 assume no further releases.

The data detail provided by the barley breeders varied from an analysis by varieties of yields and receivables for each of the five sub-regions in Victoria to State level estimates of receivables in Western Australia. The data was aggregated to the three GRDC regions using ABARE information on barley area and production over the period and NVT data on yields. The additional production attributed to a specific variety can thus be made up from several regions, each with a specific yield benefit and adoption pattern, and each displacing different older varieties. The data indicated that adoption as shown by the area of the new varieties released had already been rapid. The estimate for the 2007 crop was that about 40 per cent of the total area had been planted to new varieties released since 2002.

There is debate, but seemingly little data other than anecdotal, on the extent to which NVT yield increases are achieved on farm. Opinions, both positive and negative, vary. Some argue for example that farmers have more opportunity to optimise planting times. As part of "Gains for Grains" six experienced agricultural consultants were asked '*What percentage of yield increases achieved in research trials is achieved when results are implemented on farm – for new varieties*?' (GRDC 1992). Three responses had either a wide range or a very low value. The other three responses averaged about 90 per cent. Note that the question is a different one to the difference in yields between experiments and farms where the answer is traditionally accepted as about one third less on farm (Davidson 1962).

Table 8 shows the benefits from the breeding program as measured by the increased yields achieved and the extent of adoption estimated in 2012/13. Over the ten year period the new varieties released in the seven year period to 2007/08 are expected to displace about 80 per cent of the varieties that were being grown in 2002/03. The expected benefit in terms of increased production is of the order of about one half a million tonnes or 6 per cent of likely national production by 2012/13. About 10 per cent of total production is estimated to be from varieties bred in another GRDC region. The estimated average annual yield increase to 2012/13 is 0.75 per cent compound, consistent with values in similar studies, for example Brennan et al (2004).

Table 8 includes contributions expected by 2012/13 from 19 new releases over the seven year period to 2007/08. There were also three releases early in the period not listed, as negligible quantities are grown currently.

**Table 8: Cumulative yield increases and estimates of production in 2012/13 from new barley varieties released from 2002 to 2008**

| Variety | Origin (1) | End Use (2) | Year (3) | Production in GRDC Region ('000 tonnes) | | | Australia |
|---|---|---|---|---|---|---|---|
| | | | | Northern | Southern | Western | |
| Mackay | QLD | Feed | 2002 | 0 | | | 0 |
| SloopSA* | SA | Malt | 2002 | | 155 | | 155 |
| SloopVIC* | VIC | Malt | 2002 | | 50 | | 50 |
| Baudin | WA | Malt | 2003 | | 110 | 586 | 696 |
| Hamelin | WA | Malt | 2004 | | | 385 | 385 |
| Grout | QLD | Feed (MP) | 2005 | 166 | | | 166 |
| Fitzroy | VIC | Malt | 2005 | 116 | | | 116 |
| Flagship* | UA | Malt | 2006 | | 791 | 80 | 871 |
| Fleet* | UA | Feed | 2006 | | 427 | | 427 |
| Buloke | VIC | Malt | 2006 | | 544 | 260 | 804 |
| Vlamingh | WA | Malt | 2006 | | | 247 | 247 |
| Hindmarsh* | VIC | Feed (MP) | 2007 | 118 | 1,483 | 200 | 1,801 |
| Roe | WA | Feed | 2007 | | | 195 | 195 |
| Lockyer | WA | Feed | 2007 | | | 147 | 147 |
| Hannan | WA | Feed (MP) | 2007 | | | 84 | 84 |
| Commander* | UA | MP | 2008 | 174 | 730 | | 904 |
| NRB03470 | QLD | MP | 2008 | 290 | | | 290 |
| Vertess | TAS | MP | 2008 | | 20 | | 0 |
| Urambie | NSW | Feed | 2005 | | 20 | | 0 |
| Other (varieties released before 2002) | | | | 251 | 1,249 | 515 | 2,055 |
| **TOTALAUSTRALIAN PRODUCTION ('000 tonnes)** | | | | **1,115** | **5,580** | **2,699** | **9,394** |
| Contribution from 2002-08 Varieties (per cent) | | | | 77 | 79 | 81 | 79 |
| Cumulative Annual Yield Increase from 2002 to 2013 (per cent per annum) | | | | 0.77 | 0.80 | 0.67 | 0.75 |
| Benefit in 2013 from yield increase ('000 tonnes) | | | | 72 | 345 | 148 | 566 |

