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# An Economic Analysis of GRDC Investment in the Mungbean Improvement Program

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Enquiries should be addressed to:
Mr Vincent Fernandes
Corporate Strategy & Impact Assessment
Grains Research and Development Corporation
PO Box 5367
KINGSTON ACT 2604
Phone: 02 6166 4500
Email: v.fernandes@grdc.com.au

Author:
Agtrans Research
PO Box 385
TOOWONG QLD 4066
Phone: 07 3870 4047
Email: info@agtrans.com.au

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# Impact Assessment: An Economic Analysis of GRDC Investment in the Mungbean Improvement Program

## Executive Summary

The first commercial mungbean varieties grown in Australia in the late 1960s and 1970s were varieties introduced from AVRDC in Taiwan. CSIRO then commenced breeding for Australian environments in a program supported by GRDC. With the release of new adapted varieties such as Emerald, mungbean crop production expanded from around 10,000 tonnes in the late 1980s to 20,000 tonnes in 1996 and around 45,000 tonnes by the mid 2000s. CSIRO divested it's investment in mungbeans in 2002 and research ceased following the release of the variety White Gold.

In 2003 DEEDI and GRDC initiated the National Mungbean Improvement Program (NMIP) to increase productivity of the Australian industry. NMIP targeted improved yield and reliability through utilisation of mungbean genetic resources, improved regional adaptation and new foliar disease resistances, with widespread testing of advanced lines across the northern grains region.

Since the release of Crystal and Satin II in 2008 grower and industry confidence has risen markedly, as evidenced by increased planting area (from 45,000 to 66,000 hectares) and production (65,000 tonnes). Further benefits of these investments will be realised as new varieties with improved disease resistance come to market.

About 95% of mungbeans produced in Australia are exported. Mungbeans are mainly marketed as a vegetable rather than as bulk grain so their appearance is very important. A small proportion of mungbean seed produced is used in Australia for sprouting.

Plant breeding was a high priority for the Australian Mungbean Association (AMA) before this investment commenced. Unreliable dryland production was considered a constraint in marketing, hence the AMA has set a target of stable annual production of 50,000 tonnes by 2014. Improved yields and greater disease resistance were favoured strategies for achieving more mungbeans to be planted through higher profits and greater reliability and confidence.

GRDC investments in mungbean breeding have been complemented by agronomic advances in mungbean from previous GRDC-DEEDI and NSWDPI funded projects such as DAQ061, DAQ500 and DAN442.

During the investment period two new improved varieties (Crystal and Satin 2) were released and have been widely adopted by the industry. A number of elite lines with higher yields and greater disease resistance have been produced from which varietal releases and further industry growth are expected in the next few years.

An overview of identified benefits in a triple bottom line categorisation is shown in the following table. Not all of the identified benefits are valued in this analysis. Of the identified benefits, only the economic benefits are measurable based on the data available.

Categories of Benefits from the Investment

| Levy Paying Industry | Spillovers | | |
|---|---|---|---|
| | **Other Industries** | **Public** | **Foreign** |
| Economic benefits | | | |
| Contribution to release of two varieties to date with higher yields and reduced grading loss than previous varieties<br><br>Contribution to future releases of new higher yielding varieties with higher levels of disease resistance<br><br>Contribution to higher quality mungbeans, so increasing demand and/or price premiums<br><br>Increasing mungbeans in rotations (through increased profitability of mungbeans and more disease resistant varieties) can potentially lead to reduced chemical usage on farms (herbicides and fungicides)<br><br>Fertiliser cost reduction from nitrogen supplied by mungbeans compared to other crops that might be used in rotations<br><br>Increase in capital value of mungbean germplasm between 2003 and 2011 | Yield increases and economic benefits to other crops such as cereals and cotton from disease and weed control from increasing mungbeans in rotations | Nil | Nil |
| Environmental benefits | | | |
| Reduced use of nitrogen fertiliser compared to other rotation crops due to nitrogen self sufficiency of mungbean<br><br>Reduced use of chemicals (herbicides and fungicides) in mungbean crops and crops in mungbean rotations | Nil | Reduced use of chemicals in mungbean crops leading to reduced export of chemicals off farm<br><br>Increasing or maintaining mungbeans in rotations can potentially lead to reduced chemical/ nutrient exports in cereal/cotton growing regions | Nil |
| Social benefits | | | |
| Improved farmer well being through reduced chemical use by | Nil | Reduced chemical use resulting in | Nil |

| | | | |
|---|---|---|---|
| farmers | | reduced potential impact on regional well being | |

The investment in the two projects has produced a number of benefits some of which have been valued. The total investment of $6.1 million (present value terms) has been estimated to produce total gross benefits of $115 million (present value terms) providing a net present value of $109 million, a benefit-cost ratio of over 18 to 1 (over 30 years, using a 5% discount rate) and an internal rate of return of 53%. Even though most assumptions were conservatively estimated, this is a relatively high rate of return compared to other crop breeding programs. Breeding programs for small industries such as mungbean need to produce high rates of gain over time in terms of yield or quality in order to justify the investment. In the case of mungbean both these gains have been achieved by this investment.

# 1. Introduction

This evaluation refers to the GRDC National Mungbean Improvement Program supported by GRDC over the period 2003 to 2011. The two projects supported were both contracted with the Department of Employment, Economic Development and Innovation (DEEDI) in Queensland.

Mungbeans (*Vigna radiata*) are an annual legume grown as a spring and summer crop in subtropical areas, predominantly in Queensland and northern New South Wales. Grain yields are constrained by a short crop life cycle and have recently been impacted by drought, disease and severe weather damage at maturity that can reduce both yield and product quality.

The first commercial mungbean varieties grown in Australia (late 1960s and 1970s) were imported varieties  CSIRO undertook evaluation and breeding up until 2002 and bred Emerald (1993) and Green Diamond (1997). The area of the mungbean crop expanded from around 10,000 tonnes in the late 1980s to 45,000 tonnes by the mid 2000's.

DEEDI assumed leadership and refocused the breeding program in 2003 placing emphasis on expanded genetic diversity, development of new foliar disease resistance traits and underpinned by rigorous field evaluation throughout the northern grains region. The release of Crystal and Satin II in 2008 has reinvigorated the Australian industry and seen production grow to 65,000 tonnes.

About 95% of mungbeans produced in Australia are exported. Mungbeans are mainly marketed as a vegetable rather than as bulk grain so their appearance is very important. A small proportion of mungbean seed produced is used in Australia for sprouting.

GRDC investments in mungbean breeding and agronomy (e.g. GRDC-DEEDI-NSWDPI projects such as DAQ061, DAQ500 and DAN442) have been highly complementary in successfully adapting mungbean to modern farming practices in Australia.

Plant breeding was a high priority for the Australian Mungbean Association (AMA) before this investment commenced. Unreliable dryland production was considered a constraint in marketing. A target stable production of 50,000 tonnes per annum by 2014 was set by the AMA in order to support market development for Australian mungbeans (AMA, 2011a).

