## Who benefits most from 'public' herbicide use R&D?

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### Abstract

The Australian grains industry relies on herbicides for cost-effective weed control, spending nearly $1 billion on herbicides in 2004 (APVMA 2005). Grower and/or taxpayer funded (public) research and development organizations invest substantial sums aimed at improving the effective and efficient use of herbicides. The distribution of benefits from this R&D between growers, consumers, and the agricultural chemical industry will depend on the differential impact of the R&D on usage of specific herbicides. Agricultural chemical companies will preferentially invest in herbicide-use R&D that increases the use of their herbicides from which they can capture a price premium due to market power, such as patent protection, unique registration, and/or control of supply. In this paper, the size and distribution of the benefits from a case study of investment in R&D into herbicide resistance management using the 'double knock' technique is analysed using economic surplus techniques. A comparison is made between the public and private return on investment from the R&D when the recommended herbicide is either patent protected, or non-proprietary. The results from the case study indicate that while this form of herbicide resistance R&D is likely to provide significant returns to growers, the agricultural chemical industry will not necessarily derive much benefit.

### Key Words

R&D evaluation, economic, double knockdown technique, herbicide use.

### Introduction

Grower and/or taxpayer funded (public) research and development organisations invest in science and extension to improve the productivity and efficiency of agriculture in Australia for the benefit of society as a whole. Where research and development (R&D) increases use of proprietary technologies, such as patented chemicals or engineering, registered plant varieties or biotechnology, there is a *prime facie* case that private industry should fund such investment. Clearly, private industry will preferentially invest in R&D which increases the use of their proprietary technology, since they can capture a return on their R&D expenditure. Conversely, R&D which decreases the use of proprietary technology, or only minimally increases its use, is unlikely to be undertaken by private industry. Thus public investment may be required to optimise the investment in R&D into the use of both proprietary and non-proprietary technologies.

To determine the optimal investment in proprietary and non-proprietary innovations, public R&D organisations must take into consideration key aspects of the R&D effort. These key aspects would include the proprietary state of the innovation over time, the total benefit to growers, previous R&D efforts, and ability of private industry to extract a price rent or premium above the full cost of supply, including "normal" profits. This allows the R&D organisation to estimate any benefit to be gained by private industry from their R&D effort, and the likelihood of private investment in the R&D. The ability of private industry to 'free ride' on public R&D must be weighed against the overall benefit to growers and the likelihood of private industry undertaking the R&D independently.

Public research organisations invest substantially in herbicide-use R&D as Australian growers rely heavily on herbicides for effective weed control. The proprietary status of the herbicide adopted and/or dis-adopted due to the recommendations of R&D will determine the distribution of benefits of the R&D between growers and the agrichemical industry. The double knockdown strategy, whereby growers are recommended to apply paraquat/diquat following glyphosate, is a current area of herbicide-use R&D where the distribution of benefits between grain growers and the agrichemical industry is of interest. This paper investigates the size and allocation of benefits from R&D into the double knockdown strategy as an example of public investment in a herbicide technology.

## Methods

### *Economic Surplus Technique*

Benefits from research can be measured empirically using economic surplus methods as summarized in Alston et al. (1995). The economic surplus approach has been used in a large number of previous studies that have investigated the impacts of many different types of agricultural research, including weed management research (Sinden, et al. 2004).

### *Case Study Background*

In Australia, resistance to the herbicide glyphosate by weed populations was first observed in 1996 in the weed rigid ryegrass (*Lolium rigidum)* (Heap 2005). Populations of ryegrass resistant to glyphosate are present in all major broad acre winter cropping states (NGSWG 2006). Many strategies are being developed to overcome or delay the onset of herbicide resistance in further ryegrass populations across Australia (NGSWG 2005). The term 'double knockdown' has previously also referred to the use of a non-selective herbicide followed by a full cut cultivation, however, in this study it is assumed to specifically refer to the pre-sowing practice of applying glyphosate and then applying paraquat-diquat 4-10 days later. The application of paraquat-diquat is to kill the survivors of the glyphosate application, the weeds which are possibly resistant to glyphosate. The following is an illustrative example of an R&D project aimed at demonstrating principles, rather than a detailed empirical analysis.

### *The R&D Project*

The research project is designed to identify and demonstrate the benefits of the double knockdown strategy to growers with weed populations at risk of developing resistance to glyphosate. The research and development project includes initial identification of the double knockdown strategy; and subsequent on farm trials, laboratory testing and extension activities to illustrate its benefits and encourage adoption. The cost of the public R&D effort for this project is assumed to be $100,000 p.a. for 10 years.