Note: 1) Origin refers to the location of the breeding program, either state-based or University of Adelaide (UA).
2) As defined by Barley Australia. MP indicates evaluation for malting is scheduled or in progress.
3) Year evaluated or accredited as listed by Barley Australia following earlier release by a breeding organisation.
4) Three varieties listed in Table 5 that did not achieve significant production levels by 2007/08 have been excluded. Mackay is a significant current variety in the Northern Region but is assumed to be displaced by 2012/13.
* Indicates a variety with Cereal Cyst Nematode resistance (relevant to the Southern Region)

Hindmarsh appears to be widely adapted and is expected to make the largest contribution to national production of 19 per cent. For 17 sites in the NVT, Hindmarsh averaged 13 per cent more yield than Gairdner. Although there were only a limited number of seasons, the geographic extent of the increases achieved by Hindmarsh gives confidence that the increase is achievable in future and that this is indeed a highly adaptable variety. The next four varieties Commander, Flagship, Buloke and Baudin are expected to contribute 30 per cent to total production.

**Attribution of benefits to prior investments in project outcomes**
As discussed above the benefits accrue from the adoption of new varieties. They are the major outcome of prior investments by GRDC in breeding and in pre-breeding research. A new variety is a result of investments made over the previous breeding cycle, and increasingly from pre-breeding. The pattern of the breeding investment can be calculated by assuming the duration of a typical breeding cycle and apportioning prior investments to varieties released in a particular year (AGTRANS 2007a).

Estimates by barley breeders for the length of the breeding cycle ranged from 8 years for feed varieties to 12 years generally. New technologies are expected to result in shorter cycles. As shown by Brennan et al (2004) in wheat breeding, there has been a 12 year lag between the cross being made and the release of an improved variety. For this analysis for simplicity a 10 year lag is assumed. On that basis for example 10 per cent of the investment in 1993 can be attributed to Outputs over the period from 2002 to 2008.

**Table 9: Attribution of investments during the breeding cycles from 1992-2008 to outputs of the breeding program from 2002 to 2008 (nominal $)**

| Year (to 30 June) | GRDC | Other | Attribution to Outputs from 2002 to 2008 | | |
|---|---|---|---|---|---|
| | | | Per cent | GRDC ($,000) | Other ($,000) |
| 1992 | 1.240 | 3.242 | 0 | 0.000 | 0.000 |
| 1993 | 1.608 | 3.575 | 10 | 0.161 | 0.357 |
| 1994 | 1.975 | 3.907 | 20 | 0.395 | 0.781 |
| 1995 | 2.343 | 4.240 | 30 | 0.703 | 1.272 |
| 1996 | 2.710 | 4.572 | 40 | 1.084 | 1.829 |
| 1997 | 3.078 | 4.905 | 50 | 1.539 | 2.452 |
| 1998 | 3.445 | 5.237 | 60 | 2.067 | 3.142 |
| 1999 | 3.813 | 5.570 | 70 | 2.669 | 3.899 |
| 2000 | 4.180 | 5.902 | 70 | 2.926 | 4.132 |
| 2001 | 4.150 | 6.235 | 70 | 2.905 | 4.364 |
| 2002 | 4.150 | 6.567 | 70 | 2.905 | 4.597 |
| 2003 | 4.120 | 6.900 | 60 | 2.472 | 4.140 |
| 2004 | 3.412 | 6.376 | 50 | 1.706 | 3.188 |
| 2005 | 3.871 | 6.782 | 40 | 1.548 | 2.713 |
| 2006 | 4.540 | 7.256 | 30 | 1.362 | 2.177 |
| 2007 | 4.502 | 7.372 | 20 | 0.900 | 1.474 |
| 2008 | 4.878 | 7.722 | 10 | 0.488 | 0.772 |
| Total | 58,012 | 96,360 | 700 | 25,829 | 41,291 |

Note: GRDC and Other (mainly host organisation) investments were interpolated using actual data from Clements et al (1992), from GRDC (2000), and from the project data of Table 4.