Mungbeans are produced mainly in the northern grains region such as central and southern Queensland and the irrigated region of northern NSW. Typically, about 10% of production is irrigated but this can vary from year to year. Mungbeans are a short season spring/summer crop grown mainly as a rotation crop with cereals or cotton. There are two different types of mungbeans grown in Australia: the large seeded shiny type and the dull seeded type grown for niche markets.

Areas, yields and total tonnages for Australian mungbean production are provided in Table 1.

Table 1: Areas, Yields and Tonnages for Australian Mungbean Production

| Year ended June | Area (ha) | Yield (tonnes per ha ) | Production (tonnes) |
|---|---|---|---|
| 2004 | 44,100 | 1.07 | 47,300 |
| 2005 | 49,800 | 1.07 | 53,200 |
| 2006 | 44,000 | 1.09 | 48,100 |
| 2007 | 44,300 | 0.65 | 28,600 |
| 2008 | 45,000 | 1.10 | 45,500 |
| 2009 | 44,800 | 0.88 | 39,500 |
| 2010 | 59,000 | 1.10 | 65,000 |
| 2011 | 72,000 | 0.90 | 65,000 |
| Simple average | 51,171 | 0.98 | 50,386 |

Source: ABARES (2010) for years 2004 to 2009; Dale Reeves, AMA for years 2010 and 2011

Goal 3.2 within the AMA's strategic plan (2009-2014) refers to research on mungbean cultivars (yield and suitability) and includes the following actions (AMA, 2011a):

- Continue the industry's R&D program as a vital initiative to support the long-term development of the industry.
- Continue R&D on mungbean cultivars.
- Investigate yield performance of different varieties and determine factors that can affect actual yield versus expected potential yields.

The projects addressed in this analysis are consistent with the above strategic plan.

# 2. Project Investment

**Projects Funded by GRDC**

The two recent projects funded by GRDC in this investment cluster are listed in Table 2. Table 3 provides a summary of the objectives of each project.

Table 2: Recent Mungbean Breeding Projects Funded by GRDC

| Project Code and Title | Other Details |
|---|---|
| DAQ00060: National Mungbean Improvement Program | Organisation: Queensland Department of Primary Industries (now DEEDI)<br>Period: July 2003 to June 2008<br>Principal Investigator: Merrill Fordyce |
| DAQ00128: National Mungbean Improvement Program | Organisation: Queensland Department of Primary Industries (now DEEDI)<br>Period: July 2008 to June 2011<br>Principal Investigator: Merrill Ryan (Fordyce) |

Table 3: Project Codes, Titles and Stated Objectives

| Project Code and Title | Stated Objectives |
|---|---|
| DAQ00060: National Mungbean Improvement Program | Broad objectives were:<br>1. To develop advanced mungbean germplasm with improved yield and quality, specifically adapted for dryland and irrigated production in the northern region farming system.<br>2. To improve the overall stability of production and yield of this summer rotation crop.<br><br>Specific objectives were:<br>1. To quantify the genetic variation that existed in the Australian and international mungbean collections for both agronomic and disease resistance traits.<br>2. To make available advanced germplasm in the northern region combining improved yield, disease resistance and quality, with testing in both dryland and irrigation field trials.<br>3. To implement reliable screening methods for various foliar diseases in mungbean and evaluate breeding lines, introduced material and the lines in the Australian mungbean collection. |
| DAQ00128: National Mungbean Improvement Program (current) | The broad objectives are:<br>1. To identify the next generation of mungbean varieties from germplasm and breeding lines developed in DAQ00060 including superior resistance to disease, specific regional and systems adaptation delivering yield stability and restoration of grower confidence in mungbean as a profitable and reliable summer crop option.<br>2. To ensure delivery of better mungbean varieties faster with the AMA as a commercial partner.<br><br>Specific objectives are:<br>1. To develop five elite new mungbean lines in pedigree seed production that:<br>• combine the yield, agronomy and grain quality of current varieties;<br>• contain specific adaptation for regional, dryland or irrigated production; and<br>• have superior Powdery Mildew and Tan Spot resistance that will increase yield stability.<br>2. To identify new sources of resistance to the Halo Blight pathogen.<br>3. To maintain a watching brief over Tobacco Streak Virus in central Queensland.<br>4. To effectively integrate the Australian mungbean value chain, researchers and investors, and promote effective coordination and communication throughout the local industry. |

**Investment Inputs**

Estimates of the funding by GRDC and others by project by year for the two mungbean projects are provided in Tables 4 and 5. Table 6 shows the total investment by both GRDC and partners in the two projects.

Table 4: Investment by GRDC by Project for Years Ending June 2004 to June 2011 (nominal $)

| YE June | DAQ00060 | DAQ00128 | Total |
|---|---|---|---|
| 2004 | 200,413 | 0 | 200,413 |
| 2005 | 154,338 | 0 | 154,338 |
| 2006 | 228,938 | 0 | 228,938 |
| 2007 | 245,095 | 0 | 245,095 |
| 2008 | 259,105 | 0 | 259,105 |
| 2009 | 0 | 265,000 | 265,000 |
| 2010 | 0 | 265,000 | 265,000 |
| 2011 | 0 | 265,000 | 265,000 |
| **Total** | **1,087,889** | **795,000** | **1,882,889** |

Source: GRDC Project Specifications and Final Reports

Table 5: Investment by GRDC Partners by Project for Years ending June 2004 to June 2011 (nominal $)

| YE June | DAQ00060 | DAQ00128 | Total |
|---|---|---|---|
| 2004 | 268,861 | 0 | 268,861 |
| 2005 | 271,136 | 0 | 271,136 |
| 2006 | 322,980 | 0 | 322,980 |
| 2007 | 331,748 | 0 | 331,748 |
| 2008 | 338,897 | 0 | 338,897 |
| 2009 | 0 | 381,526 | 381,526 |
| 2010 | 0 | 445,242 | 445,242 |
| 2011 | 0 | 479,146 | 479,146 |
| **Total** | **1,533,622** | **1,305,914** | **2,839,536** |

Source: Partners' (QDPI and NSW DPI) investment based on GRDC Project Specifications

Table 6: Total Investment by GRDC and Partners in Projects for Years Ending June 2004 to June 2011 (nominal $)

| YE June | GRDC | Partners | Total |
|---|---|---|---|
| 2004 | 200,413 | 268,861 | 469,274 |
| 2005 | 154,338 | 271,136 | 425,474 |
| 2006 | 228,938 | 322,980 | 551,918 |
| 2007 | 245,095 | 331,748 | 576,843 |
| 2008 | 259,105 | 338,897 | 598,002 |
| 2009 | 265,000 | 381,526 | 646,526 |
| 2010 | 265,000 | 445,242 | 710,242 |
| 2011 | 265,000 | 479,146 | 744,146 |
| **Total** | **1,882,889** | **2,839,536** | **4,722,425** |

Source: GRDC Project Specifications

# 3. Activities and Outputs

A summary of the principal outputs (and expected outputs in the case of the project not yet completed) from each of the projects is reported in Table 7.

