



An Economic Analysis of GRDC Investment in Western Australian No Tillage Farming Association



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Executive Summary

Overview of Benefits

Industry Productivity and Profitability

Short term

- Improved soil moisture storage from reduced soil disturbance and higher level of ground cover leading to higher yields in some years
- Ability to grow crops in dry years when otherwise not possible to grow
- Increased profitability of crop production from higher average yields, with decreases or minimal increases in operational costs
- Potential for increased yields/reduced losses/decreased costs due to improved control of pests and diseases
- Increased uptake of no-till technologies in Western Australia as well as in other cropping regions of Australia

Long term

- Higher yields from improved soil structure and higher organic carbon soil content
- Potential nitrogen contributions from leguminous cover crops
- Potentially improved weed and pest control and increased soil cover from use of cover crops
- More robust cropping systems able to cope with any climatic changes
- Potentially higher market returns for grain that is produced under best management practices in relation to the environment

Environmental

- Reduced soil and wind erosion from less tillage and increased ground cover leading to more sustainable farming systems and improved water quality in waterways
- Reduced level of chemical usage for pest control and less chemical exports off farm
- Reduced air pollution from reduced stubble burning and dust
- Enhanced soil biological activity and higher level of soil organic matter

Social

- Reduced impact of smoke on air quality in cropping regions
- Increased industry, community, and research capacity from student involvement
- Improved no-till infrastructure within Western Australia, Australia and overseas countries

Estimated Net Present Value of GRDC Investment over 25 years: \$141m

GRDC Benefit to Cost Ratio: 36 to 1

The continuing investment over a long period by GRDC in the Western Australian No-Till Farmers Association (WANTFA) has been successful in assisting grain producers to innovate and introduce effective no-till technologies. The investment has provided

benefits to grain producers in the form of higher average grain yields that has led to higher average profitability, particularly in low rainfall years.

Serious adoption of no-till in Western Australia commenced just before or about the same year as the GRDC investment began in WANTFA (1996/97) and has continued to increase to 2008/09 during the period of the GRDC support. Some adoption of no-till in WA would have occurred without GRDC investment, as indicated by the advent of no-till in grain producing regions in other states.

The GRDC/WANTFA investment encouraged no-till practices in Western Australia to continuously evolve, resulting in improved outcomes of efficiency gains for those already using no-till and encouraging more cropping farmers to adopt no-till over time.

The principal benefits derived from the investment include both short-term and long-term benefits to adopters of no-till. In the short term improved soil moisture retention from reduced soil disturbance and higher degree of ground cover have led to higher yields, especially in low rainfall years. There has been increased profitability of crop production from higher average yields, with decreases or minimal increases in operational costs. In the longer term, further yield increases may be captured from improved control of pests and diseases, improved soil structure and higher organic soil carbon content, reduced reliance on chemical control of weeds and greater employment of leguminous and other cover crops. Reduced soil and wind erosion from increased ground cover has been both a private benefit and an environmental benefit.

Benefits have been attributed to the GRDC investment in the form of quicker adoption and the more effective no-till application by all adopters. These benefits have been assumed to occur from the 1998/99 year onwards.

The most important characteristic of the investment has been its integrated R&D and extension nature. This has undoubtedly led to quicker and more effective application of no-till technologies. The investment has raised awareness of no-till opportunities and benefits and provided greater confidence to those willing to undertake change.

Based on the assumptions made, the total project investment of approximately \$9 million (present value in 08/09 \$ terms) has been estimated to have produced an expected net present value of \$327 million (present value in 08/09 \$ terms) and a benefit-cost ratio of 37 to 1. The GRDC investment of \$4.1 million (present value in 08/09 \$ terms) has been estimated to have produced an expected net present value of \$141.4 million (present value in 08/09 \$ terms) and a benefit cost ratio of 36 to 1.

1. Introduction

Crop residues remaining after harvest of Western Australian grain have been commonly burnt to allow easier tillage in preparing for the next crop. A number of tillages were usually practiced to control weeds between crops and in preparing a good seedbed for the next planting.

The major benefit of minimal tillage or no tillage in grain cropping is the higher level of moisture retention in the soil due to less soil disturbance as well as reducing evaporation due to the maintenance of surface ground cover where stubble and other trash remains after harvest. Other advantages of no-till are reduced soil erosion and soil export and reduced fuel and fertiliser costs.

Disadvantages of minimal tillage or no tillage have included the difficulties in sowing where heavy stubble loads have been retained, management of weeds without tillage, and the development of herbicide resistance when herbicides are used continuously for weed control.

Although minimal tillage operations for preparing land for planting crops had been practiced for some time, no-till sowing commenced in Western Australia cropping systems only after 1990. By 1993, 220 farmers had used no-till sowing in Western Australia. Adoption of the practice escalated rapidly with about 1,000 growers sowing without tillage in 1995.

This relatively high adoption rate was linked to strong interest from cropping farmers at seminars and field days in 1994 and 1995. No-till days often had attendances of over 100 farmers. This fuelled the demand for improved communication of research results, more on-farm trials and a wider use of specialist advisers on no-till sowing. GRDC responded to this need by funding a series of R&D projects from 1996/97 to the present.

Support to this R&D area was made by GRDC via the Western Australian No-Tillage Farmers Association (WANTFA). This approach provided a strong cropping farmer involvement and was expected to enhance the ownership of findings and hence increased adoption.

2. Project Investment

Overall Objectives

WANTFA was formed in 1992 as the first no-till farmer group in Australia. Its purpose has been to drive adoption of sustainable and profitable broadacre cropping systems by sharing farmer experiences and innovations from research and field trials across its network (WANTFA website, 2009, www.wantfa.com.au).

Projects Funded by GRDC

Eight projects have been funded by GRDC in this investment cluster as listed in Table 1. Table 2 provides a summary of the objectives of each project.