The investments in barley breeding over the period from 1993 to 2001 were approximated using actual values for 1992 and for 2000 as shown in Table 9. As would be expected intuitively, the percentage allocations to the releases over the seven year period from 2002 to 2008 are equivalent to seven years of investment.

The calculated totals for GRDC and for 'Other' in Table 9 are very similar to the actual nominal totals from 2002 to 2008. The actual GRDC total in Table 4 was $25.520m compared with $25.829m as estimated for the breeding cycle in Table 9. But the key differences in an investment context arise from the differences in the price level and in the time value of money. On that basis using the Consumer Price Index and a 5 per cent discount rate, the present value cost of the investment in outputs from 2002 to 2008 is about 50 per cent higher for the more rigorous breeding cycle approach compared with simply using actual costs over the period from 2002 to 2008.

Attributing benefits from the large GRDC investment in pre-breeding research is more problematic. The benefits are difficult to evaluate and attribute, but they can be assumed to be eventually embodied in new varieties. The views of the barley breeders were that pre-breeding research would have only made a small contribution to the releases over the period from 2002 to 2008. The use of molecular marking technology is one example. Markers are used most efficiently in the earlier years of a breeding cycle so that much of their contribution will be in future releases. Where pre-breeding research results in introduction of novel material into a breeding program, the time lag to benefits being realised can be of the order of one to two decades. On balance, no allowance was seen as necessary for the benefits from pre-breeding research. Increasingly in future to avoid double counting in evaluating breeding programs, allowances will need to be made.

**The Counterfactual**

In the absence of the GRDC investment, breeding programs would most likely have been quickly cut back. But as varieties with EPR increased as a proportion of the crop, commercial interests may have purchased rights to existing germplasm and been able to fund limited ongoing programs. This would be the case particularly where there is an EPR capture mechanism for a particular end use. Imported varieties have not been a low-risk viable alternative without a major investment to develop adapted varieties.

The key assumptions in determining a baseline from which to measure benefits is that in the absence of the GRDC investment:

- there would have been a four year gap before net benefits became positive as new varieties were released, and
- The level of net benefits would then increase at only half that achieved by the GRDC investment.

**Benefits as measured by gross margin changes on farm**

The increased production of barley was shown in Table 8. The additional profits can be estimated from changes in the gross margin to take account of the additional costs involved in producing and marketing a marginal increase in production. Possible impacts of shifts in supply and demand need to be first considered.

Given that on average over one half of barley production is exported into competitive markets, barley could be assumed to be a price taker so that price effects from increased supply will be minor. Farquharson and Griffith (2001) showed that the then single desk arrangements for barley selling in NSW had capacity to practice some discriminatory pricing but only in a smaller domestic market. In an analysis of Queensland barley prices Gali and Brown (2002) showed that feed barley prices led malting barley prices.

Australian barley is a major contributor to both export malt and feed markets. In the domestic market, feedgrains are the major market and as with the export feedgrain market there are other grains that can substitute for barley to some extent. Given the above supply and demand factors, the analysis will assume the increased production has no readily quantifiable significant impact on prices. This assumption is the same as made by Brennan et al (2004) in an economic evaluation of New South Wales wheat breeding program. In relation to potential expansion of the barley industry, this analysis will not include any benefit that improved varieties will have on the rate of expansion. But the additional yield on the expanded area of barley, as forecast by ABARE, will be included as a benefit. The assumption is further justified if it is considered that competitor crops are also achieving increased yields from new varieties.