Table 7: Summary of Principal Outputs by Project

| Project | Principal Outputs |
|---|---|
| DAQ00060: National Mungbean Improvement Program | • Trial sites for field evaluation of elite lines developed in previous projects were expanded from a previous concentration on an irrigated site at Gatton to northern NSW and Central Queensland as well as including dryland sites.<br>• Thirty five regional trials with both spring and summer plantings and across dryland and irrigated sites were completed between 2003 and 2008, evaluating 224 elite breeding and germplasm lines against seven commercial varieties.<br>• Statistical analysis of multi-site trials identified that the ex-CSIRO germplasm was broadly suited to the Northern Region but had no specific regional or rainfed/irrigated adaptation.<br>• Increased integration of breeding and pathology disciplines to address quality issues was manifest during the project.<br>• The project identified sources of genetic resistance to Powdery Mildew and Tan Spot and new sources of yield and grain quality in breeding lines and incorporated these into agronomically adapted backgrounds.<br>• The project developed and implemented new glasshouse and field screening methods for Powdery Mildew and Tan Spot.<br>• The project developed and released two new varieties with improved yield of about 20% (Crystal and Satin 2), with both varieties suited to both irrigated and rainfed production.<br>• Yield results from trials have been widely extended through various organisations and media types to support northern growers in their variety selection and planting decisions.<br>• The AMA was selected as commercial partner for the National Mungbean Improvement Program (NMIP) with first right of refusal to future pipeline varieties. |
| DAQ00128: National Mungbean Improvement Program | • Selections were made from crosses identified and promoted in 2008/09 season trials. The trials included early generation increases, disease nurseries and field trials in central Qld, southern Qld and northern NSW.<br>• Five elite mungbean lines in pedigree seed production were developed.<br>• New varieties will combine the traits of yield, agronomy and grain quality of current varieties with specific adaptation for regional, dryland and irrigated production<br>• The new varieties are showing superior Powdery Mildew and Tan Spot resistance to increase yield stability. |

| | |
|---|---|
| | • Germplasm with superior disease resistance was produced with new sources of resistance to the Halo Blight pathogen identified, and breeding lines evaluated for resistance to Tan Spot and Powdery Mildew pathogens.<br>• A watching brief was maintained over Tobacco Streak Virus in Central Queensland.<br>• There was further integration of the mungbean value chain, research and investors and effective coordination and communication.<br>• New screening methods for foliar diseases were developed and implemented.<br>• In 2009, advanced breeding lines in Stage 1 and Stage 2 trials were demonstrating yield performance and combinations of key traits which will deliver the desired outcomes from the project.<br>• Parent lines were identified with excellent resistance to Powdery Mildew and Tan Spot and incorporated into the program.<br>• Initial screening also identified three lines with excellent resistance to Halo Blight.<br>• In 2010, elite line MO7213 showed yields 14% higher than Crystal across 20 sites over 3 years and also had a more resistant rating for Tan Spot and Powdery Mildew than Crystal.<br>• A further six lines of both large seeded and small seeded types were identified and will be subject to further screening in 2011; preliminary data suggest increased yields and improved disease resistance to Tan Spot and Powdery Mildew for the large seeded lines compared with Crystal; and increased yield and resistance to Halo Blight in the case of the small seeded variety compared with existing varieties Celera and Green Diamond.<br>• The project has been involved with the development and testing of a new plant breeding data management system (Katmandoo).<br>• The project has also been involved with renewing the relationship with the AVRDC (World Vegetable Centre) with regard to collaborative projects and germplasm exchange.<br>• Already 252 new mungbean lines have been imported into Australia and are just emerging from quarantine. |

In summary, the principal outputs from these two investments were:

- Varieties 'Crystal' and 'Satin 2' were released with about a 20% higher yield potential as well as superior grain quality compared with the existing varieties such as Emerald and White Gold.
- Australian and international mungbean collections were analysed identifying lines with essential genetic diversity and superior yield potential.
- New screening methods for foliar diseases were developed and implemented.
- Parent lines were identified with excellent resistance to Tan Spot and Powdery Mildew and incorporated into the program with expected variety releases in future.
- Initial screening also identified lines with excellent resistance to Halo Blight, particularly for the small seeded variety with expected variety releases in future.

- Establishment of a stronger relationship with the World Vegetable Centre including germplasm exchanges.

# 4. Outcomes

**Project Outcomes**
A summary of the principal outcomes from each of the two projects is reported in Table 8.

Table 8: Summary of Principal Outcomes by Project

| Project | Principal Outcomes |
|---|---|
| DAQ00060: National Mungbean Improvement Program | • Widespread commercial plantings of new varieties Crystal and Satin II commenced in September 2008.<br>• The varieties are being grown in both dryland and irrigated systems and in both Queensland and NSW.<br>• 600 tonnes of Crystal seed were sold in 2008/09 and this variety has replaced most other commercial varieties (e.g. White Gold, Delta and Emerald).<br>• At a sowing rate of 25 kg per ha, the above quantity of seed could have covered 24,000 ha in 2008/09.<br>• Crystal not only has superior yield to earlier varieties, but also has the best available suite of disease resistance. The variety has performed well under both drought and favourable (including irrigated) conditions.<br>• 22 tonnes of Satin II seed were produced in 2008/09 (a dull seeded variety to service niche markets) and the corresponding commercial area of crop could have been up to 1,000 ha.<br>• Satin II has replaced Satin I which has been out of production due to seed quality no longer meeting export standards. Market access to export markets (potentially about 5,000 tonnes per annum) has been reinstated. Satin II was the first variety to be released under the new pipeline commercialisation agreement with AMA.<br>• As of May 2011 Crystal is now the preferred variety for growers and accounts for about 90% of production.<br>• The new varieties have increased the gross margin per hectare and the overall production of mungbeans for the same area.<br>• The new varieties have provided potential for increased areas of legumes grown in rotations with cereals and cotton.<br>• Any increased areas grown have resulted in self sufficiency in nitrogen and have provided improved weed control in rotations leading to reduced chemical resistance and more efficient use of soil moisture in cropping rotations.<br>• An increased area of mungbean will promote more environmentally sustainable cropping systems.<br>• The new set of improved germplasm potentially can be used with further development to produce new varieties with improved grain quality, disease resistance and yield. |