Table 1: WANFTA Projects Funded by GRDC

Project Code and Title	Other Details
WAN3: No-Till Systems Scientific Officer	Organisation: WANTFA Period: 1996/97 to 2002/03 Principal Investigators: Geoffrey Marshall, Bill Crabtree
WAN5: WANTFA's Herbicide, Fertiliser and Warm Season Crop Research	Organisation: WANTFA Period: 1998/99 Principal Investigator: Bill Crabtree
WAN6: WANTFA Technology Demonstration Site (Meckering Site)	Organisation: WANTFA Period: 1999/2000 to 2003/04 Principal Investigator: Toll Temby
WAN00003: Developing Innovative and Sustainable High Residue No-Till Farming Systems	Organisation: WANTFA Period: 2002/03 to 2004/05 Principal Investigator: Neil Young
WAN00008 (previously WAN6): WANTFA Technology Demonstration Site	Organisation: WANTFA Period: 2004/05 to 2006/07 Principal Investigator: Toll Temby
WAN00012: New Frontiers No-Till Farming Systems	Organisation: WANTFA Period: 2006/07 to 2008/09 Principal Investigator: Ken Flower
WAN00013: Cover Crops for No-Till Farming Systems	Organisation: WANTFA Period: 2006/07 to 2008/09 Principal Investigator: Ken Flower
WAN00015 (previously WAN00008): WANTFA Technology Demonstration Site	Organisation: WANTFA Period: 2007/08 to 2009/10 Principal Investigator: Ken Flower

Table 2: Project Codes, Titles and Stated Objectives

Project Code and Title	Stated Objectives
WAN3: No -Till Systems Scientific Officer	The project objectives were (i) to extend information on no-till systems to farmers, Agriculture Western Australia Development Officers and other agricultural professionals, and (ii) to feed information back to researchers on priorities for future no-till research and extension
WAN5: WANTFA's Herbicide, Fertiliser and Warm Season Crop Research	The aims of the project were to initiate, contract, coordinate, conduct and have reported research activities that met the WANTFA objectives of: (i) Investigating herbicide activity in no-till soils that contain a high or low level of organic residues (ii) Assessing nitrogen fertiliser toxicity and copper placement for no-till systems (iii) Investigating yield potentials for warm season crops in no-till rotations
WAN6: WANTFA Technology	The aim of the project was to develop a no-till site of excellence that would bring together many different research ideas and technologies,

Demonstration Site (Meckering Site)	including integrated weed and disease management systems, for testing and demonstration to growers.
WAN00003: Developing Innovative and Sustainable High Residue No-Till Farming Systems	The objective of the project was to develop methods for successful establishment of crops with high residue levels at sowing within a more sustainable farming system.
WAN00008 (previously WAN6): WANTFA Technology Demonstration Site	The objective of this project was to continue with the technology demonstration site by integrating all available information for management decision making on farm, as well as take into account the broader scale catchment issues and the triple bottom line.
WAN00012: New Frontiers No-Till Farming Systems	The broad objective of the project was to improve the quality of no-till in Western Australia that results in increased farm profitability and environmental sustainability. Specific objectives were to establish two long-term no-till sites to test full stubble retention, diverse rotations and a more holistic approach to weed management.
WAN00013: Cover Crops for No-Till Farming Systems	The objective of the project was to improve the management of cover crops and highlight their benefits to encourage the use of such crops in the rotation.
WAN00015 (previously WAN00008): WANTFA Technology Demonstration Site	The objective of the project was to continue with the technology demonstration site and seek solutions to issues such as weed resistance to herbicides, maintaining permanent ground cover, greater conservation of soil and water resources and yield stability in a drying climate in order to provide significant economic, environmental and social outcomes.

Investment Inputs

Estimates of the funding by GRDC and others by project by year for the eight projects are provided in Tables 3 and 4.

Table 3: Investment by GRDC by Project for Years Ending June 1997 to June 2010 (nominal \$)

YE June	WAN3	WAN5	WAN6	WAN0003	WAN0008	WAN00012	WAN00013	WAN00015	Total
1997	82,000	0	0	0	0	0	0	0	82,000
1998	100,380	0	0	0	0	0	0	0	100,380
1999	108,679	49,838	0	0	0	0	0	0	158,517
2000	115,567	0	45,000	0	0	0	0	0	160,567
2001	120,595	0	48,000	0	0	0	0	0	168,595
2002	0	0	51,000	0	0	0	0	0	51,000
2003	91,276	0	53,000	125,000	0	0	0	0	269,276
2004	0	0	84,500	128,750	0	0	0	0	213,250
2005	0	0	0	136,475	85,527	0	0	0	222,002
2006	0	0	0	0	100,000	0	0	0	100,000
2007	0	0	0	0	100,000	244,284	55,700	0	399,984
2008	0	0	0	0	0	225,696	48,200	100,623	374,519
2009	0	0	0	0	0	239,248	36,100	103,925	379,273
2010	0	0	0	0	0	0	0	107,140	107,140
Total	618,497	49,838	281,500	390,225	285,527	709,228	140,000	311,688	2,786,503

Source: GRDC proposals and final reports

Table 4: Investment by GRDC Partners by Project for Years ending June 1997 to June 2010 (nominal \$)

YE June	WAN3 (a)	WAN5 (b)	WAN6 (c)	WAN00003 (d)	WAN00008 (e)	WAN00012 (f)	WAN00013 (g)	WAN00015 (h)	Total
1997	24,000	0	0	0	0	0	0	0	24,000
1998	24,000	0	0	0	0	0	0	0	24,000
1999	24,000	49,307	0	0	0	0	0	0	73,307
2000	24,000	0	44,500	0	0	0	0	0	68,500
2001	24,000	0	45,500	0	0	0	0	0	69,500
2002	0	0	46,500	0	0	0	0	0	46,500
2003	0	0	47,500	475,000	0	0	0	0	522,500
2004	0	0	48,500	475,000	0	0	0	0	523,500
2005	0	0	49,500	475,000	178,000	0	0	0	702,500
2006	0	0	0	0	181,400	0	0	0	181,400
2007	0	0	0	0	184,975	285,500	54,340	0	524,815
2008	0	0	0	0	0	228,300	55,230	132,000	415,530
2009	0	0	0	0	0	239,700	56,245	135,500	431,445
2010	0	0	0	0	0	0	0	143,200	143,200
Total	120,000	49,307	282,000	1,425,000	544,375	753,500	165,815	410,700	3,750,697

(a) Agriculture Western Australia contributed \$120,000 over five years

(b) Agriculture Western Australia and a number of private sector sponsors

(c) Agriculture Western Australia, University of WA, CSIRO, BankWest, Wesfarmers-Dalgety, Elders, SBS Rural IAMA, Rural Trading Company and Combined Rural Traders

(d) Including WANTFA, Western Australian Department of Agriculture, CSIRO, and other sponsors

(e) Including WANTFA, Department of Agriculture, Western Australia, Rabobank, Elders, Syngenta gps-Ag, CSBP, CBH Group

(f) Including WANTFA, Western Australian Department of Agriculture and Food, Mingenew Irwin Group

(g) Including WANTFA, Western Australian Department of Agriculture and Food, and NInghan

(h) Including WANTFA, Department of Agriculture and Food, Western Australia Agrisearch, and industry partners

Source: Partners' investment based on project proposals

Table 5 shows the combined GRDC and partner investment for each year.