Based on the work of Neve et al. (2003), Figure 1 illustrates the proportion of wheat production likely to be affected by glyphosate-resistant annual ryegrass under different scenarios. With the R&D project, and consequential higher adoption of the double knockdown strategy, development of glyphosate resistance is assumed to be lower. Adoption of the double knockdown strategy as described is assumed to prevent glyphosate resistance during the analysis period (Neve, et al. 2003), thereby reducing the cost of weed control in future wheat production. The double knockdown strategy is defined in this study as the application of glyphosate every year and paraquat-diquat in two of every three years of no tillage production. Currently adoption of the double knockdown strategy is low (O'Connell and Allard 2004) and believed to be limited to Western and Southern Regions. In this study, adoption of no-tillage is assumed to reach maximum adoption in 2008 of 49% of Southern Region wheat production and 70% of Western Region production, with adoption of the double knockdown strategy due to this R&D project reaching a maximum of 7.6% of no-tillage production in both the Southern and Western Region, Figure 1. The reduction in the cost of weed control between the with and without the research project is the aggregate benefit due to the R&D project, and is calculated from these adoption figures and costs of herbicide treatment and resistance management based on Weersink et al. (2005).

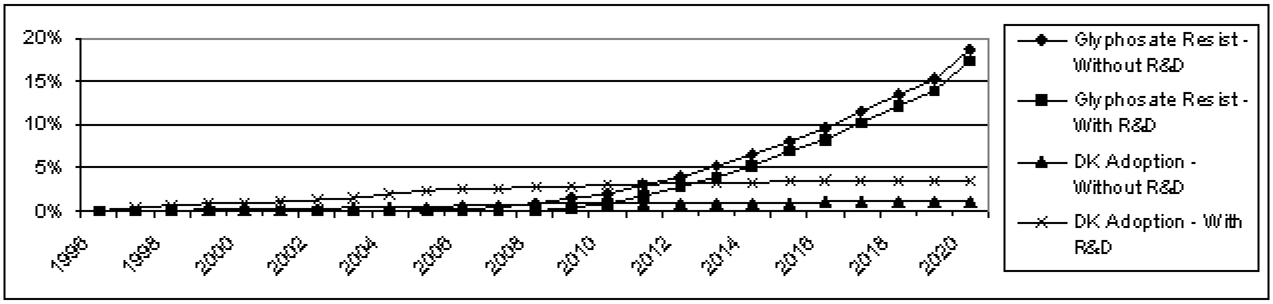


**Figure 1. Australian wheat production affected by glyphosate resistance, and treated by the double knockdown with and without the R&D project.**

The patent on paraquat-diquat, known as Sprayseed™, expired recently. However, to illustrate the issues involved, it is assumed in this study that Syngenta will be able to maintain the price premium and market share it has received on this proprietary technology for the duration of the period covered by this analysis. The aggregate price premium extracted by the chemical companies is assumed to be 2% of the price of paraquat/diquat. Given an assumed price of $8.33/ha this equates to a $0.11 per tonne of wheat production. This price premium is assumed to have no impact on the adoption of the double knockdown strategy with or without the R&D project.

*Without the R&D Project*

As the number of populations of glyphosate resistant ryegrass increases in the future, it is expected that growers would investigate the double knockdown or some similarly effective strategy without the R&D project. Without the R&D project, glyphosate resistance affects more wheat production and the average cost of weed control is higher once resistance has developed, Figure 1. The weed control cost without the R&D is calculated as described above for the with R&D scenario.

**Results**

*Economic Surplus*

The total benefits to Australian grain growers and the agrichemical company of the double knockdown strategy, with and without the R&D project, are shown in Figure 2. Lower adoption means the benefit of the double knockdown strategy is less without the R&D project. The total NPV of benefits to Australian wheat growers due to the R&D project ($9,169,000), can be compared to assumed total NPV of R&D costs of $772,000 and a Chemical Company benefit above “normal” profits of $409,000. Growers in the Western Regions receive 54% of the total benefits and Southern Region growers 42%. The benefit to cost ratio for public investment in this R&D project was 11.9 and the internal rate of return was 12.2%. The benefit to cost ratio for investment by the agrichemical company was 0.5 and the internal rate of return was -1.4%.

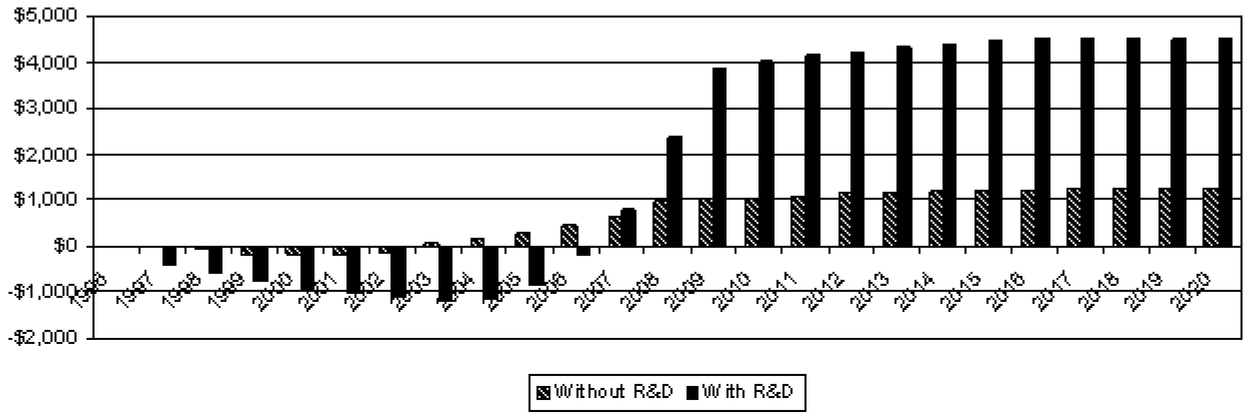


**Figure 2 Time profile of annual net benefits to Australian production due to adoption of the double knockdown strategy with and without the R&D project ($ 000).**