| | |
|---|---|
| | • New diversity from the germplasm collection will broaden the genetic base of NMIP and build on the productivity gains of Crystal and Satin II to deliver foliar disease resistance and yield stability.<br>• The closer link between the AMA and the NMIP will align future varieties more closely with industry needs, produce improved varieties faster with AMA involved in commercial seed bulk up, and allow improved promotion of new varieties. |
| DAQ00128: National Mungbean Improvement Program | • Further mungbean variety releases that exploit new traits from the wider genetic base incorporated into the crossing program in DAQ00060 (environmental adaptation and superior resistance to foliar diseases).<br>• Variety MO7213, with an average yield 14% higher than Crystal and with improved disease resistance to Powdery Mildew and Tan Spot, is expected to be released in 2012/13.<br>• A second variety with a further 10% yield increase may be released in 2013/14.<br>• A third variety with a significant yield increase over Celera/Green Diamond (small seeded type) and with resistance to Halo Blight may also be released in 2013/14.<br>• Given the rapid adoption of Crystal and Satin 2, it is likely that the new varieties will also be adopted rapidly by industry.<br>• Three new sources of Halo Blight resistance have been found and introgressed into adapted backgrounds. These will be evaluated and brought to market by 2016.<br>• The yield increases and the improved resistance may be associated with increased confidence in using mungbeans in rotations and hence an increased area of mungbeans sown in future.<br>• The AMA involvement in the commercialisation and varietal releases (e.g. bulking up of seed quicker) that commenced during the investment being evaluated has meant that growers have been able to take advantage of improved varieties earlier than otherwise.<br>• New mungbean germplasm imported into Australia via the renewed relationship with the World Vegetable Centre potentially will allow further development of new varieties in future. |

In summary, the principal short-term outcomes from these investments are new and superior varieties being grown, or expected to be grown, by producers and delivering benefits to mungbean producers by way of higher yields and improved disease resistance. Areas of mungbeans have also increased in recent years since Crystal has been released due to, at least in part, increased confidence of growers in yields and markets.

In the longer term the germplasm capital existing at the end of the investment period (2010/11) is likely to be greater than that in 2003/04.

## 5. Benefits

**Yield Increases**
The major benefits accruing to the two projects are the yield increases from the new varieties that have been released to date, and the prospective yield increases from any future commercialisation of the identified superior lines.

**Potential Production Stability**
The higher yields and improved disease resistance may provide higher average yields as well as greater confidence held by grain producers in planting mungbeans. This may in turn elicit a higher total area of mungbeans. Higher production may not only provide increased profit but also may have positive export marketing implications for the Australian industry through improved stability in servicing market demand niches in the high quality end of the market (Dale Reeves, pers.comm., 2011).

**Quality Improvements**
There have been quality gains (size and appearance) from the two varieties already released. As appearance is very important in the market place, the new varieties are already achieving a higher price than the varieties they have replaced. The varieties likely to be produced in future are predicted to be of even higher quality. Quality attributes measured include 100 seed weight, evenness of seed size, seed colour and brightness. Further Crystal has a reduced grading loss compared to the variety it has replaced (Dale Reeves, pers.comm., 2011).

**Regional Adaptability and Drought Tolerance**
The new varieties already released are broadly better adapted to all growing regions without having been bred for a specific region. However, it is likely that some of the prospective varieties from the current advanced lines may be more specifically adapted to some regions (Col Douglas, pers.comm., 2011). As some of the improved lines will be earlier maturing, they may well exhibit improved drought tolerance.

**Maintenance of mungbean in cropping rotations**
Mungbean has been playing an important role in providing a disease break for cereal grains in northern cropping systems. The mungbean crop is short–term and is suitable for both late spring and summer sowing. Also, crop rotations incorporating mungbeans can be sustainable and more profitable than a cereal-cereal rotation and mungbeans can also play a role in cotton-cereal rotations. Relative product prices and the stability of yields are key determinants of mungbean plantings but there are other minor associated advantages from the new mungbean varieties apart from higher and more stable yields (improved disease resistance). Mungbeans can reduce chemical use in the rotation due to improved pest control and can reduce the use of nitrogen fertiliser in a rotation. If the new varieties lead to increases in the annual area of mungbeans planted, then such additional benefits can be attributed to the new varieties. Work has been initiated in developing a mungbean variety for the Burdekin Irrigation Area that would fit into a sugarcane rotation.

**Environmental**
Maintaining disease breaks through rotations and increased plant resistance through use of mungbeans can lead to less chemical usage (pesticides) in cereal/cotton farming systems. Also, with greater varietal resistance to Powdery Mildew in

mungbeans, there may be less fungicide used for that crop itself. Such reduced usage may benefit the farm environment and potentially lead to reduced export of chemicals to public waterways. Nitrogen contributed by mungbean crops can reduce total nitrogen fertiliser required compared to other potential rotation crops.

**Genetic Capital**

Due to the further development of germplasm during the eight year investment, the genetic capital at the end of the investment period may actually be higher than at the beginning. Genetic capital in breeding material should also increase in future due to activities initiated at the end of the eight year period regarding the renewed relationship with the World Vegetable Centre and the commencement of importation of new genetic material.

**Overview of Benefits**

An overview of benefits in a triple bottom line categorisation is shown in Table 9.

Table 9: Categories of Benefits from the Investment

| **Levy Paying Industry** | **Spillovers** | | |
|---|---|---|---|
| | **Other Industries** | **Public** | **Foreign** |
| Economic benefits | | | |
| Contribution to release of two varieties to date with higher yields and reduced grading loss than previous varieties<br><br>Contribution to future releases of new higher yielding varieties with higher levels of disease resistance<br><br>Contribution to higher quality mungbeans, so increasing demand and/or price premiums<br><br>Increasing mungbeans in rotations (through increased profitability of mungbeans and more disease resistant varieties) can potentially lead to reduced chemical usage on farms (herbicides and fungicides)<br><br>Fertiliser cost reduction from nitrogen supplied by mungbeans compared to other crops that might be used in rotations<br><br>Increase in capital value of | Yield increases and economic benefits to other crops such as cereals and cotton from disease and weed control from increasing mungbeans in rotations | Nil | Nil |

| | | | |
|---|---|---|---|
| mungbean germplasm between 2003 and 2011 | | | |
| <u>Environmental benefits</u> | | | |
| Reduced use of nitrogen fertiliser compared to other rotation crops due to nitrogen self sufficiency of mungbean<br><br>Reduced use of chemicals (herbicides and fungicides) in mungbean crops and crops in mungbean rotations | Nil | Reduced use of chemicals in mungbean crops leading to reduced export of chemicals off farm<br><br>Increasing or maintaining mungbeans in rotations can potentially lead to reduced chemical/ nutrient exports in cereal/cotton growing regions | Nil |
| <u>Social benefits</u> | | | |
| Improved farmer well being through reduced chemical use by farmers | Nil | Reduced chemical use resulting in reduced potential impact on regional well being | Nil |

**Public versus Private Benefits**
The benefits identified from the investment are predominantly private benefits, namely benefits to mungbean producers in the northern grain growing regions of central and southern Queensland and northern NSW. Some spillover benefits also are likely to be private, mostly gains to cereal and cotton producers. There will have been some small public benefits potentially produced, mainly environmental in nature from lowered chemical usage with potential implications for water quality off-farm.