Table 5: Total Investment by GRDC and Partners in Eight Projects for Years Ending June 1997 to June 2010 (nominal \$)

Year ending June	GRDC	Partners	Total
1997	82,000	24,000	106,000
1998	100,380	24,000	124,380
1999	158,517	73,307	231,824
2000	160,567	68,500	229,067
2001	168,595	69,500	238,095
2002	51,000	46,500	97,500
2003	269,276	522,500	791,776
2004	213,250	523,500	736,750
2005	222,002	702,500	924,502
2006	100,000	181,400	281,400
2007	399,984	524,815	924,799
2008	374,519	415,530	790,049
2009	379,273	431,445	810,718
2010	107,140	143,200	250,340
Total	2,786,503	3,750,697	6,537,200

3. Activities and Outputs

Summary of Activities

WAN3 (the first of the eight projects) was funded for five years and funded a scientific officer to extend known information about no-till systems to grain producers in Western Australia.

WAN 5 included research activities on herbicide activity in no-till soils, investigated nitrogen fertiliser toxicity, addressed forms and placement of copper in no-till systems, and addressed yield potential for warm season crop in no-till rotations.

WAN 6 was the first project to support the technology demonstration site. This support was for a five year period and the site has remained a centre piece of activity for the whole investment in WANTFA up to the current day.

WAN00003 investigated the successful establishment of crops with high surface residues at sowing by means other than burning stubble to remove the residues. This was carried out through a literature review of current knowledge on high residue crop establishment systems and a field study focusing on different aspects of management agronomy and the needs for new machinery or development of agronomic methods.

WAN00008 continued with the technology demonstration site for a further three years.

WAN00012 established experimental sites on two different soil types to test long-term effects of full stubble retention, diverse rotations and holistic weed management.

WAN00013 established trials on cover crops, including grass and brassica species as well as pasture legumes, in order to assess their impacts on subsequent cash crops (e.g. cereals and canola), as well as to assess long-term benefits such as improved weed control and contribution of nitrogen and organic matter (in conjunction with the rotation work in WAN00012).

WAN00015 has continued with the technology demonstration site for a further three years.

Summary of Principal Outputs

A summary of the principal outputs (and expected outputs in the case of projects not yet completed) from each of the projects is reported in Table 6.

Table 6: Summary of Principal Outputs by Project

Project	Principal Outputs
WAN3	<ol style="list-style-type: none">1. Information integrated and disseminated in newsletters and farming system magazines, WANTFA annual conferences, field days and seminars, WANTFA website and other WANTFA and non-WANTFA infrastructure.2. Identified concerns and opportunities for no-till, including

	<p>potential constraints such as glyphosate resistance and pest and disease problems for addressing through existing and future R&D.</p> <ol style="list-style-type: none"> 3. Set up and managed the Meckering demonstration site (WAN6). 4. Provided feedback to researchers of problems with no-till operations.
WAN5	<ol style="list-style-type: none"> 1. Trifluralin works effectively on naturalised ryegrass, even when sprayed onto thick stubble and then no tilled with knife points. Use of harrows decreased the efficacy of no-till herbicides. 2. Increasing the rate of drilled urea generally increased seed damage via toxicity but toxicity was reduced when Agrotain was added. 3. Seasonal conditions did not favour the presence of copper deficiencies or grain yield responses. 4. Grain yields for warm season crops varied and management requirements are still not well-defined; grain sorghum and millet showed the highest potential.
WAN6	<ol style="list-style-type: none"> 1. Series of trials (138 trials in six years) on aspects of no-till farming systems were completed and results recorded and disseminated. 2. Issues addressed in trials were weed and disease control including use of trifluralin, use of liquid nitrogen, wide row cropping, liming, press wheels, shielded sprayers, tramlining, and claying. 3. Field days held attracting growers and agronomists from all over Western Australia as well as from other states and overseas. 4. Information and demonstration of how to change to no-till. 5. Communication to growers through conferences, annual trials result booklet, rural press, GRDC material, newsletters etc. 6. Set of research priorities for the future, including rotations, thick stubble management, weed control, subsoil constraints and soil health.
WAN00003	<ol style="list-style-type: none"> 1. Situation analysis of current knowledge on high residue crop establishment systems. 2. Investigations into effects of clumping, harvest cutting height variation and spread patterns, residue managers, disc coulters and disc seeders. 3. Contributed to solutions that allowed significant machinery practice change to occur under no-till systems. 4. Developed a seven point 'best bet' pointer publication for stubble management covers.
WAN00008	<ol style="list-style-type: none"> 1. Series of 26 trials where results were published in a trial result booklet, WANTFA newsletter, WANTFA website, and other communication outputs. 2. Demonstration to growers of successful management of no-till technologies within a triple bottom line framework. 3. Highlighted importance of weed control, stubble management and rotations, as well as controlled traffic and GPS technology. 4. Included field days, field walks, and over 800 visitors to the site in 2004 and 2006 years. 5. Focus on post seeding and pre-harvest management. 6. Formation of a Conservation Agriculture Alliance of Australia and New Zealand (CAAANZ) to communicate the benefits of sustainable agriculture beyond state borders. 7. In the latter part of the project focus was on disc seeders, under-

	seed cultivation with no-till seeders, cover crops and fertilisation.
WAN00012	<ol style="list-style-type: none"> 1. The envisaged outputs are a comparison of leading edge no-till systems (disc seeders, high seeding rates and with different rotations) with the then current no-till system (standard crop spacing, use of knife point tynes, and burning if required). 2. In 2007 and 2008 the disc seeders were not available so that those years the trials used only knife point tynes; comparisons will be made in 2009. 3. As of 2007, data had been collected on yield, grain quality, ground cover and biomass assessment, crop input costs, plant counts, climate, soil chemicals, organic carbon, nematodes, disease, insects, weeds and the water balance. 4. Economic analysis planned after the 2008 season.
WAN00013	<ol style="list-style-type: none"> 1. Demonstration of cover crop trials including sowing, management and impacts. 2. Information produced on cover crop trials, cover cropping suitability, management and benefits. 3. Information produced on the effects of fertiliser, time of sowing, optimum time for knife rolling oats, undersowing, and the feasibility of new pasture legumes (serradella and clovers) in the rotation. 4. Higher yields of wheat were obtained with a cover crop in the rotation compared to a wheat-on-wheat series. 5. Apart from the trial result booklet, information has been conveyed through other publications, newsletters and field days.
WAN00015	<ol style="list-style-type: none"> 1. Continued with trials on aspects of no-till farming systems, including 23 trials completed in 2007. 2. Trials in 2007 included those on cover crops, herbicides for weed control, fungicides in no-till, stubble management, alternative oilseeds, fertilisers and ameliorants in no-till and time of sowing. 3. Field days held attracting growers and agronomists from all over Western Australia, other states and from overseas. 4. Communication to growers through conferences, annual trials result booklet, rural press, GRDC materials, newsletters etc. 5. Movement of the centre of excellence physical site from Meckering to a site near the College of Agriculture at Cunderdin will occur in 2009 and 2010 in order to increase integration of the site with student learning. This will also value add to WAN00012 which has one of the sites at the College of Agriculture at Cunderdin.