The approach adopted for measuring benefits for barley differs in some respects from a previous evaluation (AGTRANS 2007b) of the benefits of breeding programs for the cluster 'Other Crops', durum wheat, oats, and two triticale projects. Because there was greater complexity with four programs involved and all had expanded rapidly in recent years, project costs rather than costs over the breeding cycle were used. Also a more conservative cost reduction approach was used to estimate benefits to take account of uncertainty in the impacts of large yield increases form a short period of field trials.

Table 10 summarises the major assumptions made in undertaking the evaluation.

**Table 10: Summary of major assumptions**

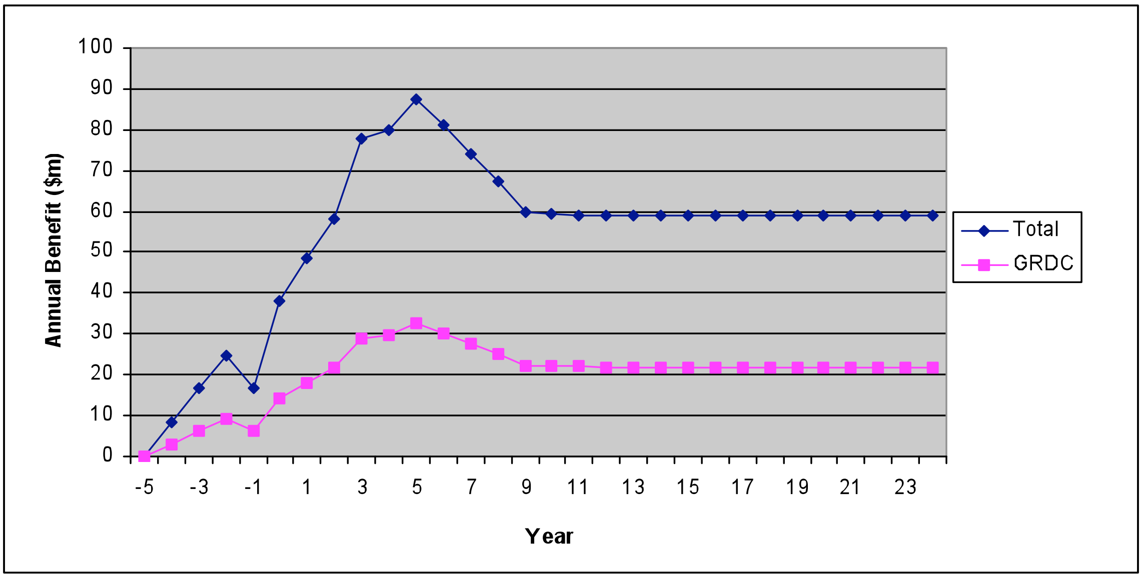
| **Description (years are financial years)** | **Value** | **Source ( by the author unless otherwise stated)** |
|---|---|---|
| **With GRDC investment** | Additional production | From new varieties produced over the period of the investment from 2002 to 2008. |
| Barley production base, 2003<br>• Area<br>• Production | <br>• 4.3 m ha<br>• 7 m t | <br>ABARE (2006) average for the period 2002 to 2004. |
| Production base, 2013-2032<br>• Area<br>• Production | <br>• 4.5 m ha<br>• 9.3 m t | <br>ABARE estimates for 2013 (Lawrence et al 2008). Nil expansion is assumed after 2013. |
| Production increase (new varieties )<br>• 2008<br>• 2013<br>• 2032 | <br>• 3.2 %<br>• 6.0 %<br>• 6.0 % | Aggregated from estimates of yield (based on NVT) and area adoption provided by barley breeders for all significant current and new varieties released. |
| Disadoption | Nil | Benefits from the new varieties are maintained as the varieties are eventually replaced by subsequent improved varieties. |
| Barley production (from new varieties)<br>• 2008<br>• 2013<br>• 2032 | <br>• 39 %<br>• 79%<br>• 79% | Aggregated from yield (based on NVT) and area adoption data provided by barley breeders for all significant current and new varieties released (see Table 8 for 2013) |
| Barley price (farm gate) | $235/t | Estimate of weighted average farm gate price for feed and malting barley based on Lawrence et al (2008) real prices for the next four years and deductions based on Edwards (2008) |
| Benefit/t, from yield increase | $200/t | Allowing for marginal increases in costs including for harvesting (NSW DPI 2008) |
| Benefit/t, from increased CCN resistance | $40/t | 5% of the yield increase to the following crop- reduced from the 10% (Sparrow and Buckby 1993) to allow for declining importance of barley as a break crop. |
| Proportion of increased production with CCN benefit | 20% | Based on estimate of benefit over one third of GRDC Southern Region (Oborne and Jervois 1993) which is 60% of the national total. |
| **Without GRDC investment**<br>Production increase<br>Lag<br>Net Benefit | <br><br>• 4 years<br>• one half | Assumes alternative breeding will develop but with a four-year lag and with net benefits one half of 'With GRDC' Investment. |
| **General Assumptions** | | |
| Indexation | CPI | To 2007/08 dollar values using CPI |
| Discount Rate (%) | 5 | As prescribed by GRDC |
| Period of analysis (years) | 25 | From last year of GRDC investment |