*Sensitivity Analysis*

Sensitivity analysis was conducted to ascertain the key variables determining the size and distribution of benefits from R&D into the double knockdown strategy, Table 1. Halving adoption of the double knockdown strategy with the R&D project decrease the benefit to Australian growers by 60% and the agrichemical company of the research by 67%, it reduces the internal rate of return (IRR) on the investment by public means nominally, but it does notably decrease the IRR for investment by the agrichemical company. Increasing the occurrence of glyphosate resistance (where the double knock has not been adopted) from 20% of Australian wheat production in 2020 to 21% with the R&D project and from 21% to 26% without the R&D project doubles the benefit of the R&D project to Australian growers and increases the benefit to the agrichemical company by 47%, increasing the IRR for both public and private investment. Altering the price premium extracted by the agrichemical company from 2% to 5% increases the benefit to the agrichemical company by 150% and increases their return on investment to 8%, with a B:C above 1.

**Table 1. Sensitivity of total Australian producer and agricultural chemical company benefit (NPV $ '000), internal rate of return on investment (IRR) and benefit to cost ratio (B:C) to changes in the adoption of the double knockdown strategy, the risk of glyphosate resistance and the price premium extracted by the agrichemical company with the R&D project.**

| | Australian Growers | | | Agrichemical Comp | | |
|---|---|---|---|---|---|---|
| **Scenario** | **NPV** | **IRR** | **B:C** | **NPV** | **IRR** | **B:C** |
| Standard | $ 9,169 | 12.2% | 11.9 | $ 410 | -1.4% | 0.5 |
| Low Adoption of DK | $ 3,630 | 11.6% | 4.7 | $ 136 | -10.5% | 0.2 |
| High Risk of Glyph. Resist | $ 18,616 | 15.2% | 24.1 | $ 603 | 2.3% | 0.8 |
| Paraquat Price Premium 5% | $ 8,554 | 11.7% | 11.1 | $ 1,024 | 8.5% | 1.3 |

## Conclusion

The distribution of benefits between Australian grain growers and agrichemical companies from more effective and efficient use of herbicide is determined by the proprietary status of the herbicide and the consequential ability of the agrichemical company to extract a price premium from the market. The case study presented demonstrates the benefits from a successful R&D project, offering a good return with a benefit: cost ratios of 11.9 and internal rate of return of 12.2%. The case study also illustrates the distribution of benefits, whereby Australian grain producers were the chief beneficiaries of this R&D, receiving 96% of the benefits due to the R&D project. The agrichemical company was only a minor beneficiary, as they received 4% of total benefit. Australian consumers receive effectively no benefit from the R&D as the increase in wheat production did not cause noticeable price changes. However it needs to be noted that the research outcomes and market conditions presented here are only speculative and assume that the innovation is effective in preventing resistance over the time period shown.

In this case study the distribution of benefits between private investors, producers and consumers differs markedly from the findings of previous studies. Qaim and Traxler (2005) investigated the benefits for patented Roundup Ready soybeans, where the patent holder received 34% of the benefit and consumers 53%, but grain growers received only 13%. Similarly, Falck-Zepeda et al. (2000) estimated that seed and biotechnology firms captured 26% of the benefits from another patented technology, Bt cotton. In this Bt cotton case though, grain growers received 50% of the benefits, while consumers received the remaining 24%. Our results provide an example of the very limited extent to which chemical companies can appropriate benefits from “public” R&D investment in herbicide use in Australia vis-?-vis their share of more recent patented biotechnological innovations. As with other types of agricultural R&D for the grain industry, grain growers not only collectively fund much of the cost of herbicide-use R&D, but also capture most of the benefits.

Unlike the market for many new biotech innovations, the Australian market for herbicides is highly competitive. Alternative methods of weed control, including the large proportion of cheap generic herbicides, are often as cost effective for grain growers as patented herbicides. Hence, the scope for chemical companies to charge significant price premiums for patented herbicides is severely constrained. Second, the fact that Australia exports most of its wheat production explains why grain growers, rather than consumers, appropriate the lion’s share of the benefits from herbicide-use R&D. For these reasons, an agrichemical company is unlikely to make a substantial investment in the type of R&D projects analysed in this initial work investigating and demonstrating the double knockdown strategy given the low prospective rate of return on their investment, -1.4%. Public and/or collective grower funded investment in some R&D projects that increase the use of proprietary innovations is therefore required if grain growers and consumers are to realise these benefits. The allocation of ‘public’ investment funds to various herbicide-use R&D projects, such as the case study, should be determined by the net return on investment to Australian grain growers and consumers, recognising any possible benefits to the agrichemical company due to the proprietary status of the herbicide.

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