4. Outcomes

Project Outcomes

A summary of the principal outcomes from each of the eight projects is reported in Table 7.

Table 7: Summary of Principal Outcomes by Project

Project	Principal Outcomes
WAN3	<ol style="list-style-type: none"> 1. Better decisions regarding weed control, nitrogen and stubble management and crop rotations. 2. Water use efficiency improved enabling crops to be more likely to be grown in dry years.

	<p>3. During life of project no-till adoption rate increased from 25% to 70% in Western Australia, with only marginal increases in other states.</p> <p>4. No-till observed to combat effects of drought and reduced soil erosion (wind and water) processes.</p> <p>5. Estimated that an extra 12 m t of grain was produced in WA in the last 3 years of the project due to adoption of no-till and was estimated to be worth \$2.4 b.</p> <p>6. No-till has increased the level of organic carbon in the soil.</p> <p>7. Management changes possibly made in other states and overseas countries as a result of the investment.</p>
WAN5	<p>1. Increased understanding of getting active herbicide onto the soil surface as well as the impact of different forms and placements of copper may have led to management changes.</p> <p>2. The role of Agrotain in reducing the toxicity of drilled urea was better understood and may have led to management changes.</p>
WAN6	<p>1. The project resulted in higher profits as farmers who practiced 2 to 3 full tillage operations did not plant crops in some years whereas those practicing no-till did.</p> <p>2. The demonstration site was a contributing factor to the rapid increase in adoption of no-till farming in WA.</p>
WAN00003	<p>1. Higher level of adoption of new management systems for crop residue in a no-till system in order to improve seedling emergence and maintain residues with associated benefits.</p> <p>2. Greater use of harvester management and modifications and use of residue management tools such as disc coulters, row cleaner residue management wheels, stubble tubes etc.</p> <p>3. Higher level of use of autosteer and exclusion of sheep from stubble paddocks.</p> <p>4. The improved residue management systems have reduced wind and soil erosion by maintaining a higher level of ground cover, rather than burning or otherwise removing the residues.</p>
WAN00008	<p>1. Maintenance of interest in no-till despite long-term constraints of weed control, stubble management and rotations.</p> <p>2. The demonstration site has continued to be a contributing factor to the accelerated adoption of relevant sustainable no-till technologies in WA.</p> <p>3. Increased interest in WANTFA activities in no-till farming from personnel in other states and countries.</p>
WAN00012	<p>1. The expected outcome is a positive change in the attitudes of growers to stubble retention systems with no burning, use of cover crops and to integrated weed management.</p> <p>2. Any significant changes in practice will depend on the results of the economic analysis and other aspects of individual farming systems.</p>
WAN00013	<p>1. Expected higher level of adoption of cover crops in cereal cropping systems.</p> <p>2. More effective establishment and management of cover crops is anticipated.</p>
WAN00015	<p>1. Stimulating a continuing interest in no-till despite long-term constraints of weed control, stubble management and rotations.</p> <p>2. The demonstration site has continued to be a contributing factor</p>

	to the adoption of relevant sustainable no-till technologies in WA. 3. Encouragement of increased interest and visitation to WANTFA activities by agriculture students in Western Australia.
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Overview of Outcomes

The GRDC investment encouraged no-till practices in Western Australia to continuously evolve, resulting in improved outcomes of efficiency gains for those already using no till and encouraging more cropping farmers to adopt no till over time. For example, in the early years of the investment, there was widespread adoption of one pass with narrow points for sowing, sometimes called no-till seeding.

However, crop residues were seen to constrain new crop establishment and therefore there was still much residue burning, or crop residues were grazed heavily or baled. For example most growers perceived residues as a problem at sowing time. Phase farming with sheep was practiced widely (excluding sheep from the cropping area for a few years). There was potential for steering between last year's rows using GPS guidance, but investment in new machinery was limited. Seedling emergence was still restricted due to stubble. Residue management constraints had not been overcome in the ten years of no-till up to 2003.

By 2006 a higher level of use of harvester management and modifications and use of residue management tools such as disc coulters, row cleaner residue management wheels, and stubble tubes was apparent. Also autosteer was more frequently used to minimise residue issues at sowing and exclusion of sheep from stubble paddocks resulted in more standing stubble being retained.

Wind and soil erosion have been lowered by the maintenance of a higher level of ground cover, rather than burning or otherwise removing the residues.

By 2005 disc seeders had still not become universally used in Western Australia but some growers had used them effectively providing less residue burial, improved seedling emergence, and a higher level of ground cover. Current trials are comparing disc seeders with standard sowing methods, but seasonal conditions (drought years) have limited stubble presence and hence trial results.

In summary, the principal outcomes from the investment were:

- (a) A faster rate of adoption of no till sowing with consequences for higher average crop yields
- (b) A higher level of effectiveness of no till sowing in terms of overcoming issues such as stubble handling and weed and disease control, thereby improving seedling emergence and ground cover
- (c) Maintenance of interest in the benefits of no-till despite constraints of weed control, stubble management and rotations
- (d) Development of increased interest in improving the quality of no-till systems
- (e) Decreased wind and water erosion

5. Benefits

Project Benefits

A summary of the principal benefits from each of the eight projects is reported in Table 8.