# 8 Cost Benefit Results

## Base Case

Based on the assumptions in section 7, the estimated increased cash flows attributable to the investment were estimated and projected over 25 years as shown in Figure 1. The cash flows evaluated are the increased profits to farmers from the yield increases achieved by new varieties. The graphs show the difference between the estimated benefits with the GRDC investment and the estimated benefits that would have eventuated without the GRDC investment. The early pattern incorporates lower benefits as a result of the decreased production due to the 2006 drought. The general pattern of a rapid rise to a peak and then a plateau reflects the displacement of new varieties by superior varieties. The benefits achieved by the new varieties are the base for any future benefits. The brief decline from a peak is not material; rather an artefact of the simple approximations made to represent the slower rate of adoption and lower level of benefits in the absence of the GRDC investment.

**Figure 1: Annual Benefit Cash Flow**




The net present values of the total investment and the GRDC investment are shown in Tables 11 and 12 respectively. This is considered to be the benefit accruing to Australia. The majority of the benefit accrues to grain growers as the majority of grain is exported at export prices or sold into a domestic feedgrain market dominated by feed wheat in most years. Therefore increased production is unlikely to have a major impact on prices. In other than drought years, export coarse grain prices are likely to lead domestic barley prices in price formation. Barley is a significant input to domestic value adding industries, particularly malting and brewing, and also intensive livestock production. In terms of the Rural Research Priorities the major contribution is to the Productivity and Added Value priority. As shown in Section 4 there were some other contributors to the other priorities, but these benefits have not been quantified.

The analysis demonstrates that under the assumptions the investment is highly likely to continue to achieve satisfactory returns and that the benefits accrue rapidly from the early years. Tables 11 and 12 show the results of the evaluation for the total investment and for the GRDC investment (the latter based simply on apportioning benefits according to costs).

**Table 11: Economic impact of the total investment**
(2007/08 $ terms, 5% discount rate)

| Total Investment | Present | +5 Years | +10 Years | +25 Years |
|---|---|---|---|---|
| Cumulative PV of Benefits ($m) | 112 | 413 | 647 | 1,022 |
| Cumulative PV of Costs ($m) | 121 | 121 | 121 | 121 |
| Cumulative NPV ($m) | -8 | 292 | 526 | 901 |
| Benefit Cost Ratio (BCR) | 0.93 | 3.43 | 5.36 | 8.48 |
| Internal Rate of Return (%) | 3.8 | 18.7 | 21.2 | 22.1 |

**Table 12: Economic impact of the GRDC investment**
(2007/08 $ terms, 5% discount rate)

| GRDC Investment | Present | +5 Years | +10 Years | +25 Years |
|---|---|---|---|---|
| Cumulative PV of Benefits ($m) | 42 | 154 | 240 | 380 |
| Cumulative PV of Costs ($m) | 46 | 46 | 46 | 46 |
| Cumulative NPV ($m) | -5 | 107 | 194 | 334 |
| Benefit Cost Ratio (BCR) | 0.90 | 3.31 | 5.18 | 8.18 |
| Internal Rate of Return (%) | 3.2 | 18.4 | 20.9 | 21.8 |