**Benefits to other Primary Industries**
The principal non-mungbean industry beneficiaries will be cereal, cotton, and sugarcane producers by way of mungbean increasing its role as a rotation crop for those industries.

**Distribution of Benefits along the Mungbean Supply Chain**
Some of the potential benefits from more profitable production will be passed along the mungbean supply chain. Part of any estimated gain achieved by producers will be transferred to plant breeders through Plant Breeders Rights.

**Benefits Overseas**
Growers of mungbean in overseas countries will benefit to some extent from Australian germplasm being exchanged with the World Vegetable Centre. However, no seed of the new varieties has been exported to date due to the difficulty of enforcing the rights held by Australians under Plant Breeders Rights and to the AMA's dedication to protecting the competitiveness of Australian growers.

**Match with National Priorities**
The Australian Government's national and rural R&D priorities are reproduced in Table 10.

Table 10: National and Rural R&D Research Priorities 2007-08

| **Australian Government** | |
|---|---|
| **National Research Priorities** | **Rural Research 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>*Supporting the priorities:*<br>1. Innovation skills<br>2. Technology |

Table 11 identifies the national and rural research priorities that each of the benefits address.

Table 11: Categorisation of Principal Benefits by Priorities

| **Benefit** | **National Research Priorities Addressed** | **Rural Research Priorities Addressed** |
|---|---|---|
| Productivity gains through yield increases and quality improvements from new varieties | Priority 3 *** | Priority 1 ***<br>Priority 2 *<br>Priority 3 * |
| Less chemical usage on farm from disease breaks and more resistant cultivars | Priority 4 **<br>Priority 1 * | Priority 5 **<br>Priority 3 * |

*** Strong contribution **Some contribution * Marginal contribution

**Additionality and Marginality**

The investment in this cluster was targeted principally towards benefits to mungbean levy payers. Breeding programs are often perceived as the mainstay of productivity improvements for many crop species so that the investment would have been regarded as a high priority by levy payers. In the event that public funding was restricted, it is likely that most of the projects in the cluster would have still been funded by industry, assuming a levy system was still in place.

Most of the limited public spillovers that have been identified would therefore still have been delivered. If no public funding at all had been available, it is likely that the investment would have been curtailed to about 75% of what GRDC actually funded. This would have been associated with a slower rate of genetic progress. Further detail is presented in Table 12.

Table 12: Potential Response to Reduced Public Funding

| | |
|---|---|
| 1. What priority were the projects in this cluster when funded? | High |
| 2. Would industry have funded this cluster if less public funding were available? | Yes, but with a lesser amount |
| 3. To what extent would industry have funded this cluster if only industry funds were available and no public funds? | 75% of that actually funded; mungbean industry may have taken a stronger role |

# 6. Pathway to Adoption

Both new varieties of Crystal and Satin 2 were released by the National Mungbean Improvement Program to the Australian Mungbean Association (AMA) in 2008. The varieties are protected by Plant Breeders Rights under the Plant Breeders Rights Act 1994. Seed is commercialised by the Australian Mungbean Association and is available from AMA approved seed producers or local seed resellers.

The background to the commercialisation process for new mungbean varieties is that in 2008 the mungbean line 3511-32 (Satin 2) was identified for commercial release. In addition to offering this line for commercialisation the co-owners (DEEDI and the GRDC) offered the successful licensee an exclusive first right of refusal to exploit future varieties to be released from the pipeline up to 30 June 2011. The AMA was successful in being awarded the right to commercialise Satin 2 and the pipeline of varieties to 30 June 2011 including the variety released as Crystal. This approach encourages prospective applicants to consider being involved with pre-commercial development of varieties within the pipeline. A pipeline licensee is encouraged to carry out early evaluation and multiplication of pre-commercial cultivars within the pipeline on a speculative basis in anticipation of their future release. The aim is to reduce the time taken in the commercialisation stages so that varieties reach growers faster.

Improved varieties are generally regarded as one of the more rapid R&D outputs that are adopted by producers, especially where information on prospective performance is readily available and where high confidence in the claimed biological characteristics of a new variety is perceived. This confidence is influenced by the extent of testing of a variety before release.

The AMA has membership covering producers, plant breeders, input suppliers such as seed graders and packers, crop consultants including both private and personnel in government departments, and traders and marketers. Strong relationships exist across the value chain network and this is important in promoting information on new varieties concerning potential profitability including the acceptability of any new varieties in the market place, both domestic and international. For example, a Crystal management package is available for growers (http://www.mungbean.org.au/pdf/Crystal%20VMP.pdf).

The AMA commenced a seed production scheme in 2005. As part of the quality control procedure for production of mungbean seed, the AMA requires that all seed crops be inspected by an independent inspector to determine trueness to type and freedom from specific diseases (AMA, 2011b). Such quality control produces greater confidence to prospective mungbean producers.

Adoption of Crystal and Satin 2 varieties was extremely rapid with maximum adoption of 90% occurring within two years. These two new varieties together with higher prices in recent years have improved the confidence of growers in the crop resulting in the increased area and production. Increased plantings have been observed by both existing and new growers of mungbean.

The same commercialisation arrangements will apply to new varieties expected to be released in the forthcoming years.

# 7. Measurement of Benefits

The benefits valued in the quantitative analysis are:

- The yield increase from the past releases of improved varieties of mungbean.
- The lower grading loss for Crystal compared to White Gold.
- The quality improvement from the past releases of improved varieties of mungbean.
- The potential yield increases and higher disease resistance that may be captured in future variety releases.

The benefits identified but not valued include:

- An increased area of mungbeans used in rotations with associated rotational advantages to other crops (disease break, no additional nitrogen fertiliser required).
- Potentially reduced use of chemicals (fungicides) in mungbean crops due to more resistant varieties leading to reduced export of chemicals off farm.
- Reduced use of chemicals (herbicides) in rotations due to higher levels of incorporation of mungbeans into rotations.
- Increase in capital value of germplasm between 2003 and the end of 2011.

**Counterfactual**

If the GRDC Mungbean Improvement Program had not existed, it is assumed there would not have been any significant breeding investment by the private sector and that no yield or disease resistance improvement would have occurred.

**Benefits from Mungbean Yield Improvement – Varieties already released**

Farming systems in the two northern region states (Queensland and NSW) contribute the majority of mungbean production in Australia. The area and production performance of the Australian mungbean industry since the investment began has been reported in Table 1. The annual area has averaged just over 51,000 ha and production just over 50,000 tonnes.

Yields have averaged about 1 tonne per hectare over this period and farm gate prices were about $600-700 per tonne. As prices fluctuate (the current prices of mungbean are considerably higher than $600 per tonne), the approach taken in this analysis is to use a conservative price based on the gross margins in DEEDI (2010).