Table 8: Summary of Principal Benefits by Project

Project	Principal Benefits
WAN3	<ul style="list-style-type: none"> • Improved decisions regarding weed control, nitrogen use, stubble management and crop rotations • Water use efficiency improvement enabling crops to be grown in some dry years • Reduced level of soil erosion • Some increase in level of organic carbon in the soil • Increased adoption of no-till practices within Western Australia • Increased adoption of no-till practices in other Australian states
WAN5	<ul style="list-style-type: none"> • More effective use of herbicides • More effective use of fertilisers and nutrient supplements including copper and urea
WAN6	<ul style="list-style-type: none"> • Improved decision making among growers about various aspects of no-till systems • More reliable yields for growers who used no till • Environmental benefits in the form of reduced soil and wind erosion
WAN00003	<ul style="list-style-type: none"> • Stubble management changes via harvester management and seeding machinery leading to increased stubble retention • Reduced level of burning and other means of stubble removal • Reduced wind and soil erosion, less destruction of surface soil structure, and improved soil moisture storage from increased ground cover
WAN00008	<ul style="list-style-type: none"> • Increased number of grain farmers using no-till technologies with improved decision making about various aspects of no-till systems • More reliable yields for growers who used no-till
WAN00012	<ul style="list-style-type: none"> • Expected increase in number of grain farmers considering full stubble retention and disc seeding with associated productivity and sustainability benefits • Higher level of awareness of alternative crops in rotations to reduce pest impacts • Greater appreciation and knowledge of the role of high quality no-till systems (with full stubble retention in rotations and minimal soil disturbance) in promoting improved retention of soil water, improved soil nutrient dynamics and soil biology, and, in the longer term, improved soil carbon levels • The development of a more robust cropping system with

	greater water use efficiency and environmental benefits to meet the challenges of climate change
WAN00013	<ul style="list-style-type: none"> • Expected increase in crop diversity through introduction of cover crops • Expected increase in soil cover throughout the season • Expected nitrogen contributions for leguminous species • Expected improvements in weed control • Expected higher yields from subsequent cash crops caused by increased soil moisture storage, more effective weed control and reduced disease
WAN00015	<ul style="list-style-type: none"> • Expected increase in number of grain farmers using no-till technologies with improved decision making about various aspects of no-till systems • Expected increase in reliability of yields for growers who use no-till • Expected environmental benefits in the form of reduced soil and wind erosion • Increased future industry capacity building by encouraging a higher level of integration between the demonstration site and student learning from Universities and Agriculture Colleges

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 WANTFA Investment

<p><u>Industry Productivity and Profitability</u></p> <p>Short term</p> <ul style="list-style-type: none"> • Improved soil moisture storage from reduced soil disturbance and higher level of ground cover leading to higher yields in some years • Ability to grow crops in dry years when otherwise not possible to grow • Increased profitability of crop production from higher average yields, with decreases or minimal increases in operational costs • Potential for increased yields/reduced losses/decreased costs due to improved control of pests and diseases • Increased uptake of no-till technologies in Western Australia as well as in other cropping regions of Australia <p>Long term</p> <ul style="list-style-type: none"> • Higher yields from improved soil structure and higher organic carbon soil content • Potential nitrogen contributions from leguminous cover crops • Potentially improved weed and pest control and increased soil cover from use of cover crops • More robust cropping systems able to cope with any climatic changes • Potentially higher market returns for grain that is produced under best management practices in relation to the environment <p><u>Environmental</u></p> <ul style="list-style-type: none"> • Reduced soil and wind erosion from less tillage and increased ground
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<p>cover leading to more sustainable farming systems and improved water quality in waterways</p> <ul style="list-style-type: none"> • Reduced level of chemical usage for pest control and less chemical exports off farm • Reduced air pollution from reduced stubble burning and dust • Enhanced soil biological activity and higher level of soil organic matter
<p>Social</p> <ul style="list-style-type: none"> • Reduced impact of smoke on air quality in cropping regions • Increased industry, community, and research capacity from student involvement • Improved no-till infrastructure within Western Australia, Australia and overseas countries

Public versus Private Benefits

The benefits identified from the investment in WANTFA are predominantly private benefits, namely benefits to grain producers predominantly in Western Australia. There also will have been some public benefits produced, mainly environmental in nature including reduced wind and water erosion and improvements in air quality from less dust and smoke in grain growing regions.

Additionality

It is likely that some continued form of support for no tillage would have eventuated if GRDC had not supported the program over this period. Hence it was likely that if the government contribution to GRDC was absent, there probably would have been some form of WANTFA support, with a lowered investment by GRDC and hence with less progress having been made.

Distribution of Benefits Along the Grains Supply Chain

Some of the potential benefits from higher average yields and more consistent annual grain supply will be passed along the supply chain to grain processors, and other Australian users of grain including intensive animal producers and ultimately consumers. However, as grain, particularly that from Western Australia, is predominantly exported, benefits will be captured in the main by Western Australian grain producers. Also, no-till (conservation agriculture) could have significant benefits as a point of differentiation of grain markets where certification of good agricultural practice is becoming increasingly important.

Benefits to other Primary Industries

The investment in the WANTFA projects has positively influenced adoption of no-till technologies in other cropping regions of Australia and possibly to overseas cropping industries. However, there are unlikely to have been any direct benefits to other primary industries apart from mixed farms with crops and intensive animal industries through a small share of no-till benefits.

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	1. Productivity and adding value
2. Promoting and maintaining good health	2. Supply chain and markets
3. Frontier technologies for building and transforming Australian industries	3. Natural resource management
4. Safeguarding Australia	4. Climate variability and climate change
	5. Biosecurity
	<i>Supporting the priorities:</i>
	1. Innovation skills
	2. Technology

The investment in the WANTFA cluster of projects was predominantly focused on National Research Priority 1 and to a lesser extent on Priority 3. The investment was focussed on Rural Research Priorities 1, 3 and 4.

6. Pathway to Adoption

Most of the projects were implemented in close association with grain producers in Western Australia. The investment produced both assembly and integration of existing information as well as generating new information from a considerable number of short-term trials and longer-term experiments. All projects were under the management of WANTFA and this in itself would have generated considerable ownership by grain producers of information produced.

A considerable amount of the investment was targeted at communication with grain producers through a range of mechanisms and media. Well attended field days and field walks were most prominent as were the WANTFA newsletters, booklets of trial results and many other print media channels.

GRDC investment in WANTFA has proceeded now for nearly 13 years. This investment has followed to a large extent the increasing adoption of no till systems in Western Australia over the same period where the proportion of farmers practicing no-till increased from about 25% to about 90%. The major motivating factor for adoption of no-till was the improved soil moisture storage, earlier seeding, and the associated increase in average yields. A no-till system was perceived originally as no till seeding with chemical control of weeds. In recent years, stubble retention and management, crop rotations and autosteer have been given prominence as components of no-till system technologies.