Before considering other possible scenarios for the outcomes from the GRDC investment, some interpretation of the pattern of future benefits is warranted. The graph (Figure 1) shows the pattern of benefits for the base case for the period of analysis. The broad pattern of benefits rising to a peak and then declining to a slightly lower plateau is influenced by four main factors:

- The early phase shaped mainly by the rapid increases in adoption rate already achieved and by the estimated increases in yields,
- The peak determined by the estimated peak adoption rate and maximum level of benefits/ha,
- The declining phase as determined initially by the assumption that in the absence of the GRDC investment, the barley breeding effort would be continued but with a lag and with reduced benefits, and
- The plateau based on the assumption that benefits would be maintained even though the current crop of varieties would eventually be displaced.

There can be some confidence on the magnitude of the rapid early benefits. The adoption data are based on results actually achieved. The yield estimates are less certain as they are based on NVT data and not farm data. However there was no consensus on whether the per cent increases achieved in NVT should be discounted to estimate farm level response.

The sensitivity analyses to illustrate other scenarios will therefore concentrate on pessimistic and optimistic factors influencing the overall level of benefits and also on the benefits in the medium term. The next section develops two scenarios to show the possible range of outcomes.

# 9 Other Scenarios

As concluded in the previous section, benefits in the early part of the analysis can be considered achieved with more confidence than those later in the period analysed. Optimistic and pessimistic scenarios therefore need to be developed by adjustments particularly to the assumptions determining the medium term level of benefits.

## *9.1 Optimistic*

The assumptions made on the potential benefits achieved if GRDC had not invested in barley breeding are the main determinant of the medium term benefits. The optimistic scenario is thus about optimism that the 'crowding out' hypothesis is <u>not</u> applicable. The 'crowding out' hypothesis describes in this context a publicly funded investment where market failure as the rationale for public investment was not necessary – the private sector would have invested anyway.

Thus a more optimistic scenario (in terms of returns to the GRDC investment) will result if the benefits in the 'without GRDC investment' situation are halved. There would then be less 'crowding out'. The initial assumption was that alternative breeding arrangements would start up with a four-year lag and with net benefits reduced by one half. The assumption recognised that with increasing EPR there would eventually be opportunities for commercial breeding operations to begin in selected markets. This analysis has shown that new varieties should continue to be rapidly adopted and eventually encourage commercial breeders in some markets where the opportunities for capture of EPR are better defined. However there is some uncertainty on the extent of possible alternative arrangements. Therefore to illustrate the potential change in benefits, the benefits in the 'without' situation were reduced by one half, resulting in benefits only a quarter of the 'with GRDC' investment. The increase in returns is shown in Table 12 for the GRDC investment. This scenario indicates that there would only be a small increase in return to the GRDC investment if a commercial alternative was less likely. The implication is that the rapid early increase in adoption of new varieties is the dominant factor in achieving high returns.

**Table 13: Return to the GRDC investment – Optimistic Scenario**
(2007/08 $ terms, 5% discount rate)

| GRDC Investment | 0 Years | 5 Years | 10 Years | 25 Years |
|---|---|---|---|---|
| Cumulative PV of Benefits ($m) | 43 | 167 | 284 | 493 |
| Cumulative PV of Costs ($m) | 46 | 46 | 46 | 46 |
| Cumulative NPV ($m) | -4 | 120 | 238 | 447 |
| Benefit Cost Ratio (BCR) | 0.92 | 3.59 | 6.12 | 10.62 |
| Internal Rate of Return (%) | 3.5 | 19.2 | 22.1 | 23.1 |

## *9.2 Pessimistic*

The pessimistic scenario is based on the following changes to the two key factors in terms of uncertainty of the assumptions:

- A reduction of one third in benefits up to the peak year in 2012/13, and
- Benefits declining from 2012/13 to zero by the end of the analysis.