The yield increase due to the two new varieties is assumed to be 15% above previous industry yields for other varieties. This may be conservative but the 20% yield gains (DEEDI, 2010) used to promote the new varieties were related to the variety Emerald, a previous mainstay variety.

Crystal is estimated to have been grown across 24,000 ha in 2008/09 and made up over 50% of the crop in 2008/09. Currently, Crystal is assumed to contribute 90% of the area planted to mungbean (NMIP, 2010). The total area of mungbean planted into the future is conservatively assumed to be the average over the 7 year period to 2009/10 at 45,300 ha. Satin 2 is estimated to have been grown across 1,000 ha in 2008/09 and is now assumed to contribute 2.5% (1,132 ha) of the total area of the mungbeans grown each year.

**Benefits from Quality Improvement - Varieties already released**
Crystal commands a higher price in the market place due to its higher quality. It has been estimated that the price premium over the varieties it has replaced would be about $50 per tonne (Dale Reeves, pers.com., 2011).

Further the grading loss from Crystal (about 10%) is lower than that of White Gold (about 15%), so a further yield gain is assumed of about 5% (Dale Reeves, pers.comm., 2011).

**Benefits from Mungbean Yield Improvement – Prospective varieties**
The assumption in this evaluation is that some new varieties will be released in the few years following the GRDC investment being evaluated. Therefore some attribution of benefits to the period of investment (2004 to 2011) can be made. The assumption is that three new varieties will be released, the first in the year ending 30th June 2013 and the second and third in the year ending 30th June 2014. It is possible that up to five new varieties may be released but the additional two varieties are less certain, as they are not expected to be released until at least 2016 and hence would be less influenced by the investment up to 2011. Assumptions regarding the three expected variety releases are provided in Table 13.

The yield gains assumed could be affected in future by declining disease resistance. Hence, the part of the yield gain due to resistance has been assumed to decline to zero over fifteen years. In the case of Variety B, an allowance of 2.5% of the 10% has been assumed due to disease resistance. Thus, fifteen years after release MO7213 reverts to a 14% yield gain, Variety A to 10% and Variety B to 7.5%.

Table 13: Potential Variety Releases: post 2011

| Year ended 30th June | Probability of release | Expected year of release | Yield gain over the existing average yields (%) | Years after release to maximum adoption | Maximum adoption level (%) |
|---|---|---|---|---|---|
| Variety MO7213 | 90% | 2012/13 | 16.5 (a) | 2 | 40 |
| Variety A (large seeded variety with higher resistance rating to Powdery Mildew and Tan Spot) | 60% | 2013/14 | 17.5(b) | 2 | 40 |
| Variety B (small seeded variety with superior | | 2013/14 | 10 (c) | | |

| | | | | | |
|---|---|---|---|---|---|
| yield and resistant to Halo Blight) | 50% | | | 2 | 5 |

(a) 14% yield increase over Crystal but with added 2.5% yield increase due to higher disease resistance (Tan Spot and Powdery Mildew)
(b) 10% yield increase over Crystal but with added 7.5% yield increase due to higher disease resistance (Tan Spot and Powdery Mildew)
(c) 10% yield increase over Green Diamond/Celera; the 10% included disease resistance to Halo Blight

Source: Base yield increases from GRDC (2010); disease resistance gain added by Agtrans Research after discussions with Col Douglas.

The future area of mungbeans is estimated conservatively at the average for the period 2004-2011 at 51,000 hectares (Table 14).

**Matching Genetic Gain from New Varietal Benefits to Investment Being Evaluated**

The investment being evaluated commenced in the year ending June 2004. It is assumed that mungbean varieties are produced from a 7 to 8 year breeding cycle from initial cross to variety release (Col Douglas, pers.comm., 2011). Hence, the influence of the projects in 2004 would have been marginal for any varieties released in that first year, as the benefit for any release in 2004 would be attributed to the previous eight years breeding activity. However, it could be argued that approximately one eighth (12%) of the benefit from that variety could be attributed to the investment in 2004; any cultivars released in 2006 could be attributed nearly 40% of the gain and so on. The two cultivars first released in 2008 therefore could be attributed approximately 60% of the gain from their release.

Releases in 2011/12, the first year after the investment has finished could be attributed approximately 90% of the benefit, 2012/13 releases approximately 75%, and 2013/14 releases approximately 60%. After 2018/19 any releases would not be influenced at all by the current investment.

**Adoption**

Adoption (and hence the delivery of benefits) has been very rapid as evidenced by adoption of Crystal and Satin 2. For varieties released after 2011, it is assumed that maximum adoption would occur in the second year of release. It is assumed that Variety MO7213 captures 40% of the total area while Variety A captures another 40%. Prospective Variety B (small seeded variety) is assumed to capture just 5% of the total production, based on the small size of that niche market. The release of MO7213 and Variety A will mean that they will replace predominantly the Crystal variety. However, the benefits from Crystal continue as the increased yield from the newer varieties is measured as the increase above the yield of Crystal.

**Genetic Capital**

Genetic capital at the beginning and end of the investment period is assumed to be the same in terms of the time value of money. Due to the further development of germplasm during the eight year investment, the genetic capital at the end of the investment period may actually be higher than at the beginning. On the other hand, much of the genetic capital present at the beginning of the investment may already have been exploited through the future varietal releases assumed in Table 13. The germplasm exchange initiated with the World Vegetable Centre would make it most likely that a genetic capital gain would have taken place over the investment period to 2011.

**Summary of Assumptions**
A summary of the key assumptions made is shown in Table 14.

Table 14: Summary of Assumptions

| Variable | Assumption | Source |
|---|---|---|
| ***General Assumptions*** | | |
| Value of mungbeans | $600 per tonne | DEEDI (2010) |
| Assumed length of breeding cycle | 8 years (may vary from 7-9 years from first cross to release) | Agtrans Research after discussions with Col Douglas |
| Attribution to investment in the eight years before variety released | 100% | Agtrans Research after discussions with Col Douglas |
| Attribution of varietal benefits to the investment being evaluated (2004 to 2011) | Number of the eight years before variety released that are included in the investment period, divided by eight | Agtrans Research |
| Attribution of varietal gains to the investment being evaluated | Crystal 60%, Satin 2 60%, MO7213 75%, Variety A, 60%, Variety B 60% | Based on year of release and formula in line above |
| ***Without the Investment*** | | |
| Areas of mungbean in years ending June 2004 to June 2011 | See Table 1 | ABARES (2010); Dale Reeves, AMA (2011) |
| Average area of mungbeans in years ending June 2004 to June 2010 | 51,000 ha | See Table 1 (ABARES, 2010); Dale Reeves, AMA (2011). |
| Average yields for mungbean before Crystal and Satin 2 were released | 1 tonne per ha | See Table 1 (ABARES, 2010) |
| ***With the Investment*** | | |
| **Crystal** | | |
| Year released | 2008/09 | Actual year of release |
| Yield increase due to Crystal | 15% of 1 tonne per ha | Adapted from DEEDI (2010) |
| Quality gain due to Crystal | $50 per tonne and grading loss reduced from 15% to 10% | (Dale Reeves, AMA) |
| Maximum adoption level for Crystal | 90% | NMIP (2010) |
| Area of Crystal in year ended June 2009 | 24,000 ha | Based on quantity of seed sold and seed sowing rate |
| Area of Crystal in year ended June 2010 and thereafter | 45,900 ha | 90% of 51,000 ha |
| **Satin 2** | | |
| Year released | 2008/09 | Actual year of release |
| Yield increase due to Satin 2 | 15% | Adapted from DEEDI (2010) |