There is scarce data available to substantiate assumptions regarding adoption of no-till technologies and systems that could be directly attributed to the GRDC

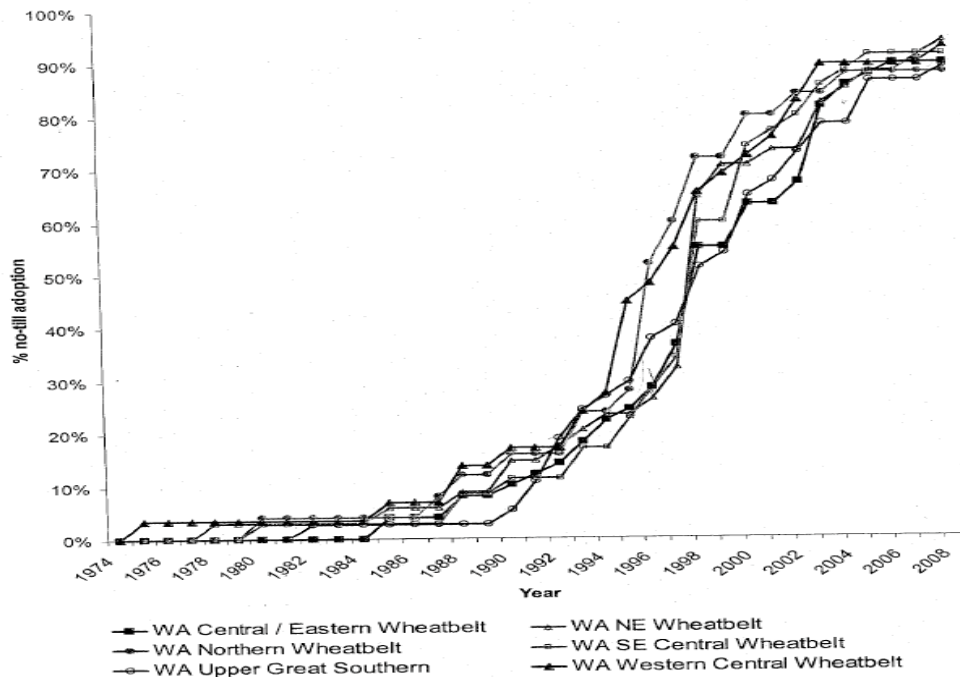
investment. However, it is highly likely that a considerable proportion of the effective use of no-till technologies as well as the speed and extent of adoption can be linked to the GRDC/WANTFA investment.

7. Measurement of Benefits

Adoption Profile for No-Till

A profile of adoption of no-till in Western Australian grain production reported by Llewellyn et al (2008) is given in Figure 1.

Figure 1: Adoption of No-Till in Western Australian Cropping Regions



This profile was for a sample of 209 cropping farmers in Western Australia. No-till was defined broadly as seeding with low soil disturbance and no prior cultivation. The definition included zero till with disc machines, knifepoints, super seeder, inverted-t, all being used for seeding with no prior cultivation. Table 11 provides an approximate estimate of the adoption of no-till in WA based on the Llewellyn et al report.

Table 11: Approximate Cumulative Adoption of No-Till in Western Australia

Year	Cumulative Percentage Using No Till
1993	20
1994	23
1995	27
1996	30
1997	40
1998	50
1999	60

2000	70
2001	80
2002	81
2003	82
2004	83
2005	84
2006	85
2007	86
2008	88

Source: Estimated from Figure 7 in Llewellyn et al (2008)

When previous survey results from the Victorian Mallee and from South Australia were compared with the Llewellyn et al (2008) results for those regions, they provided an encouraging level of consistency.

The estimates in Table 11 are somewhat higher than occasional estimates made within the WANTFA projects. For example, the reports for WAN 3 and WAN6 estimated the adoption of no-till increased from 20% in 1996 and 25% in 1997 to 75% in 2002. However, the project estimates were consistent with the underlying trends in Table 11.

Other results of the survey of interest to the current analysis were:

- In WA the proportion of grain growers employing no-till using points only (rather than disc opening) varied from 83% to 95% by region.
- Of the 209 WA grain producers responding in the survey who had used some no-till, only 0-6% by region had reduced the proportion of crops sown using no-till and 0-3% had ceased using no-till altogether.
- Of those WA growers using no-till in 2008, the average proportion of crop sown with no-till averaged 84-100% across the six grain regions
- WA growers using no-till reported only a minor increase in tillage when glyphosate prices increased, compared to other states where the responsiveness was greater.
- The proportion of WA grain growers who still burn stubble averaged 33% but varied by region, with 55% of users in the Western Central Wheatbelt still burning stubble.
- While there was little difference in the average farm area managed between adopters and non-adopters, those adopting usually had a higher proportion of their farm area cropped and also has noticeably increased their farm area since 1998.

It is concluded that no-till has been profitable to the grower for the adoption profile observed to have developed as it has.

It is evident that there are still problems with the use of no-till in terms of the management of stubble and weed control, the latter largely due to increasing herbicide resistance. While ground cover has increased somewhat due to the form of no-till currently performed, burning of stubble is still reducing the potential for moisture storage and also lessens weed control. Disc seeding and rotations with non-cereal crops are still not widely adopted in Western Australia, although considerable effort is currently being expended on these topics by WANTFA.

Western Australian Wheat Production

Statistics of Western Australian wheat production during the likely period of impact of the WANTFA investment are shown in Table 12. The high variability in yields is largely an influence of the seasonal rainfall patterns.

Table 12: Area, Yield, Production and Value of Western Australian Wheat Production

Year ending June	Area (ha)	Yield (t/ha)	Production (000 t)	Price (\$ / tonne)
1997	4,264	1.76	7,516	213
1998	4,205	1.84	7,725	198
1999	4,515	1.81	8,170	187
2000	4,556	1.98	9,004	195
2001	4,460	1.30	5,814	232
2002	4,350	1.78	7,760	262
2003	4,458	0.91	4,047	266
2004	4,917	2.25	11,070	216
2005	5,118	1.68	8,619	197
2006	4,753	1.91	9,088	203
2007	4,037	1.27	5,134	242
2008	4,100	1.49	6,100	420
2009 (a)	4,478	1.67	7,504	236
2010 (a)	4,478	1.67	7,504	236

(a) Average of previous 12 years

Value of No-till

Clearly there are many variations of no-till and the suite of optimal technologies to use for an individual farm or soil type may differ. However, assumptions on the average benefit to Western Australian no-till systems are required in this analysis.

Increased profitability

There can be both short- and long-term impacts of no-till systems on wheat yields. In the short-term the benefits primarily gained to date are derived from increased soil moisture at sowing time due to no-tillage and to increased ground cover.

Improved timeliness of sowing due to increased soil moisture with no-till can increase wheat yields. It has been stated that yields can be reduced by 1% per day when sowing is delayed beyond the first week of May in Western Australia. In other years sowing a crop may not be possible at all without no-till technologies.