Results are shown in Table 14. There are several risk factors that could contribute to a decline from the constant level assumed once adoption had stabilised. The main assumption was that the varieties being evaluated would eventually be displaced by yet to be released higher yielding varieties in the coming years. However the benefits were assumed to be maintained because the further yield increases are attributable to the further investments.

The one-third reduction in benefits to 2012/13 takes into account possible risks including changes in adoption rates as determined by:

- how well NVT percentage yield advantages translate to farm scale, and
- whether new varieties achieve accreditation for malting.

For some of the more significant emerging varieties such as Commander, accreditation for malting is highly likely as provisional malting status has already been achieved. For Grout, which is currently a significant feed variety in the GRDC Northern Region, future adoption assumed that would continue even though there is a possibility of Grout achieving malting status. Adoption of the new Northern Region variety, NRB03470, was also based on a conservative assumption of accreditation as a feed variety.

With the possible exception of Hindmarsh, there are generally enough varieties and available alternatives to minimise the overall impact on benefits from whether or not any one variety is accredited for malting. An analysis taking into account various scenarios based on probabilities of varieties achieving accreditation would become quite complex. Explicit assumptions would be needed on the premium for a malt end use, and on domestic and export markets for each variety in terms of for malting or for feed. In this analysis Hindmarsh is expected to be the most widely grown variety accounting for about 20 percent of the crop by 2012/13. Hindmarsh is yet to be accredited for malting. The rate of adoption assumed for Hindmarsh took into account to some extent the possibility that Hindmarsh might only be accredited as a feed variety. If it were not to be accredited, there could be some substitution from other malting varieties and some reduction in aggregate benefits. But the changes would be much smaller than the one-third reduction assumed for this pessimistic scenario.

The longer term decline in benefits could also take into account a pessimistic view on the impacts of climate change including higher costs for key inputs such as fuel and fertiliser. However, barley as a resilient crop may be less impacted by climate change and there is scope for adaptation to reduce the impacts.

Potential impacts and adaptations have been reviewed by Howden et al (2008). Gunasekera et al (2007) in a preliminary study of economic impacts on Australian agriculture have indicated production impacts of a 9.2 per cent decline (from the reference case of no climate change impacts) in Australian grain production by 2030. The last decade has included two major droughts, higher than historic drought incidence, but possibly realistic for the next 25 years given projections of up to 20 per cent more drought months over most of Australia by 2030 (CSIRO and the Bureau of Meteorology 2007).

Table 14: Return to GRDC investment – Pessimistic Scenario
(2007/08 $ terms, 5% discount rate)

| GRDC Investment | 0 Years | 5 Years | 10 Years | 25 Years |
|---|---|---|---|---|
| Cumulative PV of Benefits ($m) | 28 | 102 | 175 | 264 |
| Cumulative PV of Costs ($m) | 46 | 46 | 46 | 46 |
| Cumulative NPV ($m) | -19 | 56 | 128 | 218 |
| Benefit Cost Ratio (BCR) | 0.60 | 2.20 | 3.76 | 5.69 |
| Internal Rate of Return (%) | Negative | 13.7 | 18.2 | 21.4 |

The results in Table 14 of the more pessimistic assumptions on the level of benefits reached and on their long term decline do not have a major impact on the high level of returns achieved. The implication as for the optimistic scenario is that the results of the analysis are robust. The rapid early increase in adoption that has already been achieved is the key factor. The final section will consider lessons learned and what might be done to reduce the likelihood of the pessimistic scenario becoming more relevant.

# 10 Conclusions and Lessons Learned

The evaluation using the best available estimates of benefits from varieties released over the period from 2002 to 2008 suggested the investments by GRDC in barley breeding are already giving high returns. The benefit cost ratio taking into account the timing of prior investments over the breeding cycle is of the order of eight to one. The actual investment by GRDC in the projects undertaken from 2002 to 2008 was $25.5m. The Host Organisations (State Departments and two Universities) contributed $42.6m. The Net Present Value of the overall investment over 25 years is estimated at $901m.