| | | |
|---|---|---|
| Maximum adoption level for Satin 2 | 2.5% | Agtrans Research |
| Area of Satin 2 in year ended June 2009 | 1,000 ha | Based on quantity of seed sold and seed sowing rate |
| Area of Satin 2 in year ended June 2010 and thereafter | 1,132 ha | 2.5% of 51,000 ha |
| **Prospective Variety MO7213** | | |
| Year released | 2012/13 | GRDC (2010) |
| Probability of release | 90% | Agtrans Research |
| Yield increase due to MO7213 | 16.5% declining to 14% after 15 years | Table 15; adapted from GRDC (2010) |
| Maximum adoption level for Variety MO7213 | 40% | Agtrans Research |
| Time to maximum adoption | 2 years | Based on adoption profile of Crystal |
| Area of Variety MO7213 in year ended June 2014 and thereafter | 20,400 ha | 40% of 51,000 ha |
| **Prospective Variety A** | | |
| Year released | 2013/14 | GRDC (2010) |
| Probability of release | 50% | Agtrans Research |
| Yield increase due Variety A | 17.5% declining to 10% after 15 years | Table 15; adapted from GRDC (2010) |
| Maximum adoption level for Variety A | 40% | Agtrans Research |
| Time to maximum adoption | 2 years | Based on adoption profile of Crystal |
| Area of Variety A in year ended June 2015 and thereafter | 20,400 ha | 40% of 51,000 ha |
| **Prospective Variety B** | | |
| Year released | 2013/14 | GRDC (2010) |
| Probability of release | 50% | Agtrans Research |
| Yield increase due Variety B | 10% declining to 7.5% after 15 years | Table 15; from GRDC (2010) |
| Maximum adoption level for Variety B | 5% | Agtrans Research |
| Time to maximum adoption | 2 years | Based on adoption profile of Crystal |
| Area of Variety B in year ended June 2015 and thereafter | 2,550 ha | 5% of 51,000 ha |

**Results**

All past costs and benefits were expressed in 2010/11 dollar terms using the CPI. All benefits after 2010/11 were expressed in 2010/11 dollar terms. All costs and benefits were discounted to 2010/11 using a discount rate of 5%. The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2010/11).

The present value of benefits (PVB) from each source of benefits was estimated separately and then summed to provide an estimate of the total value of benefits.

Investment criteria were estimated for both total investment and for the GRDC investment alone. Each set of investment criteria were estimated for different periods of benefits. The investment criteria were all positive as reported in Tables 15 and 16.

Table 15: Investment Criteria for Total Investment and Total Benefits for Each Benefit Period
(discount rate 5%)

| **Criterion** | **0 Years** | **5 years** | **10 years** | **15 years** | **20 years** | **25 years** | **30 years** |
|---|---|---|---|---|---|---|---|
| Present value of benefits (m$) | 14.94 | 41.50 | 64.94 | 82.81 | 96.49 | 107.18 | 115.56 |
| Present value of costs (m$) | 6.09 | 6.09 | 6.09 | 6.09 | 6.09 | 6.09 | 6.09 |
| Net present value (m$) | 8.85 | 35.40 | 58.84 | 76.72 | 90.40 | 101.09 | 109.46 |
| Benefit-cost ratio | 2.45 | 6.81 | 10.66 | 13.59 | 15.83 | 17.59 | 18.96 |
| Internal rate of return (%) | 38.2 | 51.7 | 53.0 | 53.1 | 53.1 | 53.2 | 53.2 |

Table 16: Investment Criteria for GRDC Investment and Benefits to GRDC for Each Benefit Period
(discount rate 5%)

| **Criterion** | **0 Years** | **5 years** | **10 years** | **15 years** | **20 years** | **25 years** | **30 years** |
|---|---|---|---|---|---|---|---|
| Present value of benefits (m$) | 5.97 | 16.58 | 25.95 | 33.09 | 38.56 | 42.83 | 46.18 |
| Present value of costs (m$) | 2.44 | 2.44 | 2.44 | 2.44 | 2.44 | 2.44 | 2.44 |
| Net present value (m$) | 3.53 | 14.14 | 23.50 | 30.65 | 36.11 | 40.39 | 43.73 |
| Benefit-cost ratio | 2.44 | 6.78 | 10.61 | 13.54 | 15.77 | 17.52 | 18.89 |
| Internal rate of return (%) | 37.6 | 51.2 | 52.4 | 52.6 | 52.6 | 52.6 | 52.6 |

There are six sources of benefits valued in the analysis. Table 17 shows the relative estimates of the contribution from each source. The most significant contributors were the yield and quality gains from Crystal.

Table 17: Contribution of Source of Benefits to Present Value of Benefits (30 years)

| **Source of Benefit** | **$ million** | **%** |
|---|---|---|
| Crystal yield | 45.82 | 39.7 |
| Satin 2 yield | 1.29 | 1.1 |
| Crystal quality | 41.63 | 36.0 |
| Prospective variety MO7213 | 19.41 | 16.8 |
| Prospective variety A | 6.84 | 5.9 |
| Prospective variety B | 0.57 | 0.5 |
| Total Present Value of Benefits | 115.56 | 100.0 |