Across all years, the assumption is made that no-till increases average yields by 5% per annum. This is a conservative estimate as this gain would be significantly greater in some years when crops could not be sown without no-till applications. In other years, however, there may be minimal gains.

No till systems require herbicides to control weeds but these costs can be offset by the avoided costs of cultivation. Additional machinery costs for no till can exist in the short term but many growers adapt existing machinery at low costs, so this is not

always a major concern. There may be additional nitrogen required when first converting to no till if stubble is retained. However, for the purposes of this analysis, any short term nitrogen cost is assumed offset by the longer term increased nitrogen cycling from the trash and stubble. Ridge (undated) estimated the extra return from no-till in southern Australia in the short term at \$94 per ha with only \$19 per ha added costs, that is a net gain of some \$75 per ha.

Scott and Farquharson (2004) undertook an assessment of the economic impact of conservation and reduced tillage in northern NSW using gross margin analyses across eight grain growing regions. They estimated the mean improvement in gross margins from undertaking no-till compared with conventional tillage was \$89 per ha. These estimates were verified by on-farm trials conducted by NSW Agriculture at two locations in NSW. Also, using whole farm budgeting exercises showed a substantial improvement in return to capital from using no-till methods.

Taking into account the normative nature of these two estimates, the net gain actually captured by the Western Australian farming system for the no-till benefits is conservatively assumed to be about \$30 per ha. A second reason that a lower benefit is assumed for Western Australia is that the estimates for Northern NSW farming systems incorporate summer crops that provide improved weed control and higher overall gross margins per ha.

An increase of \$30 per ha, at an average WA yield of 1.67 tonnes and a farm gate price of \$180 per ha, is equivalent to a yield increase of about 10%. The 5% yield increase assumed in this analysis is therefore considered conservative.

Long-term gains

Additional long term gains are most likely in systems where more stubble is retained and Western Australian systems still have more to achieve in this regard. The gains will emanate from improved soil structure and increased organic matter, increased nutrient cycling, carbon sequestration, and further soil moisture storage.

Stubble retention and maintaining ground cover can reduce soil and wind erosion and this benefit is perhaps one of the greatest impacts of no-till systems for some WA regions.

The continued use of chemicals to control annual ryegrass can build resistance and eventually render the chemicals less effective. Many grain producers are mindful of this and seek to use alternative weed control strategies where possible, such as using rotations, weed seed catching, cutting for hay, double knock pre-seeding herbicides and growing break crops or cover crops. No significant benefits in this regard have been manifest from the GRDC investment to date, but these are potentially capturable in future.

None of the long-term gains identified here has been included in the current valuation of benefits.

Attribution of Benefits to WANTFA Investment

The following analysis assumes that some adoption of no-till systems would have occurred without the GRDC investment. This counterfactual situation is assumed as there was a rapid increase in no-till underway before the GRDC investment commenced. Also, the perceived advantages of no-till systems by growers would have driven significant adoption, as occurred in other states.

The increase in adoption in no-till in Western Australia compared to adoption in other states may have been due to its greater perceived and actual benefits in the Western Australian growing environment. Cumulative adoption profiles for the other states have lagged that of WA since about 1996 (Llewellyn et al, 2008). However, other states have also had the equivalent farmer associations associated with no-till similar to WANTFA and have had support from GRDC. While WA adoption overtook that in other states from about 1996, the rapid increase in other states also occurred from about the same time. In terms of the level of adoption in 2008, WA adoption was still about 5-10 percentage points above the other states.

It is assumed that the combined GRDC and WANTFA investment would have had a significant role in raising the speed of adoption of no-till in Western Australia, particularly in the period from 1996 to 2004. In this regard it is assumed that adoption levels would have been brought forward by three years by the GRDC/WANTFA investment from what otherwise would have occurred.

In addition it is assumed that for all those adopting no till during the period of investment impact assumed (1999 to 2008) that the yield increase of 5% would have been only 4% if the GRDC investment had not taken place.

The benefits from the quicker adoption and the more effective no-till application by all adopters are assumed to have occurred from the 1998/99 year onwards.

Benefits not Valued

The principal benefits identified but not valued in the analysis include:

- The implications of increased levels of organic matter in the soil (e.g. soil structure including higher moisture holding capacity, quicker nutrient cycling) with further increases in yields
- The reduced water and wind erosion and any air quality improvements

In the short term some of these non-valued on-farm benefits will be captured in the yield gain assumed, through reduced loss of nutrients and higher organic matter, moisture holding etc, but the partitioning of the yield gain to different sources has not been attempted.

There are also probably off-farm impacts of soil and wind erosion. Long distance transport of dust has been estimated at costing \$23 m annually in South Australia largely due to impact on human health (respiratory impacts). The relevance of this impact to WA is unknown, nor how much of the SA estimate was due to cropping, and then how much of the cropping component would be alleviated by application of no till. In short, the relationship between the management change to no-till and the soil and dust export reduction are difficult to make assumptions about for valuation purposes.

Summary of Assumptions

A summary of the key assumptions made is shown in Table 13.

Table 13: Summary of Assumptions

Variable	Assumption	Source
<i>With WANTFA No-till Investment</i>		
Average yield for WA wheat	1.67 tonnes per ha	Table 12
Individual year and average prices for wheat	Average is \$236 per tonne including freight etc	Table 12
Allowance for farm gate to port costs	\$60 per tonne	Based on Wilkinson (2006)
Average yield gain from no-till	5%	Agtrans Research
Individual year and average annual WA wheat tonnage	Average is 7.5 m tonnes per annum	Table 12
Adoption profile for no-till	Increased from 20% of farmers in 1993 to 88% in 2008	Table 11
Proportion of total crop actually sown with no-till for those 'adopting' no-till	85%	Adapted from Llewellyn et al (2008)
<i>Without WANTFA No-till Investment</i>		
Effectiveness of no-till without investment	4% average yield gain each year instead of 5% with investment	Agtrans Research
Adoption of no-till without investment	3 years slower	Agtrans Research

Results

All past costs and benefits were expressed in 2008/09 dollar terms using the CPI. All benefits after 2008/09 were expressed in 2008/09 dollar terms. All costs and benefits were discounted to 2008/09 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 25 years from the last year of investment (2009/10) to the final year of benefits assumed (2034/35).

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 (or other) as reported in Tables 14 and 15.