There were twelve projects spanning parts of the period from 2002 to 2011. Investments and outputs in the form of 22 new varieties released and accredited or being accredited from 2002 up to 2008 were included in the evaluation. Of the 22 varieties, 19 are being grown currently in commercial quantities. The investment will maintain the reputation of the barley industry in producing high-quality barley for domestic and export markets.

The rapid increase in production from varieties released early in the period of evaluation was the main feature of the evaluation. By the 2008 harvest they are likely to account for one half of the crop. The varieties were assumed to reach their maximum adoption by about 2013 by which time they would account for 80 per cent of the crop. The expected benefit attributable to the new varieties is of the order of about one half a million tonnes or 6 per cent of likely national production by 2012/13. The annual cumulative rate of yield improvement of 0.75 per cent is of the order of that achieved by similar breeding programs.

The recently released Victorian variety Hindmarsh assuming, as expected, it achieves a high quality malting profile for export markets is likely to be a major variety with about 20 per cent of the national crop by 2013. The next four varieties are expected to account for a further 30 per cent.

The breeding structure was changed after the formation of Barley Breeding Australia in 2006. A node in each GRDC region replaced the previous state-based system. As this analysis is of the outputs over the period from 2002 to 2008 from breeding cycles of the order of a decade the analysis is clearly more reflective of returns from the previous structure.

The analysis has not considered benefits in relation to investments at the project level. However benefits were aggregated by GRDC region and they are very uniform in terms of the likely percentage increase in production. The Northern and Western regions each had about one quarter of their increase from varieties bred in other regions. The corresponding figure for the Southern region was two per cent. This pattern is likely to simply reflect the relative size and location of the Southern region. It also reflects some level of integration at the national level.

As a result of the early releases and their rapid adoption, and of the assumed yield increases, the investment can be expected to break even by 2009. There can be some degree of confidence in this conclusion as it is based on the actual pattern of deliveries. There is less certainty on the yield assumptions as these in most cases are simply based on increases recorded in NVT trials. The evaluation was not able to locate any strong evidence on the transferability of NVT increases to the field situation. The confidence in the evaluation would be considerably increased if that were available (as clearly would be the utility of the NVT system). Note the issue raised is not the well accepted and well understood reliability of NVT in terms of ranking.

Given that the investment is already close to profitable under the assumptions used and is based on actual data, sensitivity analyses were more relevant to assumptions on medium term benefits. If benefits in the medium term decline substantially, the investment still remains highly profitable. The decline could result for example if there was a reduced rate of replacement varieties in future and profitability declined, for example from impacts of climate change. Based on national yield and production trends, barley appears to be increasingly competitive with wheat. The analysis assumed that position would be maintained particularly as barley is considered a highly adapted crop generally and particularly as climate change impacts increase.

The investment was evaluated against a problematic base of what might have eventuated if GRDC had not invested. The assumption was made that other breeding arrangements would evolve but there would be a lag and net benefits would be only one half of currently achieved benefits. The analysis was not very sensitive to more pessimistic assumptions indicating that the rapid early adoption of new varieties was dominating the analysis. The pessimistic assumptions included the possibility that recently released varieties might not be accredited as malting varieties. However the varieties were still assumed to be widely adopted as feed varieties.

The length of the lag until other breeding arrangements evolve will depend on how quickly EPR grow to make commercial arrangements more likely. This economic analysis has not quantified EPR because they are a transfer payment, that is a cost to the farmer and a benefit to the breeding agency. Future investment decisions will need to take greater account of EPR revenue than was the case in 2002. When the projects at the start of this period of evaluation were funded in 2002 a higher proportion of the crop was not covered by EPR.

Another conservative aspect of the analysis is the exclusion of quality aspects that may contribute to a price premium. But to some extent the adoption estimates should reflect all advantages, not only in yield.

The analysis is of a national system in transition from one based on state-based breeding programs to one now based on three nodes. The results are more attributable to the previous structure. The analysis does however provide a challenging performance benchmark for the new structure.

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