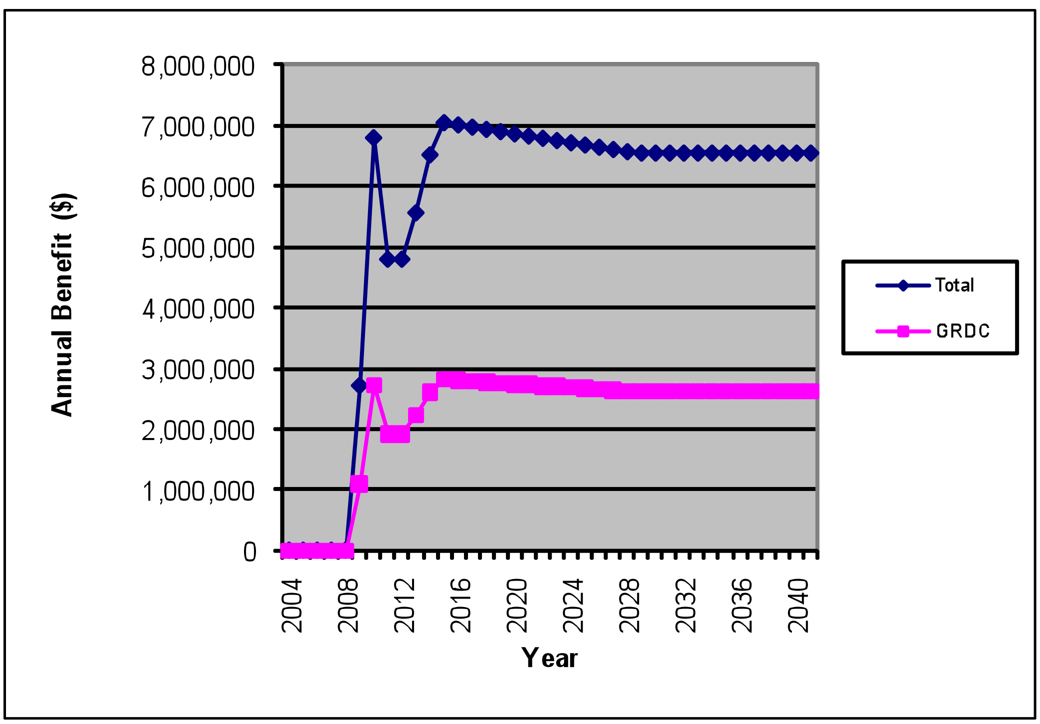
The quantified benefits are allocated to the Rural Research Priorities as expressed in Table 18.

Table 18: Allocation of Quantified Benefits to Rural Research Priorities

| **Rural Research Priority** | **Allocation** |
|---|---|
| 1. Productivity and adding value | 100% |

The annual net benefit cash flows for both total investment and GRDC investment for the 30 year period from the year of last investment are shown in Figure 1.

Figure 1: Annual Benefit Cash Flow



**Sensitivity Analyses**
Sensitivity analyses were carried out on several variables and results are reported in Tables 19 to 21. The sensitivity analyses were performed on the GRDC investment results using a 5% discount rate with benefits taken over the life of the investment plus 30 years from the year of last investment. All other parameters were held at their base values.

Table 19 shows the sensitivity of the investment criteria to changes in the discount rate.

Table 19: Sensitivity of Investment Criteria to Discount Rate
(GRDC investment, 30 years)

| Criterion | 0% | 5% (Base) | 10% |
|---|---|---|---|
| Present value of benefits (m$) | 84.63 | 46.18 | 30.64 |
| Present value of costs (m$) | 2.06 | 2.44 | 2.91 |
| Net present value (m$) | 82.56 | 43.73 | 27.73 |
| Benefit cost ratio | 41.00 | 18.89 | 10.55 |

Table 20 shows the sensitivity of the investment criteria to changes in the assumptions regarding the probabilities of the new variety releases occurring in the future. The results show the positive investment performance is carried largely by the varieties already released.

Table 20: Sensitivity of Investment Criteria to Probabilities of Three New Variety Releases
(GRDC investment, 5% discount rate, 30 years)

| Criterion | Zero probability | (45%, 25%, 25%) | Base (90%, 50%, 50%) |
|---|---|---|---|
| Present value of benefits (m$) | 35.46 | 40.82 | 46.18 |
| Present value of costs (m$) | 2.44 | 2.44 | 2.44 |
| Net present value (m$) | 33.02 | 38.38 | 43.73 |
| Benefit cost ratio | 14.50 | 16.70 | 18.89 |
| Internal rate of return (%) | 50.8 | 51.7 | 52.6 |

Table 21 shows the sensitivity of the investment criteria to changed assumptions regarding the adoption rate for the three prospective varieties. The results are not overly sensitive to this change due to the dominance of the benefits from Crystal in the analysis.

Table 21: Sensitivity of Investment Criteria to Adoption Level of Prospective Varieties (GRDC investment, 5% discount rate, 30 years)

| Criterion | Lower (Maximum of 10%, 10%, 2.5%) | Base (Maximum of 40%, 40%, 5%) |
|---|---|---|
| Present value of benefits (m$) | 38.20 | 46.18 |
| Present value of costs (m$) | 2.44 | 2.44 |
| Net present value (m$) | 35.75 | 43.73 |
| Benefit-cost ratio | 15.62 | 18.89 |
| Internal rate of return (%) | 51.3 | 52.6 |

# 8. Confidence Rating

The results produced are highly dependent on the assumptions made, some of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 22). The rating categories used are High, Medium and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some significant uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 22: Confidence in Analysis of Mungbean Breeding Investment

| Coverage of Benefits | Confidence in Assumptions |
|---|---|
| Medium | High |

# 9. Conclusions and Lessons Learned

During the investment period (2004 to 2011) two new improved varieties (Crystal and Satin 2) were released and have been rapidly and widely adopted by the industry, particularly Crystal. The improved varieties have displayed significant yield increases. Crystal, the dominant variety now grown, has an improved seed quality manifest in its price in the market place, and a lowered grading loss than the varieties it has replaced.

In addition, a number of elite lines with higher yields and greater disease resistance have been produced from which further varietal releases are expected in the next few years. The expected new varieties are likely to have higher yields and higher disease resistance.

Plant breeding was a high priority for the Australian Mungbean Association (AMA) before this investment commenced. Unreliable dryland production was considered a constraint in marketing, hence the AMA has set a target of stable annual production of 50,000 tonnes by 2014 (AMA, 2011). This target has recently been raised to 100,000 tonnes following record production in the past two years. The new varieties together with higher prices in recent years have improved the confidence of growers in the crop resulting in the increased area and production from both existing and new growers of mungbean.

The speed at which the new varieties have been adopted by industry is an important part of the positive results of the program. While the step improvement in the varieties and the small size of the industry were no doubt important factors, the cohesive approach to communications fostered by DEEDI and supported by AMA and GRDC, must also be given some credit for the rapid adoption.

As most mungbeans are grown in rotation with cereals and other crops, the increased mungbean area will lead to spinoff benefits to the rotations in the form of acting as disease break potentially leading to higher yields and less pesticide use.

The investment in the two projects has produced a number of benefits some of which have been valued. The total investment of $6.1 million (present value terms) has been estimated to produce total gross benefits of $115 million (present value terms) providing a net present value of $109 million, a benefit-cost ratio of over 18 to 1 (over 30 years, using a 5% discount rate) and an internal rate of return of 53%. Even though most assumptions were conservatively estimated, this is a relatively high rate of return compared to other crop breeding programs. Breeding programs for small industries such as mungbean need to produce high rates of gain over time in terms of yield or quality in order to justify the investment. In the case of mungbean, both these gains have been achieved by this investment.

## Acknowledgments
Col Douglas, Department of Employment, Economic Development and Innovation
Dale Reeves, Secretary, Australian Mungbean Association

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