Table 14: Investment Criteria for Total Investment for Each Benefit Period
(discount rate 5%)

Criterion	0 years	5 years	10 years	15 years	20 years	25 years
Present value of benefits (m\$)	201.25	242.66	275.26	300.81	320.83	336.51
Present value of costs (m\$)	9.10	9.10	9.10	9.10	9.10	9.10
Net present value (m\$)	192.15	233.56	266.16	291.71	311.73	327.41
Benefit cost ratio	22.11	26.66	30.25	33.05	35.35	36.98
Internal rate of return (%)	nc	695	695	695	695	695

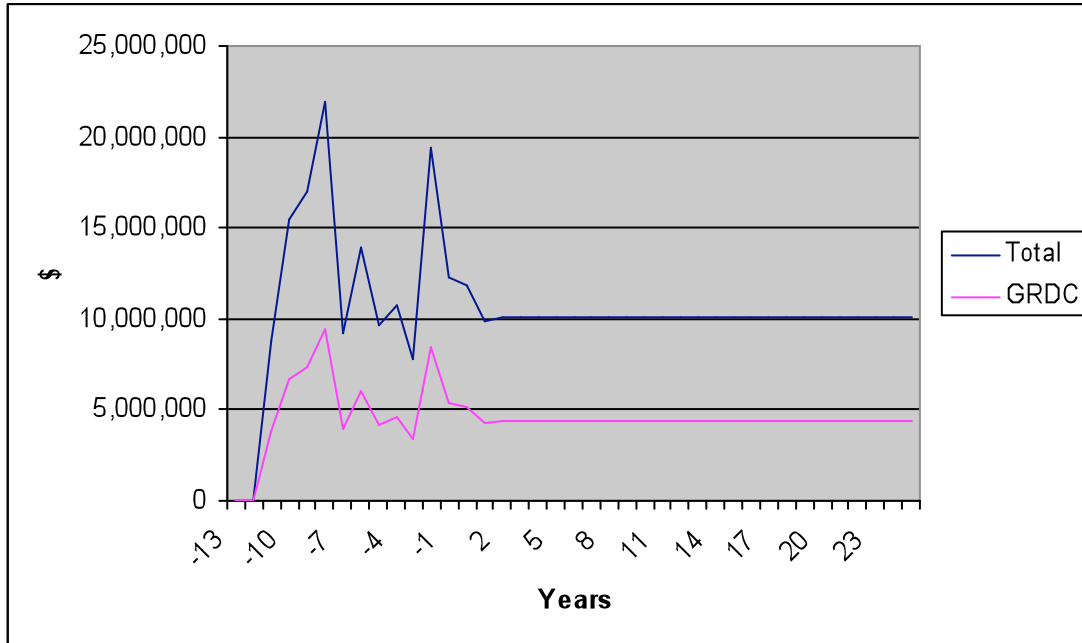
nc: not calculable due to magnitude and timing of benefits and costs

Table 15: Investment Criteria for GRDC Investment for Each Benefit Period
(discount rate 5%)

Criterion	0 years	5 years	10 years	15 years	20 years	25 years
Present value of benefits (m\$)	86.96	104.85	118.94	129.98	138.63	145.41
Present value of costs (m\$)	4.05	4.05	4.05	4.05	4.05	4.05
Net present value (m\$)	82.91	100.80	114.89	125.93	134.58	141.36
Benefit cost ratio	21.47	25.89	29.37	32.10	34.23	35.91
Internal rate of return (%)	499	499	499	499	499	499

The proportion of total benefits from quicker adoption was estimated as 25% and that from the more effective application of no-till at 75% of the total benefits. The cash flow of benefits is shown in Figure 1 for both the total investment and for the GRDC investment in the cluster.

Figure 1: Annual Benefit Cash Flow



Sensitivity Analyses

Sensitivity analyses were carried out on several variables and results are reported in Tables 19 and 20. All sensitivity analyses were performed using a 5% discount rate with benefits taken over the life of the investment plus 25 years from the year of last investment. All other parameters were held at their base values.

Table 19 shows the investment criteria when the assumption regarding the yield increase due to the WANTFA investment was adjusted downwards to 0.5 percent and adjusted upwards to 2.0 percent

Table 19: Sensitivity to Changes in Yield due to the WANTFA projects (GRDC investment, 5% discount rate, 25 years)

Criterion	Level of yield impact		
	0.5 percentage point	Base (1 percentage point)	2 percentage points
Present value of benefits (m\$)	90.88	145.41	254.46
Present value of costs (m\$)	4.05	4.05	4.05
Net present value (m\$)	86.83	141.36	250.41
Benefit cost ratio	24.44	35.91	62.84
Internal rate of return (%)	429	499	620

Table 20 shows the sensitivity of the investment criteria to changed assumptions regarding the quicker adoption due to the WANTFA investment.

Table 20: Sensitivity to Changes in Speeding up of Adoption
(GRDC investment, 5% discount rate, 25 years)

Criterion	Adoption Speeding Up		
	1 year	3 years (Base)	5 years
Present value of benefits (m\$)	126.30	145.41	160.33
Present value of costs (m\$)	4.05	4.05	4.05
Net present value (m\$)	122.25	141.36	156.28
Benefit cost ratio	31.19	35.91	39.59
Internal rate of return (%)	474	499	499

These sensitivity results show that the positive investment criteria for the base assumptions are reasonably robust to significant changes to the two key assumptions. One of the reasons for this is that there are two types of benefits assumed and each sensitivity analysis applies to only one of the benefits in each case.

8. Confidence Rating

The results produced are highly dependent on the assumptions made, many 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 21). 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 21: Confidence in Analysis of WANTFA Investment

Coverage of Benefits	Confidence in Assumptions
High	Medium

9. Conclusions and Lessons Learned

Attribution of the benefits from no-till to the GRDC investment has been difficult to make as the technology already had a significant momentum in Western Australia at the commencement of the investment and no-till systems have become adopted in most Australian cropping systems.

The most important characteristic of the investment has been its integrated R&D and extension nature. This has undoubtedly led to quicker and more effective application of no-till technologies. The investment has raised awareness of no-till opportunities and benefits and provided greater confidence in those willing to undertake change.

Based on a set of conservative assumptions, the investment is considered to have been highly profitable with a total net present value estimated at about \$327 million (08/09 \$ terms) for an investment of only about \$9 million in present value terms. The benefit cost ratio was estimated at 37 to 1.

These estimates are considered conservative since there are some longer-term productivity benefits not valued as well as considerable environmental benefits in the form of reduced soil and wind erosion that also have not been valued, due to a lack of data supporting these linkages.

Acknowledgements

Ken Flower, University of Western Australia and WANTFA

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